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Deferred Imitation Across Changes in Context and Object: Memory and Generalization in 14-Month-Old Infants

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Abstract

The influence of changes in context and object characteristics on deferred imitation was assessed in 14-month-old infants. In Experiment 1, infants in the imitation group saw an adult demonstrate target acts on miniature objects in an unusual context (an orange polka-dot tent). When later presented with larger objects in a normal laboratory room, these infants performed significantly more target acts than did controls. In Experiment 2, three groups of infants were tested. Infants in an imitation(no change) group saw an adult demonstrate target acts and were subsequently tested in the same room using the same objects as the adult. Infants in the imitation (context + object size & color change) group followed the same procedure, but both the context and two salient featural characteristics of the objects (size and color) were changed between encoding and the recall test of deferred imitation. Control infants did not see the target demonstrations. Results showed that the combined changes in context and object features led to a significant decrease in imitative performance. Nonetheless, in comparison to the controls, infants exhibited significant recall as indexed by deferred imitation. The results show that imitation generalizes across changes in object size, object color, and test context. The implications for theories of memory and representational development are discussed.

Keywords

infants; imitation; recall; memory; context; shape; generalization; stimulus similarity; amnesia; play

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Deferred imitation is of interest to developmental cognitive psychology because it provides a direct measure of nonverbal memory. Imitation assesses more than recognition. It taps infants' capacity to generate actions on the basis of stored representations. To date, there has been little research into variables that may dampen deferred imitation, and hence the promise of using deferred imitation to inform theories of nonverbal memory has not been fully mined. Perhaps young infants can perform deferred imitation if and only if the context and focal objects at encoding and recall remain identical. If so, this would constrain theories of infant representation. Similarly, if deferred imitation is a fragile, tightly context-bound ability, it would impact views of social and personality development hypothesizing imitation

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to be a potent learning mechanism in infancy. For deferred imitation to be of functional significance, infants must be able to transfer information gained through observation to different contexts, with different objects, at later points in time.

There has been little investigation of how changes in context and focal object influence deferred imitation. However, there is an extensive literature documenting that such changes between encoding and retrieval often produce a decline on measures of memory in both animals (Hickis, Robles, & Thomas, 1977; Spear, 1973; Winocur & Olds, 1978) and humans (e.g., Godden & Baddeley, 1975; Rovee-Collier, 1990). Animal research has suggested that younger subjects are more dependent upon a consistent context for memory retrieval than adults. Immature rat pups showed greater disruption of performance than adults when there was a change of context between training and test (Solheim, Hensler, & Spear, 1980). Richardson, Riccio, and McKenney (1988) found that rat pups' performance on a retention test was significantly better when the testing occurred in the identical context as training after a 5-min delay.

Rovee-Collier and her colleagues demonstrated that retrieval is often poorer in human infants when the context is changed between encoding and testing. The best known work concerns 6-month-olds using the mobile conjugate reinforcement paradigm in which foot kicks produce mobile movement. Infants were tested either in the original training context (a crib with a patterned liner) or in a different context (a different crib liner or no liner; Amabile & Rovee-Collier, 1991; Borovsky & Rovee-Collier, 1990; Rovee-Collier, Schechter, Shyi, & Shields, 1992; Shields & Rovee-Collier, 1992; for similar work with 3-month-olds, see Rovee-Collier & Hayne, 1987). Six-month-olds tested in the original training context exhibited excellent retention after delays of up to 2 weeks, whereas infants tested in a novel context failed to exhibit retention after delays of 1 to 3 days. It was reported that infants stared "blankly" at the test mobile after the crib liner was changed, as if they could not recognize the out-of-context mobile (Rovee-Collier, 1990).

Rovee-Collier also found that changes in the features of the focal object may dampen performance on memory tests in infants. In the mobile conjugate reinforcement paradigm, 6-month-olds' performance falls to chance if they are tested with a novel mobile after delays of 1 to 14 days, although infants succeed after these delays if the mobile is not changed (Borovsky & Rovee-Collier, 1990; Hill, Borovsky, & Rovee-Collier, 1988; Shields & Rovee-Collier, 1992). Recent findings using an operant procedure that was modified for older infants suggest a shift by about 9 months of age in as much as infants begin to generalize across changes in both object features and context (Aaron, Hartshorn, Klein, Ghumman, & Rovee-Collier, 1994).

Exploring deferred imitation across changes in context and focal object is important for both applied and theoretical reasons. Regarding the former, for imitation to serve as an important learning mechanism beyond the laboratory, infants must be able to transfer knowledge acquired from observing others to novel settings, even if the featurally identical objects are not available. Highly context-specific and object-bound knowledge would be of less use.

On a more theoretical level, classical developmental theory assumed that infants developed the capacity for representation at approximately 18 months of age (Piaget, 1962). Meltzoff (1985, 1990; Meltzoff & Moore, 1994, 1995) used results from deferred imitation to challenge this notion. Deferred imitation provides a particularly powerful challenge to traditional developmental theory because it involves generating *action* on the basis of stored representations of absent events, not merely responding with attentional changes. Imitation after a 24-hour delay has now been reported in 9-month-old infants (Heimann & Meltzoff, 1996; Meltzoff, 1988c) and at even younger ages under some circumstances (Barr, Dowden, & Hayne, 1996; Meltzoff & Moore, 1994). Moreover, it has been established that 14-month-olds can imitate novel acts from memory after delays spanning 1 week to 4 months (Meltzoff, 1988b, 1995b). Bauer and Mandler (1992) found that 11- to 13-monfh-olds can duplicate temporal sequences from memory, and Bauer and Hertsgaard (1993) showed that 13.5- to 16.5-month-old infants exhibit imitation of a series of actions after a 1 -week delay. Work on deferred imitation in atypical populations has also been reported (Rast & Meltzoff, 1995). However, in all these studies, the context was carefully held constant between the sessions. Perhaps Piagetian theory simply needs to be expanded to encompass the idea that deferred imitation is possible at young ages if and only if the context remains identical between encoding and test.[1]

There are some data suggesting that deferred imitation may not be strictly bound to the original context or focal objects. Hanna and Meltzoff (1993) found toddler imitation of peer models across a change in context (from laboratory to home) after a 48-hour delay when using the same focal objects in the two sessions. Meltzoff (1988a) found that 14-month-old infants who viewed televised models could reenact the observed behaviors using real, three-dimensional objects after a 24-hour delay, indicating some stimulus generalization. Using older infants closer to the Piagetian age cutoff, Bauer and Dow (1994) showed that 16-and 20-month old infants could reenact behaviors using featurally modified stimuli after a 1-week delay.

In the studies of deferred imitation reported here, the adult demonstrated the target acts inside a highly unusual context. Instead of Rovee-Collier’s crib liner, we used a “room-liner.” The walls were covered from ceiling to floor with garish orange and white polka-dot material forming a special tent. Recall, as assessed by deferred imitation, was subsequently tested in a plain, white-walled room. The general procedure was developed for 14-month-old infants in Experiment 1. Experiment 2 was more systematic, using the following three groups: (a) control—no demonstrations were shown, (b) imitation(no change)— encoding and recall occurred in identical contexts with identical objects, and (c) imitation(context + object size & color change)—there was a change in both context (polka-dot tent vs. normal room) and focal objects (size + color). The results showed significant dampening of performance between the “no change” and “context and object change” groups, indicating that infants were sensitive to these changes, but still showed successful deferred imitation.

[1]Other tests of early representation, for example using preferential-looking measures to assess object permanence (e.g., Baillargeon, 1993; Spelke, Breinlinger, Macomber. & Jacobsen, 1992), also use identical encoding and testing sites. There is often a particular stage or box in which infants see displays.

EXPERIMENT 1A

Method

Subjects—Twenty-four normal, 14-month-old infants participated in this experiment. Criteria for admission were that an infant have no known physical, sensory, or mental disabilities, be full term (over 37 weeks gestation), and be of normal birth-weight (range = 2,500–4,500 gms at birth) according to maternal report. The mean age at the time of test was 60.82 weeks (*SD* = 0.73, range = 59.71–61.86). There were equal numbers of male and female participants. Two additional infants were dropped from the study, 1 due to a procedural error and 1 because the infant failed to interact with the experimenter or explore any of the toys during the warm-up period.

Test Environment and Apparatus—The demonstration period took place in a visually distinctive context: a three-walled tent constructed out of fabric with a bright orange background and a white polka-dot pattern. The fabric walls of the tent reached from the edge of the ceiling to the floor. The polka-dot pattern filled the infants' entire field of vision. Inside the tent, the parent and the experimenter sat across from one another at a brown, wood-grain table (1.2 × 0.6 m) with the infant on the parent's lap.

The response period took place in a normal laboratory room which had white walls and was unfurnished except for the test equipment. The table used during the response period was different from the one in the encoding site (a solid black vs. a wood-grain surface, respectively).[2] A video camera above and to the left of the experimenter was focused to include the infant's torso, head, and most of the table top. The response period was electronically timed by a character generator which recorded the elapsed time and video frames onto videotape.

Stimuli—The objects used to demonstrate the target acts and those subsequently given to the infants during the response period differed in size. The experimenter performed the target acts upon miniature (approximately half-sized) replicas of the full-sized objects used by the infants. Both stimulus sets were novel objects constructed in the laboratory or adapted from store-bought items.

The first object was a dumbbell-shaped object that appeared to be one piece but could be pulled apart. The miniature dumbbell consisted of two unpainted wooden cubes (1.7 × 1.7 cm) each with a 4.4-cm length of rigid, off-white tubing extending from it. One length of the tubing was slightly narrower and fit inside the other. The target action demonstrated by the adult consisted of holding each end of the object and pulling it apart with a definite movement. The full-sized dumbbell presented to the infants consisted of two unpainted wooden cubes (2.5 × 2.5 cm) each with a 7.5-cm length of rigid, off-white tubing.

The second object was a box with a recessed button that produced a buzzing sound when pressed with a wooden stick. The miniature black box (8.4 × 7.6 × 4.8 cm) had a black

[2]The table change ensured that not only the peripheral context of the room walls but also the immediate context of the table top was altered between encoding and the retrieval test.

button (1.5 × 1.8 cm) that lay slightly below the top face of the box and was presented with an unpainted wooden stick (5.0 × 0.6 × 0.9 cm). The target act for the box consisted of pushing the recessed button with the wooden stick which activated a switch inside the box, producing a buzzing sound. The full-sized object presented to infants was a black box (16.5 × 15.0 × 5.4 cm) with a black button (2.2 × 3.0 cm) and a wooden stick (10.0 × 1.2 × 1.8 cm).

The third object was a hollow, orange plastic egg that rattled when shaken. The miniature egg (4.8 cm high × 3.2 cm diameter at its widest point) had been cut in half so that two metal nuts could be put inside it. The target act consisted of holding the egg in one hand and shaking it horizontally. The full-sized egg was 6.4 cm high × 4.5 cm in diameter and did not contain metal nuts. All infants were presented with the empty, silent egg in order to control for the possibility that they might accidentally discover the target property of rattling through tactile exploration; therefore, any shaking produced by the infants would be due to imitation.

Design—Each infant was randomly assigned to one of two test conditions: imitation(context +object size change) (*n* = 12) or baseline control (n = 12). Each group included an equal number of males and females. In each group, the stimuli were presented in six orders, across which each stimulus occurred equally often in each position. One male and one female infant were randomly assigned to each order; thus, order and sex of infant were counterbalanced within and between the experimental groups.

Procedure—Infants and parents were led to a reception room that contained the polka-dot tent. For approximately 10 min, the infant was allowed to explore the portion of the room outside the tent while the parent filled out consent and information forms. After the test procedure was described, infant and parent were escorted inside the tent, and the experimenter and the infant briefly exchanged warm-up toys in order to allow the infant to acclimate to the environment. Once the infant seemed comfortable, infants in the imitation(context + object size change) group observed the experimenter perform the target acts inside the polka-dot tent. Baseline infants received the identical warm-up experience inside the tent, but were not shown the target acts.

In demonstrating the target acts, the experimenter sequentially brought up each of the miniature objects from below the table. Once the infant fixated on the object, the experimenter performed the target act three times in approximately 20 s. If the infant became distracted at any time during the demonstration period, the experimenter would attempt to redirect the infant's attention to the task by using such phrases such as "look over here" or "see what I have." Words describing the target acts or task, such as "pull," "shake," "pick up," "copy," or "imitate," were never used by the experimenter.

For infants in both conditions, the initial period (warm up alone or warm up + demonstration) was followed by a 10-min delay. During the delay, infants were removed from the tent and allowed to play with toys made available to them (the toys were unrelated to the test stimuli). Next, infants and parents were escorted into a white-walled laboratory room, and the infants were presented with the full-sized objects in the same order as the demonstration. A 20-s response period was timed starting from when the infant first touched each object.

Scoring—For each infant, whether imitation or control, the video record contained three 20-s response periods. The videotapes provided no artifactual information about the infants' group assignment. The scorers were uninformed of the infants' test condition. Dichotomous operational definitions of each target act were provided to the scorers. A "yes" for the dumbbell was scored when the two halves visibly separated. A "yes" was scored for the box if the insertion of the stick into the recessed button created a buzzing sound. A "yes" for the egg was scored if the infant shook the egg, where shake was defined as a bidirectional movement which retraced itself. To assess scoring agreement, the primary scorer coded the entire data set, and this scorer and a secondary one recoded a randomly selected 50% of the infants. There were no disagreements on either the intra- or interobserver assessments.

Results and Discussion

Each infant was presented with three objects, and for statistical analysis, each was assigned a score ranging from 0 to 3 according to how many target acts he or she produced (see Table 1). Infants in the imitation condition performed significantly more target actions (M = 1.83, SD = 0.84) than did infants in the control condition (M = 0.75, SD = 0.75), Mann-Whitney U = 25.50, $t(22) = 3.34$, $ps < .01$. The results show that 14-month-olds can perform deferred imitation despite changes in context and certain object characteristics.

EXPERIMENT 1B

A replication study was conducted that differed from the previous one in two ways. First, a new experimenter was used. Second, Meltzoff's (1985) object-manipulation control was used to supplement the baseline control used in Experiment 1A. Infants in this control group observed the experimenter manipulate the miniature test objects, but the experimenter did so in ways that did not involve producing the target acts. This control assessed whether infants might be prompted to produce the target acts simply due to watching the adult play with the toys. If witnessing object manipulations inexorably leads to the production of the target acts, there should be no significant difference between the imitation and object-manipulation groups, because both saw the adult manipulate the same objects for the same duration. We considered this outcome an unlikely possibility based on prior work (Meltzoff, 1988b, 1988c). This condition also provided an occasion to test whether infants can imitate a second set of actions with the same test objects (the "control manipulations" performed by the experimenter). Such results would broaden the findings of Experiment 1A by showing that the objects used in the study have more than one affordance (Gibson, 1979)—that infants can imitate different acts with the same toy depending upon what was shown (see Meltzoff, 1985, 1995a, for discussions about affordances in studies of imitation and the usefulness of the object-manipulation control).

Method

Subjects—Twenty-four 14-month-old infants participated in this study. Criteria for admission were the same as in Experiment 1A. The mean age at the time of test was 61.02

weeks (*SD* = 0.63, range = 59.86–61.86). There were equal numbers of male and female participants. Three infants were dropped from the study due to procedural errors.

Test Environment, Stimuli, and Procedure—The test environment and stimuli were identical to those used in Experiment 1A. Each infant was randomly assigned to one of two test conditions: imitation(context + object size change) (*n* = 12) or object-manipulation control (*n* = 12). Infants in both conditions observed the adult handle the miniature objects in the novel context (the orange polka-dot tent). However, only imitation infants viewed the adult perform the target acts. The control group saw the adult handle the same objects, for the same length of time, but in a different way. The control act for the dumbbell consisted of holding the center of the tube and moving the object on the table in a circular motion. The diameter of the circle approximated the linear distance between the ends of the dumbbell in the pulled-apart state of the imitation condition. The control action for the box consisted of rubbing the stick up and down the face of the box so that the stick was seen in close proximity to the hole. The control act for the egg consisted of the adult pushing the miniature egg back and forth between her finger tips to create a rattling sound as it slid on the table top. The remainder of the procedure matched Experiment 1A.

Scoring—The scoring procedure and definitions for the target acts were the same as those in Experiment 1A. Intra- and inter-observer agreement for the target acts was high, as evaluated by both Pearson *r* (1.0 and .95, respectively) and kappa (1.0 and .94, respectively). In addition, the control acts performed by the adult in the object-manipulation condition were scored following the same procedure. Intra- and inter-observer agreement on the control acts was high, according to both Pearson *r* (.97 and 1.0, respectively) and kappa (.94 and 1.0, respectively).

Results and Discussion

Main Analyses—The results of Experiment 1B replicated and extended Experiment 1A. Table 2 presents the number of target acts (ranging from 0–3) produced by infants in the imitation condition versus the object-manipulation control condition. Infants in the imitation condition produced significantly more target acts ($M = 2.17$, $SD = 0.72$) than did infants in the object-manipulation control ($M = 0.67$, $SD = 0.78$), Mann-Whitney $U = 14.0$, $t(22) = 4.91$, $ps < .001$.

Because the same stimuli were used in Experiments 1A and 1B, it is reasonable to combine data for a larger analysis. The data were analyzed in a 2 (study: 1 A/1B) × 2 (condition: imitation/control) analysis of variance (ANOVA). There was a significant main effect of condition, $F(1, 44) = 33.56$, $p < .001$, and no significant main effect of study. The study x condition interaction was not significant, indicating that the effects replicated across the two studies.

It is also of interest to examine the strength of the effect at the level of each individual test object. Table 3 provides the raw frequency data. Chi-square analyses indicated significant differences between infants in the imitation and control conditions for each test object.

Subsidiary Analyses—In the object-manipulation control, infants observed the adult handle the objects in ways that were different from the target acts. This control was used principally to supplement the baseline condition used in Experiment 1A. Nonetheless, infants' imitation of these arbitrary control acts was also assessed. The data showed imitation: 50% (6 of 12) of the infants in the object-manipulation control group produced at least one of the control actions as compared to only 8% (1 of 12) of the infants in the imitation condition, $p < .05$, Fisher's exact test. A Mann-Whitney *U* test also yielded a significant difference between groups. Thus, Experiment 1B not only replicated Experiment 1A using a second type of control (equating for the time the experimenter handled the miniature test objects), it strengthened the inferences that can be drawn by showing that imitation in 14-month-olds extends to a range of novel acts.

EXPERIMENT 2

Experiment 2 extended the previous experiments in two ways. First, it included an additional change in focal object. More importantly, it tested whether the change in the physical world was also registered as a change in the infants' perceptual world. In Experiment 1, there was no attempt to assess whether the physical changes were psychologically salient to the infant. Stronger conclusions about memory, generalization, and representation would be warranted if infants could be shown to imitate despite having registered the perceptual changes between encoding and recall. There are several ways to assess perceptual pick up of the information (e.g., increased looking at the novel context or modified object, etc.), but we thought it most informative to test whether imitation itself would be dampened by the changes. If imitation is dampened, the changes must at least have been perceived. One can then ask whether the dampened imitation still ex-ceeds control rates. Such a finding would allow the interpretation that there is recall and imitation across functionally important perceptual changes.

Three groups of infants were tested. Infants in the imitation(no change) group were shown target acts using full-size objects in a plain room and were subsequently tested in the same room with the same objects. Infants in the imitation(context + object size & color change) were shown the target displays in the polka-dot room with miniature, multicolored objects. They were subsequently tested in a plain test room with full-sized, plain-colored versions of the objects. A baseline control group was also included. We tested whether (a) the two experimental groups produced significantly more target acts than the control group (which would demonstrate imitation) and (b) there was a reduction of imitation between the two experimental groups (which would indicate that the changes were perceptually registered, and indeed functionally significant).

Method

Subjects—Thirty-six normal, 14-month-old infants participated in this experiment. Criteria for admission into the study were the same as in Experiments 1A and 1B. The mean age at the time of test was 60.61 weeks (*SD* = 0.64, range = 59.86–61.86). There were equal numbers of male and female participants. Four additional infants were dropped from the study due to procedural errors.

Stimuli—The miniature objects used to demonstrate the target acts in the imitation(context + object size & color change) group were the same size as those used in Experiment 1, but each was painted with two bright colors. The cubes of the dumbbell were painted turquoise blue with a canary yellow plastic tube connecting them. The box face and the interior of the hole were painted royal blue, and the stick and the body of the box were painted fire-engine red. The top half of the egg was made of kelly green plastic and the bottom half of the egg was made of lavender plastic. To an adult eye, these color changes were quite striking. With the dual differences in color and size combined, this stimulus set was quite different in appearance from the objects subsequently used in the test period. For the test, infants in all groups were given the full-sized, plain-colored objects as used in Experiment 1.

Design—Each infant was assigned to one of three (n = 12) test conditions: imitation(no change), imitation(context + object size & color change), or baseline control condition. Order of stimulus presentation and sex of subjects were counterbalanced within and between the experimental groups. In this study, the testing of infants in the imitation (context + object size & color change) and baseline control condition was completed before the imitation (no change) condition.

Procedure—Infants in the imitation (no change) group saw the adult demonstrate the target acts using the full-sized, plain-colored objects inside the normal laboratory room. After the 10-min delay, these infants returned to the same room and were presented with the same test objects as those used by the adult. Infants in the imitation(context + object size & color change) group saw the adult demonstrate the target acts on miniature, multi-colored objects inside the polka-dot tent. After the delay, infants were presented with the full-sized, plain-colored objects inside the normal room. Baseline control infants did not see the target acts and were simply presented with the full-sized, plain-colored objects in the normal laboratory room, as in Experiment 1A. Thus, the room and objects were identical during the test for all groups, but the treatment infants received before the test varied. The response periods were 20 s for each object, as in Experiment 1.

Scoring—Operational definitions identical to those in Experiment 1 were used. Scorers were naive to the infants' group assignment. There were no disagreements on either intra- or inter-observer assessments.

Results and Discussion

Table 4 presents the results for each test condition. A one-way ANOVA showed that there was a significant difference in the number of target acts produced as a function of condition, $F(2, 33) = 30.39$, $p < .001$. (A Kruskal-Wallis test yielded identical results.) A follow-up Tukey HSD test revealed that the scores of both the imitation(no change) (M = 2.58, SD = 0.52) and the imitation(context + object size & color change) (M = 1.42, SD = 1.00) conditions were significantly different from the baseline control (M = 0.33, SD = 0.49), and that there was also a significant difference between the imitation(no change) and imitation (context + object size & color change) conditions. The latter effect supports the inference that the infants encoded the combined changes in context, object size, and object color. These perceptual changes were functionally significant in as much as they dampened performance; however, infants still imitated (produced more target acts than controls). This experiment cannot determine what change (context, focal object, or combination) caused the performance decrease, but other work in our laboratory suggests that context change alone does not have a major effect on memory retrieval as indexed by deferred imitation in 12-month-olds after delays up to 1 week (Klein & Meltzoff, 1996). Therefore, we suspect that the change in focal object is the principal source of the effects.

To further illuminate the effect of context and object change, it is of interest to combine the data from Experiments 1 and 2 into a larger analysis. Preliminary analysis showed no significant difference in the number of target acts performed in the control groups in Experiments 1 A, 1B, and 2, $p > .30$, therefore, the data were combined into one control group, for the purposes of this analysis ($n = 36$). Similarly, the two imitation(context + object size change) groups in Experiment 1 did not significantly differ, $p > .30$, so the data were combined ($n = 24$). A one-way ANOVA was then performed on the number of target acts produced by the following independent groups drawn from both experiments (Figure 1): imitation(no change) ($M = 2.58$, $SD = 0.52$), imitation(context + object size change) ($M = 2.00$, $SD = 0.78$), imitation(context + object size & color change) ($M = 1.42$, $SD = 1.00$), and controls ($M = 0.58$, $SD = 0.69$). The results showed a significant difference among the groups, $F(3, 80) = 29.58$, $p < .001$. A Tukey HSD test confirmed that each of the imitation groups differed from the controls, and that the difference between the imitation(no change) and imitation(context + object size & color change) groups reached significance. Figure 1 shows that there was a monotonic decrease in the number of target acts performed as a function of extent of change from encoding to test situation. This supports the inference that infants were registering the perceptual changes from encoding to test.

GENERAL DISCUSSION

The experiments reported here show that deferred imitation in 14-month-old infants is not limited to the conditions present during the original modeling. In experiments encompassing 84 infants, strong evidence was found for imitation across changes in context (polka-dot tent vs. normal room) and focal object characteristics (size and color). Experiment 2 provided evidence of both memory and generalization. The results showed that infants perceived the changes in context and object and that the changes were functionally significant to them: Deferred imitation was significantly poorer in the group with changes in context and object size and color than in the group with no changes. Nonetheless, performance was significantly greater than control levels.

These experiments extend the work of Hanna and Meltzoff (1993) and Bauer and Dow (1994). This previous work had varied only one dimension (either context or object) and used older infants. Moreover, Bauer and Dow (1994) allowed motor practice (immediate imitation) before the delay was imposed, however, the infants in our tests were not allowed motor practice. In these experiments, the adult showed infants what to do with the objects but did not allow them to handle the objects. The delay was then imposed and the context and focal objects changed. This design allows the inference that infants are not merely reapplying/generalizing their own *already performed* actions but must be organizing their actions based on a representation of the original event in the world.

Meltzoff (1985, 1990) argued that recall in this type of deferred imitation test implicates a “nonverbal declarative memory” (for an extended analysis of declarative vs. procedural memory in infancy, see Meltzoff, 1990, 1995b, and Mandler, 1990). Our results substantially strengthen this inference by showing that deferred imitation is not highly context bound or object specific. Tests with infants, animals, and adult patients suggest that procedural memory is often constrained in this way but that declarative memory is not (Diamond, 1990; L. R. Squire, personal communication, October 15, 1995).

The relation between these findings and the development of symbolic play is noteworthy. It has been reported that from approximately 14 months of age on, infants show a marked increase in decontextualized pretend play, for example, “drinking” from miniature teacups or “conversing” into toy telephones (Belsky & Most, 1981; Fein, 1981; Fenson, Kagan, Kearsley, & Zelazo, 1976; Jackowitz & Watson, 1980; McCune, 1995; McCune-Nicolich, 1981). It can be argued that this type of pretend play builds upon deferred imitation coupled with generalization (Harris, 1994; Leslie, 1987; Lillard, 1993, 1994; Meltzoff & Gopnik, 1989). Viewed in this way, development in symbolic play uses progress made in deferred imitation in which infants observe acts demonstrated by others and subsequently reenact them in wholly new contexts using perceptually discriminable objects after a delay.

Meltzoff and Moore (1992, 1994, 1995) proposed the identity hypothesis to explain the function that action imitation serves for infants: Infants use imitative behavior to probe whether or not similar looking people will interact with them in the same way. Results from work by Baldwin, Markman, and Melartin (1993) supported and extended this notion by demonstrating that 9- to 16-month-old infants who discovered a hidden or “nonobvious” target property in an object often reenacted the relevant behavior on a novel, similarly shaped object but did not generalize to perceptually dissimilar objects. The objects used in the studies reported here also have properties that are nonobvious, in as much as they are not detectable or verifiable through visual exploration alone. The findings show that despite changes in object size and color, 14-month-olds expected objects of the same shape to have the same underlying properties (buzzing, rattling, pulling apart). Infants this age seem to hypothesize that if objects have the same form they may have the same function and, importantly, think this even if this function was first revealed through the action of another, not the self.[3]

DeLoache and her colleagues discovered a phenomenon in older children that bears on the work reported here. In this work, 2.5- and 3-year-old children observed a toy being hidden in a scale-model room and were then asked to find a replica toy in the corresponding location in a full-sized room (or vice versa). Three-year-olds were highly competent at this, whereas 2.5-year-olds were limited to finding the toy in the original display (DeLoache, 1987, 1989). The generalization involved in the deferred imitation tests reported here is conceptually simpler and develops earlier, but both paradigms require the understanding that

[3]The findings support the idea that 14-month-olds depend heavily on shape information when generalizing actions to new objects and contexts. Baldwin (1989, 1992) suggested that such shape-based expectations may in turn underlie children’s acquisition of basic-level category names (e.g., *shoe, bottle*), which refer to objects that arc similar in form (Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976). Other work also highlights the importance of shape in early object categorization and language (Heibeck & Markman, 1987; Imai, Gentner, & Uchida, 1994; Landau, Smith, & Jones, 1988; Smith, Jones, & Landau, 1992).

one miniature stimulus is "like" another and that what is known about the first can be applied to the second (DeLoache, 1987, 1989; Meltzoff, 1990). Deferred imitation provides a nonverbal measure of analogical mapping, and the conceptual and developmental relation between DeLoache's task and deferred imitation across object and context transformations deserves further study.[4]

Finally, this work on deferred imitation can be used to inform debates about infantile amnesia. It has been suggested that contextual changes and perceived size change may be important contributors to infantile amnesia (Campbell & Spear, 1972; Hayne, Rovee-Collier, & Borza, 1991; Rovee-Collier & Hayne, 1987). Meltzoff (1995b) showed that in the special case when the context and focal objects remain identical between encoding and testing, infants can perform deferred imitation over exceedingly long delays even without practice (a 4-month delay, straddling the 18-month-old "stage-6 cognitive boundary"). For work showing long-term memory across changes in context and objects but involving motor practice, see Myers, Perris, & Speaker, 1994; also see Myers, Clifton, & Clarkson, 1987; and Perris, Myers, & Clifton, 1990, for related work.) By using the procedure developed here and substantially longer delays, one could investigate the relative contributions to infantile amnesia of context change, object changes, and single-episode versus multiple-practice learning opportunities.

In conclusion, the results reported here suggest that deferred imitation can serve as an important learning mechanism during infancy: Infants gain knowledge through observing another's actions on objects and use this knowledge after a delay, generalizing across surface changes in object characteristics and contextual surround. Moreover, these findings underscore that deferred imitation is a useful paradigm for investigating infants' capacity to act based on stored representations of absent events.

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[4]One might ask why the 14-month-olds exhibited generalization in deferred imitation, whereas older children had difficulty transferring their knowledge in DeLoache's task. One factor may be the greater similarity in scale between our pairs of stimuli (approximately 1:2 ratio) in comparison to those used in the DeLoache studies (approximately 1:7 or 1:4 ratio; see DeLoache, Kolstad, & Anderson, 1991). DeLoache's task also involves projecting a spatial relation (the object is hidden in location x in the scale model, so it must also be in location x' in the larger room), whereas our task involves the projection of a single action from one object to an analogous one.

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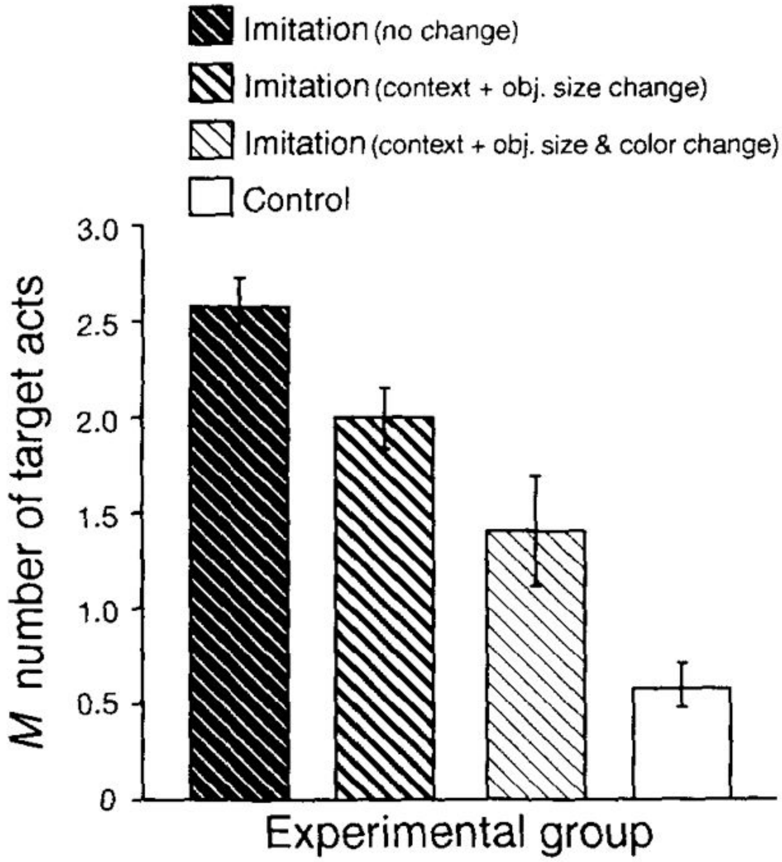

Figure 1.

Mean number of target acts produced by infants as a function of treatment. Infants in the three imitation groups (shaded bars) saw an adult demonstrate three target acts. Control infants did not see the demonstrations. Infants in the imitation(no change) group were tested in the same room with the same objects as those used by the adult. Infants in the imitation(context + object size change) group were tested in a different context (orange polka-dot tent vs. normal room) using objects differing in size from the originals. Infants in the imitation(context + object size & color change) group were tested in the different context using objects differing both in size and color from the originals. Error bars indicate ± 1 *SE.*

TABLE 1

Experiment 1A: Number of Target Acts Produced as a Function of Condition

	N of Target Acts				
Condition	**0**	**1**	**2**	**3**	**Total *n***
Baseline Control	5	5	2	0	12
Imitation (context + object size change)	1	2	7	2	12

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TABLE 2

Experiment 1B: Number of Target Acts Produced as a Function of Condition

Condition	*N* of Target Acts				Total *n*
	0	**1**	**2**	**3**	
Object-Manipulation Control	6	4	2	0	12
Imitation (context + object size change)	0	2	6	4	12

TABLE 3

Experiment 1A and 1B: Number of Infants Producing Target Acts as a Function of Test Object and Experimental Condition

	Test Object		
Condition	**Dumbbell**	**Box**	**Egg**
Control	6	8	3
Imitation (context + object size change)	15	23	10
$\chi^2(1, N = 48)$	5.42*	17.85**	3.80*

Note. N = 24 in each condition. Entries indicate how many of the 24 infants produced the target acts for each test object.

* $p \leq .05$.

** $p < .001$.

TABLE 4

Experiment 2: Number of Target Acts Produced as a Function of Condition

	N of Target Acts				
Condition	**0**	**1**	**2**	**3**	**Total *n***
Control	8	4	0	0	12
Imitation (context + object size & color change)	2	5	3	2	12
Imitation (no change)	0	0	5	7	12