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Learning the Rules: Observation and Imitation of a Sorting Strategy by 36-Month-Old Children

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Abstract

Two experiments were used to investigate the scope of imitation by testing whether 36-month-olds can learn to produce a categorization strategy through observation. After witnessing an adult sort a set of objects by a visible property (their color; Experiment 1) or a nonvisible property (the particular sounds produced when the objects were shaken; Experiment 2), children showed significantly more sorting by those dimensions relative to children in control groups, including a control in which children saw the sorted endstate but not the intentional sorting demonstration. The results show that 36-month-olds can do more than imitate the literal behaviors they see; they also abstract and imitate rules that they see another person use.

Keywords

imitation; rules; abstract reasoning; social learning; children

Imitation is an early developing ability that allows children to acquire skills and behaviors from other people in their culture. Aspects of imitation may be specific to humans; indeed, imitation has been implicated in the development of complex social-cognitive processes, such as theory of mind (e.g., Meltzoff, 2007; Meltzoff & Gopnik, 1993), and has been proposed as a fundamental mechanism for transmitting culture from one generation to the next (e.g., Boyd & Richerson, 1996; Meltzoff, Kuhl, Movellan, & Sejnowski, 2009; Tomasello, 1999). To understand how imitation contributes to these achievements, an important question concerns the type of information that can be imitated.

The overarching goal of this article is to extend the typical studies of imitation, which have largely examined imitation of concrete actions (means) and outcomes (ends). We test imitation at a more abstract level—whether children can learn a cognitive strategy or rule from observing another’s behaviors. We test whether watching an adult sort several objects along a particular dimension (e.g., their nonobvious sound-making properties) will lead children to sort objects along the same dimension.

Past research has established that children can quickly and efficiently learn to perform simple behaviors from watching others. This includes imitating the physical outcomes that

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people produce using objects. Experiments with infants and toddlers show imitation of a wide range of outcomes, including opening containers, activating lights or sounds, and using simple tools (e.g., Carpenter, Call, & Tomasello, 2002; Meltzoff, 1988, 2007; Nielsen, 2006; Want & Harris, 2001). Toddlers can also infer what the intended outcome of a model's behavior is even if they do not see the model achieve the goal. In an experiment by Meltzoff (1995), 18-month-olds saw an adult attempt to complete a variety of tasks, but they never saw him succeed. When given their turn at solving the problem, the children demonstrated their understanding of the model's underlying goals or intentions by performing the act that would achieve the inferred goal rather than replicating the same unsuccessful actions used by the adult.

Children can also copy the exact means or literal actions that others use (e.g., Barr, Dowden, & Hayne, 1996; Bauer, 1992; Flynn & Whiten, 2008; Meltzoff, 1988; Nagell, Olguin, & Tomasello, 1993; Nielsen, 2006; Tennie, Call, & Tomasello, 2006). In one experiment, a group of 14-month-olds saw an adult act in distinct and novel ways on objects to produce outcomes. For example, an adult bent and touched a light panel with his head, and the light turned on (Meltzoff, 1988). When given the object for the first time after a week delay, 67% of the children produced this novel act. In contrast, none of the children in a control group who saw the adult manipulate the object but not produce the target act did so. Children are highly attuned to the specific actions others produce, and there are circumstances in which they overimitate, that is, reproduce actions that are unnecessary or even counterproductive for completing an outcome (Horner & Whiten, 2005; Lyons, Young, & Keil, 2007; McGuigan, Whiten, Flynn, & Horner, 2007; Whiten, Custance, Gomez, Teixidor, & Bard, 1996).

A growing body of research is focused on the conditions that govern imitation, with findings showing that children's imitation is regulated by the overall goal of the demonstration and their understanding of how purposeful, effective, and contextually appropriate the acts are (Bekkering, Wohlschläger, & Gattis, 2000; Brugger, Lariviere, Mumme, & Bushnell, 2007; Carpenter, Akhtar, & Tomasello, 1998; Carpenter, Call, & Tomasello, 2005; DiYanni & Kelemen, 2008; Flynn & Whiten, 2008; Gergely, Bekkering, & Király, 2002; Gleissner, Meltzoff, & Bekkering, 2000; Nielsen, 2006; Repacholi & Meltzoff, 2007; Want & Harris, 2001; Williamson & Markman, 2006; Williamson, Meltzoff, & Markman, 2008).

In adults, another important part of imitation is duplicating the *strategy*, *organization*, or *rules* that another person uses when tackling a task. For example, graduate students may attend a scientific talk by an experienced speaker and use that talk as a guide or template when constructing one they later give themselves. The students would not copy the exact words or content from the model's presentation, but they might decide to apply the model's organizational structure. This type of social learning is not tied to concrete outcomes of manipulating an object, as is the case, for example, when learning about a tool's function (e.g., Casler & Kelemen, 2005, 2007). Instead, this scenario involves learning an abstract cognitive strategy that could be applied across a very broad set of situations and used when faced with a new problem. Rule imitation adds an important component to investigations of how cultural knowledge is transmitted and influences individual behavior (e.g., Smith, Kalish, Griffiths, & Lewandowsky, 2008).

There is evidence that children and other primates can imitate the organization of a series of behaviors (Byrne & Russon, 1998; Subiaul, Cantlon, Holloway, & Terrace, 2004; Subiaul, Lurie, et al., 2007; Subiaul, Romansky, Cantlon, Klein, & Terrace, 2007; Whiten, Flynn, Brown, & Lee, 2006). For example, children are more likely to remember and reproduce the actions in a series that are necessary (vs. unnecessary) for producing meaningful outcomes (e.g., Barr & Hayne, 1996; Bauer, 1992; Bauer & Mandler, 1989). Young children have also been shown to imitate another's action organization in a different way (Flynn & Whiten, 2008; Whiten et al., 2006). In Flynn and Whiten's (2008) experiment, for example, 3- and 5-year-olds saw a model open a locked puzzle box either by first assembling and then manipulating each of a number of keys or by assembling and manipulating each of the keys in turn. Even though both approaches would yield the same outcome of unlocking the box, the children were more likely to use the approach they saw demonstrated (even with a novel key) rather than the other approach.

Further, Subiaul and colleagues investigated whether *rhesus macaque* monkeys, typically developing children, and individuals with autism can imitate an arbitrary sequence of actions (pressing pictures in a particular order; Subiaul et al., 2004; Subiaul, Lurie, et al., 2007; Subiaul, Romansky, et al., 2007). In this work, several pictures appear simultaneously on a touch-screen. When the pictures are touched in a specific sequence (e.g., A → B → C → D), monkeys receive a reward of a food pellet, and humans see an entertaining video clip. When a mistake is made (e.g., A →D), the trial ends, and no reinforcement is provided. The spatial configuration of the pictures on the touch-screen changes on each trial so that the sequence of pictures, rather than specific motor movements, must be learned. Participants in these studies watched a model activate the correct sequence of pictures to obtain a reward. Later, the participants were given the opportunity to play the game themselves. The 2-, 3-, and 4-year-olds who watched the model were faster to implement the observed sequence than those who had not seen the demonstration.

Here, we investigate a different kind of abstract imitation in young children: the ability of 36-month-olds to extract a categorization rule from observing the behavior of a model. We tested whether children who watch an adult intentionally sort a group of objects into two categories along a particular dimension (e.g., the invisible sound-making properties of the object) will later sort along that dimension themselves. To correctly reproduce a sorting strategy, children would have to identify the dimension the model was using for categorizing and then reenact it in their own sorting behavior. Such behavior would be particularly striking if the dimension used by the adult was different from the one the children spontaneously used.

Sorting strategies are an interesting case because the relevant groupings can be applied across many materials and situations and can lead to further learning. For example, grouping strawberries by color to predict their ripeness and flavor could also be applied to other types of fruit across seasons; furthermore, grouping objects by their invisible properties (such as sound) is an important principle for establishing natural kinds in biology and other sciences. If 3-year-olds can acquire such categorization strategies by watching others use them, it suggests a powerful, nonverbal mechanism by which generalizable rules or strategies can be learned.

In Experiment 1, we examined whether 36-month-old children would sort a series of objects by color rather than by shape after watching a model demonstrate a color sorting strategy. In Experiment 2, we investigated whether children would sort objects by a nonobvious dimension (the sound each object made) after watching a model demonstrate that sorting strategy. Several alternative mechanisms, such as stimulus enhancement or the matching of endstates (sometimes called emulation; e.g., Want & Harris, 2002), could lead to increased sorting along a particular dimension. To rule out these lower order explanations, we also included relevant control groups, thus isolating the importance of observing a model's intentional sorting behavior.

Experiment 1: Visible Properties

Past research has shown that young children preferentially sort by shape (e.g., Brian & Goodenough, 1929; Kagan & Lemkin, 1961; Melkman, Koriat, & Pardo, 1976; Suchman & Trabasso, 1966). In Experiment 1, we test whether children who see an adult intentionally sort an array of objects (containing two shapes and two colors) into two groups on the basis of their color will subsequently adopt the same sorting strategy. For example, one set of eight objects included two black and two white hats and two black and two white spoons. Children could choose to group the objects by color or shape, or to place them randomly. To assess the importance of the intentional demonstration, we also measured the sorting behaviors of children in three control groups. The *baseline* group established children's rate of color sorting when the adult did not act on the objects. The *presort* group addressed the possibility that seeing the outcome of the sorting demonstration—namely, the objects sorted by color—would lead children to sort by color. Finally, the *presort + manipulation* group was included to control for the possibility that increased attention to the objects-in-categories (as opposed to witnessing the adult's sorting behavior) might lead children to sort by color. If children, like adults, can learn a rule from another person's intentional intervention, they should be more likely to sort the objects by color after witnessing that sorting behavior than are children in the control groups.

Method

Participants—Eighty 36-month-old children (40 boys)—whose ages ranged from 2;11 (years;months) to 3;1—were recruited through the University of Washington's participant list. The racial/ethnic composition of the sample was 86% Caucasian, 1% Asian, 8% mixed race, and 5% other/unknown, with 4% self-reporting as being of Hispanic ethnicity. Direct measures of socioeconomic status were not obtained, but the sample was generally middle to upper middle class according to previous studies using the same participant pool. Four additional children's data were excluded because of experimenter error.

Materials—We used two sets of eight objects, each containing equal numbers of objects of two shapes and two colors. One set consisted of two white and two black hats (5.5 × 5 × 2 cm) and two white and two black spoons (10.5 × 2.5 × 1 cm). The second set included two green and two pink dice (2.5 × 2.5 × 2.5 cm) and two green and two pink crayon erasers (7 × 1.5 cm diameter). The objects were sorted into a two-bowled tray (23.5 × 5 × 4.5 cm), hereafter referred to as *bowls* (see Figure 1A).

Procedure—Children were tested individually in a university laboratory room, and their behavior was digitally recorded for subsequent analysis. Each child was randomly assigned to one of four independent groups, each consisting of a demonstration phase and a response period.

Demonstration phase

Sorting: The experimenter placed one of the sets of eight objects in a randomly intermixed heap on the table (within approximately a circle of 10 cm radius). The bowls were placed on the table slightly beyond the heap from the children. The experimenter drew the children's attention (e.g., "It's my turn first") and then, one at a time, picked up and placed each object of one color into one bowl and then placed each of the objects of the other color into the other bowl.

Baseline control: Children in this control group saw no demonstration; the session began with the response period described below. This provided a baseline assessment of the degree to which children spontaneously sorted by shape or color without observing a demonstration.

Presort control: The experimenter presented children with the eight objects from a particular set, as in the sorting group. However, the objects were presented inside the bowls, already sorted by color (e.g., the green dice and crayons in one bowl; the pink dice and crayons in the other). The experimenter drew the children's attention to the objects by moving her hand in front of the bowls and saying, for example, "See, we are going to play with these." This condition controlled for the possibility that children would sort the objects into two groups on the basis of merely seeing the outcome of the sorting process—the two-category configuration.

Presort + manipulation control: As in the previous control group, the experimenter in this condition presented children with the eight objects already sorted in the two bowls by color. However, this control group was even more rigorous inasmuch as the experimenter also manipulated the objects. She explained, "It's my turn first," and proceeded to lift and return each object one at a time from the bowl on the child's right and then did the same for each object in the left-hand bowl. This controls for the possibility that children will sort the objects into groups on the basis of seeing the endstate configuration plus a person actively handling the objects in each of the bowls.

Response period: The response period for all groups was identical. The experimenter placed the objects in a mixed pile on the table in front of the children (either emptying them out of the bowls in the sorting, presort control, and presort + manipulation control groups, or simply placing them there in the case of the baseline control group). The bowls were placed slightly farther back on the table but still within reaching distance for the children. The children were then given the opportunity to place all of the objects into the bowls (e.g., "Now it's your turn to play with these"). If they did not sort the objects into the bowls exhaustively by color (all four of one color in one bowl and all four of the other color in the other bowl), they were given a second opportunity to do so. In this case, the experimenter removed all of the objects from the bowls; placed the eight objects into a mixed pile on the table; offered a second, neutral prompt ("You can have another turn"); and gave the child the opportunity to place the objects into the bowls. The objects of Set A were then removed.

Next, children were given a second set of objects (Set B) to test generalization. These eight objects were placed in a mixed pile on the table. No demonstration was shown. This provided a test of whether children in the sorting group would transfer the color sorting strategy from one array of objects to a novel set. As with Set A, the children were given up to two opportunities to place the objects of Set B into the bowls by color. The order in which the set of objects was presented was counterbalanced across the experimental groups, as was the color placed in the left or right bowl during the demonstration phase.

Dependent measures and scoring: Research assistants, blind to the experimental group, scored the children's sorting behaviors from video. To be credited with a sort, the child had to place all four objects of one dimension (shape or color) into one bowl and all of the other objects into the opposite bowl. The scorers recorded whether children reached this criterion and, if so, by which dimension (shape or color). Two dependent measures were calculated: a *preferential-sort score* and a *color-sort score*.

Preferential-sort score: Children were given up to two chances to place the objects of Set A and up to two chances to place the objects of Set B into the bowls. The preferential-sort score measures whether a child's first sort of the objects was by shape or color. If the child's first sort for a set of objects was by color, it was scored as 1; if it was by shape, it was scored

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as −1. If the child failed to sort a set of objects by color or shape he or she received a score of 0. The scores from each of the two sets of objects were then summed, resulting in a score that ranged from −2 (two shape sorts) to 2 (two color sorts) for each child.

Color-sort score: The color-sort score is a measure of whether the children ever sorted a set of objects according to color. For each set, the scorer made a yes/no judgment of whether the child placed all of the objects of one color in one bowl and all of the objects of the other color in the second bowl, either on the first or second attempt (when given) with each set of objects. Each "yes" judgment was scored as a 1 and each "no" as a 0, resulting in a score for each participant ranging from 0 (neither set sorted by color) to 2 (both sets sorted by color).

Scoring agreement was assessed by recoding a randomly chosen 25% of the data by a scorer who was blind to the experimental group and to the hypotheses of the study. The agreement was 100%.

Results and Discussion

Preliminary analyses of the preferential-sort scores show that children readily sorted the objects during the response period according to either the color or shape dimension: 71 of the 80 children (89%) sorted at least one of the sets of objects either by color or by shape. The mean number of sets sorted (out of 2) ranged between 1.40 and 1.50 (*SD* = 0.68–0.76) for all four experimental groups, with no significant difference among groups, $F(3, 76) = 0.10$, $p = .96$, $\eta_p^2 = .00$. Thus, children were equally likely to sort the objects along one of the two dimensions regardless of group.

Even though the children in all groups were equally likely to engage in a sorting behavior, Figure 2 shows that the particular dimension on which they sorted varied as a function of experimental group. A one-way analysis of variance (ANOVA) of the preferential-sort scores showed that children in the sorting group were more likely to sort by color on their first sort (*M* = 0.90, *SD* = 1.1) than were children in each of the three control groups (baseline *M* = −0.50, *SD* = 1.0; presort *M* = −0.30, *SD* = 1.4; presort + manipulation *M* = 0, *SD* = 1.4), $F(3, 76) = 4.97$, $p = .003$, $\eta_p^2 = .16$. Follow-up comparisons using the Student–Newman–Keuls (SNK) method showed that children in the sorting group were significantly ($p < .05$) more likely to sort by color than were children in each of the controls and that the control groups did not significantly differ from one another. Additionally, only in the sorting group was the mean preferential-sort score significantly above zero, $t(19) = 3.60$, $p = .002$, Cohen's $d = 0.80$, indicating that only after observing the model sort by color were the children more likely to initially sort objects by color than by shape. In contrast, the initial sorts of the children in the baseline control group were significantly below zero, indicating that their first sorts were more likely to be by shape than by color, $t(19) = 2.24$, $p = .04$, Cohen's $d = 0.50$. The first sorts of the other two control groups (presort and presort + manipulation controls) were at chance levels.

The distribution of the raw preferential-sort scores documents the strength of this effect. As shown in Table 1, 65% of the children (13 of 20) in the sorting group had scores of 1 or 2, indicating preferential sorting by color rather than by shape. In contrast, only 25% of the children (15 of 60) across all of the control groups combined had scores of 1 or 2, $p < .01$, Fisher's exact test, Cramer's $V = .36$.

This pattern of results is the same when considering the color-sort scores. As shown in Figure 3, and as confirmed by a one-way ANOVA, children in the sorting group were more likely to sort by color at some point (*M* = 1.30, *SD* = 0.86) than were children in the control groups (baseline *M* = 0.65, *SD* = 0.67; presort *M* = 0.70, *SD* = 0.73; presort + manipulation

M = 0.80, *SD* = 0.83), $F(3, 76) = 2.93$, $p = .04$, $\eta_p^2 = .10$. The follow-up SNK test showed that the sorting group was significantly more likely to sort by color than the controls and that there was no significant difference between the control groups. The distribution of color-sort scores is shown in Table 2. In the sorting group, 55% of the children (11 of 20) sorted both sets of objects by color during their interaction with them, whereas only 17% (10 of 60) did so in the controls, $p < .001$, Fisher's exact test, Cramer's $V = .38$.

These data show that the spontaneous rate of sorting by color was low in the control groups. In fact, children in the baseline control group had a spontaneous preference to sort by shape, which is consistent with previous literature. Moreover, the control groups demonstrate that children did not sort by color after seeing the objects presorted by color (presort control) or after the model drew attention to the sorted objects and handled them in their respective bowls (presort + manipulation control). The uniquely high level of color sorting in the sorting group suggests that witnessing the model's sorting behavior led the children to sort by color.

Recall that children in the sorting group saw the adult sort the eight objects in Set A, but they did not see her sort the eight objects in Set B. The objects of Set B were simply put in a heap on the table, and the children were allowed to play with them, thus providing an opportunity to test whether they would generalize a color-sorting strategy. A two-way, mixed-model ANOVA on the color-sort scores showed no main effect difference between the scores on Set A (*M* = 0.48, *SD* = 0.50) and Set B (*M* = 0.39, *SD* = 0.49), $F(1, 76) = 1.80$, $p = .18$, $\eta_p^2 = .02$. There was a significant main effect for Test Group, as expected, and no significant Set (2) × Test Group (4) interaction (the values for Sets A and B, respectively, are as follows: sorting *M* = 0.70, *SD* = 0.47, *M* = 0.60, *SD* = 0.50; baseline *M* = 0.30, *SD* = 0.47, *M* = 0.35, *SD* = 0.49; presort *M* = 0.45, *SD* = 0.51, *M* = 0.25, *SD* = 0.44; presort + manipulation *M* = 0.45, *SD* = 0.51, *M* = 0.35, *SD* = 0.48), $F(3, 76) = 0.627$, $p = .60$, $\eta_p^2 = .02$. This indicates that children were as likely to discriminately sort the objects by color as a function of test group when using Set B as they were when using Set A. Further, a specific examination of the color-sort score of Set B shows that the children in the sorting group (*M* = 0.60, *SD* = 0.50) had a significantly higher score than did the children in the combined control groups (*M* = 0.32, *SD* = 0.47), $t(76) = 2.30$, $p < .05$, Cohen's $d = 0.58$. The children in the sorting group thus transferred the color sorting strategy to the objects of Set B even though this strategy was only demonstrated for the objects of Set A, showing generalization.

Experiment 2: Invisible Property

In Experiment 2, we investigated whether children would adopt a strategy that involved sorting along an *invisible* dimension—namely, the sound the objects made when they were shaken. Children in the sorting group watched as a model sorted four identical-looking objects into two categories on the basis of the sound that each one made when the experimenter shook them (e.g., either a jingle or a rattle). As in Experiment 1, we gave the children an opportunity to interact with that set of objects as well as with a second set. Because the objects in a given set were identical in appearance, the children could either sort by the invisible property (that could only be revealed by first shaking the objects to reveal the sound) or they could group them randomly. Because pilot testing showed that sorting by sound was a difficult task for 36-month-olds, we reduced the number of objects to four (two producing one sound and two producing another). On the basis of the results of Experiment 1, we predicted that the children would be more likely to sort the objects by sound in the sorting group versus the control groups.

Method

Participants—Forty-eight 36-month-olds (24 boys; age range = 2;11–3;1) were recruited through the University of Washington's participant list. The racial makeup of this sample was 87% Caucasian, 2% Asian, 4% mixed race, and 8% unknown, with 4% additionally reporting Hispanic ethnicity. Three additional children's data were excluded because of experimenter error (1) and noise during the testing session (2). None of the children had participated in Experiment 1.

Materials—In this procedure, we used two sets of four objects each. The appearance of the objects in each set was identical. Unbeknownst to the child, the objects were hollow and filled with different sound-making material. One set of four objects consisted of four small, white hats (5.5 × 5 × 2 cm). We inserted a rattle made of a few grains of hard rice kernels into two of them and inserted a small jingle bell into the other two. The weights of the objects were indistinguishable to an untrained adult—each filler weighing fractions of an ounce. An informal sample of untrained adults reported that the jingle and rattle sounds were readily distinguishable. The other set of four objects consisted of four yellow ducks (5.5 × 4.5 × 5 cm), two of which contained coins, and two of which contained packets of salt. Again, the sound-making properties were readily discriminable, but the weight was indistinguishable.

Procedure—Each child was randomly assigned to one of three independent groups: sorting, sound-only, or presort + manipulation. (The presort control group used in Experiment 1 could not be conducted because the experimenter had to handle the objects for children to hear that they made distinct sounds.) Each condition consisted of a demonstration phase and a response period.

Demonstration phase

Sorting: The experimenter placed the four objects of Set A in a square arrangement (approximately 12 × 12 cm) on the table in front of the children (see Figure 1B). Although the children did not know it, the two objects that made one kind of sound (e.g., the two hats containing rice) were on their right side, and the two objects that made the other sound were on their left side. The two bowls were placed on the table slightly farther away from the children than the objects. The adult drew the children's attention (e.g., "It's my turn first") and proceeded to sort the objects into the bowls according to the sound they made when shaken. The experimenter always started with the same object (the one on the right of the square that was closest to the child). She picked it up, shook it, and listened intently, and then she placed it into the bowl on the child's right side. She then picked up and shook the second object, which made the same sound, and placed it into the right bowl. Finally, she shook each of the other objects, one at a time, while listening intently to each, and she placed them into the left bowl.

Sound-only control: The procedure for this control group was virtually identical to the sorting group, except that there was no sorting. The experimenter brought out Set A, placed the four objects in a square on the table, and drew the children's attention to them (e.g., "It's my turn first"). The experimenter then shook each of the objects in the same order described for the sorting group. Instead of sorting the objects into the bowls, the experimenter simply returned the objects to the same place on the table. This provided a measure of spontaneous (baseline) sorting behavior on the basis of witnessing the adult shaking the objects and producing two different sounds.

Presort + manipulation control: In this control group, children saw the final endstate of the sorting behavior but not the intentional sorting by the adult. The experimenter brought out the objects of Set A presorted in the bowls (the two objects with one sound property were in the right bowl, and the two with the other sound property were in the left bowl). The adult then drew the children's attention to them (e.g., "It's my turn first") and picked up and shook each of the objects in the right bowl, one at a time, putting them back in their bowl. She then repeated this shaking and sound making with the objects in the left bowl. This group was highly matched to the sorting group: The children saw the adult shake the objects, heard that two of the objects produced one kind of sound and two produced another kind of sound, and saw the adult put the objects in the bowls according to the sound properties. The experimental question is whether this was sufficient for children to subsequently sort by the property of sound or whether they had to witness the adult's active sorting behavior.

Response period: For all groups, the experimenter then placed the objects of Set A in a square arrangement on the table in front of the children (see Figure 1B). Although the children did not know it, the individual objects were placed in a different orientation during the response period than they had been during the demonstration. The two objects that made the first type of sound were placed at the front of the square (in the row closest to the children), and the two objects that made the other sound were placed in the back row. This prevented children from achieving the correct categorization through an imitation strategy of copying a remembered sequence of motor behaviors by the experimenter. The bowl was placed behind the objects but still within reaching distance for the children.

The children were then given an opportunity to place the objects into the bowls (e.g., "Now it's your turn to play with these"). Once the children had placed all of the objects into the bowls, the experimenter removed them from the table and, out of view of the child, put them aside so that the child's sorting could be scored later. (A second group of Set A objects was used because it was not always possible to code from the video whether the children had sorted the identical-appearing objects by sounds. At the end of the session, the experimenter retrieved the bowls and determined whether the objects had been sorted by sound. This procedure allowed us to obtain two trials worth of data with identical arrays.) The identical group of Set A objects was brought out and placed on the table in the same square arrangement used for the first trial, and the children were given a second opportunity to sort the objects into a new two-bowled tray ("Here, you can have another turn"). When all four objects were sorted into the bowls, the experimenter removed them.

Next the experimenter placed the objects from Set B on the table in a square arrangement such that the objects with matching sounds were in the front and back of the square configuration. No demonstration was provided for the objects of Set B. The children were simply invited to play with them. Once the children placed all four of the objects into the bowls, the experimenter gave them another opportunity with an identical set of objects and bowls. As with the Set A objects, each child in Experiment 2 had two chances to place the Set B objects into the bowls. The set of objects presented as Set A was counterbalanced across participants as was the sound that was placed on the right during the demonstration.

Dependent measure and scoring: Children received a score of 1 if they placed the two objects that produced the same sound in one bowl and the two that made the other sound in the other bowl. Because children were given four such trials (two of Set A and two of Set B), scores ranged from 0 to 4 for sorts by sound.

Results and Discussion

When given the opportunity to handle the objects, almost all of the children (90%) shook all four objects on at least one of the four trials. The mean number of objects shaken per trial was 3.20 (*SD* = 1.16) in the sorting group, 3.22 (*SD* = 1.17) in the presort + manipulation control, and 2.53 (*SD* = 1.41) in the sound-only control. A one-way ANOVA showed no significant difference among groups, $F(2, 45) = 1.57$, $p = .22$, $\eta_p^2 = .07$, indicating that the children across the groups shook and heard the sounds approximately equally during the response period.

Figure 4 shows the mean number of trials sorted by sound as a function of experimental group. A one-way ANOVA yielded a significant difference in sorting as a function of group, $F(2, 45) = 5.49$, $p = .007$, $\eta_p^2 = .20$. Follow-up tests (SNK) showed that the children in the sorting group sorted by sound significantly more often ($M = 2.44$, $SD = 1.45$) than did the children in the sound-only control ($M = 1.13$, $SD = 0.81$) or in the presort + manipulation control ($M = 1.43$, $SD = 1.15$) groups and that there was no significant difference between the two control groups.

Table 3 shows the number of children who produced sorts on the basis of sound. In the sorting group, 38% of the children (6 of 16) sorted by sound on all four trials, whereas none of the 32 children in the control groups did so, $p = .001$, Fisher's exact test, Cramer's $V = .54$. The significantly higher level of sorting by sound in the sorting group suggests that the children learned this rule from observing the model. As in Experiment 1, the children gleaned important information from observing the rule-governed sorting behavior itself and applied it to both Set A and Set B (hence, the sorting on all four trials).

Recall that children in the sorting group witnessed the adult sorting the objects by sound for Set A but not for Set B. Set B was simply placed on the table to see what the child would do, testing for generalization. A two-way, mixed-model ANOVA on the sound-sort scores showed no main effect difference between Set A and Set B; both sets had identical sorting scores ($M = 0.83$, $SD = 0.81$). There was a significant main effect for Test Group, as expected, and importantly, no significant Set (2) × Test Group (3) interaction, $F(2, 45) = 1.22$, $p = .30$, $\eta_p^2 = .05$ (the values for Sets A and B, respectively, are as follows: sorting $M = 1.38$, $SD = 0.89$, $M = 1.06$, $SD = 0.93$; sound-only control $M = 0.50$, $SD = 0.52$, $M = 0.63$, $SD = 0.72$; presort + manipulation control $M = 0.63$, $SD = 0.72$, $M = 0.81$, $SD = 0.75$). In short, children performed as well in discriminately sorting the objects as a function of test group using Set B as they did when using Set A, suggesting generalization.

General Discussion

The results of this work demonstrate that children profit from an adult's demonstration of a sorting strategy. In both experiments, the children showed increased sorting by the target dimension in the sorting group versus the controls. It is noteworthy that in the response period, the objects were placed in a random (Experiment 1) or predetermined (Experiment 2) arrangement that was different from the arrangement used during the model's demonstration. Thus, to sort along the modeled dimension, the children could not imitate the particular actions or the strict sequence of picking up and placing that the adult used. The children had to abstract the model's organizational strategy or sorting rule and apply it to their own sorting behavior.

What did the children in the sorting groups of Experiments 1 and 2 learn from watching the adult's demonstration? One possibility is that the demonstration highlighted the fact that the objects had the target properties. That is, the demonstration may have simply shown children that the objects varied by color (Experiment 1) or by sound (Experiment 2). However, this attention explanation taken alone seems unlikely. In Experiment 1, children in all conditions could see that the objects varied in color, and in Experiment 2, they were equally likely to shake the objects to produce the sounds.

A second possibility is that the model's demonstration in the sorting condition primed children to sort the objects by color or sound. In a case attributed to priming in the observational learning literature (Byrne & Russon, 1998), a learner observes an actor engage in certain behaviors and receive a reward. This observation activates the learner's previously acquired habit or representation of what can be done with the elements in that situation, making these highlighted behaviors more likely to occur in the learner's subsequent interactions with the materials. We think that this process is an unlikely explanation for our results for several reasons. First, it is improbable that the children had prior representations for how to interact with our stimuli, particularly for the objects we constructed for Experiment 2: four identical hats that looked the same in every respect but nonetheless produced two different sounds. Second, grouping the objects by color or sound did not lead to any explicit, extrinsic reward; the model's behaviors did not lead to another end, such as obtaining food or opening a container to get a sticker. Even the feedback given to the children during the response periods was neutral (e.g., "You can have another turn").

Additionally, observing the outcome/endstate did not lead the children in the control groups to sort by color or sound (presort control of Experiment 1; presort + manipulation controls, Experiments 1 and 2) The fact that the children in the presort + manipulation group in both experiments showed low levels of sorting by the target dimensions is particularly striking. The modeled behaviors were very similar in this control group and in the sorting group. In both cases, the adult picked up each object and placed it into the appropriate bowl, which resulted in two groups that were sorted by the target dimension. The key difference, however, was that in the sorting groups, children saw the adult demonstrate a particular transformation—that is, she moved the objects from a mixed pile on the table via an intentional act of sorting In the presort + manipulation control, in contrast, she simply picked them up and returned them to the presorted configuration in the bowls The significant difference in the children's sorting between these two groups indicates the key importance of the model's demonstration of intentional sorting behavior for the acquisition of the sorting rule.

A third explanation for our results is that children interpreted the adult's demonstration as a social prompt or request for them to engage in the same sorting strategy that the adult had used. Children's sensitivity to social cues in learning situations is well documented Mutual eye gaze, the use of motherese, and stressed acts may identify a social or a pedagogical context to children that prompts them to replicate adult behavior (e.g., Csibra & Gergely, 2006). Although this social context may have motivated children, it cannot provide a full account of the effect. The presort + manipulation demonstrations (Experiments 1 and 2) also involved these same features of a pedagogical exchange, including direct instructions to attend to the behaviors (i.e., "It's my turn now, watch") and overt manipulation of the target objects; however, the children in these control groups did not produce the sorted outcome.

Although attention, priming, and social support/demands may play some role, the explanation we favor is that children in the sorting conditions learned something more fundamental from watching the model's demonstration. We suggest that the children in the sorting conditions learned to identify the new organization (e.g., objects were sorted by sound-making properties) and/or how to produce a sort by the target dimension (e.g., separating exemplars of the same shape to group them by the invisible kind of sound). Every object has many characteristics; it is not always obvious which one is relevant in a situation (Quine, 1960). Details, such as an object's color (a visual feature) and the kind of sound it makes when shaken (a functional property), can be indicative of other underlying properties. For example, the color of a fruit can indicate whether it is ripe or poisonous, and the sound that an object makes can indicate its invisible contents or kind (type of biological species).

A number of experiments, including those using the dimensional change card-sorting task (e.g., Frye, Zelazo, Palfai, 1995; Zelazo, Carlson, & Kesek, 2008), show that preschoolers and early elementary age children have difficulties switching between multiple properties for objects and that performance on early sorting tasks predicts scores on later general intelligence measures (Arlin, 1981; Bigler & Liben, 1992). The results of the current experiments suggest that observing an adult's sorting behavior is a direct and efficient way to instruct children to group objects by different properties than they would do spontaneously.[1] Such demonstrations may be one way in which social interaction and the observations of experts in the culture help shape children's categories, which in turn may influence cognitive development more generally (Meltzoff et al., 2009).

The current research significantly expands studies of preschoolers' imitation. In addition to the reproduction of precise actions and/or outcomes, our results suggest that children can also learn a rule or strategy through the observation of another's behavior. The children in our experiments were shown to identify and to apply the same categorization strategy that an adult demonstrated. Critically, the children's sorting behavior depended on observing a model produce the rule to be replicated. Other physically similar demonstrations were not effective for generating the relevant sorting. The range of control groups used here is one step toward isolating the essential components of the model's demonstration and thereby specifying the cognitive strategies that 36-month-olds can abstract from observation. We are currently conducting additional experiments with 18-month-olds to examine the development of imitation of abstract rules (Pinkham, Williamson, Jaswal, & Meltzoff, 2008). This expansion of research on childhood imitation to include rules and strategies, not simply concrete behaviors and endstates, deepens our understanding of children's social learning processes; it contributes to our understanding of how the children's observation of adults can sculpt human cultural practices, thinking, and development.

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[1]In the traditional dimensional change tasks, the child builds up a routine of sorting in one way and must inhibit this for the switch trials; no such habit was created in the current research. Sorting demonstrations may help children establish such routines (Moriguchi, Lee, & Itakura, 2007) and enhance their tendency to switch their sorting rules (Brace, Morton, & Munakata, 2006).

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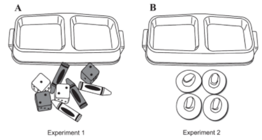

Figure 1.
An example of the materials and spatial layout used to initiate the response period in (A) Experiment 1 and (B) Experiment 2.

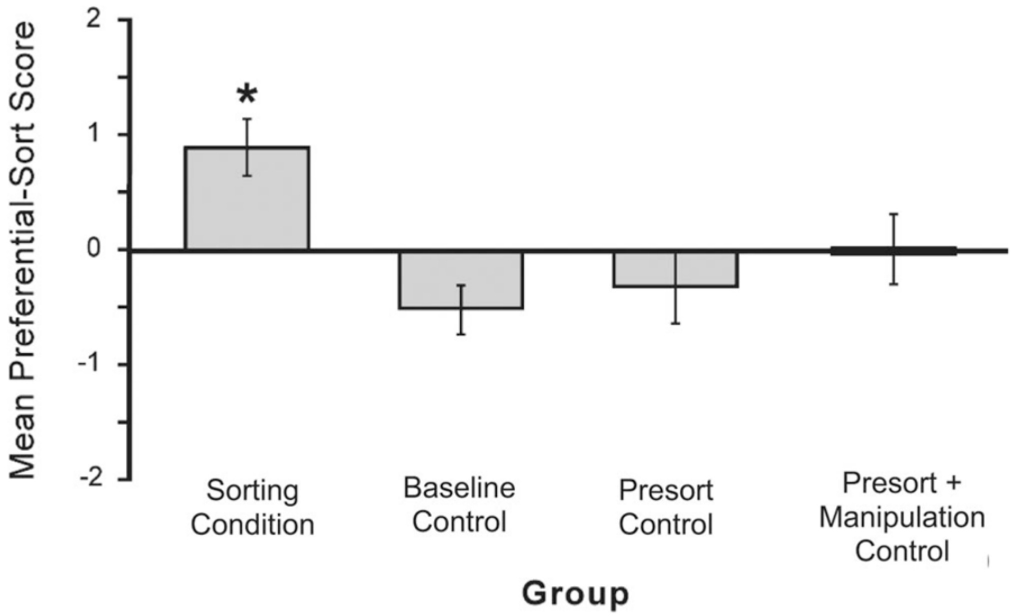

Figure 2.

Experiment 1: Mean preferential-sort score by group for Experiment 1 (±*SE*). The asterisk indicates that the treatment group was significantly different from each of the control groups.

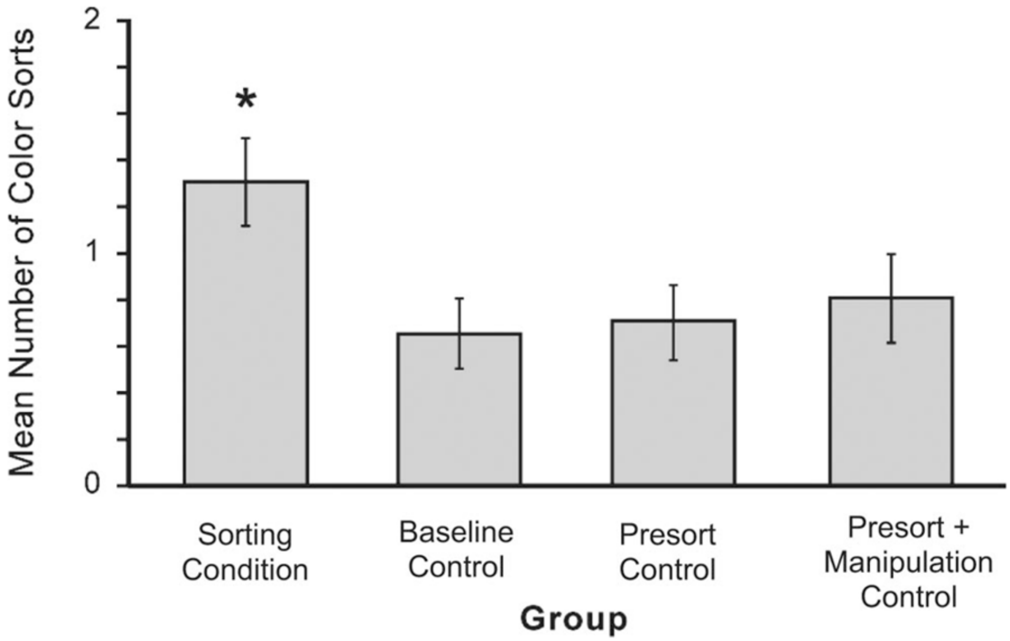

Figure 3.

Experiment 1: Mean color-sort score as a function of group for Experiment 1 (±*SE*). The asterisk indicates that the treatment group was significantly different from each of the control groups.

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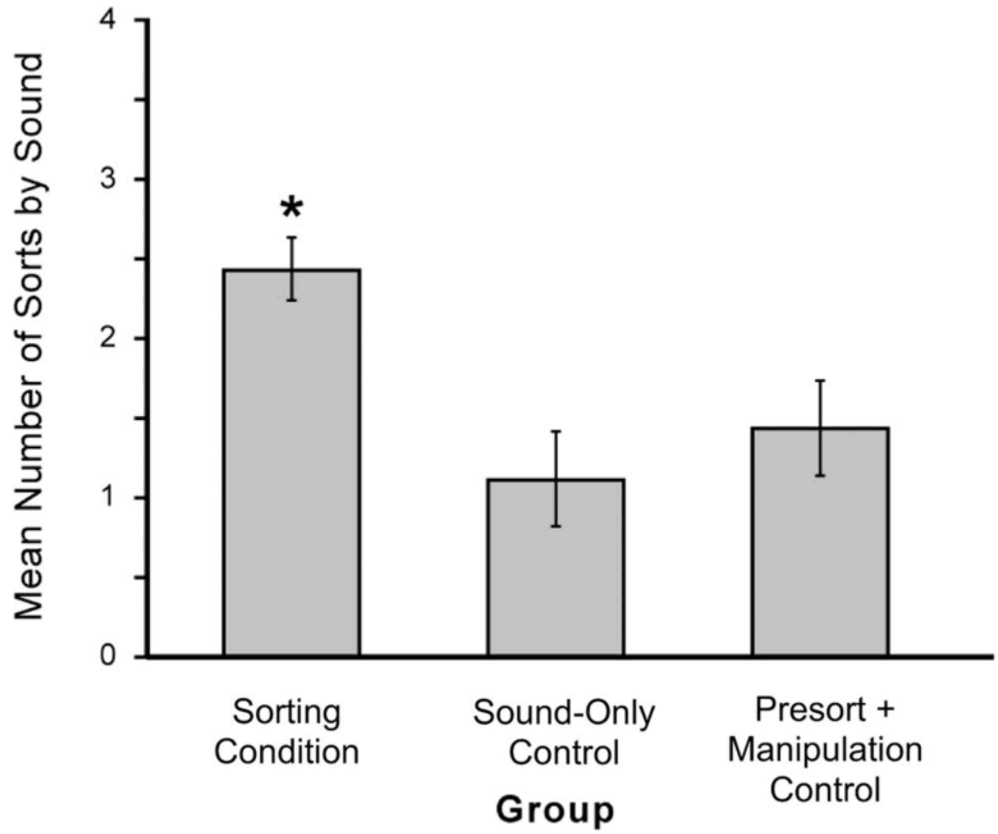

Figure 4.
Experiment 2: Mean number of sound sorts (±*SE*). The asterisk indicates that the treatment group was significantly different from each of the control groups.

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Table 1

Experiment 1: Number of Subjects Scoring Each Preferential Sort Score as a Function of Experimental Group

	Preferential sort score				
Experimental group	**−2**	**−1**	**0**	**1**	**2**
Sorting	0	3	4	5	8
Baseline control	4	5	8	3	0
Presort control	6	2	7	2	3
Presort + manipulation control	3	5	5	3	4

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Table 2

Experiment 1: Number of Subjects Sorting Zero, One, or Two Sets of Objects by Color as a Function of Experimental Group

	***N* sets with color sort**		
Experimental group	**0**	**1**	**2**
Sorting	5	4	11
Baseline control	9	9	2
Presort control	9	8	3
Presort + manipulation control	9	6	5

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Table 3

Experiment 2: Number of Subjects Sorting by Sound on 0–4 Trials as a Function of Experimental Group

	***N* trials with sort by sound**				
Experimental group	**0**	**1**	**2**	**3**	**4**
Sorting	2	2	5	1	6
Sound-only control	3	9	3	1	0
Presort + manipulation control	4	5	3	4	0