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## Brief Report

# Social learning promotes understanding of the physical world: Preschool children's imitation of weight sorting



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## ABSTRACT

We investigated whether social learning, specifically imitation, can advance preschoolers' understanding of weight. Preschoolers were randomly assigned to experimental and control groups. The experimental group saw an adult intentionally categorize an array of four visually identical objects based on weight. Then, children's weight-based sorting of the objects was evaluated. To test generalization, children were presented with novel objects (differing in shape, color, and weight from the original ones) and not shown what to do with them. Results indicate that 48-month-olds learned to sort by weight via observing the adult's demonstration of categorization and that children generalized weight sorting to novel objects. This shows that children imitate at a more abstract level than merely motor actions. They learn and imitate generalizable rules. 36-month-olds did not succeed on this weight sorting task. Children's cognitive development constrains what children learn through social observation and imitation.

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## Introduction

Object weight pervades our everyday cognition and scientific thinking. Balance and digital scales make this property public, shareable, and precise. Because weight cannot be seen, how humans come

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to understand the concept of weight poses an interesting developmental problem (Smith, Carey, & Wiser, 1985). We hypothesize that social learning plays a role. The current study addresses three interrelated issues: (a) how children can learn about invisible object properties, (b) children's ability to use imitation to acquire abstract rules, and (c) the interaction of cognition and social learning during early childhood.

Piaget reported that young children exhibit little or no understanding of weight at a conceptual level—only at the physical level of exerting different forces to manipulate objects of various weights (Inhelder & Piaget, 1958; Piaget, 1952). Subsequent investigations suggest earlier competencies. For example, 3- and 5-year-olds predict object weight based on size (Gordon, Forssberg, Johansson, Eliasson, & Westling, 1992) and begin to choose heavy versus light objects to tip scales in rule-governed ways (Siegler, 1976). At a more primitive level, studies report that infants can perceive and learn about differences in object weight (Mash, 2007; Molina & Jouen, 2003; Mounoud & Bower, 1974). They can use object appearances (e.g., color, material) to guide their actions with differently weighted objects (Hauf, Paulus, & Baillargeon, 2012; Paulus & Hauf, 2011). Moreover, infants adjust their reaches based on how much the object compresses a soft support structure, presumably revealing its weight (Hauf et al., 2012), and neuroscience studies using electroencephalography (EEG) show that infants use their own self-experience with heavier versus lighter objects to form expectations about the actions of another person lifting those same objects (Marshall, Saby, & Meltzoff, 2013).

One key development during the preschool years is learning to consider weight independently from visual appearance. Between 3 and 4 years of age, children improve in reporting that two visually identical objects have different weights (Smith et al., 1985) and in choosing the heavier of two visually identical objects to make a balance tip (Schrauf, Call, & Pauen, 2011). After receiving explicit verbal instruction and feedback, preschoolers will also sort visually identical objects based on a weight difference (Povinelli, 2012). In this latter work, children handled pairs of objects, saw where to place each depending on its weight, and received explicit rewards for correct placements. When subsequently tested, 3- to 5-year-olds showed high performance when sorting the same objects, which transferred to objects that varied in color from the original pair. In a further test, an apparatus forced children to decide where to place an object (based on a learned visual cue to its weight) before hefting the specific object. Only at 5 years of age did children show above-chance sorting performance without tactile experience of the weight. Thus, previous research indicates that with explicit training preschoolers can group objects by weight, especially in conjunction with first-person kinesthetic experience.

Another possible way children may learn about weight is through observing others' interactions with objects of different weights. Research shows an increasing scope to imitation during the preschool years (e.g., Herrmann, Legare, Harris, & Whitehouse, 2013; McGuigan, Whiten, Flynn, & Horner, 2007; Meltzoff & Williamson, 2013). In the social realm this includes conventions and rituals (e.g., Herrmann et al., 2013), and in the physical realm it includes instrumental knowledge about object properties and functions (e.g., Cladiere & Whiten, 2012). Several studies indicate that children's imitation is not limited to reproducing specific motor acts. Children infer and imitate the intended goal of a series of unsuccessful behaviors (e.g., Meltzoff, 1995). For example, 18-month-olds who saw an adult repeatedly try but fail to pull apart a dumbbell-shaped toy were as likely to produce the goal of pulling the object apart as were those who saw the adult successfully complete the act. Children will also disregard inefficient acts in favor of reaching a goal using their own means (which has been called "emulation"; Nagell, Olguin, & Tomasello, 1993). Related research has used imitation to study causal understanding (Horner & Whiten, 2005; Meltzoff, Waismeyer, & Gopnik, 2012; Schulz, Hoopell, & Jenkins, 2008). After observing a sequence that includes an ineffective action and an effective action, 3-year-olds often reproduce the causally efficient action but omit the unnecessary act (Want & Harris, 2001; Williamson & Meltzoff, 2011). In addition, 3-year-olds are more likely to use an emulative strategy to retrieve a reward from a puzzle box than are 5-year-olds (McGuigan et al., 2007).

Research also provides evidence of preschoolers extracting more abstract information, such as rules and strategies, from observing others' behavior, which is a crucial foundation for cultural learning. Three prominent examples have emerged.

First, Subiaul and colleagues described "cognitive imitation," in which children reproduce an observed sequence rule (Subiaul, Romansky, et al., 2007; Subiaul, Lurie, et al., 2007). Preschoolers who saw an adult press pictures on a screen in a particular order needed fewer trials to learn the

sequence than did children who learned through trial and error. A replication extended the finding to linear motor–spatial sequences (left → middle → right; Subiaul, Anderson, Brandt, & Elkins, 2012).

Second, preschoolers imitate the hierarchical organization underlying others' acts (Flynn & Whiten, 2008). For example, 3-year-olds saw an adult use one of two strategies to unlock a box to get a reward (Whiten, Flynn, Brown, & Lee, 2006). One strategy was to first assemble all of the keys needed to open the box, then to insert them all, and then to open all of the locks. The second strategy was to assemble each key and use it to open the lock before moving on to assemble and use the next key. Children tended to copy the strategy that was demonstrated by the adult even though the results of opening the box could be acquired by using either of the two strategies.

Third, and most relevant to the current work, Williamson, Jaswal, and Meltzoff (2010) investigated 36-month-olds' imitation of an object categorization rule. Children who saw an adult sort objects into two different bins according to an invisible property (e.g., sounds made when shaken) were more likely to sort the objects by the target property than were children in control groups. Taken together, these findings show that preschoolers are not reproducing what they literally saw but rather are extracting more abstract rules from others' acts and using these to guide their own subsequent behavior.

The current study tested whether social learning may play a role in children's use of weight in a categorization task. Children in the experimental group saw an adult sort visually identical objects into two piles based solely on their weights. Children received no prior experience in handling the objects and no explicit training or feedback about how to arrange them. Then, children were given an opportunity to sort those objects and a new set of objects that was not previously manipulated (generalization). We predicted that the adult's demonstration would promote children's categorizing of the objects by the invisible property of weight.

We further hypothesized that the adult's intentional sorting behavior is key for promoting weight sorting. It is possible, however, that the intentional sorting demonstration is not needed and that other social learning processes might be sufficient. For example, the adult's acts may increase children's interest in the objects (stimulus enhancement), or seeing the objects in the end-state arrangement (emulation) may prompt weight sorting. To test these alternatives, children were randomly assigned to either the experimental treatment or one of two closely matched controls that equated these other factors but did not include a sorting demonstration by the adult.

Given that young preschoolers have difficulties in using object weight functionally when confronted with visually identical objects (e.g., Povinelli, 2012; Schrauf et al., 2011; Smith et al., 1985), we also hypothesized that the age at which children imitate weight sorting may be later than that for sorting by other object properties (e.g., color and sound, which occurs at 36 months; Williamson et al., 2010)—illustrating cognitive gating of social learning (see Discussion).

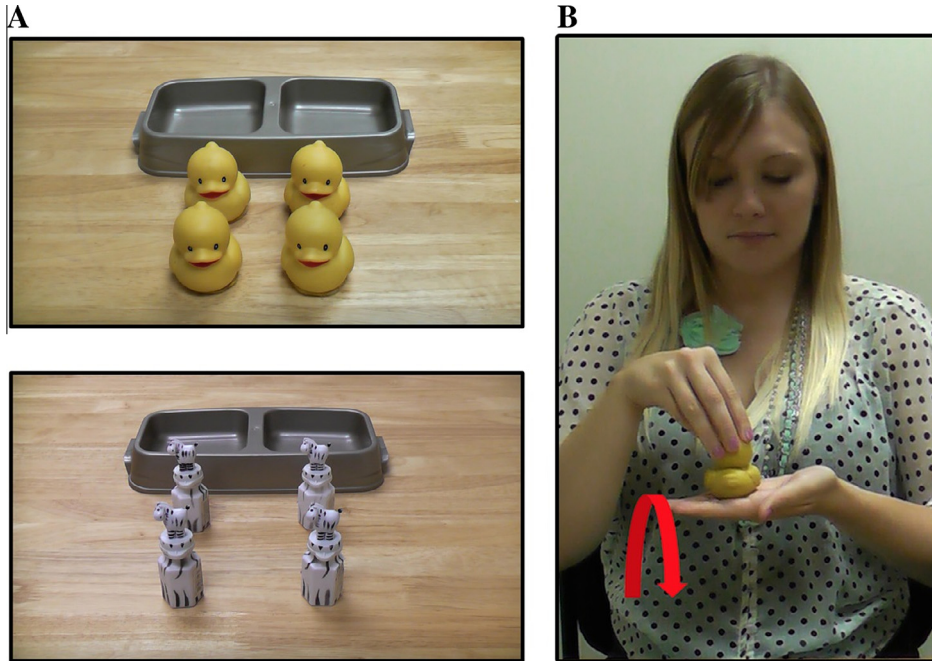
## Method

### Participants

A sample of 96 children participated. Half were 36 months old ( $M = 36.6$  months,  $SD = 1.67$ ; 24 boys) and half were 48 months old ( $M = 48.9$  months,  $SD = 1.66$ ; 24 boys). According to parental reports, the sample was 72% White, 21% Black, 3% of Hispanic ethnicity, and 3% mixed race or other, with 1% not reporting race/ethnicity.

### Materials

The stimuli were sets of objects, each composed of four visually identical exemplars (Fig. 1A). Two of the sets consisted of four yellow rubber ducks ( $5.5 \times 4.5 \times 5$  cm), and the other two sets consisted of four plastic zebras ( $5 \times 5 \times 4$  cm). Within each set, the objects differed only in weight. Two ducks weighed 87.5 g ("heavy") and two weighed 21.7 g ("light"). Two zebras weighed 41.5 g ("heavy") and two weighed 11.6 g ("light"). Pilot work suggested that each set's weights were readily discriminable



**Fig. 1.** (A) Photographs of the experimental materials showing a set of four visually identical ducks, a set of four visually identical zebras, and the two-bin tray. Within each set, two objects are heavy and two are light. (B) The arrow depicts the adult “hefting” an object—moving it up and down in the palm of her hand, as if weighing it—during the demonstration.

by untrained adults. The experimenter sorted the objects into a two-binned tray ( $23.5 \times 5 \times 4.5$  cm), hereafter referred to as “bins,” as a function of their weight.

### Procedure

Children were tested individually in a laboratory, and their behaviors were videotaped. Each child was randomly assigned to one of three independent groups. Three factors were counterbalanced among the groups: (a) child’s sex, (b) stimuli presentation order (ducks vs. zebras as the first set), and (c) side of the heavy objects during demonstration (left vs. right).

### Demonstration period

*Experimental group: hefting + sorting.* The experimenter placed the first set of four objects (e.g., the ducks) in a square arrangement (approximately  $12 \times 12$  cm) on the table. Unbeknownst to the participant, the two objects of one weight were on the right side and the two objects of the other weight were on the left side (counterbalanced). The bins were placed on the table behind the objects (from the participant’s viewpoint).

The experimenter drew the child’s attention (e.g., “It’s my turn first”). The experimenter picked up the first object, put it on his or her flat palm, and “hefted” it six times (two bouts of three hefts). No language was used to describe this event, but to an adult it looked like the experimenter’s hand was rising and falling to test the object’s weight (Fig. 1B). The experimenter always started with the same object (the object on the right in the row closest to the child). The experimenter placed the object into the bin on the child’s right side. The experimenter then picked up the second object on the right side, hefted it in his hand, and placed it into the same bin as the first object. After that, the experimenter hefted the two remaining objects in turn and placed each object into the left bin. During the demonstration, the experimenter kept a neutral face and gave no other cues or instructions other than

showing visual attention to his or her hand and demonstrating purposive behavior. To an adult, the hefting and sorting appeared to be intentional.

*Control Group 1: hefting + no sorting.* Children might sort objects spontaneously by weight regardless of the demonstration, and two control groups assessed this possibility. Control Group 1 was matched to the experimental group except that the (presumed) critical feature was omitted. That is, everything was the same as previously described but the objects were not sorted. As in the experimental group, the experimenter drew the child's attention to the four objects on the table ("It's my turn") and picked up and weighed each object in his hand (hefting each object six times). However, instead of sorting the objects into the bins, the experimenter simply placed the objects back on the table. Thus, children in this control group saw only the weighing process.

*Control Group 2: presorted + hefting.* This group controlled for "emulation." The experimenter's demonstration included both the hefting gesture and the postsorted end state. The only difference between this group and the experimental group was that the children did not see the adult intentionally sort the objects by their weights. In this control, the four objects were presorted by weight into the bins. The experimenter drew the child's attention ("It's my turn"), picked up and hefted each of the two objects from the bin on the child's right (six times each), and then put each object back into the bin. Then, he or she did the same with the objects in the left bin. Thus, the weighing behavior and the perceptual end state in Control Group 2 matched the experimental group, but participants did not see the adult actively sort the objects.

#### *Response period*

The response period was identical for all groups. After the demonstration, the experimenter placed the four objects in front of the child. The objects were placed in a square configuration, but unbeknownst to the child, the two objects with the same weight were now placed in the horizontal (instead of vertical) rows. Whether the two heavy objects or the two light objects were closer to the child was switched across the four trials.

Children were told, "Now it's your turn." This generic verbalization maintained a comfortable give-and-take social interaction with children. The phrasing was chosen to prompt children to act, but not to provide specific information about what was required to solve the task. The words "copy," "sort," "kind," "categorize," and all such related terms were purposely excluded so as not to give verbal cues that the task involved categorization.

Children were allowed to manipulate the objects until they placed them all into the bins. If necessary, children were asked, "Can you put them inside?" The experimenter then removed the bins for later scoring. For the second trial, the experimenter placed an identical set of the same kind of objects on the table for children to sort with no prior demonstration. (This second set of ducks/zebras was necessary because the objects were visually identical and sometimes children briefly blocked the camera view; thus, for each trial, we retained the objects in the bins for subsequent scoring.)

#### *Generalization trials*

After these two trials, the second set of objects was introduced to assess children's generalization of the sorting rule. If the duck set was used in the demonstration, the zebra set was used as the generalization set and vice versa. Crucially, these objects had *different* weights than the original objects, and the experimenter did not perform any demonstration with these objects. The experimenter simply placed the four objects on the table in a square arrangement for two trials of the response period procedure. If children were reluctant to act, they were prompted with general statements (e.g., "It's your turn," "Can you put them inside?").

#### *Dependent measures and scoring*

The dependent measure was the number of trials in which participants correctly sorted the objects by weight. To be credited with a "correct sort," children needed to place the two objects of one weight into one bin and place the two objects of the other weight into the other bin. Each correct sort was scored as 1, yielding a *sorting score* (range = 0–4) across the four trials.

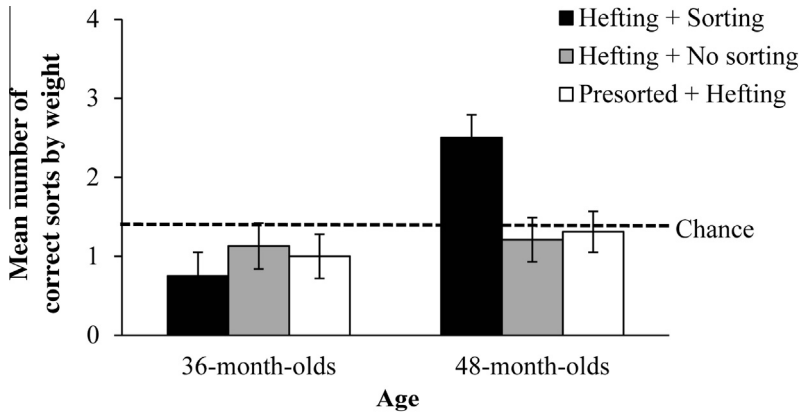


Fig. 2. Mean numbers of weight sorts ( $\pm 1$  SE) as a function of age and test group.

## Results

Preliminary analyses showed no significant effects of participant sex, object type (ducks vs. zebras), presentation order (ducks vs. zebras first), or the side on which the weights were placed. We collapsed across these factors in all subsequent analyses.

A 2 (Age: 36 vs. 48 months)  $\times$  3 (Test Group: experimental vs. Control 1 vs. Control 2)  $\times$  2 (Testing Set: demonstration vs. generalization) repeated-measures analysis of variance (ANOVA) revealed two significant effects. First, there was a main effect of age,  $F(1, 96) = 8.43, p = .005, \eta_p^2 = .08$ , showing that 48-month-olds were more likely to sort the objects by weight than were 36-month-olds.<sup>1</sup>

Second, there was a significant Age  $\times$  Test Group interaction,  $F(2, 95) = 4.64, p = .01, \eta_p^2 = .09$  (Fig. 2). Follow-up one-way ANOVAs revealed no significant difference in 36-month-olds' sorting scores as a function of test group,  $F(2, 45) = 0.52, p = .60, \eta_p^2 = .02$ , and a significant effect of test group for 48-month-olds,  $F(2, 45) = 4.75, p = .01, \eta_p^2 = .17$ . As predicted, 48-month-olds in the hefting + sorting group had significantly higher sorting scores than did children in Control Group 1 (Student–Newman–Keuls,  $p = .006$ ) and Control Group 2 ( $p = .02$ ), with no significant difference between the two controls ( $p = .83$ ).

We also compared children's performance with chance placement of objects into the bins. All children placed all four objects into the bins on each trial. On most trials (90.11%), they placed two objects into each bin. Assuming that two objects are placed into each bin, there were 24 possible combinations of the four objects in the two bins, and by chance alone for one third of these (8 combinations), the two light objects would be in one bin and the two heavy objects would be in the other bin. Taking into account that there were four trials, chance performance was a target score of 1.33 (one third of the four trials). Comparisons with this chance value using a one-sample  $t$  test revealed that 48-month-olds in the hefting + sorting group categorized the objects by weight significantly more often than would be expected by chance,  $t(15) = 3.86, p = .002, d = 1.99$  (Fig. 2).

## Discussion

This study contributes three new findings. First, preschoolers learned to sort visually identical objects by weight based on observing another's behavior without verbal instructions or directly

<sup>1</sup> In a more fine-grained analysis, we also examined children's sorting on each trial. Individual Friedman's tests were conducted for each trial in each group at each age. Only the 4-year-olds' in the hefting + sorting group showed a significant difference in their performance between trials,  $\chi^2(3) = 12.00, p = .007$ . Follow-up sign tests indicate that in this group, fewer children sorted on Trial 1 (31%) than on Trial 2 (75%,  $p = .04$ ) and Trial 3 (81%,  $p = .03$ ), with intermediate numbers of children sorting on the Trial 4 (63%). Trials 3 and 4 were generalization trials using novel objects and novel weights.

reinforced training. After witnessing a single hefting + sorting demonstration, 48-month-olds sorted by weight more often than would be expected by chance. Second, we showed that the adult's demonstration was crucial for promoting weight sorting. After seeing closely matched behaviors that did not involve showing children the adult sorting behavior, children did not categorize the objects by weight. Third, the observed age pattern raises the intriguing possibility of development (without yet isolating exactly *what* develops; see below); in contrast to 48-month-olds, 36-month-olds showed no benefit from the social demonstration for their weight sorting. These results shed light on how social learning may contribute to preschoolers' cognitive development, in this case their use of object weight.

The above-chance sorting performance of 48-month-olds in the experimental group cannot be explained by a superficial duplication of the adult's exact behaviors. The spatial positioning of the heavy and light objects on the test trials was *different from* that used in the adult's demonstration; thus, literal duplication of the adult's lifting and placing movements would have led to an incorrect pattern. In addition, the majority of these children sorted on more than two trials; thus, children generalized the weight sorting to a different set of objects with different absolute weights. This generalization was made without the adult demonstrating how to sort these new objects; for the generalization trials, neither the adult nor the children had manipulated or sorted the new set of visually distinct objects. The adult's intentional sorting led children to employ an abstract rule (i.e., "sort by weight").

Social learning researchers have long recognized the importance of characterizing what features of a demonstration influence the uptake and use of the new information (e.g., Carpenter & Call, 2002; Meltzoff, 1988; Want & Harris, 2002). The current control groups began to isolate the critical features of the demonstration for promoting sorting. Observing the weighing actions alone (Control Group 1) did not induce weight sorting. Thus, the improved performance of the experimental group cannot be explained by increased interest in the objects due to the adult's manipulations of them (i.e., *stimulus enhancement*). Observing both the adult's hefting gestures and the final sorted end state (Control Group 2) also did not prompt sorting. This suggests that children do not infer the sorting strategy from the sorted (two groups of two objects) configuration (i.e., *emulation*). This latter result is striking because the adult's behaviors in Control Group 2 bore such similarity to those used in the experimental group. In Control Group 2, the experimenter picked up the presorted objects from the bins, hefted them, and returned them to the same position; in the hefting + sorting group, the experimenter picked up the objects from the table, hefted them, and sorted them into the bins. The finding that only children in the hefting + sorting group categorized the objects by weight highlights the importance of seeing intentional sorting behavior for children's acquisition and reproduction of the weight-sorting rule.

How does perceiving another's intentional sorting behavior help children to learn about object properties? Past research indicates that children look for explanations of others' behaviors (e.g., Moll, Koring, Carpenter, & Tomasello, 2006; Southgate, Chevallier, & Csibra, 2009). We speculate that because the objects in the two bins were visually identical, children sought a relevant property that could be used to make sense of the adult's behavior (e.g., Watson-Jones, Legare, Whitehouse, & Clegg, 2014). When a behavior is difficult to understand based on visible surface cues alone, children may consider specifically internal properties or causes (Legare, Gelman, & Wellman, 2010; Legare & Lombrozo, 2014; Sobel, Yoachim, Gopnik, Meltzoff, & Blumenthal, 2007). The internal property of weight "explains" the adult's behaviors because the adult can be interpreted as categorizing the objects into two kinds—heavier versus lighter objects. Identifying this property may require some experience with the objects; the 48-month-olds in the experimental group showed higher rates of sorting on the second and third trials relative to the first trial. Once that rule is abstracted, it can be applied to the generalization array despite differences in shape, color, and even absolute weight. Future research that manipulates the identity of the agent (e.g., Meltzoff, 1995) or asks children to explicitly explain their object manipulations and interpretation of the adult's behavior (as in Watson-Jones et al., 2014) would be useful for testing these ideas and for determining whether children are inferring that the rule is the adult's goal.

Past work using a similar test paradigm found that 36-month-olds imitated sorting objects by color and by the sounds they made when shaken (Williamson et al., 2010). However, the 36-month-olds in the current study did not benefit from the sorting demonstration for the property of weight. These combined results indicate that it is unlikely that 36-month-olds have difficulty with the purely

categorization aspects of the task or with imitating. Instead, it is likely that the invisible property of weight is a difficult one for preschoolers to understand and use as a basis for categorization, particularly when there are no visual cues to differences because the objects to be sorted are visually identical. Comparative studies also identify weight as a difficult property; chimpanzees need more training to discriminate weight relative to other properties (Povinelli, 2012; Schrauf & Call, 2009).

The 36-month-olds' failure in the current study is also unlikely to be due to difficulty with perceptual discrimination (e.g., that the difference between the heavy and light objects was below a just noticeable difference in sensory weight discrimination). It has been shown that even infants can detect smaller weight differences than those used here based on direct manipulations of objects (e.g., Hauf et al., 2012; Marshall et al., 2013; Paulus & Hauf, 2011).

One possible contributor to what makes weight a difficult concept for children is that it is an invisible internal property. At around 4 years of age, children show improvements on a variety of tasks requiring them to make judgments about the insides of objects (e.g., Gelman, 2003; Gelman & Wellman, 1991; Meltzoff et al., 2012; Smith et al., 1985; Sobel et al., 2007). Children also show changes in performance on the appearance/reality task at 4 years of age (Flavell, Flavell, & Green, 1983; Gopnik & Astington, 1988), which involves reconciling conflicts in internal properties and external appearance. Thus, the 48-month-olds may benefit from the adult's hefting + sorting demonstration because they are on the cusp of grasping that invisible internal properties are relevant for categorizing objects. Witnessing the adult's demonstration may prompt children to *seek an explanation for the adult's sorting behavior*, which they can then discover or confirm when given their own kinesthetic experience with the objects. In contrast, the 36-month-olds may have difficulty in assessing insides and ignoring the identical visual features (e.g., appearance–reality, executive functions). Such an argument would align with the notion that children's cognitive level constrains their learning from social interaction (Gopnik & Meltzoff, 1997; Kuhn et al., 1995; Vygotsky, 1978).

In sum, this article shows that social learning, and specifically “abstract imitation” (Williamson et al., 2010), is effective for promoting 48-month-olds' categorization of visually identical objects by weight. Furthermore, we have identified an age-related change in children's ability to take advantage of the demonstration of weight sorting. Our interpretation is that children need conceptual underpinnings to draw the correct inferences from the social modeling.

Future studies comparing imitation of sorting by a variety of visible and invisible object properties would help to isolate what about weight is particularly difficult for young children. The current results add to a growing literature suggesting that young children can learn a wide scope of information by simply observing others' behaviors. Crucially, children's imitation is not limited to surface-level behavior reproduction but rather encompasses generalizable rules. Such abstract imitation of rules and strategies may provide a mechanism for the rapid cultural learning that characterizes our species and supports human pedagogy (Legare & Lombrozo, 2014; Nagell et al., 1993; Williamson et al., 2010).

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