The effect of event structure on imitation in infancy: Practice makes perfect?

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BRIEF REPORT

The Effect of Event Structure on Imitation in Infancy: Practice Makes Perfect?

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In this study, we compared 18-month-old infants' ability to imitate enabling and arbitrary sequences that were matched across stimuli, actions, and goals. In addition, we compared imitation by infants with and without prior practice of the target actions. Imitation following a 1-week delay was facilitated by an enabling structure but was not enhanced by prior practice.

memory deferred imitation event structure practice

An enabling sequence of events is defined as a series of steps that must be performed in a specific temporal order to achieve the sequence goal. To drive a car, for example, the door must be unlocked before the key is put in the ignition. An arbitrary sequence of events, on the other hand, is a series of steps that can be performed in any order. To make a salad, the mushrooms can be added before or after the tomatoes. Previous research has demonstrated that children (Brown, 1975; Fivush, Kuebli, & Clubb, 1992; Hudson & Nelson, 1983; Murachver, Pipe, Gordon, & Owens, 1993; Price & Goodman, 1990) and adults (Ratner, Smith, & Dion, 1986) use enabling relations to facilitate their recall of past events, recalling more of an event if the components are enabling than if they are not. Based on either verbal (Fivush et al., 1992; Hudson & Nelson, 1983; Murachver et al., 1993; Price & Goodman, 1990; Ratner et al., 1986; Slackman & Nelson, 1984) or behavioral (Fivush et al., 1992; Price & Goodman, 1990) recall measures, children report more information when asked to remember events with enabling relations than when asked to remember events that are more arbitrary in nature.

A growing body of research suggests that preverbal infants also use event structure to organize their recall of multistep events. In a large number of studies, Bauer and her colleagues used an imitation paradigm to examine the effects of event structure on recall by 1- and 2-year-old subjects. In Bauer's procedure, an experimenter models a series of actions, and the infant's ability to reproduce those actions is assessed immediately and following a delay. Bauer's studies have shown that infants reproduce the target event more accurately when the component actions are enabling than when they are not (Bauer, Hertsgaard, & Wewerka, 1995; Bauer & Mandler, 1989; Bauer & Shore, 1987). This same pattern of results has been obtained whether the infants are tested with short (Bauer & Mandler, 1989) or long (Bauer, 1992; Bauer & Fivush, 1992) sequences, whether the target events are familiar or novel (Bauer & Mandler, 1989; Bauer & Shore, 1987; Bauer & Travis, 1993), and whether infants are given single or repeated exposures to the events prior to testing (Bauer & Travis, 1993; see also Fivush et al., 1992). Furthermore, when irrelevant components are added to enabling sequences, infants (and children) frequently omit or displace these components during reenactment, preserving the enabling relations within the sequence (Bauer, 1992; Bauer & Mandler, 1989; Hudson & Nelson, 1983; Price & Goodman, 1990).

Taken together, the findings described here provide strong support for the conclusion that infants and children use enabling structure to facilitate their recall of an event. Without exception, however, these studies have compared subjects' retention for enabling and arbitrary sequences that involved different test

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stimuli, component actions, and sequence goals (for a similar argument, see Bauer & Fivush, 1992). In a recent study of children's verbal recall, Owens and Murachver (1995) found that the benefit of enabling structure was maintained when the enabling and arbitrary events were matched across stimuli, actions, and goals. In light of this, one purpose of the following study was to compare infants' memory for enabling and arbitrary events that were matched, as closely as possible, across these three variables. In addition, in all but one study comparing long-term memory for enabling and arbitrary event sequences conducted with infants (Bauer et al., 1995), subjects were given the opportunity to practice the target sequence immediately after the demonstration prior to the retention interval. A second purpose of this study, therefore, was to compare memory for enabling and arbitrary sequences following a 1-week delay by infants with and without prior practice.

Forty infants (20 males, 20 females) between the ages of 18 and 19 months (M = 557.90 days, SE = 1.87) were recruited through public birth records and by word of mouth. Eight additional infants were tested but were not included in the final sample due to maternal or sibling interference (n = 3), procedural error (n = 1), scheduling difficulties (n = 2), or failure to handle any of the test objects (n = 2).

There were two sets of stimuli. The "frog" stimuli consisted of a plastic frog secured to the top of a large metal spring, a blue Plexiglas plank (21.00 cm × 3.75 cm), and a green, rectangular, wooden block (6 cm × 3 cm × 4 cm). The "rattle" stimuli consisted of a yellow wooden stick (15 cm long) with a plug on one end that fitted into a hole cut in a red plastic ball (4 cm diameter) and two large plastic beads connected by elastic with loops of green ribbon attached to each end. For both sets of stimuli, an enabling sequence and an arbitrary sequence were devised. Each version contained comparable component actions (see Table 1) and virtually identical goals. The goal for both the enabling and the arbitrary "frog" sequences was to make the frog jump, and the goal for both the enabling and the arbitrary "rattle" sequences was to make a noise using the plastic beads. These events were based on similar events used by Bauer and her colleagues (e.g., Bauer & Thal, 1990) but were modified in order to match the stimuli, actions, and goals.

All infants were tested in their own homes. The purpose of the study and details of the procedure were explained to the caregiver, and informed consent was obtained. Caregivers were instructed not to prompt the infant to perform any particular action and were asked not to discuss the event with their infant during the retention interval. Throughout each session, the infant and the experimenter were seated facing each other on the floor; the caregiver was seated behind the infant and held him or her gently by the hips. Before each session, the experimenter interacted with the infant for approximately 5 min, until the infant appeared relaxed and comfortable.

At the beginning of the first (demonstration) session, all infants were presented with the stimuli for two event sequences, one set at a time, for a 90-s period. During this baseline phase, the spontaneous production of the target behaviors was assessed. Following the baseline phase, the experimenter modelled the first sequence three times, without explicit narration. The experimenter said only "look at this" or "watch" and kept the stimuli just out of the infant's reach.

Two three-act sequences were modelled for each infant. Each infant observed one enabling sequence and one arbitrary sequence. If an infant observed the "enabling frog" sequence, he or she also observed the "arbitrary rattle" sequence. Similarly, if an infant observed the "arbitrary frog" sequence, he or she also observed the "enabling rattle" sequence. The order of sequence type (enabling or arbitrary) and test stimuli (frog or rattle) was counterbalanced across subjects. Infants were randomly assigned to one of two practice conditions, and there were an equal number of males and females in each condition. Infants in the *practice condition* were allowed to practice the target sequence for 90 s following the demonstration. Infants in the *no-practice condition*, on the other hand, were not allowed to touch the stimuli until the long-term retention test, 1 week later. Following the 1-week delay (± 5 hours), the experimenter re-presented each set of stimuli in the order in which they had been presented during the demonstration session. The infant was given the first set of stimuli, and his or her behavior was video-recorded for a 90-s period. The infant was then given the second set of stimuli, and his or her behavior was video-recorded for an additional 90-s period.

TABLE 1
The Three Target Actions for Each of the Enabling and Arbitrary Sequences

	Step		
Sequence	**1**	**2**	**3**
Causal Frog	Put plank on block	Put frog on plank	Push plank
Arbitrary Frog	Put block on plank	Put frog on plank	Push frog
Causal Rattle	Put beads in ball	Push stick in ball	Shake stick
Arbitrary Rattle	Push stick in ball	Clap beads together	Put ribbon on stick

The number of target actions emitted (total score, maximum = 3) and the order in which those actions were produced (sequence score, maximum = 2) during baseline and during the 1-week retention test were scored from videotape. Infants were credited with performing a correctly ordered pair of actions (i.e., Action 1–2, or Action 2–3) if one or both pairs occurred at any time during the 90-s period. A second experimenter, blind to the subject's condition, coded 70% of the videotapes (κ = .88 and .77 for the total score and sequence score, respectively). Preliminary analyses indicated that there was no main effect of gender, and gender did not enter into any significant interactions for any dependent variable. The data were, therefore, collapsed across gender for subsequent analysis.

The total scores were subjected to a 2 (phase) × 2 (practice condition) × 2 (sequence type) ANOVA with repeated measures over phase and sequence type. There was a significant main effect of phase, $F(1, 38) = 51.72$, $p < .0001$. Overall, infants produced more target behaviors during the 1-week retention test than they produced during baseline. There was no significant effect of practice condition, and practice condition did not enter into any significant interaction. Infants without prior practice performed the same number of target behaviors during the 1-week retention test ($M = 1.40$, $SE = 0.18$) as infants who were allowed to practice those actions immediately after the demonstration ($M = 1.57$, $SE = 0.19$).[1] This finding is consistent with several recent studies comparing long-term retention of single actions by infants with and without prior practice (Abravanel, 1991; Meltzoff, 1995). There was also no main effect of sequence type. Infants produced the same total number of behaviors from the enabling and arbitrary sequences during the test. This finding is consistent with previous work by Bauer and her colleagues (Bauer & Hertsgaard, 1993; Bauer & Mandler, 1989; Bauer & Thal, 1990; Bauer & Travis, 1993).

Sequence scores were subjected to a 2 (phase) × 2 (practice condition) × 2 (sequence type) ANOVA with repeated measures over phase and sequence type. Again, there was no main effect of practice condition, and practice condition did not enter into any significant interaction. The mean sequence scores are shown in Table 2 as a function of phase and sequence type. There was a significant main effect of phase, $F(1, 38) = 40.61$, $p < .0001$; infants exhibited higher sequence scores during the 1-week retention test than they exhibited during the baseline phase prior to the demonstration. There was also a significant effect of sequence type, $F(1, 38) = 4.91$, $p < .05$, and a significant sequence type × phase interaction, $F(1, 38) = 7.22$, $p < .01$. To evaluate this interaction, separate one-way ANOVAs across sequence type were calculated for each phase. Although there was no effect of sequence type during baseline, there was a significant effect of sequence type during the 1-week retention test, $F(1, 39) = 6.64$, $p < .01$ (see Table 2). Given that an infant's sequence score was dependent on the number of target behaviors

TABLE 2
The Mean (and Standard Error) Sequence Scores (Max = 2.00) as a Function of Sequence Type

Sequence Type	Baseline	Delayed Test
Enabling (n = 20)	0.05 (0.03)	0.85 (0.14)
Arbitrary(n = 20)	0.05 (0.03)	0.35 (0.08)

[1] Infants in the practice condition exhibited forgetting over the 1-week delay. Their mean imitation score immediately after the demonstration ($M = 2.02$, $SE = 0.17$) was significantly higher than their mean imitation score during the 1-week retention test, $F(1, 19) = 5.52$, $p < .03$.

that he or she performed, we also conducted an analysis of covariance across sequence type using the absolute number of behaviors emitted as a covariate. This analysis also yielded a significant main effect of sequence type on sequence scores, $F(1, 77) = 21.74$, $p < .0001$.[2] Finally, in order to determine whether the observed sequence scores were greater than would be expected by chance alone, we calculated a chance sequence score for each subject and compared that score to the observed sequence score in a manner identical to that described by Bauer and Mandler (1992).[3] Paired t tests revealed that the observed sequence scores were significantly different from chance for the enabling sequences, $t(39) = 5.61$, $p < .0001$, but that they were not significantly different from chance for the arbitrary sequences.

The results of this experiment demonstrated that despite a large degree of similarity between the test stimuli, target actions, and sequence goals, infants still reproduced enabling sequences more accurately than arbitrary sequences. Furthermore, infants who were allowed to practice the target actions at the end of the demonstration (practice condition) performed no better during the 1-week retention test than infants who were never allowed to practice (no-practice condition).

What are the implications of these findings for the organization of infant memory? Two arguments have been put forward to explain why memory for enabling sequences may be superior to memory for arbitrary sequences. It has been suggested that each step in the enabling chain provides an effective retrieval cue for the next step (Bauer, 1992; Bauer & Travis, 1993; Mandler, 1990; Slackman, Hudson, & Fivush, 1986). That is, given the superior organization of the memory for the enabling sequence, once infants have performed the first action, that action will cue the next action in the same sequence. The lack of enabling relations between individual steps in an arbitrary sequence, on the other hand, limits the ability of one action to cue another. Second, instead of influencing retrieval directly, the structure of the sequence may influence the expression of the memory once it is retrieved. That is, although the same amount of information is accessible at the time of the test, infants may recognize that enabling sequences demand a particular temporal order, whereas arbitrary sequences do not (Fivush et al., 1992). This explanation is consistent with the finding that, in most of the studies conducted to date, the primary effect of enabling structure on infant memory is not to increase the number of target actions recalled per se but rather to improve the accuracy of the order in which those actions are reproduced (Bauer & Hertsgaard, 1993; Bauer & Mandler, 1989; Bauer & Thal, 1990; Bauer & Travis, 1993). The number of actions to be recalled and the total length of the retention interval may determine whether event structure will influence memory organization, retrieval, expression, or all three (Bauer et al., 1995; Fivush et al., 1992).

Recently, studies of imitation have emerged as the dominant paradigm for examining memory processing in 1- to 2-year-old children (for review, see Meltzoff, 1990). In these tasks, subjects observe an experimenter performing an action, and their ability to remember and reproduce that action is assessed following a delay. A fundamental assumption of these paradigms is that tasks that require subjects to remember actions they have merely observed present a greater cognitive challenge than tasks that require subjects to remember actions they have actually performed in the past. It is assumed that the former ability reflects procedural memory, and the latter requires declarative memory (McDonough, Mandler, McKee, & Squire, 1995; Meltzoff, 1990, 1995). Despite their prevalence in the literature on infant memory development, these basic assumptions have rarely been tested. Recently, both Abravanel (1991) and Meltzoff (1995) failed to find any differences in infants' memory following practice or observation alone. Similarly, in this study, we found no effect of prior practice on

[2] We also conducted an analysis of variance across sequence type using the maximum sequence score each infant could have obtained as a covariate. That is, the maximum sequence score for an infant who performed 0 or 1 target behavior during the long-term test was 0, the maximum sequence score for an infant who performed 2 target behaviors was 1, and the maximum sequence score for an infant who performed 3 target behaviors was 2. This analysis also yielded a significant effect of sequence type on sequence scores, $F(1, 77) = 13.62$, $p < .0005$.

[3] For each subject, a chance sequence score was calculated for each sequence by adding the number of correctly ordered pairs of target actions to the number of incorrectly ordered pairs of target actions and dividing by 2.

infants' ability to imitate three-step sequences following a 1-week delay. Although it is likely that extensive motor practice may facilitate long-term retention in a manner similar to that seen following other kinds of rehearsal, there is no evidence to suggest that the practice and no-practice conditions tap fundamentally different memory processes. Taken one step further, these findings raise the possibility that other paradigms used with infants that also involve practice (e.g., the mobile conjugate reinforcement paradigm) may not reflect memory processes fundamentally different from those observed in imitation paradigms.

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