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LEARNING, INSTRUCTION, AND COGNITION

Investigation of an Activity-Based Text-Processing Strategy in Mixed-Age Child Dyads

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The authors examined an activity-based listening strategy with first- and third-grade children in mixed-grade dyads. On the basis of theories of cognitive development and previous research, the authors predicted the following: (a) children in an activity-based strategy would recall more story events compared with those in a repetition strategy and (b) children who performed activity would recall more events compared with those who observed activity. In addition, previous visual imagery research suggested that (c) recall in favor of the activity-based strategy would be observed when the toys were removed and imagery instructions were provided. The results

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confirmed the first prediction that the activity-based strategy would improve children's memory for story content. The second prediction was not supported: Physical manipulation did not improve memory beyond observing the actions performed by a peer. Last, third-grade students benefited from imagery instructions after training, whereas first-grade students did not. The authors discuss the theoretical and education implications of the results.

Keywords: activity, embodiment theory, imagery, indexical hypothesis, listening, manipulatives, strategy

Results from the National Assessment of Education Progress (National Center for Education Statistics, 2007) suggested that children in U.S. public schools continue to struggle to acquire "proficient" or "advanced" levels of reading achievement. The 2007 National Assessment of Education Progress estimated that 68% of fourth-grade children in the United States were at a "basic" or "below basic" level in their reading achievement. Furthermore, large disparities in reading achievement are present among socioeconomic groups. For example, in 2007, an estimated 83% of fourth-grade children who were eligible for free or reduced-price lunch failed to reach "proficient" or "advanced" levels in reading achievement. This finding is a striking difference when compared with children who were not eligible for free or reduced-price lunch programs, where 56% failed to reach "proficient" or "advanced" levels of reading achievement.

Reading is likely the most complex skill that young children are required to learn in their elementary school years. A considerable amount of classroom instruction is devoted to the development of reading skills. In 2007, 75% of fourth-grade teachers reported more than 7 hours per week of language instruction (National Center for Education Statistics, 2007). When considered with respect to current reading achievement levels, the amount of time spent engaged in language arts instruction indicates that effective interventions targeted at improving children's reading skills are essential.

After a systematic examination of the reading instruction literature, the National Reading Panel (National Institute of Child Health and Human Development, 2000) concluded that teaching children a number of reading comprehension strategies is one of three fundamental components of an effective reading intervention.[1] The panel concluded that scientifically based instructional strategies may enhance reading comprehension in young children. However, the National Reading Panel review further concluded that there is a paucity of scientifically based investigations of reading instructional strategies with elementary-age children.

[1]In this article, we did not consider the other two components, *phonemic awareness* and *reading fluency*.

Early receptive and productive language skills have been positively associated with reading achievement (Beron & Farkas, 2004; Nation & Snowling, 2004; Ouellette, 2006; Wise, Sevcik, Morris, Lovett, & Wolf, 2007). Furthermore, experimental evidence suggests that learning strategies targeted at developing receptive and productive language skills represent an effective means of improving students' reading achievement (e.g., Elleman, Lindo, Morphy, & Compton, 2009; Gambrell, Pfeiffer, & Wilson, 1985; Mastropieri & Scruggs, 1997). On the basis of these results, it is expected that facilitating the development of receptive and expressive oral language will result in higher reading achievement. Of importance to the development of oral language skills is the ability to construct mental representations of target information being received, expressed, or both. Of interest to the present study are two related cognitive explanations of memory: dual-coding theory (e.g., Paivio, 1971; Thompson & Paivio, 1994) and embodiment theory's indexical hypothesis (e.g. Glenberg, 1997; Glenberg & Robertson, 2000).

Dual-Coding Theory

According to dual-coding theorists, "memory is infused throughout all aspects of comprehension" and "there can be no meaning or comprehension without memory" (Sadoski & Paivio, 2001, p. 91). Dual-coding theory proposes that memory consists of verbal and visual codes (Paivio, 1971; Thompson & Paivio, 1994). According to this view, symbols such as words and numerals are encoded as *logogens*, whereas pictures and objects are encoded as *imagens*. Both forms of encoding are modality specific, with logogens and imagens being symbolic and iconic representations (Bruner, 1964), respectively. The two forms of representation are further connected via referential connections (linking mechanisms between the two codes). The presence of referential connections allows the activation of modality-specific representations (e.g., words) to activate alternative-mode representations (e.g., visual images) in memory.

Empirical investigations of dual-coding theory-related predictions have consistently found that concurrent presentation of pictures and text facilitates recall of target information in adults and children (for reviews, see Carney & Levin, 2002; Levie & Lentz, 1982; Levin, Anglin, & Carney, 1987; Mayer, 2001; and Mayer & Gallini, 1990). Greenhoot and Semb (2008) performed a listening study with preschool children that framed its theoretical predictions within dual-coding theory. In this study, children listened to stories under one of four presentation formats: (a) verbal and picture, in which children listened to a story along with pictures of story events; (b) verbal and irrelevant picture, in which children listened to a story accompanied by unrelated pictures; (c) verbal only, in which children listened to stories without pictorial support; and (d) picture only, in which children viewed pictures of story events. Results of the study were generally convergent with the results from other examinations of children's learning from pictures and text (e.g., Digdon, Pressley, & Levin, 1985; Levin & Berry, 1980; Pressley, Levin, Pigott, LeComte, & Hope, 1983). However, and of particular interest to the present study, the study identified age-related differences in children's ability to benefit from pictures and text. Younger children (around 40 months) remembered a comparable proportion of story details when narratives were presented either with or without pictures, whereas older children (around 50 months) exhibited marked memory benefits when pictures were added to the aural narratives. The results suggest a developmental transition in preschool students' ability to benefit from text-accompanying iconic representations.

Embodiment Theory and the Indexical Hypothesis

Glenberg's indexical hypothesis is an embodied explanation of meaning (Glenberg, 1997; Glenberg & Robertson, 2000). Theories based on principles of embodiment propose that an individual's cognitive processes depend on his or her physical interaction with the environment (Lakoff & Johnson, 1980). The indexical hypothesis is a developmental theory of language predicting that memory requires the indexing of symbols to their respective concrete representations (Glenberg & Robertson, 2000). According to the indexical hypothesis, indexing is facilitated by a person physically interacting with an object associated with a symbolic representation. This phenomenon is similar to creating referential connections between logogens and imagens in dual-coding theory (e.g., Paivio, 1971; Thompson & Paivio, 1994). However, whereas dual-coding theory is silent with respect to the contribution of physical activity to establishing referential connections, its facilitative role is central to embodiment theory's indexing operations.

The activity-based component of the indexical hypothesis is supported by several areas of basic and applied research (for a recent review, see Marley & Levin, 2006). Of specific importance to the indexical hypothesis are findings associated with subject-performed tasks (e.g., R. L. Cohen, 1981; Engelkamp & Zimmer, 1989; Kormi-Nouri, Nyberg, & Nillson, 1994; Saltz & Donnenwerth-Nolan, 1981). The prototypical subject-performed task study has participants study a list using memorization or physical activity. These studies, which have usually been performed with college-age participants, consistently find that performing actions on a list increases memory for discrete list items. Similar studies focusing on young children's memory for paired associates and novel events have replicated this effect (e.g., Salmon, Bidrose, & Pipe, 1995; Salmon, Yao, Bernsten, & Pipe, 2007; Saltz & Dixon, 1982; Wolff & Levin, 1972). However, studies designed to disentangle visual (e.g., watching an experimenter perform the task) from enactive (self-performed) encoding have not resulted in conclusive evidence of the added benefits of motoric encoding in either basic (Golly-Haring & Engelkamp, 2003) or applied contexts (Glenberg, Brown, & Levin, 2007; Marley, Levin, & Glenberg, 2007).

The Imagery Effect

Dual-coding theory and the indexical hypothesis postulate that the presence of linkages between symbolic and iconic representations should result in one's ability to generate internal dynamic representations (i.e., visual imagery) of target information (e.g., Glenberg & Robertson, 2000; Sadoski & Paivio, 2001). In the context of processing a narrative, a learner's ability to benefit from imagery instructions (e.g., "Close your eyes and try to picture what is happening in the story") in the absence of concrete representations (pictures or manipulatives) is considered evidence of the ability to construct dynamic representations (visual imagery). (For selected empirical documentations of the imagery effect, see Cooper, Tindall-Ford, Chandler, Sweller, 2001; Guttman, Levin, & Pressley, 1977; Leahy & Sweller, 2008; Levin & Pressley, 1978; Pressley & Levin, 1980; Tindall-Ford & Sweller, 2006.)

The indexical hypothesis predicts that a period of indexing through physical manipulation will facilitate one's ability to generate imagery of target content. Inconclusive results have been found testing this prediction, however, with (a) some investigators comparing activity-based listening and reading strategies with verbal-only strategies finding improved memory upon removal of manipulatives (Glenberg, Gutierrez, Levin, Japuntich, & Kashak, 2004; Marley et al., 2010, Experiment 1); whereas (b) others have found no difference between activity-based and verbal-only strategies (Marley et al., 2007, 2010, Experiment 2). Furthermore, investigations that have included experimenter-performed manipulations have found comparable results between child- and experimenter-performed activity upon removal of manipulatives and provision of imagery instructions (Marley et al., 2007, 2010, Experiment 1).

The absence of consistent empirical benefits from imagery instructions and differences between child-performed and experimenter-performed activity may be attributed to several factors. Of interest to the present study is the developmental imagery hypothesis (Levin, 1976; Levin & Pressley, 1978; Pressley, 1977). The developmental imagery hypothesis specifies that children's ability to benefit from imagery instructions improves during the elementary school years. Early cognitive developmental theories further support this prediction (e.g., Bruner, 1964; Piaget & Inhelder, 1971). Furthermore, this hypothesis parallels the dual representation hypothesis (DeLoache, 2000; Uttal, Scudder, & DeLoache, 1997), an empirically supported developmental hypothesis suggesting that young children, around 30 months of age, are often unaware that instructional manipulatives are representations of abstract contexts. As noted earlier, Greenhoot and Semb (2008) found analogous age-related differences in preschool students' ability to benefit from pictures provided with narratives. On the basis of these related findings, it is of considerable interest to identify developmental transitions in children's picture-processing and imagery-generation abilities.

The Present Study

The purpose of the present study was to extend the aforementioned research investigations to young children in learning dyads. Specifically, for first- and third-grade students administered either an activity-based listening strategy or a listening-only strategy in mixed-grade pairs we investigated the following research questions:

1. Research Question 1: Will children who are exposed to manipulatives representing a story's characters and setting perform higher on cued- and free-recall measures of story content (an activity-based strategy), relative to children who solely listen to the same story (nonactivity)?
2. Research Question 2: Will activity-strategy children who perform story-relevant manipulations recall a greater number of story events on cued- and free-recall measures, relative to their activity-strategy peers who observe the toys being manipulated?
3. Research Question 3: Will children who are provided with an activity-based strategy and a period of visual imagery training perform better on free- and cued-recall measures of story events, relative to their nonactivity counterparts, when the toys are no longer available?

The first two research questions follow from the previously cited vast list- and text-processing literature in which concrete representations of to-be-learned content produce higher levels of recall in comparison to processing without such concrete representations. The third question follows from earlier learning-strategy research on self-generated imagery (e.g., Levin & Pressley, 1978; Wolff & Levin, 1972), as well as Marley et al.'s (2010) findings. On the basis of the results of these studies and the developmental imagery hypothesis (Levin, 1976; Pressley, 1977), we expected that third-grade children (but not first-grade students) would likely benefit from an activity-based imagery-training strategy.

We applied an activity-based listening strategy with mixed-grade pairs in this study for three main reasons. First, mixed-grade collaborative learning strategies (e.g., "buddy reading") are commonly used in the classroom (Friedland & Truesdell, 2004). Therefore, examining an activity-based learning strategy in a collaborative context increases the study's educational relevance or ecological validity (Shadish, Cook, & Campbell, 2002). Second, the use of what has been termed "scripted cooperation" (O'Donnell & Dansereau, 1992, p. 122) allows the roles and activities of the participants to be specified in advance (for examples of scripted dyadic cooperation, see Horn, Collier, Oxford, Bond, & Dansereau, 1998; Jones, Levin, Levin, & Beitzel, 2000). Specification of roles and activities permits a controlled examination of the effects of participant-performed manipulation and self-generated imagery. Last, in previous investigations, the experimenter performed the manipulations in the observe strategy condition (Marley et al., 2007, 2010). Reciprocal peer tutoring research, wherein both members take turns tutoring, suggests that age differences in learner dyad composition can affect learning outcomes for both members of the dyad (for reviews, see Person & Graesser, 1999; Robinson, Schoefield, & Steers-Wentzell, 2005; Roscoe & Chi, 2007).

METHOD

Participants

Participants were 78 first- and third-grade children (52% female; 61% Anglo, 37% African American, and 2% Hispanic) from a suburban elementary school in the Midwestern United States. For all children attending the school, 52% were eligible for free or reduced-price lunch during the 2007–2008 academic year. All participants were recruited in accordance with the American Psychological Association's human subjects standards and the institutional review board of the second author's institution.

Design

The design of the study was a randomized experiment, with 78 children divided into 39 dyads. Each dyad consisted of 1 first-grade child and 1 third-grade child, with both children of the same gender. The 39 dyads were randomly assigned to one of two strategy conditions: repetition ($n = 20$ dyads), where children listened to stories and repeated aloud designated sentences; and activity ($n = 19$ dyads), where children listened to stories and moved objects representing the story characters of designated sentences. The random assignment procedure resulted in a gender split of 14 girls and 6 boys in the repetition condition and 9 girls and 10 boys in the activity condition. In addition, participant action (perform, observe) represented a within-subjects factor, with children in a pair taking turns manipulating the objects (or repeating sentences) for the perform sentences or watching (listening to) their partners do so for the observe sentences. We interspersed a third type of sentence, participant nonaction, throughout the stories to ease transitions between action sentences and make the experimental stories more storylike. Before the experiment, we asked teachers to rate each of their participating children's general academic performance as low, medium, or high. We used this measure as a covariate in subsequent analyses to increase statistical power by reducing experimental error.

Materials

We created three 20-sentence stories with alternating green ("perform") and yellow ("observe") sentences (6 each, 12 total) and eight nonaction sentences for each pair member (see Appendix A for an example of story content). The stories were equivalent in structure and content, relating to events that occurred on a farm. According to the Flesch-Kincaid readability norms, the stories were written at a fourth-grade, 9-month reading level. Furthermore, the activity-based strategy and the stories were pilot tested with three dyads to assure that they were both within first- and third-grade children's vocabulary and comprehension grasp.

Participants listened to each story in a partially counterbalanced order, with one third of the students in each condition assigned to each story order. We assessed participants on cued recall of story events (see Appendix B for an example of cued-recall content) for the first two stories. For the third story, we assessed participants on cued and free recall of story events. We included free recall, which has previously been found to be sensitive to imagery instructions (Marley et al., 2010), only for the third story because teachers were concerned about the amount of time that students were out of the regular classrooms. As a result, a free-recall measure could not be administered for all three stories.

Procedure

Strategy practice. We used a six-sentence practice story about a grocery store to introduce students to the strategy they would apply for Story 1. In the repetition condition, at the end of each sentence, dyad members alternated in repeating the part of the story the pair just heard. In the activity condition, students were shown a set of Playmobil toys (for examples of the farm toys, see playmobil.com) representing the characters, objects, and setting of the story content. On alternating sentences, activity-condition dyad members took turns moving the toys, as directed by the part of the story that they had just heard. In both conditions, nonaction sentences were followed by a pause to signify the end of an idea unit.

Story 1. After the practice passage, all participants viewed toys that corresponded to the objects that represented the farm setting. This was followed by the presentation of Story 1. In the repetition condition, the toys were covered with a blanket, and the story was orally presented in the same manner as in the strategy training section. In the activity condition, participants listened to the story while performing the actions that they had just practiced. Activity participants alternated their actions in accordance with their strategy training. After listening to the story, participants were separated into two different rooms with the experimenter or a graduate assistant present, provided with a distractor task ("Simon," a children's electronic memory game) for 2 min to mitigate the effects of short-term memory (see, for example, Hwang & Levin, 2002), and then orally asked 12 questions that assessed action sentence events (cued recall). We performed all assessments in the aforementioned one-on-one context to assure independence of performance on the outcome measures.

Story 2. After testing, each dyad was brought back into the same room. The participants then received instructions to “make pictures in [their] head” of the story actions before they manipulated the toys or repeated what they heard. Both children in a dyad were given two practice sentences apiece to insure that they understood the instructions. Assessment procedures were the same as for Story 1.

Story 3. Participants in both conditions listened to the final story together without the toys (activity condition) or repeating what they had heard (repetition condition). After participants heard each sentence, they were instructed to do the following: “Close your eyes and make pictures in your head.” In addition to the previous assessment procedure, we included free recall of story events before testing for cued recall. In addition, in a previous study we found that free recall was relatively more sensitive to imagery-strategy instruction and practice, as would be reflected on Story 3 (Marley et al., 2010).

Scoring

All responses were scored by two scorers who were unaware of students’ experimental conditions. For cued recall, 12 points were possible, with 1 point awarded for each correct answer (which included correct synonymous responses). For free recall, after calibrating their scoring with 30 children’s answers, two independent raters scored all of the free-recall responses for (a) two types of proposition types, action and nonaction; and within each proposition type (b) actors/objects, actions, and locations. For example, the fifth story sentence in Appendix A (an action proposition) stated, “The hen came out of her nest and pecked at her two baby chicks.” This action sentence (a sentence that children manipulated or repeated) can be broken into two propositions: “The hen came out of her nest” and “[The hen] pecked at her two baby chicks.” If the child said, for example, “The hen got out of the nest and pecked the chicks,” he or she received two action proposition points for recalling both propositions, two actor object points for “the hen” and the “chicks,” one action point for “pecked,” and one location point for “nest.” If the child said, “The hen pecked,” he or she would not receive proposition points, but would receive one actor/object point for “the hen” and one action point for “pecked.” The sixth story sentence, “The baby chicks woke up and were hungry,” contains two nonaction propositions. Interrater agreement for free recall of action propositions and nonaction propositions, as measured by the intraclass correlation (Shrout & Fleiss, 1979), were .98 and .86, respectively. For free recall of actors, objects, actions, and locations, the intraclass correlations were .97, .98, .98 and .95, respectively. The resulting scores were averaged across the two raters.

Analysis

Repeated-measures analyses of variance, separately by grade level, were conducted with strategy condition (activity, sentence) and participant action (perform, observe) as the between- and within-subjects factors of interest, respectively. In these analyses, we statistically controlled for story topic and teachers' ratings of students' general academic performance, and we allocated a Type I error probability of .05 to each statistical test on all outcome measures. In addition, we calculated Cohen's *d*s for all contrasts of interest by dividing the difference between condition means by the pooled within-conditions standard deviation (J. Cohen, 1988). According to J. Cohen (1998), *ds* in the .20, .50, and .80 ranges are interpreted as small, medium, and large effects, respectively.

RESULTS

Research Questions 1 and 2

The results of Stories 1 and 2 address Research Questions 1 and 2. The main effect of strategy condition is associated with whether the presence of manipulatives resulted in improved memory for story events. The strategy condition by participant action interaction investigates whether differential recall was present when a child performed the actions (or repeated the sentences) described by the narrative relative to observing the actions being performed (or listening to the sentences being repeated). Tables 1 and 2 summarize the cued- and free-recall results, respectively.[2]

First-grade results. The strategy condition effect was statistically significant on the Story 1 cued-recall measure, with activity participants answering a greater number of items correctly in comparison with repetition participants (respective adjusted Ms = 9.37 and 6.49), $F(1, 34) = 18.16$, $MS_e = 4.37$, $p < .001$, Cohen's $d = 1.37$. However, the theoretically anticipated interaction of strategy condition and participant action (i.e., participant performed/observed manipulation/sentence repetition) was not statistically significant, $F(1, 34) < 1$, $MS_e = 0.93$, $p = .93$.

[2]Although we do not subscribe to the practice of reporting effect sizes associated with statistical tests that are not significant (e.g., see Levin & Robinson, 2003; Onwuegbuzie & Levin, 2003), at the request of a reviewer of this journal, we included such effect sizes in Tables 1 and 2.

TABLE 1
Adjusted Mean Cued Recall on Each Story, By Grade, Strategy Condition, and Participant Action (standard errors in parentheses)

	First grade			*Third grade*	
	Repetition	*Activity*		*Repetition*	*Activity*
Story 1 (toys present)			Story 1 (toys present)		
Perform	3.19 (.26)	4.60 (.27)	Perform	3.69 (.27)	5.56 (.28)
Observe	3.31 (.29)	4.77 (.30)	Observe	3.11 (.23)	5.43 (.24)
Total	**6.49** (.46)	**9.37** (.48)	Total	**6.80** (.39)	**11.00** (.40)
	$d = 1.37$			$d = 2.40$	
Story 2 (toys + imagery)			Story 2 (toys + imagery)		
Perform	3.17 (.29)	4.32 (.30)	Perform	3.56 (.23)	5.13 (.23)
Observe	2.76 (.32)	4.49 (.33)	Observe	3.79 (.29)	4.91 (.30)
Total	**5.93** (.50)	**8.81** (.52)	Total	**7.35** (.35)	**10.04** (.37)
	$d = 1.28$			$d = 1.69$	
Story 3 (imagery only)			Story 3 (imagery only)		
Total	4.52 (.54)	4.70 (.56)	Total	**5.89** (.55)	**7.76** (.57)
	$d = .07$			$d = .75$	

Note. Story means are adjusted for teachers' ratings of student general academic performance and outcome story identification. Total score means in boldface indicate statistical differences between the two conditions on the basis of a familywise Type I error probability of .05.

TABLE 2
Adjusted Mean Free Recall on Story 3, By Grade and Strategy Condition (standard errors in parentheses)

	First grade			*Third grade*	
	Repetition	*Activity*		*Repetition*	*Activity*
Total propositions	3.68 (.71)	3.69 (.73)	Total propositions	7.12 (.76)	5.46 (.79)
	$d \approx .00$			$d = .48$	
Action propositions	2.76 (.54)	2.41 (.56)	Action propositions	5.63 (.68)	4.62 (.71)
	$d = .25$			$d = .33$	
Nonaction propositions	0.92 (.27)	1.28 (.27)	Nonaction propositions	**1.49** (.21)	**0.84** (.22)
	$d = .29$			$d = .67$	
Actors	3.40 (.65)	3.98 (.67)	Actors	6.10 (.72)	4.94 (.74)
	$d = .19$			$d = .36$	
Objects	1.35 (.33)	1.14 (.34)	Objects	3.56 (.50)	3.04 (.52)
	$d = .13$			$d = .23$	
Actions	3.32 (.63)	3.22 (.65)	Actions	6.28 (.73)	5.03 (.75)
	$d = .03$			$d = .38$	
Locations	1.35 (.33)	1.37 (.34)	Locations	3.20 (.46)	2.44 (.48)
	$d = .01$			$d = .36$	

Note. Story means are adjusted for teachers' ratings of student general academic performance and outcome story identification. Total score means in boldface indicate statistical differences between the two conditions on the basis of a familywise Type I error probability of .05.

For Story 2 cued recall, in which imagery instructions were provided along with manipulation or repetition, a statistically significant difference in favor of the activity condition (adjusted $M = 8.81$) relative to the repetition condition (adjusted $M = 5.93$) was observed, $F(1, 34) = 15.74$, $MS_e = 5.10$, $p < .001$, $d = 1.28$, when the imagery training instructions were provided. However, as with Story 1, the condition by participant action interaction was not statistically significant $F(1, 34) = 1.24$, $MS_e = 1.27$, $p = .27$.

Third-grade results. As with the first-grade students, there was a statistically significant difference on the Story 1 cued-recall measure, with activity participants recalling more story events correctly than their repetition counterparts (Ms = 11.00 vs. 6.80, respectively), $F(1, 34) = 54.33$, $MS_e = 3.05$, $p < .001$, $d = 2.40$. Also as with the first-grade participants, the interaction of condition with sentence activity was not statistically significant, $F(1, 34) < 1$, $MS_e = 1.06$, $p = .35$.

For Story 2 cued recall, we found similar results, with adjusted means of 10.04 and 7.35 for activity and repetition conditions, respectively, $F(1, 34) = 26.81$, $MS_e = 2.54$, $p < .001$, $d = 1.69$. Again, the interaction of interest was not statistically significant, $F(1, 34) = .66$, $MS_e = 1.47$, $p = .42$.

Research Question 3

The third research question—whether the activity-based strategy can be effectively replaced with an imagery strategy—is addressed in Story 3. At this time, the manipulatives were removed, and the children in both experimental conditions were instructed simply to imagine story events.

First-grade results. For the Story 3 cued-recall measure, when imagery instructions replaced the toys, the previously observed strategy-condition effect was no longer apparent, $F < 1$, $MS_e = 5.94$, $p = .83$, with adjusted means of 4.70 for activity and 4.52 for repetition students (see Table 1). Furthermore, we found no statistical differences associated with strategy condition on any of the free-recall measures, all Fs < 1, ps $> .35$, with the two strategies yielding equivalent adjusted means on all measures (see Table 2).

Third-grade gesults. Contrary to what was found with the first-grade students and of focal interest here, activity students outperformed their repetition peers on the Story 3 cued-recall measure (i.e., when all students were instructed to imagine story events with no toys present), with adjusted means of 7.76 and 5.89 for activity and repetition, respectively, $F(1, 34) = 5.36$, $MS_e = 6.11$, $p = .03$, $d = .75$ (see Table 1). At the same time, from Table 2 it may be seen that on all free-recall measures, children in the repetition condition recalled descriptively more in comparison with their activity-strategy counterparts. However, on only one of those measures (nonaction propositions) was the difference between conditions statistically significant, with adjusted means of 1.49 and .84 for repetition and activity, respectively, $F(1, 34) = 4.32$, $p = .045$, $d = .68$. For all other measures, Fs < 2.24, ps $>.14$. The third-grade students' free-recall results are somewhat surprising, given the results of previous research (Marley et al., 2010) and predictions derived from the indexical hypothesis.

DISCUSSION

In this study, we examined the efficacy of an activity-based listening strategy designed to increase elementary-age children's memory for story events. On the basis of theories of cognitive developmental (Bruner, 1964; Piaget & Inhelder 1971) and previous experimental investigations (Glenberg et al., 2004; Marley et al., 2007, 2010), we expected to observe the following outcomes in mixed-age dyads: (a) children in the activity-based strategy condition would recall more story events relative to children in the repetition strategy condition; (b) children who performed story-relevant actions would exhibit improved recall of story events relative to children who observed the actions being performed; and (c) children in the activity-based strategy condition would recall more story events, relative to repetition-strategy participants, when the manipulation instructions were replaced with imagery instructions.

The first and second predicted outcomes should be considered together. The first prediction was supported by the results of the present experiment. Evidence from our study suggests that first- and third-grade children who were given the opportunity to interact with objects described by the narrative passage did remember more story content than those who were not afforded the same opportunity. However, the second prediction—of better memory for sentence content when children performed the described actions than when they observed their partners do so (a more fine-grained test of the benefit of physical manipulation)—did not materialize. This finding is consistent with the results of Marley et al.'s (2007) listening study, in which no benefit was found for actual manipulation over observed manipulation, as well as Glenberg et al.'s (2007) study, where observed and performed activity were equally beneficial in a paired reading context.

These equality outcomes are somewhat surprising in light of the self-performed task literature indicating that a performance-over-observation effect is likely to be observed in within-subjects designs, such as the present one (Engelkamp & Zimmer, 1997). This result implicates Paivio's (1971) dual-coding theory as a more parsimonious explanation for the comparable benefits of performed and observed manipulations. In other words, the indexing of symbolic representations to concrete objects may be achieved simply by providing access to dynamic visual representations, irrespective of whether those representations are performed or observed. At the same time, the present equivalence occurred with the interrelated sentences of a narrative passage (rather than with the arbitrary unrelated sentences used in much of the self-performed task research), and so a future parametric investigation might be warranted (but see Levin, 1976).

The third prediction of improved imagery-generation capability after a period of manipulation training was examined in Story 3. The cued-recall results for the third-grade children are of considerable interest from a theoretical perspective. As was predicted by the developmental imagery hypothesis, third-grade students improved in their ability to visualize story events after a brief period of manipulation-and-imagery instruction (relative to their listening-only peers), whereas first-grade students did not benefit in a similar manner. This result is consistent with associative-learning and text-processing research that has yielded similar age-related differences (Levin, 1976; Levin & Pressley, 1978; Marley & Levin, 2006; Pressley, 1977; Wolff & Levin, 1972). Furthermore, the results implicate a developmental transition analogous to that identified in preschool students' ability to benefit from concrete representations (DeLoache, 2000; Greenhoot & Semb, 2008; Uttal et al., 1997).

An alternative interpretation, however, is that the instruction, "Make pictures in your head" prompted third-grade students to create dynamic visual (and/or motoric) images, whereas the first-grade students may have created static images and need more instruction to create dynamic images. Future research might investigate this hypothesis by asking children to describe the nature of their visual images. Alternatively, and as was noted earlier, instructions such as "Imagine yourself moving the toys" have been previously employed in similar activity-based learning contexts (e.g., Bender & Levin, 1976; Glenberg et al., 2004; Glenberg, Jaworski, Rischall, & Levin, 2007; Wolff & Levin, 1972) and might prove to be more understandable and effective imagery eliciters for young children. It is surprising that the aforementioned cued-recall benefits associated with activity-strategy third-grade students' use of the imagery-generation strategy for Story 3 were not similarly observed on the free-recall outcomes. This finding is not consistent with the bulk of the previous indexical hypothesis research findings (Glenberg et al., 2004; Marley et al., 2007, 2010, Experiment 1), where whatever differences there were favored the activity-based strategy (but see Marley et al., 2010, Experiment 2).

Strengths and Limitations

The dyadic format of the study enhances the ecological validity of the activity strategy and its appeal to practitioners who could readily adapt it to classroom contexts. For example, it is not uncommon for teachers to pair younger and older children for engaging in the previously mentioned buddy reading (Friedland & Truesdell, 2004). In buddy reading dyads, children either take turns reading to one another or the older child reads to the younger one. The utility of the activity-based strategy in this circumstance is that the dyad members could take turns manipulating and reading to one another. It might be expected that this alternating activity will increase the engagement of both children, while simultaneously improving their recall of story events. Furthermore, this approach could be extended by teachers to teach children how to create memorable images of the events taking place in a story. The present findings are similarly consistent with the suggestion that both members in mixed-grade dyads receive developmentally appropriate cognitive benefits. In other words, the older member of the dyad is not engaged in a learning experience that solely benefits the younger child. This finding converges with previous research suggesting that both members optimally benefit when dyad members only differ in age by two to three years (e.g., Allen, 1976; Robinson et al., 2005; Roscoe & Chi, 2007).

We recognize three limitations to the present study. The first limitation is the size of the sample. With 39 dyads assigned to one of two conditions, the statistical power to identify small to medium effect sizes is restricted. The second limitation of the study is related to its laboratory nature. Although the composition of the dyads has ecological validity for a teacher-on-one dyad context, in a regular classroom environment a teacher may have to interact with 10–15 dyads—or more—at once. Additional examinations of the activity-based strategy should investigate the efficacy of the present strategy in a classroom environment with whole-group or multidyad formats. A third limitation is the study is that it did not permit for an examination of student differences. Among other learner characteristics, previous research has implicated working memory and past knowledge as predictive of listening and reading comprehension (e.g., Carretti, Borella, Cornoldi, & Beni, 2009; Daneman & Merikle, 1996; Ozuru, Dempsey, & McNamara, 2009). Further aptitude-by-treatment interaction research (Cronbach & Snow, 1977) should be performed to examine whether these and other student-differences measures differentially affect the efficacy of the activity-based learning strategy.

Three major conclusions result from the present study: First, supporting recent research findings, the narrative recall of first- and third-grade students was greatly enhanced by the use of text-relevant manipulatives. Second, the degree of text-learning facilitation achieved through a child's actual manipulation of story objects did not exceed that achieved by simply watching the manipulations being executed by either an older or younger child partner. Third, after brief experience with physical manipulation, third-grade (but not first-grade) students were able to generate visual imagery that improved their recall of text content. Further research is necessary to identify with what types of learners and under what contextual conditions the present activity/imagery strategy is most effective.

AUTHOR NOTES

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APPENDIX A

Example of Story Content

1. Early in the morning the rooster with the red head flew to the very top of the barn and sang, "cock a doodle doo", to wake everyone up.[a]
2. It was the start of a busy day and everyone had chores to do.[c]
3. The farmer picked up the bucket of water next to the cart and went around the barn to the big pig.[b]
4. The big pig was happy to see the farmer and so he went, "oink, oink."[c]
5. The hen came out of her nest and pecked at her two baby chicks.[a]
6. The baby chicks woke up and were hungry.[c]
7. The farmer left the bucket of water for the pig to drink and went out front to the cart to get something.[b]

8. The dog in the backyard chased the baby pig once in a circle around the sunflower. [a]
9. The dog remembered that he was not to chase the pigs and so he stopped.[c]
10. The farmer climbed up the ladder to the upstairs part of the barn and looked around for the pitchfork.[b]
11. The bird in the tree flew to the side roof of the barn, but it was slippery when it landed and so it fell to the ground.[a]
12. The pitchfork was not upstairs and so the farmer climbed down the ladder and looked under his cart.[b]
13. The farmer thought about where the pitchfork could be.[c]
14. Outside the barn, the little girl went to the hens and put their eggs in her basket so she could take them home later.[a]
15. The little girl knew that she had to be careful not to break the eggs.[c]
16. The farmer found his pitchfork behind the door next to the bench, and put it in the cart.[b]
17. The little boy took a basket of vegetables to the rabbits and fed them the lettuce and carrots. [a]
18. The little boy laughed as the rabbits ate their food.[c]
19. The farmer was tired and so the farmer went and sat on the bench.[b]
20. The farmer, the little boy, and the little girl were glad that the day was almost over.[c]

[a]First child's action sentence.
[b]Second child's action sentence.
[c]Nonaction sentences.

APPENDIX B

Cued Recall for Day on the Farm Story

1. Where did the rooster fly? (To the top of the barn)
2. Where did the farmer pick up the bucket of water? (Next to the cart)
3. Where did the hen come from to peck at her baby chicks? (The nest)
4. Where did the farmer leave the bucket of water? (Next to the big pig)
5. Where did the dog chase the baby pig? (Around the sunflower)
6. What did the farmer use the ladder for? (To go upstairs in the barn)
7. What happened when the bird tried to land on the side of the barn? (It fell to the ground)
8. Where did the farmer look for his pitchfork after he climbed down the ladder? (Under the cart)

9. Where did the girl put the hen's eggs? (In her basket)
10. Where did the farmer find his pitchfork? (Behind the door next to the bench)
11. Where did the boy take the basket of vegetable? (To the rabbits)
12. What did the farmer do at the end of the story? (He sat on the bench)