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The development of children's action memory: When do actions speak louder than words?

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Summary. Although acting consistently has been found to improve memory, the reasons for this are unclear. In this investigation, we tested whether acting improves recall by integrating separate elements within an action into an organized whole and whether this process may be strategic. First graders, fourth graders, and college-aged adults listened to, acted out, or watched the performance of action-object phrases and then verbally reported or enacted the phrases. Phrases composed of transitive verbs were expected to be integrated more by action than phrases composed of intransitive verbs, and consequently recalled better, especially by the younger children. Recall increased between first and fourth grades, suggesting that some aspects of action memory may be strategic; however, there was no evidence that acting improves recall by means of integration. The pattern of results suggested that the nature of an action's outcome may contribute to the enactment effect.

Introduction

Enacting events consistently improves memory. The effectiveness of action in facilitating memory has been demonstrated many times for paired associates (e.g., Bender & Levin, 1976; Wolff & Levin, 1972), simple commands (e.g., Bäckman & Nilsson, 1984; Cohen, 1983; Cohen & Stewart, 1982), and sentences (e.g., Saltz & Dixon, 1982; Saltz & Donnenworth-Nolan, 1981). Although acting aids memory, it is not clear why. To identify some of the processes underlying the enactment effect, developmental differences in action memory and the impact of an action's internal organization were explored in this study.

One explanation of the enactment effect is that action memory is nonstrategic, whereas memory of words involves intentional encoding. Children have difficulty in using mnemonic strategies, and, as a result, memory of words varies with age (e.g., Flavell, 1985). If action memory is nonstrategic, then developmental differences should not occur. Cohen and Stewart (1982) compared recall of words and subject-performed tasks (SPTs) for 9-, 11-, and 13-year-old children. SPTs involved simple actions, such as clapping hands or putting a cap on a pen, and the words presented symbolized the actions performed. Word recall increased with age; however, no age differences were found for recall of SPTs. When children were questioned about their efforts to learn the items presented, at all ages they reported attempting to memorize the words, but not the actions. Moveover, primacy effects occurred for word recall, but not for that of the actions, indicating that children rehearsed only to facilitate retention of the words. Cohen and Bean (1983) and Cohen (1983) provided additional evidence that action memory does not involve the strategic use of rehearsal.

In contrast to Cohen's findings, children's action memory has been observed in many studies to improve with age (e.g., Foellinger & Trabasso, 1977; Foley & Johnson, 1985; Johnson, Perlmutter, & Trabasso, 1979; Price & Goodman, 1990; Ratner, Smith, & Dion, 1986). This suggests that action memory may be strategic and that young children may not engage certain processes that adults do. Consistent with this notion, acting sometimes benefits recall less for children than for adults (e.g., Saltz & Dixon, 1982), which is quite surprising, given the theoretical significance of acting and enactive representation in young children's cognitive development (e.g., Bruner, 1964; Nelson, 1974, 1986; Piaget, 1962). Foley and Johnson (1985) also found that 6-year-olds' recall of their own actions was the same as that of another person's actions, whereas 9-year-olds and adults recalled more of the actions they performed. Once again, acting seemed to facilitate performance less for the younger than for older children. These results appear to contradict Cohen's findings; however, the impact of acting on recall may depend on the age of the child. In Cohen's studies children younger than age 9 were not tested, whereas in each of the studies in which age differences were found, children under the age of 9 were

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included. Thus, action memory may involve strategic components, but these strategies may be developed by middle childhood, earlier than strategies for word recall (e.g., Foellinger & Trabasso, 1977). If the processes that young children have more difficulty engaging can be identified, clues toward understanding the basis of the enactment effect may be provided.

In the Saltz and Dixon study children were required to act out complex sentences composed of an agent, action, objects, and modifiers. Saltz and Donnenworth-Nolan (1981) suggested that enactment facilitates memory by integrating parts of a sentence into a motorically organized node. Zimmer and Engelkamp (1989) and Mohr, Engelkamp, and Zimmer (1989) also argue that although organization occurs in action memory, it is enhancement of item-specific information, such as integration, that underlies the enactment effect. If acting integrates components of an action and does not facilitate performance as much for children, then integration may not occur as readily for children either. Certainly, in preparation for recall, young children are less likely than older children and adults to integrate noun pairs (e.g., Pressley, 1977); however, integration can be increased by the presentation of words that are more related to one another along some semantic dimension (e.g., Pressley, 1982). When an inherent relation between items to be remembered is recognized, children make use of the connection by creating some elaboration based on the association. It is possible, then, that integration during acting may be improved in a similar fashion. Related actions and objects may be integrated more readily than less related pairs, and developmental differences in the enactment effect might be reduced or eliminated for the related items. If so, acting would appear to serve an integrating function and to benefit young children less because integration is required.

There is evidence that memory varies in the case of actions involving different levels of integration among the elements composing them. Engelkamp and Perrig (1986) investigated the integrating effects of acting for verbs that were paired with attributive or prepositional phrases. Attributive phrases represented a location in which an action was performed (e.g., smoke the pipe in the lounge, press the shirt in the train), whereas prepositional phrases represented changes in location that were a direct result of the action (e.g., put the towel on the window sill, pick up the coin from the floor). Location was expected to be integrated within a motor program in the prepositional phrases, whereas it was expected to be stored separately from the motor program in the attributive phrases. As a result, better memory was expected in the case of the prepositional than in that of the attributive phrases. When recall was cued by the location, more prepositional than attributive phrases were reported, in accordance with the hypothesis.

If less integration between location and action leads to poorer recall, differences in memory of phrases containing transitive and intransitive verbs may also occur. Intransitive verbs encode actions that do not require objects in their meanings (e.g., sit, dance, walk, leap). If objects appear with these verbs, they are not essential to the meaning of the verb or the action it represents (e.g., sit beside the book). Objects, however, are not optional arguments for transitive verbs (e.g., push, pull, hit, throw) and represent obligatory components of the verb's meaning (Braine & Hardy, 1982; Hopper & Thompson, 1980). Consequently, the actions transitive verbs encode are modified to a greater extent by the characteristics of the objects acted on and are integrated more with the action. For example, the action encoded by "pick up" varies considerably, depending on the object that is picked up (e.g., a penny vs. sand or a piano). When intransitive verbs appear with objects, the action is not modified across a very wide range. "Sitting" next to a penny or sand or a piano is virtually the same action, regardless of the object the actor sits next to. If acting improves recall because integration is enhanced, the transitive phrases should be recalled better than the intransitive phrases. Furthermore, if acting integrates information less for children than for adults, less facilitation should occur for intransitive than for transitive phrases.

It is important to point out that the effects of action type are expected to emerge only when the actions are performed (e.g., Paris & Lindauer, 1976). The anticipated effects of integration that acting provides depend on movements of the body that would be unlikely to be activated in response to words. No differences in recall of the two action types, when presented verbally, would also provide evidence that characteristics of the words (e.g., meaningfulness, distinctiveness, or familiarity) unrelated to the movements involved in the actions do not contribute to any effects of action type.

Who performs these movements, however, may influence whether the different types of action affect recall. Younger children may benefit more from watching someone else perform the actions than from carrying out the actions themselves. Wolff and Levin (1972) found that 5-year-olds tended to recall actions involving the manipulation of two toys better if the experimenter rather than the child performed the actions. They suggested that young children may be less able to enact meaningful interactions between objects, and so their recall may be improved most when they are watching a more expert person. Indeed, younger children's poorer enactment of actions may contribute to the reduced benefits acting appears to provide them. When decoding words, individuals construct mental models of the referents and relations among them (e.g., Johnson-Laird, 1983; Van Dijk & Kintsch, 1983). Acting may lead the learner to specify more features of the words than are typically accessed (e.g., Bäckman, Nilsson, & Chalom, 1986; Paris & Lindauer, 1976; Saltz, 1988), bringing about improved recall. Recall, however, would not be improved if the learner enacted the same number of features accessed by words. To ensure that children would not be penalized by poorer action symbolizations of their own, subjects watched the experimenter perform the actions in one condition. To determine if younger children produce poorer actions, the number of movements performed while acting were coded. Although there are discrepancies in the literature (e.g., Cohen, 1989), we did not expect differences in SPT and EPT conditions for adults and older children, especially if the number of movements performed for the two groups were equal.

Finally, it is possible that the enactment effect is less robust for younger children because they have more diffi-

culty in recoding actions into words (e.g., Bruner, 1964). Perhaps acting does not boost their recall as much as it does for adults because children cannot verbally recode the actions they carry out as easily as older children or adults. To test this possibility, action recall was reported verbally in one condition and enacted in another.

In summary, we asked whether action memory improves before age 9 and if the enactment effect is less powerful for younger children because of poorer integration, action symbolization, or verbal recoding. To answer these questions first graders, fourth graders, and adults were tested in each of three conditions: Verbal-Verbal, Action-Verbal, and Action-Action. Action-object phrases were presented in all conditions, but in the Action-Verbal and Action-Action conditions they were enacted during presentation. Phrases were recalled verbally in the Verbal-Verbal and Action-Verbal conditions, but enacted in the Action-Action condition. Two types of phrase, transitive and intransitive, were presented within each condition. Two separate groups participated within each age level: subject-performed-task (SPT) and experimenter-performed-task (EPT). Thus, the Verbal-Verbal condition was duplicated within each actor group (i.e., SPT and EPT) and each subject who saw or performed actions was his or her own control.

Method

Subjects. Thirty-six first graders (M age = 6 years 11 months), 36 fourth graders (M age = 9 years 10 months), and 36 college students (M age = 25 years 3 months) participated in this study. Within each grade level, 18 subjects were assigned randomly to one of two groups: SPT or EPT. Within each of these groups, an equal number of males and females were included. Children were recruited from one of two metropolitan Detroit public elementary schools and were tested at their schools. College adults were students at Wayne State University and were tested on campus.

Materials. Three lists from a pool of 60 action-object phrases were constructed so that each subject received 20 phrases within each of three conditions, Verbal-Verbal, Action-Verbal, and Action-Action. Within each list, 10 of the phrases contained transitive verbs and 10 contained intransitive verbs. Verbs learned by children at least by age 3 (e.g., Huttenlocher, Smiley, & Charney, 1983 a; Huttenlocher, Smiley, & Ratner, 1983 b) were selected for inclusion. Within each list, word frequency was matched across transitive and intransitive verbs (Carroll, Davies, & Richman, 1971). Objects were chosen to be low associates of the verbs with which the objects were paired. The degree of association between each verb and its object was rated by 40 college students. There were no differences between the transitive and the intransitive phrases within each list. Transitive and intransitive action-object pairs were assigned randomly to each list, with the restriction that reassignments would be made if associations across objects on the list were present. The test phrases appear in the Appendix. No actual objects were presented with the verbs in any of the conditions. Each subject received all three lists and list presentation was counterbalanced across condition (Verbal-Verbal, Action-Verbal, and Action-Action) and actor group (SPT and EPT). Presentation of the verb phrases was random within each list.

Although each subject received a total of 20 phrases within each condition, the lists were divided in half for both first and fourth graders so that five transitive and five intransitive pairs were included on each list. Each half-list of 10 phrases was presented separately and children recalled each half before the other half was presented. Following the procedure of Saltz and Dixon (1982), the lists were separated so that performance in the Verbal-Verbal condition would be roughly equivalent across age. Assessment of the interaction between age and acting, the principal hypothesis of the study, is clearer if baseline performance does not differ with age.

Procedure. All subjects were tested individually, children in an empty classroom and college students in a campus laboratory, by one of two female experimenters. Each experimenter tested approximately half of the subjects. All sessions were videotaped. Each subject received all three conditions (i.e., Verbal-Verbal, Action-Verbal, and Action-Action), counterbalanced for order across subjects. Before each condition, subjects were given two examples to ensure that they understood the instructions. After presentation of each practice phrase, subjects were asked to recall the item. Subjects were told that they would be required to recall the test phrases after all of them had been presented.

In the SPT Action-Verbal condition, the experimenter read each phrase, the subject repeated the phrase, and then acted it out. After the phrases were presented, the subject recalled them verbally. The procedures were exactly the same in the SPT Action-Action condition, except that the phrases were also enacted during recall before they were verbally described. In the EPT Action-Verbal and Action-Action conditions, the experimenter read each phrase, the subject repeated it, and then the experimenter acted out the action in a standardized fashion. When all the phrases were presented, the subject recalled them. In the Action-Verbal condition the subject recalled the phrases verbally and in the Action-Action condition the subject enacted the phrases during recall, just as in the analogous SPT conditions. In the Verbal-Verbal condition for both the SPT and EPT groups, the experimenter read each phrase and then the subject repeated the phrase twice with no enactment. After all the phrases had been presented, the subject recalled the phrases verbally. Note that the Verbal-Verbal condition is exactly the same under SPT and EPT instructions.

The number of accurately recalled verb phrases served as the dependent measure. For the children the recall of each half was added together so that recall could be compared directly to that of adult performance. Thus, for both adults and children the number of items it was possible to recall (i.e., 10 transitive and 10 intransitive phrases) was the same. Both verb and object were required to be correct in order to score the phrases as accurate. Substitutions of verbs and objects were accepted if the meaning of the phrase was retained. Accuracy of the preposition in the intransitive phrases was not necessary to credit the subject with a correctly recalled phrase.

Results

Action recall

The mean numbers of action phrases recalled appear in Table 1. The numbers of phrases recalled was entered into a 3 (Grade) $\times 3$ (Actor: SPT or EPT) $\times 3$ (Condition: Verbal-Verbal, Action-Verbal, Action-Action) $\times 2$ (Action-Verb Type: Transitive or Intransitive) ANOVA. Grade and Actor were between-subject factors, whereas condition and Action-Verb type were within-subject factors; t tests were carried out as post-hoc tests to identify differences among means. Only differences that were significant at or below the .05 level are reported.

Significant main effects of Grade, $F\,(2,102) = 15.76$, $p < .0001$, Condition, $F\,(2,204) = 61.46$, $p < .0001$, and Action-Verb type, $F\,(1,102) = 12.56$, $p < .001$, were noted. First graders recalled fewer phrases ($M = 6.2$) than fourth graders ($M = 8.8$) or adults ($M = 8.4$), who performed equally well. Participants in the Action-Verbal ($M = 9.0$) and Action-Action ($M = 8.4$) conditions recalled more phrases than those in the Verbal-Verbal ($M = 6.0$) condition. Contrary to expectations, intransitive phrases

Table 1. Mean numbers of action phrases recalled.

Grade	Subject-Performed Task (SPT)					
	Condition					
	Verbal-Verbal		Action-Verbal		Action-Action	
	Action-Verb type					
	Transitive	Intransitive	Transitive	Intransitive	Transitive	Intransitive
First graders	2.5	2.6	3.0	3.9	3.2	3.2
Fourth graders	3.2	2.9	4.2	5.2	3.8	5.1
College adults	2.8	3.1	5.1	5.1	4.1	5.2
	Experimenter-Performed Task (EPT)					
First graders	2.6	2.9	3.6	3.6	2.8	3.8
Fourth graders	3.6	4.2	5.4	5.3	4.6	5.0
College adults	3.4	2.6	4.4	5.1	4.0	5.2

Table 2. Mean numbers of action phrases recalled as a function of Grade and Condition.

Grade	Condition		
	Verbal-Verbal	Action-Verbal	Action-Action
First graders	5.4	7.0	6.6
Fourth graders	7.0	10.0	9.2
College adults	6.0	9.8	9.2

(M = 4.1) were recalled better than transitive (M = 3.7) phrases.

These effects, however, were modified by two second-order interactions: Condition × Action Verb, F (2,204) = 3.66, p <.05, and Grade × Condition, F (4,204) = 3.37, p <.05. Although intransitive phrases were recalled better overall, this difference only emerged in the enactment conditions. Mean Action-Verbal intransitive and transitive recall was 4.7 and 4.3, respectively. Comparable means for the Action-Action condition were 4.6 and 3.8. In contrast, intransitive (M = 3.1) and transitive (M = 3.0) recall was virtually identical in the Verbal-Verbal condition.

The interaction between Grade and Condition was consistent with the prediction that the amount of facilitation provided by enactment would be less for the first graders than for the fourth graders or the adults. These means appear in Table 2. Although acting improved recall at all ages, the difference between the enactment conditions (i.e., Action-Verbal and Action-Action) and the Verbal-Verbal condition was greater for fourth graders and adults than for first graders.

Finally, there was a four-way interaction between Grade, Condition, Actor, and Action-Verb type, F (4,204) = 2.57, p <.05. To explore this complex interaction, the two action-type phrases were analyzed separately. Separate 3 (Grade) × 2 (Actor) × 3 (Condition) ANOVAs were conducted for transitive and intransitive recall. For intransitive recall the effects of Grade, F (2,102) = 11.41, p <.0001, Condition, F (2,204) = 44.14, p <.0001, and the interaction between Grade and Condition, F (4,204) = 3.03, p <.02, were noted. The effects are all as reported previously: first graders performed more poorly than fourth graders or adults; Action-Verbal and Action-Action recall was higher than Verbal-Verbal recall; and the amount of facilitation in the Action-Verbal and Action-Action conditions was less for first graders than for fourth graders or adults. These means appear in Table 3. For transitive recall, only the effects of Grade, F (2,102) = 11.2, p <.0001, and Condition, F (2,204) = 17.05, p <.0001, were significant. This suggests that transitive recall of the fourth graders and adults was depressed in the enactment conditions. In other words, acting may not have facilitated transitive recall any more for the older groups

Table 3. Mean numbers of action phrases recalled as a function of Grade, Condition, and Action-Verb-type.

Grade	Action-Verb type					
	Transitive			Intransitive		
	Condition					
	Verbal-Verbal	Action-Verbal	Action-Action	Verbal-Verbal	Action-Verbal	Action-Action
First graders	2.6	3.3	3.0	2.8	3.8	3.5
Fourth graders	3.4	4.8	4.2	3.6	5.3	5.1
College adults	3.1	4.8	4.1	2.9	5.1	5.2

Table 4. Classification of verbs according to direction of movement.

Movement	Action-Verb type					
	Intransitive			Transitive		
Forward/backward	bounce hop leap skip trip	crawl jog march step walk	float jump run swim	carry	chase	kick
Up/down	hide move	kneel sit	lie	draw lift pull on throw away	feed pick up reach tickle	hang up poke squeeze touch
Side to side	dance slide twirl	fall stretch twist	shake turn wiggle			
Stationary	blow	wave		bend catch fold pet shut	bite cut hit push smell	break fill hug rub wash

than it did for the first graders. If so, intransitive recall should be greater than transitive recall in the enactment conditions. Inspection of the means indicated that Action-Verbal and Action-Action intransitive recall was greater than transitive recall for both fourth graders and adults. These differences, however, were significant only in the Action-Action condition ($ps < .01$). Neither of the comparisons between transitive and intransitive recall in the enactment conditions was significant for the first graders.

It is surprising that no effects of Condition emerged in any of these analyses, because condition was a factor in the four-way interaction. Fourth graders and adults, however, did show different patterns of transitive and intransitive recall in the SPT and EPT Action-Verbal conditions: Fourth graders recalled fewer transitive than intransitive phrases ($p < .01$) in the SPT Action-Verbal condition, but an equal number in the EPT Action-Verbal condition. Adults recalled fewer transitive than intransitive phrases ($p < .001$) in the EPT Action-Verbal condition, but an equal number in the SPT Action-Verbal condition. These differences, however, were not detected in any of the ANOVAs and must be considered with caution. Means for these conditions appear in Table 1.

In summary, acting during encoding facilitated performance for all age groups; however, consistently with other findings, the facilitation provided was less for the youngest group, at least under some conditions. Importantly, overall performance of the fourth graders and of the adults was equivalent, and the degree of facilitation that acting provided was the same. At all ages, watching another act or performing the action oneself did not affect performance consistently. For the most part, SPT and EPT recall was equivalent. The type of action performed or watched influenced performance more, but had less impact on recall for the youngest children. Contrary to our expectations, then, it was the older, not the younger, individuals who were more sensitive to the effects of watching or performing different types of actions. Furthermore, when differences emerged, it was the intransitive, not the transitive, actions that facilitated performance most, especially in the Action-Action condition, suggesting that the role that acting plays in integrating components of the action is not so central to the enactment effect. Instead, the enactment effect seems to be related to some characteristic of movement, especially because the effect of action type only emerged in the enactment conditions. We turn now to exploring what these characteristics might be and how they might be related to age differences in the enactment effect.

Action coding

Action integration. Although transitive actions were expected to incorporate objects acted on to a greater extent, perhaps more integration actually occurred for the intransitive actions. Actions performed within the SPT Action-Verbal condition were coded dichotomously as integrated or not, to test this possibility. Integration was defined as a modification of the action in response to the characteristics of the symbolic object. For example, "jump over the puddle," was scored as integrated if the subject propelled his or her body forward rather than up and down. Up-and-down movements would occur if the subject was enacting only "jump" without respect to the "puddle". Similarly, "push the refrigerator" was required to include indicatons of effort (e.g., grunts or resistance against the hands). As predicted initially, more integration occurred within each age group for the transitive actions ($ps < .05$) and integration did not increase with age, unlike recall patterns. For first graders, a mean of 61.2% of the transitive actions and 38.8% of the intransitive actions were integrated. Comparable means for the fourth graders were 62.0% and 38.8%; and for the college students, 57.7% and 42.2%. Because integration could not account for recall in the SPT Action-Verbal group, SPT Action-Action and EPT actions were not scored.

Movement during acting. The direction of movement along a path has been identified as an important characteristic of memory of actions (e.g., Abrahamsen, 1975; Smyth, Pearson, & Pendleton, 1988). Inspection of the actions presented in this study indicated that movement in one of three directions (forward/back, up/down, or side to side) was overrepresented among the intransitive verbs. In Table 4, the intransitive and transitive verbs are categorized according to the direction of the predominant movement of the body. Virtually all of the intransitive actions (28 out of 30) involved movement in one of these directions, whereas only half of the transitive actions encoded any movement at all. Greater movement during acting could have improved recall of the intransitive phrases and individuals of different ages may have produced different amounts of movement, leading to age-related differences in the facilitation that acting provided.

To explore the role of movement in recall, forward/backward, up/down, and side to side movements of each action performed in the SPT Action-Verbal condition

Table 5. Mean numbers of movements performed for each action.

Grade	Subject-Performed Task		Experimenter-Performed Task	
	Action-Verb type			
	Transitive	Intransitive	Transitive	Intransitive
First graders	.89	1.42	.85	1.23
Fourth graders	.89	1.31	.90	1.47
College adults	1.09	1.37	.70	1.55

were coded. Multiple movements or no movement could be designated for each action. Forward or backward movement occurred when at least one step involving both feet was made in front of or behind the actor. Up movements occurred when arms were raised so that the elbow was above the chin or when both feet were lifted off the floor. Down movements occurred when at least one knee was bent. Side to side movement occurred when both feet stepped right or left, when one foot stepped twice to the right or left, or when the actor swayed in either direction. In the EPT Action condition, experimenters' movements were coded for a third of the subjects. Two coders rated 10% of all tapes and agreed 87% of the time.

The mean number of movements performed per action appears in Table 5. At each age more movements were performed for intransitive than for transitive actions ($p < .0001$), suggesting that movement alone could have enhanced recall of the intransitive phrases. This interpretation is not supported, however, by correlations calculated within each age and verb type between the total number of phrases recalled and the amount of movement performed. If movement did determine recall, subjects who performed more movements should have recalled more phrases. This did not occur: none of the correlations was significant ($rs = -.24$ to $.32$). Furthermore, movement is inadequate to explain developmental changes in action facilitation. Although movement increased slightly with age, the increase was not significant ($F < 1$). Because these findings were not consistent with recall patterns, movement in the Action-Action condition was not scored.

Movement-based clustering. Movement during encoding did not account for developmental differences in action facilitation. An alternative hypothesis is that older children and adults relied more than younger children on movement in order to organize recall. To assess clustering, each action phrase was classified as one of three movements: movement of the legs, the arms, or the entire body. The number of category repetitions was divided by the total number of phrases recalled minus the number of categories represented in recall to calculate a modified ratio of repetition (Wallace & Underwood, 1964). Although first graders ($M = .52$) clustered less than fourth graders ($M = .63$), this difference was not significant.

Discussion

As predicted, first graders recalled fewer action phrases than fourth graders, who performed as well as adults. Thus, action memory does improve during childhood, suggesting that memory of actions, like memory of verbal materials, may involve strategies that change with age. Processes involved in action memory, however, may develop more quickly than processes underlying memory of verbal materials, because action memory seems to improve little, if at all, during middle childhood (approximately age 9) and young adulthood. This finding appears to resolve the apparent inconsistency between studies in which age differences are found in action recall and those in which age differences do not appear. This conclusion, however, is tentative because our procedure may have underestimated performance differences between the older children and adults. The fourth graders might not have recalled as well as the college students if all the phrases had been presented in one list.

Acting facilitated recall for older children and adults to a greater extent than for younger children, consistent with the findings of Saltz and Dixon (1982); however, this difference did not appear to be related to recoding difficulties or to integration. First, performance in the Action-Action condition did not differ from the Action-Verbal condition for the youngest children. Thus, less facilitation from acting was not affected by verbally recoding actions for recall. In fact, few differences were present between the two conditions at any age and when differences did emerge for the older children and adults, acting during recall depressed performance rather than facilitated it. Second, the age-related patterns of facilitation also did not appear to depend on integration, reducing the likelihood that integration is the strategic process that contributes to the enactment effect. Although the transitive actions were integrated more than the intransitive actions, they were not recalled better. When differences occurred, it was intransitive recall that was superior to transitive recall. It is important to note that these differences emerged only when the phrases were enacted, indicating that the features of the words used to encode these actions were not as important as some characteristic of the actions or some cognitive process evoked by acting.

One possible process that may have been influenced by acting is organization. Older children and adults may have organized their recall along some dimension of the action to a greater extent than the younger children did, providing greater structure to either encoding or retrieval, or to both. Even though organization did occur on the basis of body movement, clustering in the action conditions did not increase with age. Organization, then, appears not to account for developmental changes in the enactment effect, and may not be central to the general support that acting provides recall which (e.g., Mohr et al. 1989; Zimmer & Engelkamp, 1989).

Movement provided by the action may have been more central. More movements were possible for the intransitive than for the transitive phrases, and subjects did perform more movements for these phrases. Movement, however, could not account for other aspects of recall. Children and

adults who moved more did not recall more and movement did not increase with age. Therefore, the reduced benefits that acting afforded the younger children could not be accounted for by poorer enactment of the phrases.

Perhaps recall of the transitive actions was facilitated less by acting because the outcomes of these actions more often involved a change of state that required symbolic, probably imaginal, representation. For example, to enact the phrase, "hit the balloon", the actor needed to represent the path of the balloon across the room symbolically. The final location of the actor's hand, the outcome of the actual action performed, did not provide information concerning the symbolic action. In other transitive actions, such as "break the bubble", the object changed state and its transformed properties had to be symbolized separately from the actor's movement. In contrast, intransitive actions involved movement that directly represented the outcome of the action (e.g., walk, leap, jump) and much less often included changes of state in the object. Imaging movement and transformation is more difficult than imaging static referents (e.g., Dean, 1976; Dean, Duhe, & Green, 1983; Pressley, 1977); however, generating images is easier if props are available to support the image (e.g., Foley, Aman, & Gutch, 1987; Dean, 1976). Movements inherent in the intransitive actions, which directly represented outcomes of these actions, may have supported recall of the symbolized actions by functioning as "props". Visible consequences of actions are important in reducing memory confusions (Foley et al., 1987), suggesting that action memory may be bolstered by observable outcomes. The youngest children in our study, however, may have had difficulty even in benefitting from the movement provided by the intransitive actions. It is possible, then, that action may facilitate recall less for younger children because movement-related images may be difficult for them to use.

Finally, acting or watching another act had little impact on performance. Watching another person perform the actions did not help the youngest children benefit more from acting as we had thought it might. Furthermore, our results are at odds with those of Engelkamp and Zimmer (1985) and Foley and Johnson (1985), who found that recall differed between those who acted and watched, but are consistent with others who have found no differences (e.g., Cohen, 1983; Cohen & Bean, 1983). Perhaps the number of movements performed is important, and because the two groups were similar, performance may not have varied.

In summary, action recall improved during childhood, suggesting that memory of actions, like memory of verbal materials, may involve strategic processes that change with age. These processes, however, appear not to be related to age differences in verbal recoding or integration of action components, or to how phrases are enacted. Our results, though tentative, suggest instead that the enactment of movement paths, which create visible consequences of an action and may support the use of elaborative images representing an action's outcome, may be more important. Developmental differences in the enactment effect may be linked to changes in the ability to use images while acting, which may rival that of adult levels, at least in simple tasks, by middle childhood. Of course, the impact of the variables we have identified as important will have to be tested more directly in future studies. Useful manipulations may involve the presence or absence of objects, the types of transformation objects undergo, and the amount of movement that occurs. If the impact of an action's outcome on memory can be supported, the enactment effect may have implications for the development of action concepts (e.g., Behrend, 1990; Huttenlocher et al. 1983a), social cognition (e.g., Shantz, 1983), event memory (e.g., Nelson, 1986), and reality monitoring (e.g., Foley & Johnson, 1985).

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Appendix

Transitive and intransitive phrases presented for recall

Transitive Phrases

bend the toothpick	bite the sand	break the bubble
carry the elephant	catch the feather	chase the kitten
cut the log	draw on the sidewalk	feed the giraffe
fill the pail	fold the socks	hand up the picture
hit the balloon	hug the cactus	kick the pencil
lift the piano	pet the dinosaur	poke the lightening
pick up the elf	pull on the tights	push the refrigerator
reach for the worm	rub the key	shut the suitcase
squeeze the moon	smell the milk	throw away the ladder
tickle the giant	touch the star	wash the marbles

Intransitive Phrases

blow inside the cup	bounce through the clouds	crawl under the blanket
dance by the fence	fall through the rainbow	float between the snowflakes
hide behind the pumpkin	hop behind the snail	jog toward the castle
jump over the puddle	kneel by the gorilla	leap over the spider
lie under the hippo	march toward the tricycle	move through the chimney
run between the dragons	shake inside the tunnel	sit beside the book
skip behind the butterfly	slide around the pole	step over the snake
stretch between mountains	swim beside the mouse	trip beside the monster
turn toward the sun	twirl around the tree	twist under the umbrella
walk by the baby	wave inside the box	wiggle around the snowman

References

Abrahamsen, A. (1975). Experimental analysis of the semantics of movement. In D. A. Norman & D. E. Rumelhart (Eds.), *Explorations in cognition* (pp. 247–276). W. H. Freeman: San Francisco.

Bäckman, L., & Nilsson, L. (1984). Aging effects in free recall: An exception to the rule. *Human Learning, 3*, 53–69.

Bäckman, L., Nilsson, L., & Chalom, D. (1986). New evidence on the nature of encoding of action events. *Memory & Cognition, 14*, 339–346.

Behrend, D. (1990). The development of verb concepts: Children's use of verbs to label familiar and novel events. *Child Development, 61*, 681–696.

Bender, B., & Levin, J. (1976). Motor activity, anticipated motor activity, and young children's associative learning. *Child Development, 47*, 560–562.

Braine, M., & Hardy, J. (1982). On what case categories there are, why they are, and how they develop: An anagram of *a priori* considerations, speculation, and evidence from children. In E. Wanner & L. R. Gleitman (Eds.), *Language acquisition: The state of the art* (pp. 219–239). New York: Cambridge University Press.

Bruner, J. (1964). The course of cognitive growth. *American Psychologist, 19*, 1–15.

Carroll, J. B., Davies, P., & Richman, B. (1971). *The American Heritage word frequency book*. New York: Houghton Mifflin.

Cohen, R. (1983). The effect of encoding variables on the free recall of words and action events. *Memory & Cognition, 11*, 575–582.

Cohen, R. (1989). Memory for action events: The power of enactment. *Educational Psychology Review, 1*, 57–80.

Cohen, R., & Bean, G. (1983). Memory in educable mentally retarded adults: Deficits in subject or experimenter? *Intelligence, 7*, 287–298.

Cohen, R., & Stewart, M. (1982). How to avoid developmental effects in free recall. *Scandinavian Journal of Psychology, 23*, 9–15.

Dean, A. L. (1976). The structure of imagery. *Child Development, 49*, 949–958.

Dean, A. L., Duhe, D. A., & Green, D. A. (1983). The development of children's mental tracking strategies on a rotation task. *Journal of Experimental Child Psychology, 36*, 226–240.

Engelkamp, J., & Perrig, W. (1986). Differential effects of imaginal and motor encoding on the recall of action phrases. *Archives of Psychology, 138*, 261–272.

Engelkamp, J., & Zimmer, H. D. (1985). Motor programs and their relation to semantic memory. *German Journal of Psychology, 9*, 239–254.

Flavell, J. (1985). *Cognitive development*. Englewood Cliffs, NJ: Prentice-Hall.

Foellinger, D., & Trabasso, T. (1977). Seeing, hearing, and doing: A developmental study of memory for actions. *Child Development, 48*, 1482–1489.

Foley, M. A., Aman, C., & Gutch, D. (1987). Discriminating between action memories. *Journal of Experimental Child Psychology, 44*, 335–347.

Foley, M. A., & Johnson, M. (1985). Confusions between memories for performed and imagined actions: A developmental comparison. *Child Development, 56*, 1145–1155.

Hopper, P. J., & Thompson, S. A. (1980). Transitivity in grammar and discourse. *Language, 56*, 251–299.

Huttenlocher, J., Smiley, P., & Charney, R. (1983 a). The emergence of action categories in the child: Evidence from verb meaning. *Psychological Review, 90, 72–93.*

Huttenlocher, J., Smiley, P., & Ratner, H. (1983 b). What do word meanings reveal about conceptual development? In T. B. Seiler & W. Wannenmacher (Eds.), *Concept development and the development of word meaning* (pp. 210–233). Berlin, Heidelberg, New York: Springer.

Johnson, L., Perlmutter, M., & Trabasso, T. (1979). The leg bone is connected to the knee bone: Children's representation of body parts in memory, drawing, and language. *Child Development, 50*, 1192–1202.

Johnson-Laird, P. (1983). *Mental models: Towards a cognitive science of language, inference, and consciousness*. Cambridge, MA: Harvard University Press.

Mohr, G., Engelkamp, J., & Zimmer, H. (1989). Recall and recognition of self-performed acts. *Psychological Research, 51*, 2–13.

Nelson, K. (1974). Concept, word, and sentence: Interrelations in acquisition and development. *Psychological Review, 81*, 267–285.

Nelson, K. (1986). *Event knowledge: Structure and function in development*. Hillsdale, NJ: Erlbaum.

Paris, S., & Lindauer, B. (1976). The role of inference in children's comprehension and memory for sentences. *Cognitive Psychology, 8*, 217–227.

Piaget, J. (1962). *Play, dreams, and imitation*. New York: Norton.

Pressley, M. (1977). Imagery and children's learning: Putting the picture in developmental perspective. *Review of Educational Research, 47*, 585–622.

Pressley, M. (1982). Elaboration and memory development. *Child Development, 53*, 296–309.

Price, D., & Goodman, G. S. (1990). Visiting the wizard: Children's memory for a recurring event. *Child Development, 61*, 664–680.

Ratner, H., Smith, B., & Dion, S. (1986). Development of memory for events. *Journal of Experimental Child Psychology, 41*, 411–428.

Saltz, E. (1988). The role of motoric enactment (m-processing) in memory for words and sentences. In M. M. Gruneberg, P. E. Morris, & R. N. Sykes (Eds.), *Practical aspects of memory: Current research and issues* (Vol. 1, pp. 408–414). Toronto: Wiley.

Saltz, E., & Dixon, D. (1982). Let's pretend: The role of motoric imagery in memory for sentences and words. *Journal of Experimental Child Psychology, 34*, 77–92.

Saltz, E., & Donnenworth-Nolan, S. (1981). Does motoric imagery facilitate memory for sentences? A selective interference test. *Journal of Verbal Learning and Verbal Behavior, 20*, 322–332.

Shantz, C. U. (1983). Social cognition. In J. H. Flavell & E. M. Markman (Eds.), *Handbook of child psychology: Vol. 3. Cognitive development* (4th ed., pp. 495–555). New York: Wiley.

Smyth, M., Pearson, N., & Pendleton, L. (1988). Movement and working memory: Patterns and positions in space. *Quarterly Journal of Experimental Psychology, 40 A*, 497–514.

Van Dijk, T., & Kintsch, W. (1983). *Strategies of discourse comprehension*. Orlando, FL: Academic Press.

Wallace, W. P., & Underwood, B. J. (1964). Implicit responses and the role of intralist similarity in verbal learning by normal and retarded subjects. *Journal of Educational Psychology, 55*, 362–370.

Wolff, P., & Levin, J. (1972). The role of overt activity in children's imagery production. *Child Development, 43*, 537–547.

Zimmer, H., & Engelkamp, J. (1989). Does motor encoding enhance relational information? *Psychological Research, 51*, 158–167.