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Precision of Imitation as a Function of Preschoolers' Understanding of the Goal of the Demonstration

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The authors argue that imitation is a flexible and adaptive learning mechanism in that children do not always reproduce all of the details they can from a demonstration. Instead, they vary their replications depending on their interpretation of the situation. Specifically, the authors propose that when children do not understand the overall reason for a model's behavior, they will be more likely to imitate precisely. By copying conservatively in these situations, children may have a good chance of reproducing the action of the model correctly. In contrast, when the reason for an action is clear, children will be more likely to deviate from the manners and flourishes of the model and use their own means to complete the action.

Keywords: imitation, goals, children, social learning

Imitation is an early developing, complex ability that children can use for a variety of purposes. We argue that imitation is a flexible and adaptive learning mechanism that children use differently depending on the situation. In particular, our proposal is that children will imitate differently depending on how well they understand the demonstration at hand. When the reason for a demonstration is clear, we hypothesize that children will deviate from a model's precise manners in favor of their own means. When the overall goal of an action is not obvious, however, children should imitate conservatively, retaining more of the exact actions used by the model. In doing so, children will be more likely to successfully complete the intended action, even with a limited understanding of its purpose.

Imitation, in general, has long been recognized as a rapid and efficient means to acquire information. Bandura (1986), for example, noted that by using observation, a learner can benefit from the experiences of others and avoid the painstaking and sometimes dangerous process of trial-and-error learning. Recently much theoretical and experimental attention has focused more specifically on the importance of the ability to imitate precise actions—that is, the movements and means used to achieve a goal. In a study by Meltzoff (1988b), for example, 14-month-olds saw a model bend at the waist and turn on a light with the head. When presented with the light, approximately two thirds of the children also used this unusual manner to turn the light on even though more common means, such as a press with the hand, were available.

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Although the Meltzoff (1988b) experiment shows that even infants can copy the precise manners of a model in addition to the outcome that is produced, comparative research suggests that this ability may be unique to humans (cf. Tomasello, 1999). Observational and experimental studies suggest that nonhuman primates copy others actions in qualitatively different ways than do human children. In general, nonhuman primates do not include the exact actions demonstrated but instead focus on the objects manipulated and the outcomes produced in demonstrations (cf. Whiten, Horner, Litchfield, & Marshall-Pescini, 2004). This difference has led to the proposal that such precise imitation may be integral to the spread and maintenance of innovations needed for the development of complex human culture (Boyd & Richerson, 1996; Meltzoff, 1988a; Tomasello, 1999).

Despite the theoretical emphasis that these findings and theories place on faithful imitation, there is growing evidence that children do not always copy a model's actions in such detail. One example of this variation in imitation comes from a series of studies performed by Bekkering and colleagues (Bekkering, Wohlschläger, & Gattis, 2000; Gattis, Bekkering, & Wohlschläger, 2002; Wohlschläger, Gattis, & Bekkering, 2003). In the general procedure used in these studies, children imitate a model reaching either across the body (crosslaterally) or with the hand on the same side of the body (ipsilaterally) to a goal, such as one of two dots on a table. In general, even preschoolers will successfully imitate the goal of these actions. That is, they will reach for the same dot as the model. However, young children often fail to imitate the precise action the model used to complete the action. In particular, when the model uses a crosslateral reach, children often use an ipsilateral one instead. Thus, the common replication pattern is for children to complete the same goal as the model but to use a different means in doing so. However, when the procedure is made slightly easier by removing the goal of the action, children are more likely to imitate the specific actions of the model. Thus, when the dots are removed and children see only a model reaching ipsilaterally or crosslaterally to the table, they are significantly more likely to reproduce the same arm movement as the model. In very similar situations, then, children are shown to imitate with different degrees of precision.

The authors of these studies (Bekkering et al., 2000; Gattis et al., 2002; Wohlschläger et al., 2003) proposed an information-processing account to explain this variation in the precision of imitation. According to this theory, when an observed action is simple enough, children are able to include the exact manners and actions used by the model in their reproductions. However, when children attempt to reproduce a difficult demonstration, their resources for imitation are taxed. As a result of these high demands, the children cognitively select and copy only the critical elements of the demonstration and lose some fidelity to the model. Thus, when children see a model reaching for a dot on a table, the exact movements used to perform the action are lost and only the more general goal of reaching for the appropriate dot is reproduced. In contrast, when the children observe the simpler demonstration of the reach alone, they are able to select more of the subgoals of the demonstration and can remember and reproduce even the precise movements used by the model.

By this cognitive limitations account, the reason children do not imitate precisely is that they are unable to do so. The children are either unable to select all of the relevant goals from a demonstration or unable to remember and reproduce the same motor program used by the model (Wohlschläger et al., 2003). Although it is likely that children do modify their imitation when they encounter tasks that strain their information-processing capacities, this may not be the only time they make changes in their replications. Children may also modify their reproductions on the basis of the perceived importance of the components of the demonstration. Thus, on the basis of their interpretation of an event, there may be cases where children will disregard some of the components of the demonstration even when they remember them. In addition to deviating from a model's actions because they are too difficult, then, children may also imitate more or less precisely depending on what they are trying to learn.

Regardless of whether children actively vary their imitation, studies on folk psychological theories held by children suggest that one type of information that may influence children's precision is their interpretation of the model's intentions. Prior research shows that children vary how they imitate depending on whether they believe the actions used in a demonstration are purposeful. One example of this comes from a study by Carpenter, Akhtar, and Tomasello (1998). Toddlers in this study saw a model perform two manners that resulted in an outcome, such as an interesting light turning on. One manner was verbally marked as intentional ("There!") and one was marked as accidental ("Whoops!"). Children as young as 14 months old used these cues to guide their imitation, reproducing more of the intentional than accidental manners.

Indeed, children may not even need to rely on such linguistic cues to judge whether a manner is important. Some actions themselves may have particular characteristics that suggest they are intentional. Brand, Baldwin, and Ashburn (2002) reported that mothers demonstrate actions for children in different ways than they do for adults. In demonstrations to children, for example, they are more likely to use exaggerated movements and repeat actions. If children are indeed sensitive to these variations, they may be more likely to imitate the components of the demonstration highlighted by these exaggerated features, either because these actions are easier to understand or because the children learn that unusual repetition or range of motion indicates intentionality.

In addition, if an action is unusual and salient, children may assume that the model had a reason for producing it, and they may imitate such manners on the assumption that they are purposeful. One action that may have such characteristics is the previously described bending action used in the Meltzoff (1988b) study. The exaggerated use of the head to turn on a light in this demonstration may have led children to believe it was intentional and to imitate it. It was as if the children reasoned, "I don't know why he is using his head instead of his hands, but he must have a good reason for it." Indeed, a modification of this procedure showed that the imitation of the unusual manner decreases when another reason is given for the action (Gergely, Bekkering, & Kiraly, 2002). In this study, 14-month-olds again saw a model use her head to turn on a light. The basic Meltzoff results of novel imitation were replicated when the study was duplicated in the same way. However, in another condition, the model said she was cold and used her hands to hold a blanket over her shoulders, thus covering her arms and hands. The use of the head was now understood as a necessary means of completing the action because the model's hands were occupied, and children were less likely to reproduce the unusual manner. The majority of the children in this condition (79%) used only their hands to turn on the light, supporting the idea that children imitate elements that they believe are important to include in their own replications.

In addition to considering information about the specific manners used in a demonstration, children also appear to use their interpretation of the intended action to modulate the precision they use in their reproductions. For example, in another study by Meltzoff (1995), 18-month-olds were shown a model who persistently pulled at the end of a dumbbell-shaped toy with two fingers but never succeeded in pulling the object apart. In general, these children did not copy the physical actions of the fingers slipping from the edge of the toy, as the model demonstrated, but instead completed the perceived intention by pulling the object apart. In a similar procedure where a model used a one-handed grip to separate a very large barbell, 18-month-old children again did not restrict their small hands to the movements used by the model (Meltzoff, 1996, as cited in Meltzoff & Brooks, 2001). Instead, they invented their own means to pull the object apart, such as by putting the object between their legs and pulling with both hands. Both of these studies, therefore, show that when children understand the overall purpose of a demonstration, they will disregard the model's precise actions if another means is needed to successfully complete the goal.

In these studies, the goal of the action was pitted against an exact replication of the model's actions—children could not imitate the actions and successfully complete the goal. Carpenter, Call, and Tomasello (2002), however, showed that children also use their understanding of the goal of an action to organize their reproduction of a useful demonstration. In this study, 2-year-olds saw a model perform a complicated series of actions to open a box. In one condition, the children did not know the goal or outcome of the action before seeing the demonstration. In the other conditions, the children were first made aware of the goal of the model, for example, by seeing the box in its open state before the demonstration. When the children were prepared with the reason for the action on the box, they were significantly more likely to successfully open the box on the first trial than when the purpose of the action was not known until the end of the demonstration. These results suggest that this understanding of the purpose allowed the children to interpret their observation of the event and to better orchestrate the actions needed to complete the opening.

Finally, a recent study by Carpenter, Call, and Tomasello (2005) suggested that children will imitate the same demonstrations in different ways depending on their interpretation of the model's intent. In this task, 12- and 18-month-olds saw a model move a toy mouse in a distinct hopping manner. In one condition, this action was used to complete the larger goal of moving a mouse into a house. In the other, children saw only these stylized movements. Overall, the children in these studies imitated with different degrees of precision depending on the task. When the mouse was moved so it could be placed in the house, infants were less likely to reproduce the model's stylized movements and sounds than when the actions alone were demonstrated. The authors proposed that when no overall goal was present, the children interpreted the playful actions alone as the purpose of the demonstration and therefore imitated them.

In summary, several studies suggest that children use their interpretation of both the model's manners and the overall goal of the action to guide their imitations. When a model's manner is thought to be unnecessary, either because it is explicitly marked as accidental (Carpenter et al., 1998), another reason is given for it (Gergely et al., 2002), or it impedes the attainment of the overall goal of the action (Meltzoff, 1995; Meltzoff, 1996, as cited in Meltzoff & Brooks, 2001), it is disregarded in favor of a more efficient means. However, when the manner itself is seen as the goal of a demonstration, it is imitated in detail (Carpenter et al., 2005).

In some cases, however, children may not be able to judge what manners or actions are important in a demonstration. In particular, when children do not understand the overall goal or purpose for a model's action, they may not be able to determine which aspects of the demonstration are relevant. A question to consider, then, is how precisely children imitate the actions of a model in these situations, where the purpose of the actions and manners is ambiguous. One possibility is that children in such situations will copy the actions of the model in more precise detail. By using this conservative strategy, children would have a good chance of copying the critical elements of the demonstration and, therefore, of successfully completing the intended action.

Some support for this idea that children may imitate in detail when the overall purpose of the action is not clear comes from the Carpenter et al. (2002) study described above. Here, the children who discovered the outcome only after watching the lengthy demonstration were less likely to successfully open the box than were those who knew the outcome ahead of time. However, these children imitated a particular twisting manner used by the model more often than did the children who knew the purpose of the demonstration and often successfully completed the overall goal. A study by Harnick (1978) showed a similar pattern of results. The 14- to 28-month-olds in the Harnick study saw a model perform several irrelevant actions, such as waving her hands and making noise, before working a ball through a maze. The children's imitation of these irrelevant actions was shown to vary depending on the difficulty of the task. When the task was moderately difficult (e.g., 18-month-olds had to remove a barrier that blocked the ball), children imitated these unnecessary actions. However, when the task was very easy for the children, they did not imitate these aspects as often. Bauer and Kleinknecht (2002) also reported that children vary their imitation of irrelevant actions depending on the difficulty of the task.

We have two goals in the studies of this research project. The first is to investigate how children's understanding of the goal of an action influences their imitation. Our hypothesis, in line with the findings of other studies (Bekkering et al., 2000; Carpenter et al., 2002; Gleissner, Meltzoff, & Bekkering, 2000; Harnick, 1978; Wohlschläger et al., 2003), is that children will imitate the actions of a model in greater detail when the reason for those actions is not clear. In doing so, the children will have a good chance of successfully completing the model's intended behavior. When the reason for an action is clear, however, we expect children to copy with less fidelity. Instead of using the model's specific manners, children may replace them with their own more efficient means. Our second goal in this research project is to determine whether such a difference in imitation can be attributed solely to information-processing constraints or if evidence can also be found for children actively varying their reproductions depending on their understanding of the event.

Study 1

This first study is an initial examination of variability in children's imitation. It was designed to test the hypothesis that children would imitate the same demonstration with different degrees of precision depending on how well they understood the purpose of the actions. The children in this study saw a model place an object on a mat using slightly unusual manners. Half of the children received no explanation for this placement; they only saw the demonstration and were given an opportunity to reproduce it. For the rest of the children, the placement of the object was part of a larger goal. After the object was put down in the same unusual way, the model added additional props to make a meaningful, puzzlelike display. We expected the children who were given this reason for the placement to imitate using fewer of the model's distinctive manners than the children who had no explanation for the demonstration.

Method

Participants

The participants of this study were 25 students of a university nursery school, with approximately equal numbers of boys and girls. The children's families were largely White and middle class, but the school also includes a number of children of African American, Hispanic, Asian, and Native American descent as well. One child's data were excluded because of a camera malfunction. The remaining children's ages ranged from 3 years 4 months to 3 years 11 months, with a mean age of 3 years 8 months.

Materials

This procedure required three sets of four objects that were relatively unfamiliar to the children. The first set consisted of thin, cylindrical objects. Two of these were hair rollers and two were inactive penlights. The second set included disk-shaped objects: two sponges and two coasters. Cup-shaped objects made up the third set. Two of these were lids from laundry soap bottles and two were containers used to dye eggs. All of the objects in each set were different colors from one another and were presented to the children on silver trays. Additional pieces were constructed from craft foam to fit with these objects and make meaningful puzzle displays. The activities of the experiment took place on a plasticcoated mat. Each child was seen individually in a designated lab room at their preschool, and a camcorder was used to videotape these sessions.

Procedure

This procedure was designed to allow us to compare children's imitations when there was a clear reason for the model's actions and when there was no obvious goal. A between-subjects design was used to present children with these two situations. In both conditions, the children were told they were going to play a game that consisted of taking turns, with the experimenter going first. All of the children first saw the experimenter bring out a tray of objects and choose one of the four.

After the model picked an object from the array, she performed a series of actions with that object. For example, a penlight was raised between two index fingers, placed horizontally on the mat, and rotated 90 degrees. In one condition, the *no-context condition*, this was all the children saw. No reason was given for this placement behavior. In the second condition, the *meaningful-context condition*, the identical actions were used to place the object; however, additional props were then added to make the object part of a larger, recognizable, puzzlelike display. For example, one bud-shaped and two leaf-shaped pieces of colored craft foam were arranged around the penlight to make it the stem of a flower.

After this demonstration, the mat was cleared away and the children were presented with the tray of four objects. The children were allowed to chose an object and place it on the mat. The instructions given were, "Now it's your turn." The experimenter waited until the children placed the object and let it sit for approximately 1 s. In the no-context condition, the child was simply asked to place the object back on the tray and the trials continued. In the meaningful-context condition, after the child placed the object, he or she was given the additional pieces and allowed to complete the puzzle.

Children received three such trials, with different actions used on each. In addition to the cylinders used as flower stems, the disks were used as train wheels and the cups as noses in a face. Which set came first was counterbalanced across subjects, and the order of the targets on the tray was randomized, as was the target object selected from each set, with each object being used six times.

Each child's reproductions were coded from the videotape for replication of the actions and manners used in the model's demonstration. The placement of each of the objects consisted of three distinct coded components. As mentioned, the demonstration with the cylinders involved lifting the object between the index fingers, placing it horizontally, and rotating it 90 degrees. The disks were slid across the mat with a distinctly extended index finger and turned over. The cups were inverted and turned 90 degrees with a two-handed grip. Each of these elements was coded on a 2-point scale with 0 = *no*, 1 = *maybe*, and 2 = *yes*, for a total of 6 possible points per trial. A research assistant who was uninformed of the hypothesis of the experiment performed reliability coding on a randomly chosen quarter of the trials. Overall agreement on the coding of each component was 92%. As the coding scale was ordinal, Cohen's kappa with linear weighting was calculated, $k = .91$.

Results and Discussion

A preliminary analysis of the children's choices from the arrays of four different-colored objects (e.g., two hair rollers and two pen lights) revealed no differences across the conditions. Overall, the children chose the same kind of object as the model did on 70% of the trials. This tendency to choose from the same category as the model was significantly greater than chance, $t(71) = 1.61$, $p < .001$. In those cases where the children did choose an object that was of the same category as the model's selection, over half of the time they chose the object that was a different color from the one the model picked (on 39% and 41% of the trials overall in the meaningful-context and no-context conditions, respectively).

This pattern of choosing an object from the same category as the model may suggest that children expect that the kind of an object, although not the color, is important for achieving the goal in these situations. Baldwin, Markman, and Melartin (1993) also found that children expect members of the same category to have some functional features in common. In this study, 9- to 16-month-olds explored novel category members as if they expected them to have similar nonobvious properties as familiar members of those categories. It is possible that in some cases, children will consider even more detailed features than category kind, such as color, to be important for fulfilling a function. For example, children may find such details important when deciding a preference or trying to individuate objects.

Preliminary analyses of children's imitation scores revealed no effects of age, set of objects (cylinders, disks, or cups), or order of presentation of the object sets. Overall, there was no significant difference in the children's imitation scores between the two conditions (for the no-context condition, $M = 3.42$; for the meaningful-context condition, $M = 2.67$), $t(22) = 1.46$, $p = .16$, although the trend was in the predicted direction. There was, however, a marginal Trial × Condition interaction, $F(2, 44) = 2.75$, $p = .08$, with significantly higher imitation scores on the third and final trial of the meaningful-context condition ($M = 3.67$ points per trial) than on the first trial ($M = 2.00$), $t(11) = 2.64$, $p = < .05$, and marginally higher scores on the third trial than on the second trial ($M = 2.33$), $t(11) = 1.82$, $p < .10$. The patterns of results were, therefore, different on the first two trials and the last trial. Given this trend, we performed post hoc separate analyses on the early versus the late trials.

Imitation scores in both conditions were relatively high on the third trial (for the no-context condition, $M = 3.00$ points per trial; for the meaningful–context condition, $M = 3.67$ points per trial), and there were no significant differences between them, $t(22) = 0.70$, $p = .49$. This lack of differences and the high rate of imitation in the context condition was likely a result of the children becoming accustomed to our task. By the third trial, they may have noticed that the experimenter consistently used unusual manners and attributed importance to them. The first two trials, therefore, are probably a more representative measure of how children would normally imitate when presented with such a situation.

On the first trial alone, as well as on the first two trials combined, a significant difference was observed between the conditions. There was no significant difference on the second trial alone, however; $t(22) = 1.26$, $p = .22$. In line with the prediction, though, on the first trial alone, the children in the no-context condition had significantly higher mean imitation scores ($M = 3.83$) than did the children in the meaningful-context condition ($M = 2.00$), $t(22) = 1.83$. This pattern was also observed when the results of the first two trials were combined (for the no-context condition, $M = 3.63$; for the meaningful–context condition, $M = 2.17$), $t(46) = 2.89$, $p < .01$, see Figure 1. The results of the early trials of this experiment give some evidence that when there was no obvious reason for the demonstration, children copied the details of the model's actions with more fidelity than when the reason for the action could be inferred.

We have proposed that children will actively modulate their imitations on the basis of the situations in which they are trying to learn. By this account, the children in these studies are actively changing how faithfully they imitate depending on their understanding of the situation. An alternative explanation, however, is

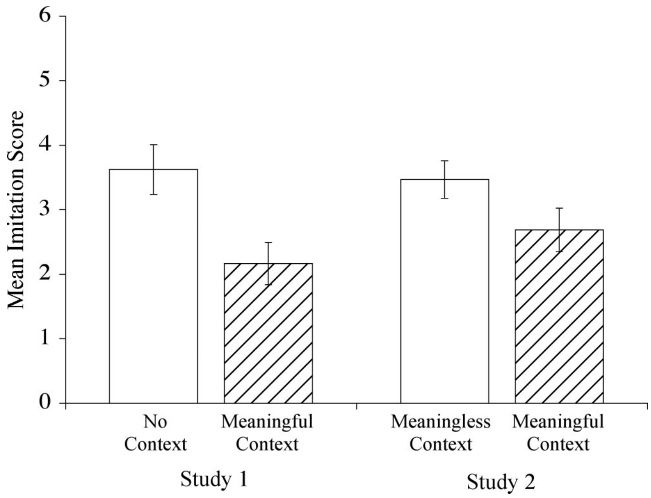

Figure 1. Mean imitation score per trial in each condition (with vertical lines depicting standard errors) for the first two trials of Study 1 and Study 2.

that children lose some fidelity in their imitation because of the difficulty of the meaningful-context condition. Study 2 was a first attempt to control for this possibility, as well as an attempt to replicate the results of Study 1.

Study 2

In the procedure used in Study 1, there were differences in how distracting the two demonstrations used for the different conditions were. In addition to adding a reason for the model's actions, the demonstration itself was more complex in the meaningful-context condition than it was in the no-context condition: Colorful pieces were added to the display to make the puzzle arrays. It is possible that these additions were responsible for the differences in imitation between the two conditions. The children simply may have lost their focus on what was happening in the demonstration with the addition of movements and pieces in the meaningful-context condition. Study 2 was designed to control for this possibility.

The same overall logic of Study 1 was used in this study. How children imitated in a condition where the reason for the action was made known was compared with their imitation when there was no clear reason for the placement of the object. To better equate how distracting the two conditions were, though, we added extra props to the display in both conditions. The meaningful-context condition was the same as in Study 1. An object was placed on the mat and the puzzle pieces were added to make a meaningful display. Instead of a no-context condition, however, we used a meaningless abstract context as a comparison in the *meaningless-context condition*. After the placement of the object in this new condition, additional pieces of craft foam that were roughly the same size and color as those used in the meaningful-context condition were added to the mat. However, the pieces themselves and the resulting display were meaningless. For example, instead of making the bud and petals of a flower, the extra pieces of foam were arranged to produce only an abstract display of two green rectangles and a red square with the target object. This arrangement still did not provide an obvious reason for the placement of the object, but it did take the children's attention from the target actions as in the meaningful-context condition. Therefore, if the disturbance caused by the placement of the additional pieces in the context condition of Study 1 was the only reason for the variation observed, the children should imitate at relatively low rates in both of these conditions. However, if children are instead varying their reproductions depending on their understanding of the model's demonstration, they should again imitate less precisely in the meaningful-context condition than in the meaningless-context condition where no purpose is given for the demonstration.

Method

Participants

A different 32 students of a university nursery school participated in this study, with approximately equal numbers of boys and girls. Their ages ranged from 3 years 1 month to 3 years 11 months with a mean age of 3 years 5 months.

Procedure

The methodology of this study was very similar to that of Study 1. The children in both conditions again saw a model choose an object from an array and place it using slightly unusual manners. Given the elevated rates of imitation on the third trial of Study 1, the procedure was shortened to include only two trials. The same actions and manners were used to place the cylinder and disk sets of objects. In both conditions, after the placement, additional pieces were added to the display. In the meaningful-context condition, the same props used in Study 1 were added to make a meaningful puzzlelike arrangement. In the meaningless-context condition, additional pieces of the same color and approximately the same size as those used in the meaningful-context condition were placed on the mat with the target object. However, these pieces were not meaningful in themselves, and they were placed in a meaningless, abstract configuration. The order of the sets of objects was counterbalanced across children, and the placement of the objects on the tray was randomized as was which object was used as the target, with each object being used four to five times.

After this demonstration, the mat was cleared and the children were allowed to choose one object from the array and place it on the mat. The children were then given the additional props to add to the display. Again, we videotaped the procedure and coded their imitation of the model's manners for the three components on a scale of 6 possible points per trial. A research assistant who was uninformed of the overall hypothesis of the study performed reliability coding on a randomly chosen quarter of the trials. Overall agreement was 93%, with a linearly weighted Cohen's kappa of .91.

Results and Discussion

Preliminary analyses revealed no effects of age, order of set of objects, or trial number. We therefore collapsed across the trials. Even with the addition of the meaningless context, the results of Study 2 were very similar to those of Study 1. A one-tailed t test again showed a significant difference between the conditions (see Figure 1). Children in the meaningless-context condition imitated at significantly higher levels (M = 3.47 points per trial) than did the children in the meaningful-context condition (M = 2.69), $t(30) = 1.75$, $p < .05$. Thus, as in Study 1, when the reason for the action was not clear, children imitated more precisely than when the reason for the action was clear. This was true even though the children in the meaningless-context condition now had a comparably complex demonstration to encode and reproduce. This difference in imitation between these conditions also supports an active explanation for the variation in the precision of imitation. If the difference in precision observed in Study 1 was merely an effect of the difference in the amount of activity between the conditions, children's fidelity should have decreased with this complex demonstration. However, no such drop in imitation was observed. Instead, the children imitated in much the same way the children in Study 1 did, copying significantly more of the model's precise actions in the condition in which no context was given for the placement.

Study 3

Study 3A

The proposal that children vary how precisely they imitate depending on their understanding of the demonstration brings up many questions about how this variation occurs. One issue is when children disregard or retain elements of the demonstration for reproduction. In all of the conditions of Studies 1 and 2, children saw the demonstration before a reason was given for those actions. This was a relatively conservative test of our hypothesis, but the children did imitate differently depending on whether they had that understanding. These results show that preschoolers can use information obtained after their observation of a demonstration to modify their reproductions. If the children understand the reason for an action while they observe it, however, there may be an even more pronounced effect of understanding on their imitation. For example, if children understand the overall goal of a demonstration when the model is acting, the children may not attend to or encode the specific actions the model uses. Thus, understanding the goal of an action during observation instead of only after the demonstration could lead to even greater variance from a model's actions.

To test this possibility, we included in Study 3 a new condition in which the purpose of the action was made clear to the children before they saw the demonstration. In this condition, the model arranged the puzzle props first and then placed the target object into the display using the distinct manners. Thus, before the children saw the demonstration, they knew why the model was placing the object on the mat. If differential encoding of the event is responsible for the drop in imitation, then we would expect even lower levels of imitation in this condition than in the standard condition where the context is presented after the demonstration.

Method

Participants. This study included a new group of 48 children from the same university nursery school, with approximately equal numbers of boys and girls. Their mean age was 3 years 5 months, with a range from 3 years to 3 years 11 months.

Procedure. This experiment consisted of three between-subjects conditions. Two of these conditions were the same as those of Study 1 where children saw the demonstration either with no context or with the meaningful context presented after the demonstration. In the new condition for this study, children were made aware of the reason for the placement of the object before they saw the model perform the demonstration. Thus, in the *context-before condition*, the model first placed the puzzle props into the correct, meaningful orientation and then chose one object from an array and placed it with the distinct manners. The mat was then cleared, and the children were told, "Now it's your turn," and allowed to imitate the action. In the other two conditions, as in the previous studies, the model first chose and placed an object. In the *context-after condition*, the puzzle props were then added to the display to provide a reason for the demonstration. In the no-context condition, the children only saw the placement of the object; no explanation was given.

This study again consisted of two trials in which the order of the objects was counterbalanced and the order of the objects on the tray was randomized, as was the target object used, with each object being chosen 12 times. A coder who was blind to the hypothesis of the study again performed reliability coding on a randomly chosen quarter of the trials. Overall agreement on each coded component of the action was 93%, with a linearly weighted Cohen's kappa of .91.

Results

Preliminary analyses revealed no significant effects of trial number, age, set of objects, or order of objects. The data were therefore collapsed across trial and object set. A one-way analysis of variance (ANOVA) with mean imitation score as the dependent variable and condition as the independent variable revealed a significant main effect of condition, $F(2, 45) = 11.52$, $p < .0001$ (see Figure 2). Consistent with previous results, the children's imitation scores were significantly higher in the no-context condition ($M = 3.91$) than in the context-after condition ($M = 2.19$); for the Tukey–Kramer post hoc test, $p < .05$. Moreover, the no-context scores were also significantly greater than those of the context-before condition ($M = 1.78$); for the Tukey–Kramer post hoc test, $p < .05$. There was no significant difference between the context-before and context-after conditions, $p > .05$. Thus, children again imitated more precisely when the reason for the action was unknown compared with when the reason for the action was clear. This was true whether the reason was given before or after the demonstration was observed.

Although no difference was shown in this study, it is possible that the children may still have encoded the demonstration differently depending on when the reason for the action was presented to them. A test of memory for the model's actions might be a more sensitive test for an effect of understanding at encoding than is a

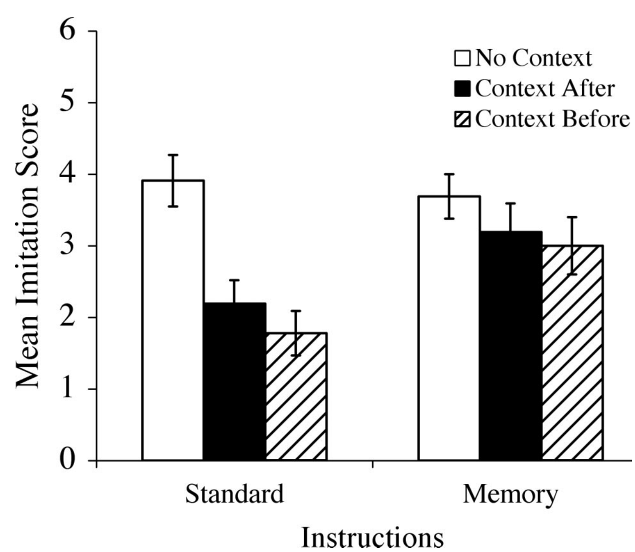

Figure 2. Mean imitation score per trial in each condition (with vertical lines depicting standard errors) for Study 3A, where standard instructions ("Now it's your turn") were given, and for Study 3B, a memory control ("Do everything I did").

spontaneous imitation procedure. Therefore, one goal of Study 3B was to be a memory control to Study 3A.

Study 3B

Study 3B included the same three conditions as Study 3A. Children again saw the placement event with either no context, a context given before the demonstration, or a context given after the event. When the children were given an opportunity to copy the actions, however, they were now explicitly instructed to reproduce as much of the model's demonstration as they could. In addition to providing a more sensitive measure for possible differences in encoding, this manipulation will also speak to the question of why children are varying their imitation in the different conditions. According to the information-processing account, the observed decrease in imitation in the two context conditions would result from children being unable to remember or reproduce the precise actions. If this is the reason for the variation in children's imitation, this memory manipulation should have little effect. Children should reproduce actions with the same precision in this task as they do in the standard imitation studies. However, if this memory task shows that children do remember additional details that they do not normally reproduce, it would be evidence that in addition to information processing, children can also play an active role in varying the precision of their reproductions.

Method

Participants. The participants of this study were a different group of 49 preschoolers from the same university nursery school. One child's data were excluded from the analyses because of an experimenter error. The remaining children had a mean age of 3 years 4 months, with a range from 2 years 11 months to 3 years 11 months, and consisted of approximately equal numbers of boys and girls.

Procedure. The same demonstrations used in the preceding study were used, and the children participated in one of the three same conditions: no context, context before, or context after. The sole change in this study was that at the children's opportunity to reproduce the model's actions, they were instructed to imitate the model: "Do the same thing I did. Do just what I did." This instruction was only given after the children saw the demonstration.

Results

A research assistant who was uninformed as to the hypothesis of the study performed reliability coding on a randomly chosen quarter of the trials. Overall agreement on each component of the action that was coded was 92%, with a linearly weighted Cohen's kappa of .89. Preliminary results revealed no unexpected significant effects. Data were therefore collapsed across the two trails.

First, a comparison to Study 3A shows that the memory manipulation was effective. A two-way ANOVA with condition and study as independent variables and imitation score as the dependent variable also shows a main effect of study. Overall, children imitated more in the current study when instructed to reproduce the actions of the model ($M = 3.29$) than they did in the previous study where they were given only standard instructions ($M = 2.63$), $F(1, 90) = 5.41$, $p < .05$. There was also a marginal Condition × Study interaction, $F(2, 90) = 2.44$, $p = .09$ (see Figure 2). As was reported earlier, the children in Study 3A imitated differently depending on their understanding of the action. Children who were shown a context for the placement of the object imitated significantly fewer of the model's distinct actions than did children who were given no reason for the placement. This was true whether the context was shown before or after the placement event.

A different pattern of results, however, was observed in Study 3B, the memory control. A one-way ANOVA of Study 3B, with the tendency to reproduce the actions score and condition as the independent variable, showed no difference between the scores in the no-context ($M = 3.68$), context-after ($M = 3.19$), and context-before ($M = 3.00$) conditions, $F(2, 45) = 0.93$, $p = .40$. In contrast to the spontaneous imitation tasks, this memory manipulation reveals no difference in how precisely children imitate when the reason for an action is known or unknown. The children reproduce the actions of the model in the same detail in all of the conditions of the memory task.

That the children showed the same degree of memory for the modeled actions whether a reason was presented before or after the demonstration is somewhat surprising given the findings of Carpenter et al. (2002). In their study, 2-year-olds imitated a series of actions used to open a box differently depending on whether they understood the purpose of the action during that observation. Children who did understand the purpose were better able to complete the goal of opening the box than were those who did not, and they imitated a specific manner of the model less often than did those children who did not understand the purpose of the action at encoding. From these results, it would seem that having an understanding of an action at encoding and not just after the demonstration can be important for structuring one's imitation. However, in our study, we found no evidence of this effect. Children were able to remember and reproduce the same amount of a model's display whenever they understood the purpose of the action or if they did not at all.

A potential explanation for these different results could lie in differences in the difficulties of these two tasks. The demonstration used in these tasks may have been simpler than the one used in the Carpenter et al. (2002) task, especially for these older children. Understanding the reason for an action may only lead to differences in encoding when children are overwhelmed by a demonstration and information-processing constraints become involved. If so, then we would expect to see negligible effects of understanding the demonstration in a simpler opening task.

The pattern of results observed in the context conditions of this memory task differed from those of Study 3A. Children had significantly higher imitation scores in the memory study than in the standard study in the context-before condition (memory study $M = 3.00$, standard study $M = 1.78$), $t(30) = 2.42$, $p < .05$; the memory study scores were only marginally higher than the standard study scores in the context-after condition (memory study $M = 3.19$, standard study $M = 2.19$), $t(30) = 1.95$, $p = .06$. However, there was no difference in scores in the no-context conditions across studies (memory study $M = 3.67$, standard study $M = 3.91$), $t(30) = 0.46$, $p = .65$. Thus, when a context was provided, children showed a significant increase in the number and degree of actions and manners reproduced when they were instructed to reproduce the model's actions. In these cases, the children imitated with the same precision as if no context was provided at all. These results suggest that the reduction in precision observed in the previous studies was not simply a matter of forgetting the details of the action. When the purpose of the action was clear on this task, children could have reproduced the model's actions in greater detail, but they did not.

General Discussion

The variation shown in these studies overall suggests that imitation is a flexible and adaptive learning mechanism that children use differently depending on the situation. In particular, these studies show that how precisely children imitate depends on whether they have a clear understanding of the purpose of the actions. When the reason is clear, children are less faithful to the model's demonstration and instead use their own means to copy the actions. When the reason for the demonstration is not clear, however, children are more likely to reproduce the manners of the model in greater detail, which may help them complete the demonstrated actions.

These studies also provide evidence that this variation in precision is not solely an effect of limited cognitive resources, as suggested by Bekkering and colleagues (Bekkering et al., 2000; Gattis et al., 2002; Wohlschläger et al., 2003). When instructed to imitate the model in Study 3B, the children were able to imitate the model's actions in precise detail in those conditions where a meaningful context was given for the demonstration. In fact, the children were shown to retain and reproduce equal amounts of information whether or not they understood the overall goal of the demonstration. This shows that processing limits are not the only factor that can influence the precision of a replication. Thus, children are not restricted to mimicry. They do not reproduce everything they observe, nor do they copy everything they can remember (see also Meltzoff, 2005). Instead, children can use their understanding of an event to guide how they reproduce the actions they observe.

Given this observed variation in children's imitation, it is worth considering the consequences of these different patterns. It is likely that both precise and imprecise imitation have benefits for the learner. First, precise replication may be particularly useful when the reason for an action is not clear. By imitating in as much detail as possible, children may have a better chance of successfully replicating the intended action than if less fidelity is used and important components of the actions are disregarded.

There are several ways that a conservative imitation pattern could allow children to complete the intended outcome of the demonstration. First, if the actions used in the demonstration are functional, copying precisely could allow children to produce the same physical result. This seems to be the case in Meltzoff's (1988b) study in which children succeeded by using their heads to turn on a light panel. Second, the precise actions performed by the model could be the sole goal of the demonstration, as in Carpenter et al. (2005) or in various body-imitation studies where the goal is to perform gestures alone (e.g., Meltzoff & Moore, 1994, 1997). The point of the exchange could be to take turns making specific movements, as is done, for example, in gestural communication. Again, by copying conservatively, children would retain the critical elements of the demonstration and allow an interaction based on mutual actions to take place. It is still unclear which, if either, of these interpretations children are making in the no-context conditions of these studies. Further studies in which researchers manipulate, for example, whether the model is present for the children's imitation period could begin to determine whether children are seeking a function for the demonstrated actions that they reproduce or if they are imitating these elements for social means such as to engage or please the model.

The use of such conservative patterns may not be limited to imitation. Children may stay close to known examples in many situations where the reason for a behavior is not obvious. Another line of our research examines how children interpret the preference judgments of others (Williamson & Markman, 2006). These studies show that preschoolers expect people's preferences to apply to a very narrow subordinate category of objects and that children do not readily generalize beyond this limited set. As in imitation, very detailed differences seem to be important in children's extensions of preference, and the reasons for other's preferences are also not always clear. It is possible that many forms of cultural learning involve attention to detail and sometimes appear arbitrary. Varying little from a model's example, then, may be a commonly used, efficient way to learn many types of culturally relevant information.

There are likely also benefits to less conservative replication strategies as well. In particular, when the goal of an action is clear, using one's own and perhaps easier means may allow for more efficient reproduction of the action. In support of this idea, some comparative studies show that nonhuman primates perform some tasks more quickly (Whiten, Custance, Gomez, Teixidor, & Bard, 1996) and more efficiently (Nagell, Olguin, & Tomasello, 1993) than children do by using less precise replications. The moderate drop in precision observed in our context conditions may similarly prevent children from becoming mired in unnecessary detail. Future studies considering different variables of the situation, such as how long children take to complete a task or their social referencing during the task, may provide further support for the benefits of different patterns of imitation.

How well a behavior is understood may also influence imitation across the life span. Intuitively, even adults seem to show this pattern of staying close to a model when put into a situation they do not understand. For example, one may look to others when unsure of which utensil to use at a fancy dinner party or to determine how to arrange recycling containers in a new city. Preschoolers are at the upper end of the age range for subjects used in most studies of imitation in the field, so their results may reflect how relatively mature learners behave in such situations. Given their variation due to this factor, it may be interesting to consider whether younger children also vary their imitation on the basis of their understanding of demonstrations. It is difficult to know exactly what demonstrations will be clearly understood by children. In these studies, the preschoolers' spontaneous reactions (e.g., the children's ability to correctly complete the puzzles) suggest that the children's understanding of the demonstrations did differ by condition. It is possible, however, that younger children would not understand our puzzlelike representations or many other tasks as well as preschoolers do. If even younger children do use a conservative pattern when faced with a difficult situation, one prediction from this account is that infants and toddlers may imitate faithfully in even more situations than do preschoolers.

The variability shown in children's imitation and the potential uses of these different patterns bear on recent proposals to limit what should be considered imitation for children. Experiments in comparative psychology show that although nonhuman primates will copy the outcome of demonstrations, they do not consistently copy the precise means used to complete those ends (cf. Whiten et al., 2004). In investigating this difference, researchers have identified other social learning mechanisms in primates, such as stimulus enhancement, mimicry, and emulation (cf. Tomasello, 1999).

Recently, Want and Harris (2002) proposed that how children replicate actions should be classified according to these same learning mechanisms. However, although these distinctions in social learning may illustrate fundamental cognitive differences between the species, the use of applying these distinctions to children's replications is less clear.

The results of our studies and those of several other researchers (Bauer & Kleinknecht, 2002; Bekkering et al., 2000; Gattis et al., 2002; Gergely et al., 2002; Gleissner et al., 2000; Wohlschläger et al., 2003) show that children do not use a static level of precision in their imitation, not even on two very similar tasks. Instead, children actively change how they imitate depending on the situation. Bauer and Kleinknecht have argued that this variation is evidence that children can use these different learning mechanisms. However, as the children in the different conditions in all of these studies were typically developing, underlying cognitive differences cannot be responsible for the observed variations in imitation. Without such underlying differences, invoking different learning mechanisms is unnecessary and may cloud the issue. By instead considering reproductions of different degrees of precision to be modulations of a single learning mechanism, the specific factors that influence imitation can be isolated and understood. With an understanding of what influences this learning mechanism, it may be possible to draw broader conclusions about how children acquire new information more generally.

References

Baldwin, D. A., Markman, E. M., & Melartin, R. L. (1993). Infants' ability to draw inferences about nonobvious object properties: Evidence from exploratory play. *Child Development, 64,* 711–728.

Bandura, A. (1986). *Social foundations of thought and action*. Englewood Cliffs, NJ: Prentice Hall.

Bauer, P. J., & Kleinknecht, E. E. (2002). To 'ape' or to emulate? Young children's use of both strategies in a single study. *Developmental Science, 5,* 18–20.

Bekkering, H., Wohlschläger, A., & Gattis, M. (2000). Imitation of gestures in children is goal-directed. *Quarterly Journal of Experimental Psychology: Human Experimental Psychology, 53*(A), 153–164.

Boyd, R., & Richerson, P. J. (1996). Why culture is common, but cultural evolution is rare. In W. G. Runciman, J. M. Smith, & R. I. M. Dunbar (Eds.), *Evolution of social behavior patterns in primates and man: Proceedings of the British Academy* (Vol. 88, pp. 77–93). Oxford, England: Oxford University Press.

Brand, R. J., Baldwin, D. A., & Ashburn, L. A. (2002). Evidence for 'motionese': Modifications in mothers' infant-directed action. *Developmental Science, 5,* 72–83.

Carpenter, M., Akhtar, N., & Tomasello, M. (1998). Fourteen- through 18-month-old infants differentially imitate intentional and accidental actions. *Infant Behavior & Development, 21,* 315–330.

Carpenter, M., Call, J., & Tomasello, M. (2002). Understanding "prior intentions" enables two-year-olds to imitatively learn a complex task. *Child Development, 73,* 1431–1441.

Carpenter, M., Call, J., & Tomasello, M. (2005). Twelve- and 18-month-olds copy actions in terms of goals. *Developmental Science, 8,* F13–F20.

Gattis, M., Bekkering, H., & Wohlschläger, A. (2002). Goal-directed imitation. In A. N. Meltzoff & W. Prinz (Eds.), *The imitative mind: Development, evolution, and brain bases* (pp. 183–205). New York: Cambridge University Press.

Gergely, G., Bekkering, H., & Kiraly, I. (2002, February 14). Rational imitation in preverbal infants. *Nature, 415,* 755.

Gleissner, B., Meltzoff, A. N., & Bekkering, H. (2000). Children's coding of human action: Cognitive factors influencing imitation in 3-year-olds. *Developmental Science, 3,* 405–414.

Harnick, F. S. (1978). The relationship between ability level and task difficulty in producing imitation in infants. *Child Development, 49,* 209–212.

Meltzoff, A. N. (1988a). Imitation, objects, tools, and the rudiments of language in human ontogeny. *Human Evolution, 3,* 45–64.

Meltzoff, A. N. (1988b). Infant imitation after a 1-week delay: Long-term memory for novel acts and multiple stimuli. *Developmental Psychology, 24,* 470–476.

Meltzoff, A. N. (1995). Understanding the intentions of others: Re-enactment of intended acts by 18-month-old children. *Developmental Psychology, 31,* 838–850.

Meltzoff, A. N. (2005). Imitation and other minds: The "like me" hypothesis. In S. Hurley & N. Chater (Eds.), Perspectives on imitation: From cognitive neuroscience to social science (pp. 55–77). Cambridge, MA: MIT Press.

Meltzoff, A. N., & Brooks, R. (2001). "Like me" as a building block for understanding other minds: Bodily acts, attention, and intention. In B. F. Malle, L. J. Moses, & D. A. Baldwin (Eds.), *Intentions and intentionality: Foundations in social cognition* (pp. 171–191). Cambridge, MA: MIT Press.

Meltzoff, A. N., & Moore, M. K. (1994). Imitation, memory, and the representation of persons. *Infant Behavior & Development, 17,* 83–99.

Meltzoff, A. N., & Moore, M. K. (1997). Explaining facial imitation: A theoretical model. *Early Development and Parenting, 6,* 179–192.

Nagell, K., Olguin, R. S., & Tomasello, M. (1993). Processes of social learning in the tool use of chimpanzees (*Pan troglodytes*) and human children (*Homo sapiens*). *Journal of Comparative Psychology, 107,* 174–186.

Tomasello, M. (1999). *The cultural origins of human cognition.* Cambridge, MA: Harvard University Press.

Want, S. C., & Harris, P. L. (2002). How do children ape? Applying concepts from the study of non-human primates to the developmental study of 'imitation' in children. *Developmental Science, 5,* 1–41.

Whiten, A., Custance, D. M., Gomez, J., Teixidor, P., & Bard, K. A. (1996). Imitation learning of artificial fruit processing in children (*Homo sapiens*) and chimpanzees (*Pan troglodytes*). *Journal of Comparative Psychology, 110,* 3–14.

Whiten, A., Horner, V., Litchfield, C. A., & Marshall-Pescini, S. (2004). How do apes ape? *Learning & Behavior, 32,* 36–52.

Williamson, R. A., & Markman, E. M. (2006). *Early emerging domain differences in the scope of generalization: Preschoolers' extensions of labels versus preferences*. Unpublished manuscript.

Wohlschläger, A., Gattis, M., & Bekkering, H. (2003). Action generation and action perception in imitation: An instance of the ideomotor principle. *Philosophical Transactions: Biological Sciences, 358,* 501–515.

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