Dynamic Visual Support for Story Comprehension and Mental Model Building by Young, At-Risk Children

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Multimedia technology allows precise coordination of linguistic and visual information and may provide teachers with tools for enhancing literacy foundations in children—especially those who might otherwise be at-risk for school failure. This research explores the hypothesis that a multimedia environment with dynamic visual support facilitates language comprehension when children listen to short stories. Kindergarten children heard stories in three conditions: Helpful video, in which dynamic, silent video accompanied the beginning of stories; No video, in which children only heard the stories; and Minimal video, in which static images of characters and places accompanied the beginning of stories. In all conditions, the ending of the story was presented without visual support. Overall, the pattern of results suggests that dynamic visual support can provide a framework for understanding and remembering linguistic information.

☐ Children of all socioeconomic and ethnic groups are exposed to a wide variety of stories, long before they enter school. For example, storybook reading appears to be a fairly widespread social occurrence across families of different socioeconomic status (SES) and cultural backgrounds (Bus & van Ijzendoorn, 1988; Heath, 1983; Ninio, 1980; Snow, 1983; Snow & Goldfield, 1983; Snow & Ninio, 1986). However, families in low-SES homes tend to spend a smaller portion of their literacy activities focused around written narratives than do higher SES families (Anderson & Stokes, 1984; Heath, 1983; Purcell-Gates, 1989; Teale, 1986). Lower-SES parents also differ from higher SES parents in the types of discussions that occur during and after story book reading (Heath, 1983; Wells, 1985).[1] As a result, when children from different backgrounds enter school and encounter demands to answer questions about a story or to retell a story, they begin to show clear differences in the level of traditional knowledge and skills that they have acquired during these preschool experiences.

Concern over children who arrive in kindergarten with deficiencies in story-related abili-

1 We stress that these findings represent general tendencies and are not descriptive of all homes in a particular economic class.

ties is amply justified, because these early comprehension and retelling skills almost certainly play a large role in children's later success as readers and writers. Research has shown strong links between children's listening comprehension ability and reading comprehension ability, and between story retelling ability and story writing ability (Crowder & Wagner, 1992; Curtis, 1980; Juel, 1992; Morrow, 1985, 1986; Pezdek, Lehrer, & Simon, 1984; Smiley, Oakley, Worthen, Campione, & Brown, 1977; Yuill & Oakhill, 1991).

Unfortunately, explanations of individual differences in early and later literacy skills do not spell out easy answers for instructional intervention. Although an early lack of frequent, rich discussions about books can be mitigated to some degree by providing these experiences in the classroom (Feitelson, Kita, & Goldstein, 1986; Morrow, 1988, 1990), the single year that kindergarten teachers have available to them makes it almost impossible for them to use traditional discussion alone for providing at-risk children with the equivalent of multiple years of parent-led discussions prior to entering school. Moreover, good story-related discussions are often predicated on at least a preliminary understanding of the basic events in the story, and teachers may find it difficult to provide each at-risk child with the background knowledge and other support necessary for achieving this level of story comprehension. If teachers are to significantly help all at-risk children acquire a strong foundation for literacy, they may need more powerful tools than those currently available in most classrooms.

Multimedia technology that allows precise coordination of linguistic and visual events may provide teachers with one such tool. As a first step, our present investigation aims to improve children's comprehension of a story and retelling of story events by using video to support children's ability to visualize and imagine the events described by sentences in stories. If at-risk children can successfully imagine a story world when they are given part of the information through video and part of the information through oral sentences alone, then teachers may be able to use video to augment and enrich discussions about stories that will help at-risk children practice important language comprehension and language production skills. Our notion is that discussions and practice of this kind would be out of the children's reach in traditional verbal settings. In this sense, we argue that video may serve an important and thus far largely untapped role in improving at-risk children's language skills.

MENTAL MODELS, IMAGERY, AND YOUNG CHILDREN

Our use of video has its roots in theories of mental models (see McNamara, Miller, & Bransford, 1991, for a review). Cognitive research supports the use of mental models as language comprehension tools, and there appears to be a relationship between mental models and images. In particular, good readers seem to transform information in a text into mental models that include visual-spatial information about story scenes (Glenberg & Langston, 1992; Glenberg, Meyer, & Lindem, 1987; Johnson-Laird, 1983; Morrow, Bower, & Greenspan, 1989; Sharp & mcNamara, 1990). However, young children, especially those who may be at-risk for school failure, may lack the necessary background knowledge to create images for scenes and objects that are incompletely described by a text. These children may also lack the required working memory resources for constructing images. For example, Pressley, Cariglia-Bull, Deane, and Schneider (1987) found that less-verbal children appeared to expend more working memory resources on basic language comprehension processes, leaving too few resources available for imagery.

Picture frameworks for stories may enable some children to overcome limitations in background knowledge and working memory. In a series of studies by Guttman and colleagues (Guttman, Levin, & Pressley, 1977), children listened to short stories illustrated by pictures that depicted part of, but not all of, the story information. For example, the partial picture that accompanied the sentence "One evening

Sue's family sat down to eat a big turkey for dinner," showed the family seated at the table, but the mother's head occluded the center of the table where the turkey would be. Using the partial picture as a framework, kindergartners were more successful in imagining and remembering single sentences than comparison children who were not provided with partial pictures.

In order for kindergartners to use imagery as a strategy for building mental models of stories, we need to develop frameworks that will allow kindergartners to move beyond imagining single, short sentences. Dynamic images may be powerful enough to serve in this capacity, because they are familiar (through television), because they can show story events in a natural, familiar way (Gibson, 1966), and because they can convey in a short amount of time much background information that children might not possess.

Evidence from research comparing television and text comprehension appears to support the claim that dynamic visuals can enable children to form good mental models for stories. For example, children remember central story actions better for televised stories than for orally-presented stories, even when the orally-presented stories are accompanied by static pictures (Gibbons, Anderson, Smith, Field, & Fischer, 1986; Hayes, Kelly, & Mandel, 1986; Meringoff, 1980). Memory for details and vague characters is also enhanced by television (Beagles-Roos & Gat, 1983). Unlike the partial picture studies, however, all of these studies provided children with dynamic images for the entire story and did not require children to visualize any of the story information for themselves.

In the present study, we used dynamic images as a *framework* for understanding a story, rather than as the medium of presentation for the entire story. Gernsbacher (1990) notes that the initial parts of short stories are the most difficult parts for readers to comprehend and transform into mental models, so we placed this framework at the beginning of our stories. In what we call the *helpful video* condition, we presented children with dynamic images only for the beginning portion of the story. Children then listened to the ending sentences of the story and had to generate their own imaginal or visual images. It was our expectation that providing a mental model framework for the story up to the point of the ending sentences would increase the likelihood that children would mentally represent the information in the ending sentences and connect it to the previous parts of the story. Our procedure is somewhat unusual in that children heard stories that we read to them. After each sentence we interspersed short, silent video clips that enacted the story information they had just heard. If dynamic visual images can serve as a mental model framework, children should be better at remembering the ending sentences when the beginning sentences were accompanied by video (helpful video condition) than when the stories had no visual support (no video condition).

In addition to the comparison of dynamic images versus no images, we included a second visual condition that we refer to as *minimal video support*. The video supports in this condition were largely static images (i.e., stills) of characters and places. This information provided much less specific information and as such provided a less developed framework for the ending sentences. Instead, the minimal video served mainly to supply referential information. Our expectation was that this information would provide some assistance to students but not as much as the dynamic video. Thus, we predicted that memory for the ending sentences would be best in the helpful video condition where there was dynamic visual support for the verbal information and worst in the no visual support condition. The minimal support condition should lead to performance between these two.

METHOD

Participants

Eighteen kindergartners (ages 5 years, 2 months to 6 years, 1 month, M = 5 years, 7.5 months) were selected from three classes at an inner-city school in Nashville located across

the street from public housing. All of the children were from this predominately low-income area, and all scored below age-level norms on the Peabody Picture Vocabulary Test-R (percentile scores ranged from -1% to 45%, M = 9.9%).[2] Thirteen of the children were male and of these, 12 were African-American and 1 was Caucasian. Of the 5 girls, 4 were African-American and 1 was Caucasian.

Materials and Design

The design was a within-subjects design in which each child was presented with four stories in each of three conditions: helpful video support, minimal video support, and no video support. Dependent measures were (a) idea units recalled from the *story framework* sentences, that is, those preceding the imagination sentences and (b) idea units recalled from the *imagination* sentences, that is, the ending sentences that were always read without any video.

The experimental materials consisted of a set of 12 test stories, each accompanied by video clips that had visuals but no audio. All stories were created from available commercial video. Of the test stories, 7 had animated (cartoon) clips; 5 had live-action clips. Some video clips required more verbal description than others in order to set up a story scenario, so the set of test stories ranged from 5 to 17 sentences (M = 11.8 sentences) in length. Excerpts from 2 example stories are shown in Table 1, and a sample of complete stories is given in the Appendix.

The imagination sentences of each story were always at the end of the story. We refer to these as imagination sentences because in all three presentation conditions, these were the sentences presented without any form of visual support. We wanted children to listen to and visualize in their own imaginations the events described in these final sentences. Story content varied but in general the stories each contained multiple characters who were engaged in purposeful action. The imagination sentences always conveyed the culmination of the purposeful activity.

The set of 12 stories was randomly divided into four sets, with the constraint that no 2 stories in the same set contained the same characters. Each set of 3 stories contained 1 story in each condition. Three counterbalanced versions of the story sets were created so that across participants each story appeared equally often in each of the three conditions and no child was presented with the same story more than once. Because we were interested in possible practice effects, we created two presentation orders. Half the children received the four story sets in one order, and half received the four sets in the reverse order. For stories that contained the same characters, introductory sentences (e.g., "This is another story about Donald") were adapted appropriately for each presentation order. The two presentation orders were combined with the three counterbalanced versions of each story to create a total of six sets of materials that were rotated across participants.

The three conditions for each story were implemented as follows:

Condition One: Helpful video framework

In this condition, the reading of almost every sentence in the story (except the imagination sentences) was followed by the showing of a video clip that illustrated the information in the sentence. The video would then "freeze" and remain on the screen while the experimenter read the next sentence in the story. The video clip for this next sentence would then replace the frozen still from the previous video clip. The video clips in this condition were designed to provide maximal information about the characters, actions, and spatial relationships described by the story. The mean

2 Time constraints prevented us from testing all eligible students in the three classrooms, so students were randomly selected from those whose parents agreed to their participation. PPVT score and birthdate were unavailable from one child who withdrew prior to the completion of this study. However, teacher ratings and the child's performance on introductory sessions suggested that this child was similar to other children in the study. Analyses with and without this child's data showed the same overall pattern of results, so we report the first set of analyses only.

Table 1 ☐ Examples of Story and Video Materials

Text	*Helpful Video*	*Minimal Video*
Two Mice Story		
Once there were two mice who were brothers. They lived in a big city. One of the mice was short, and he always wore a big hat . . .	*Tall mouse and short mouse walking on a road in the big city*	*City scene with buildings and street (no mice)*
The two mice began to run home as fast as they could.	*The two mice run down the road*	
Imagination sentences: All of a sudden, the short mouse fell into a hole. The tall mouse did not see his brother fall into the hole, so he kept on running.		
Donald Duck Story		
One day, a duck named Donald took some money out of his purse.	*Donald opens purse.*	
He gave the money to his three nephews, which made them very happy . . .	*He hands money to the nephews. Nephews jump for joy.*	*Nephews jump for joy.*
He made them put their money into a bank that was shaped like a little house.	*Donald holds bank and nephews unhappily deposit coins.*	
Then Donald went to sleep on the couch, holding the bank on his stomach . . .	*Donald sleeps on couch with bank.*	
They (nephews) tiptoed upstairs where they could look down at Donald.	*Nephews sneak upstairs and peer over banister.*	
One of the nephews had a fishing rod with a hook on a string.	*Nephew produces fishing rod.*	
He lowered the hook and the string down to the bank, and lifted up the bank with the hook.	*Nephew lowers rod, and bank begins to rise above Donald, held in place by the hook.*	
Before any of them could get a good hold on the bank, the bank fell off the hook! One of the nephews raced downstairs to try to catch the bank before it hit Donald in the head.	*Bank falls. Nephew runs downstairs and ends up next to Donald with arm outstretched toward bank, inches from Donald's head.*	
Imagination sentences: The nephew caught the bank. But then the door to the bank fell open, and the coins fell out of the bank and fell right on Donald's nose! And that woke Donald up!		

Note. For complete text of the Two Mice Story and the Donald Duck Story, see Appendix A. Ellipses indicate text deleted for purposes of table presentation.

number of helpful video clips per story was 6.5, and examples are described in Table 1.

To ensure that children would need to listen to the imagination sentences for stories in this condition and could not easily guess the endings of the stories based on the helpful video framework, we collected normative data from 18 college students. These participants listened to the 12 stories presented without the imagination sentences at the end. Half the participants saw the helpful video with the stories and half the participants saw no video with the stories. All participants were asked to guess what happened next in the story and to write a five-sentence ending. The results suggested that the imagination sentences could not be easily guessed, even when the stories appeared in the helpful video condition. Participants in the helpful video group guessed only 9% of the idea units in the imagination sentences, compared to participants in the no video group who guessed 6.5% of the idea units. This difference was not significant, (t = 1.38).

Condition Two: Minimal video framework

Stories in this condition had a mean number of 2.5 clips. Examples are described in Table 1. As in the helpful video condition, a video image was always on the screen during the reading of the story. The video clips in this condition provided illustrations that were consistent with and relevant to the story as a whole, but provided minimal information that would be useful in visualizing the imagination sentences. For example, for the Two Mice story (see Table 1) the minimal video clips showed the house and city that the mice lived in, but did not depict the two mice or the road that they were running on. For the Donald Duck story, the minimal video clips showed closeups of Donald Duck and his nephews, but did not illustrate the larger setting or dynamic spatial relationships between the characters and props. As in the helpful video condition, video clips always ended in a frozen still that remained on the screen until the next video clip was played.

In an attempt to control for time allowed for comprehension, the experimenter paused briefly after all sentences in the minimal condition that would have been followed by a video clip in the helpful condition.

Condition Three: No video

In this condition, each story was read without any accompanying video clips, and the video monitor was turned off. Again, the experimenter briefly paused after sentences that would have been accompanied by video in the helpful condition, in order to approximately equate the time allowed for comprehension.

Procedure

Each child was tested individually in 5 sessions conducted on separate days by one of two experimenters. Each child was always tested by the same experimenter. The first session served as an introductory session, and the remaining four sessions were test sessions. Each session lasted approximately 30 minutes. Three stories, one in each condition, were administered in each test session. Two practice stories were used in the introductory session and two additional practice stories were used at the beginning of test sessions 1 and 2 to ensure that the students understood the procedure and instructions.

Introductory session

The introductory session involved three phases. In Phase 1, the experimenter first engaged the child in conversation, and then introduced a puppet (the "story witch"). Children were told that the story witch could not understand adults but could understand children. The puppet and child engaged in some play, talked about a short story that the child listened to without any video, and talked about what it means to imagine.

The experimenter then moved into Phase 2 by telling the child that the experimenter would read a story, and the child would have to repeat each sentence to the puppet, so that the puppet could listen to the story too. This story, the Jimmy story, was 12 sentences long and was created to ensure that children understood what we meant when we asked them to match visually presented information to orally presented information.

Eight of the sentences in the Jimmy story were illustrated with a video clip. Clips were played through the use of video buttons in a Hypercard stack on a Macintosh computer connected to a videodisc player and TV monitor. The experimenter played each clip after reading a sentence, before the child repeated the sentence to the puppet.

Four of the sentences in the story were paired with a set of contrast clips that contained a matching clip and a mismatching clip. For example, the sentence, "When he got on his bike, the front wheel fell off," was paired with a clip that illustrated these actions *(matching clip)* and also a clip that showed the boy mounting the bicycle, the handle bars falling off, and the boy making a pratfall *(mismatching clip)*. The sentences were given as follows: (a) the experimenter told the child to try to imagine the sentence, (b) the experimenter read the sentence, (c) the experimenter told the child to

repeat the sentence to the puppet, and (d) the experimenter told the child to tell the puppet to "try to make the sentence into a movie." These instructions were constructed to give children a clear purpose ("movie-making") for comprehending the sentence. They were also designed to help ensure that failure to imagine would not be due to the children simply being metacognitively unaware that imagery processes should be used as they listened to the target sentence.

The puppet played the clip and the child judged the accuracy of the clip, with feedback from the experimenter. Half of the time the matching clip was played first, and half of the time the mismatching clip was played first. In the latter case, the matching clip was always shown after a child rejected a mismatching clip. If the child rejected a matching clip, the mismatching clip was presented for contrast until the child agreed that the matching clip was better.

In Phase 3 of the session, the children practiced the experimental task. The puppet "went to sleep" while the experimenter read the Sarah story. The Sarah story was designed to be similar to the experimental stories. The experimenter read the story, playing an accompanying video clip after each of the first seven sentences. Before reading the final sentence, the experimenter said, "Here is the part we want the story witch to make into a movie, so try to imagine it." The end of the clip from the previous sentence remained on the screen during the reading of the imagination sentence, so that children would not have to regenerate their own images of the character and objects in the story scene. Instead, they could look at the screen and imagine the movement of characters and objects within that scene, as described by the imagination sentence. This aspect of the procedure was designed to minimize the working memory demands of the imagination task.

When the puppet awoke, the child retold the entire story, with prompts from the experimenter. The puppet then tried to show a matching clip for the imagination sentence ("She took a big jump!") but actually showed a mismatching video clip *(Sarah turns and walks away)*. With guidance from the experimenter if necessary, the child judged the clip to be incorrect, and the puppet then showed the matching clip.

Test sessions

There were four test sessions. Each test session began with some initial conversation between the puppet and child. Test sessions 1 and 2 followed this conversation with a practice story to remind the children of the procedure. Then the puppet went to sleep, and the experimenter read three stories in a row from one set of test stories. (In Test sessions 3 and 4, the experimenter dispensed with a practice story and proceeded directly with the reading of the three stories.) Prior to the imagination sentences of each story the experimenter said, "Now here is the part we want the story witch to make into a movie, so try to imagine it."

In order to increase the likelihood that we were testing comprehension and memory of mental models, and not short-term rote memory of the sentences (see, for example, Johnson-Laird, 1983), we delayed recall of all of the stories until the end of the test session. After the child listened to the first and second stories in the trio, the experimenter would tell the child, "The story witch is still asleep, so I'm going to read you another story." After the third story had been read, children's memory for the three stories was tested, beginning with the first test story that they had heard.

At the beginning of the test phase, the video monitor was turned off, and the puppet awoke and asked the child for a story, using a series of prompts. If a child started to talk about a different story, the experimenter directed the child back to the target story, with the appropriate prompt.

The retellings were elicited by three increasingly-specific prompts as shown in Table 2. The experimenter first gave the child a *general verbal prompt* (e.g., "Tell her (the puppet) the story about the duck named Donald."). If a child failed to respond, the experimenter would provide an example sentence for the

Table 2 ☐ Experimental Procedure for the Test Sessions

Phase	*Prompt Type*	*Example(s)*
1. Listen to three stories.	(None)	
2. Test phase	General Verbal *(all conditions)*	E: Tell her the story about the two mice. S: There were two mice. Puppet: What happened to the two mice? Then what?
	Video (always silent) *(For helpful condition)*	E: Here is a movie that I showed you for the first part of the story. This movie might help you remember more about the story. *(Show last clip helpful video.)* Puppet: Oh, is that part of the story? What's happening there? Then what happened?
	(For minimal condition)	E: Here is a movie that I showed you for part of the story. This movie might help you remember more about the story. *(Show last clip minimal video.)* Puppet: Oh, is that part of the story? What's happening there? Then what happened? E: Here's a movie that I didn't show you before, but this movie shows part of the story. This movie might help you remember more about the story. *(Show last clip helpful video.)* Puppet: Oh, is that part of the story? What's happening there? Then what happened?
	(For no video condition)	E: Here is a movie that I didn't show you before, but this movie shows part of the story. This movie might help you remember more about the story. *(Show last clip helpful video.)* Puppet: Oh is that part of the story? What's happening there? Then what happened?
	Specific Verbal *(all conditions)*	E: Did they fall into a hole? Did both of them fall into the hole or just one? Which one? What did the other mouse do?

child to repeat to the puppet (e.g., "Tell her 'There was a duck named Donald'.") The puppet then probed the child for additional information using additional general prompts (e.g., "And then what?") until the child indicated that he or she did not remember any more.

The experimenter then gave the child a *video prompt*. The nature of the video prompt and the instructions that accompanied it were adapted for each of the three presentation conditions. Descriptions of these prompts and instructions are below, and examples are shown in Table 2:

1. For stories in the *helpful video condition*, children were told that they were going to see part of the story they had already been shown and that the video might help them remember more about the story. Children saw one video clip, and this clip was the last one shown during presentation of the story, just prior to the reading of the imagination sentences. The video clip was played without sound, just as it had been played during the story.

2. For stories in the *minimal video condition*, it was important that children see two clips, in order to have access to all of the types of cues

available for stories in the helpful video condition. Showing two clips instead of one had the potential to bias recall in favor of stories in the minimal condition, but we predicted that recall would still be better for stories in the helpful video condition.

The first video clip that children saw for stories in the minimal condition was the last clip shown during presentation of the story, just before the reading of the imagination sentences. As for stories in the helpful video condition, children were told that they were going to see part of the story that they had already been shown, and that the video might help them remember more about the story. This ensured that a previously-seen clip that could be used as a retrieval cue was shown for stories in both the helpful and minimal conditions.

The second video prompt was a different video clip. This video clip was the same prompt shown when the story was in the helpful video condition. Notably, the clip had not been shown during the presentation of the story when the story was in the minimal condition. Therefore, children who saw the story in the minimal condition were told that this was a clip that they had not seen before, but the clip showed part of the story and might help them remember more about it. This prompt ensured that children in both the minimal and the helpful video condition had an equal opportunity to use any implicit visual clues provided by this particular video clip to aid their recall. Our hypothesis was that there were few implicit clues that would be helpful if children had not seen the clip at the time of comprehending the story.

3. For stories in the *no video condition,* children saw the same video clip given as a prompt in the helpful video condition. Children were told that they were going to see some video that they had not seen before, but this video showed part of the story and might help them remember more about it.

Pilot-testing indicated that many children seemed unsure about how to respond to the video prompts and how much of the story they should tell the puppet. Therefore, each video prompt was accompanied by the following questions from the puppet: "Oh, is that part of the story? What's happening there? And then what happened? Do you remember anything else about the story?"

The third and final level of prompting was termed *specific verbal prompts.* These were questions that the experimenter asked the child in order to specifically elicit information about the imagination sentences. These were provided because previous research and pilot-testing have shown that when children are asked to recall a story, they often fail to include all of the information that they remember (e.g., Morrow, 1985). We wanted to ensure that if children failed to recall the information in the imagination sentences, it was due to a problem in story comprehension and not simply a problem in understanding the recall task.

The entire recall test for each story ended with the puppet trying to show a brand new video clip to match the information in the imagination sentences. As described above, this part of the procedure was included to give children an additional incentive to try to visualize the information in the imagination sentences when they heard them, so that they could later judge the accuracy of the puppet's clip. For half the stories the puppet showed a clip that correctly illustrated the information in the imagination sentences and for the other half the puppet's clip incorrectly illustrated the sentences. The child then either congratulated the puppet or told her that she had made a mistake. Pilot-testing had revealed that children were very eager to have a chance to control the video themselves, so for motivational purposes each child was also allowed to show the puppet an additional clip that illustrated some piece of the story information that he/she had remembered.

Scoring

We first transcribed videotapes of the test sessions, and then we deleted the instructions accompanying the video prompts and any other clues about the condition of the story, so that all scoring of the transcripts was done by raters who were blind to the

experimental condition of the children they were scoring.

Prior to scoring, each test story in the materials set was divided into a set of general idea units.[3] Two raters then scored children's retellings of these stories and points were assigned depending on the level of prompt that had been necessary to elicit the idea unit. Inter-rater agreement on score assignment was 88% for the imagination sentences and 94% for the story framework sentences. Discrepancies were resolved in discussion.

Children received more points for remembering an idea with fewer prompts: Idea units recalled following the general verbal prompt received a score of 3, those recalled following the video prompt received a score of 2, and those recalled following the specific verbal prompt received a score of 1. For the minimal condition, which was unique in having two types of video prompts (helpful cue and minimal cue), the idea units recalled following either type of video prompt were given a score of 2. Separate scores were calculated for the imagination sentences and for the story framework sentences.

The imagination sentences for each story contained two general idea units. If both idea units were recalled at the general verbal prompt, where answers were given a weight of 3, then the story received the maximum score of 6. For some of the more complex idea units, half credit was usually given when the child supplied partial information. For example, for the idea unit "The coins fell on Donald's beak and woke him up," half credit was given for the information that the coins fell. However, half credit was not given for apparent guessing on yes-no questions that were given as specific verbal prompts. Using the Two Mice story in Table 1 as an example, children who simply replied yes to the question "Did they fall into a hole?" were not given credit if their answers to the following questions indicated incorrectly that both mice fell or that the tall mouse fell.

Five of the children had data from one of the 12 stories discarded due to equipment failure or experimenter error. One child withdrew from the school before completing the last 3 stories. Scores for these children were computed on the remaining stories.

RESULTS

Analyses of variance (ANOVAs) were performed with subjects as the random variable. We also conducted a supplementary ANOVA for each comparison, using items (stories) as the random variable. These items analyses were parallel to the analyses by subjects and are not reported here.

Preliminary ANOVAs on data from the imagination sentences and from the story framework sentences showed no effect of the two orders of story presentation ($F < 1$) and no significant order by condition interactions ($Fs < 2.53$), so data were collapsed across the two presentation orders and the ANOVAs were recomputed.

Planned contrasts were supplemented by Tukey's (HSD) post hoc comparisons to allow multiple comparisons of means. An alpha level of .05 was used for all statistical tests.

In reporting the results, we first consider the effect of providing a video context on memory for the imagination sentences. A second set of analyses considers the impact of the video on memory for the story framework sentences.

Imagination Sentences

Mean recall score for the imagination-sentence idea units was 2.66 for stories in the helpful video condition, 1.63 for stories in the minimal video condition, and .85 for stories in the no video condition. An ANOVA showed a significant effect of condition, $F(2,34) = 23.50$, MSe

3 We were primarily interested in children's memories for general events in the stories, so our idea units tended to be larger than traditional idea units consisting of only one isolable piece of information. For example, we considered "The short mouse fell into the hole" to be one general idea unit rather than three separate units [(a mouse fell) (the mouse was short) (the place he fell was into a hole).] Using our larger idea units decreased the likelihood that children could receive points for merely guessing, especially in response to the specific verbal prompts.

Table 3 ☐ Mean Idea Units Recalled by Type of Prompt

Sentence/ Story Type	General Verbal	Prompt Type: Video	Prompt Type: Specific Verbal	Total
Imagination Sentences (Maximum total = 2)				
Helpful	.57	.34	.27	1.18
Minimal	.34	.20	.20	.74
No Video	.15	.09	.24	.48
Story Framework Sentences (Maximum total = 5)				
Helpful	2.02	.45	.08	2.55
Minimal	1.50	1.01	.02	2.53
No Video	.89	.56	.03	1.48

= .63, $p < .001$. Tukey's post hoc comparisons revealed that memory for imagination sentences in the helpful stories was significantly greater than in the minimal and no video stories, and memory for imagination sentences in the minimal video stories was significantly greater than in the no video stories ($ps < .05$).

These mean scores reflect the weights that we assigned to the different prompts that elicited recall, so that recalls elicited from fewer prompts received higher mean scores. Our next analyses were designed to examine more closely the effects of different prompts on recall. We recalibrated the recall data without assigning weights, allocating 1 point per idea unit in the imagination sentences per story, for a maximum of 2 points per story. Children received a separate score for the amount of information that they recalled after each prompt type. Subject means per story are shown in Table 3.

We were particularly interested in children's recalls that were elicited by the general verbal prompt, because this prompt was unspecific and purely verbal. Table 3 shows that children recalled more information from stories in the helpful condition ($M = .57$) than from stories in the minimal ($M = .34$) and no video conditions ($M = .15$). An ANOVA on the mean recall data in response to the general prompt indicated a significant effect of condition $F(2,34) = 8.45$, $MSe = .10$, $p < .01$. Planned comparisons showed that the advantage of the helpful condition over the minimal condition was significant, $F(1,34) = 4.76$, $MSe = .10$, $p < .05$, (although this comparison only approached significance in a Tukey post hoc comparison). Tukey comparisons also revealed that the scores for the helpful condition were greater than scores for the no video condition ($p < .01$). The minimal and no video conditions did not differ significantly, even in planned comparisons, $F(1,34) = 3.25$, $MSe = .10$, $p < .10$.

In general, this finding supports our hypothesis that video would allow children to form a coherent mental model that would facilitate the comprehension and recall of the auditorily presented imagination sentences. According to this view, children should be able to retrieve information about the stories without *requiring* the presence of video at retrieval. The finding that children could recall more information after the general verbal cue for stories with helpful video than for other stories is consistent with this hypothesis.

The mean recall scores shown in Table 3 for the information elicited by the video prompts and specific verbal prompts suggest that these prompts succeeded in eliciting additional information about the imagination sentences. This is not surprising, given that additional prompts are often useful in helping children to remember parts of a story (e.g., Morrow, 1985). Unfortunately, ANOVAs on the amount

of information elicited by these prompts are not appropriate, because these means are conditional on recall in response to the general prompt.

However, the pattern of recall for stories in the minimal condition can provide some clues about the way that video prompts might help to elicit recall. Helpful video shown during retrieval might function as a facilitating retrieval cue, but according to our hypothesis, this should only happen if the helpful video was also shown at encoding (e.g., Bransford & Johnson, 1972). Therefore, helpful video should be an effective retrieval cue for stories in the helpful condition, but not for stories in the minimal condition. To examine this hypothesis, we looked at responses to video prompts in the minimal condition. The score shown in Table 3 (M = .20, out of a maximum score of 2) is a combined score from the responses to both the helpful video cue and the minimal video cue (recall that the minimal condition was the only one with two types of video prompts). This relatively low score indicates that responses to both of these video prompts were limited. We examined further the recalls for this cell and found that the low score was attributed to the fact that 89% of the time children gave no response at all to the video prompt. When we looked at the 11% of the time that children responded to a video prompt, we discovered that the helpful video cue prompted only half of these responses (the other half of the responses were given in response to the minimal video cue). This low response level suggests that helpful video had little added benefit at retrieval if it was not also present at encoding.

Overall, the recall data for the imagination sentences support our hypothesis that children will best understand and remember the imagination sentences when the sentences appear in stories supported by a helpful video framework.

Our related hypothesis was that the advantage of the helpful video framework lies in the way that it enables children to form more coherent mental models of the story. According to this hypothesis, the helpful video framework should also help children to better understand the story framework sentences. This is explored next.

Memory for the Story Framework Sentences

In general, children performed at a low level in their recall of the story framework sentences (we discuss this further in the Discussion section). Despite the fact that the number of idea units in the story framework sentences varied from 5 to 15, children's recalls of story framework sentences tended to be uniformly short, usually containing less than 5 idea units total. Initially, we analyzed the proportion of idea units recalled for each story (number recalled divided by the total idea units per story). However, this procedure seemed to us to unfairly bias the recalls of short stories over the recalls of longer stories. In particular, scores from some of the longer stories appeared to force the mean scores to be artificially low.

In addition to these analyses we also performed our analyses on the total number of idea units recalled per story. This method of scoring served to more fairly give each story equal weight in the analyses. To further equalize the influence of each story, we imposed a limit of 5 (the number of idea units in the shortest test story) on the maximum number of idea units that a child could receive credit for in a particular story. Only 12.5% of the children's recalls exceeded this limit: 12 of these stories were in the helpful condition, 11 were in the minimal condition, and 4 were in the no video condition.

These two types of analyses yielded identical patterns of results. We consider the second set of analyses to be more justifiable, so we report this set here.

The maximum score per story on the story framework sentences was 15 (if all five idea units were recalled following the general verbal prompt and were each given a weight of three). An ANOVA showed a significant effect of condition $F(2,34) = 10.50$, $MSe = 5.16$, $p < .01$. Planned contrasts showed that the difference between the helpful (M = 7.05) and minimal (M = 6.53) conditions was not significant

$F < 1$, $MSe = 5.16$. However, Tukey post hoc comparisons showed that both the helpful video condition and the minimal video condition differed significantly from the no video condition ($ps < .01$).

We then divided the recalled statements according to the type of prompt they followed. These means are shown in Table 3. Again, we were interested in whether children's recalls would differ across conditions following the general verbal prompt. An ANOVA on this data showed a significant effect of condition $F(2,34) = 10.88$, $MSe = .53$, $p < .001$. A planned contrast showed that the helpful ($M = 2.02$) condition was significantly greater than the minimal ($M = 1.5$) condition, $F(1,34) = 4.64$, $MSe = .53$, $p < .05$, although this difference only approached significance in a Tukey post hoc comparison. Additional Tukey post hoc comparisons revealed that the helpful and the minimal video conditions were both significantly greater than the no video condition ($ps < .05$).

These results suggest that the story representations formed in the helpful video condition were superior to those formed in minimal and no video conditions. In particular, the fact that the general verbal prompt elicited more information from stories in the helpful condition than from stories in the minimal condition suggests that children were better at generating their own retrieval scheme for the story framework sentences in helpful video stories than for story framework sentences in minimal and no video stories. This in turn supports the idea that children had a more coherent, retrievable mental model for the story framework sentences in helpful video stories than for story framework sentences in minimal and no video stories.

As noted previously, we did not analyze separately the data for recalls following the video and specific verbal prompts, because these data are not independent of statements recalled following the general verbal prompts. However, two aspects of these data deserve note. First, the low proportion of responses following the specific verbal prompt is really not surprising, because these cues specifically asked about information in the imagination sentences, not the story framework sentences. Second, the apparent advantage of the minimal condition following the video cue could be owing to the fact that children were provided with two video cues in the minimal condition and only one video cue in the helpful and no video conditions. Because both cues depicted some general features of the story, children in the minimal condition could receive more points for the story framework sentences by merely describing something that they saw in both cues, as opposed to children in the other two conditions who saw only one cue.

As before, we were interested in the effectiveness of the helpful video as a retrieval cue when it was *not* present at encoding, so we again examined the responses in the cell for the minimal condition following the video cue ($M = 1.01$), to see if these responses tended to occur primarily after the minimal or helpful cue. As with the imagination sentences, children tended to respond to both types of cues to the same degree ($t < .01$), suggesting that the helpful video had no added benefit over minimal video shown during encoding.

Story Length Effects

Although we did not design the study to test directly for effects of story length, we examined whether there was any relationship between the children's performance and the number of idea units in the different stories. All stories had two idea units in the imagination sentences, but there were three stories that had between 5 and 7 story framework idea units, five stories that had between 10 and 12 story framework idea units, and four stories that had between 14 and 15 story framework idea units. Correlations between the amount of story framework information that children retold and the number of idea units in the story framework portion of the story were computed separately for each condition. In the helpful condition, there was a significant positive relationship, indicating that children retold more story framework information for the longer stories ($r = .76$, $p < .01$). There was no significant relationship in the other two

conditions. There was also no significant relationship in any condition between the amount of information retold from the imagination sentences and the number of idea units in the story framework portion of the story. Hence, it does not appear that memory for the imagination sentences was contingent on a specific story length. However, the helpful video that accompanied the story framework sentences appeared to enable children to give correspondingly longer recalls for longer stories. This further supports the view that children built more coherent mental models for stories with helpful video frameworks than for stories with minimal or no video frameworks.

Supplementary Analyses

Recall that normative data from college students suggested that children would not be able to guess the content of the imagination sentences, even when the stories were in the helpful video condition. However, to further satisfy ourselves that guessing did not account for the advantage of stories in the helpful video condition, we recomputed the children's scores by eliminating from the data set the idea units that the adults had correctly guessed (7 out of the 24 original idea units were guessed by at least one adult).

ANOVAs on the children's adjusted scores continued to show a strong advantage for the helpful video condition. There was an overall effect of condition, $F(2,34) = 22.17$, $MSe = .55$, $p < .001$. Tukey post hoc comparisons showed that scores for stories in the helpful video condition ($M = 2.14$) were significantly greater than scores for stories in the minimal ($M = .95$) condition and no video condition ($M = .57$), ($ps < .01$). There was no significant difference between the minimal and no video condition, even in a planned contrast, $F(1,34) = 2.32$, $MSe = .55$.

DISCUSSION

Our major interest was in children's ability to remember and retell the sentences that they had to visualize in their own imaginations, without any accompanying video. As predicted, children were better able to do this when stories were accompanied by a helpful video framework than when stories had either a minimal video framework or no video framework. Our interpretation of these findings is that dynamic video provided visual and spatial information that enhanced the way children encoded the beginning of stories. With the support of the video, children could more richly represent the characters, settings, and beginning story actions. This framework made it easier for children to encode the ending story actions in the imagination sentences that were presented through language alone.

To our knowledge, these are the first data to show that a visual framework can aid kindergartners' comprehension of complex (i.e., more than a single sentence) story material. The fact that our frameworks were dynamic, rather than static, is in our view a key reason why they were more effective in supporting comprehension than the static picture frameworks provided in previous studies (Digdon, Pressley, & Levin, 1985; Guttman et al., 1977).

Children were also better at recalling information from the story framework sentences when those sentences were accompanied by helpful and minimal video clips than when they were not accompanied by video clips. However, we did not find a difference between helpful and minimal conditions for the retelling of the story framework sentences when we looked at the weighted scores for those sentences. This was surprising because the helpful video provided more information about the story framework sentences than the minimal video did. Moreover, our explanation of the helpful video advantage for the imagination sentences rests on the notion that children formed better, more integrated representations for story framework sentences in the helpful condition than they did for story framework sentences in the minimal and no video conditions.

This puzzling lack of difference between the helpful and minimal conditions in overall memory for the story framework sentences may be due to motivational factors. Our observations of children's affect during the experi-

mental sessions suggested that children often seemed reluctant to say a great deal, despite our attempts to introduce the experimenter, the puppet, and the procedures in a way that we felt would make them comfortable with the setting. As a result, when children remembered the imagination sentences, which were clearly the focus of the study, they appeared disinclined to continue retelling all the information that they knew from the story framework sentences, perhaps out of fear of being wrong. This motivational account is in line with the overall low performance observed.

Our subsequent analyses on the unweighted amount of information that children could recall from the story framework sentences suggested that children did form superior representations for story framework sentences in the helpful video condition. Namely, we found that when children were given only a general verbal cue, they could retell significantly more from framework sentences accompanied by helpful video than from framework sentences accompanied by minimal or no video. This is consistent with the notion that the representations for the story framework sentences in the helpful video condition were better integrated, and therefore more easily retrieved, than representations for the framework sentences accompanied by minimal video or no video.

Overall, our results indicate that dynamic video can provide a framework that facilitates subsequent language comprehension. We do not claim that the experiment here unequivocally supports our view about the exact role of dynamic video in mental model building. More research is needed to determine whether video actually plays the role in mental model theory we have proposed, or whether it provides other benefits that result in improved story representations.

It is noteworthy that, even in the helpful video condition, the retelling performance of the children was low. An important direction for future research is to create environments where video frameworks support higher levels of performance. Our observations suggest several elements that may be key to creating these environments. First, children may need longer, richer stories to engage them in more elaborated verbal practice. The stories we created may not have been interesting enough to fully engage and sustain the children's attention. Our stories were short in order to allow us to conduct a within-subjects experiment, but as a result there was very little character development, suspense, and other elements that make children's stories interesting. Second, children may benefit greatly from new, multimedia avenues for interaction and assessment that do not require them to answer questions in a highly traditional, verbal mode.

In research that is currently underway, we have developed longer video and verbal materials that are much more interesting to children than our initial short stories. These stories also communicate important content. For example, our new materials illustrate the value of literacy and include important universal themes, such as being afraid to do something and standing up for one's beliefs. The stories also include links to science and mathematics concepts that are designed to help set the stage for learning from expository as well as narrative texts (Kamil, 1991; Kirsch & Jungblut, 1986).

In studies with these materials, we are exploring ways that multimedia technologies can help children deepen their comprehension and overcome their reluctance to talk about stories that they have heard and seen. For example, software that we are developing allows children to easily revisit video scenes that they want to re-explore. In addition, traditional question-answering has been replaced by the purposeful activity of making a book that retells the video story. To make this book, children use the multimedia software to sequence pictures and narrate the story events. Our research with these new materials suggests that they dramatically increase children's motivation for story discussion. The goal of this research is first to help students experience what it is like to comprehend deeply and to experience the value of building mental models of stories. We then build on these experiences as children gradually learn to create their own mental models of language-based situations without having to rely on dynamic visual support.

In summary, data from the present study suggest that multimedia technologies may provide valuable tools for accelerating the development of literacy in young children who are at-risk of school failure. The most important finding of the present research was that children's ability to comprehend language was facilitated by dynamic video information designed to aid the development of an initial mental model of actors and settings described in short stories. Of course, the ability to retell sentences from short stories is not an indicant of high literacy. Effective story comprehension requires the ability to make appropriate inferences, for example, and these were not assessed in the present study. For us, one of the main functions of the present study is the support it provides for continuing to explore ways to use multimedia technologies to strengthen literacy. □

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Appendix ☐ Sample Stories Used in the Experimental Sessions

Brackets [ ] indicate the presence of a silent video clip in the helpful video condition. Imagination sentences are in italics. The complete set of 12 stories can be obtained from the authors.

1. [ ] Once there were two mice who were brothers. They lived in a big city. One of the mice was short, and he always wore a big hat. The hat was so big that sometimes it fell over his eyes and made it hard for him to see. The other mouse was older, and taller, and he had dark hair. The tall mouse wore a tiny little hat that sat on top of his dark hair. One day the tall mouse and the short mouse were walking home from school. The two mice had to be careful on their way home. They had to be careful because there were many big holes in the road that they could fall into. As the two mice were walking home from school, they suddenly remembered that this was the day that their Mommy mouse was making cookies. The two mice loved cookies. They could not wait to get home and eat the cookies. So instead of being careful, the two mice began to run home as fast as they could [ ].

All of a sudden, the short mouse fell into a hole. The tall mouse did not see his brother fall into the hole, so he kept on running.

2. [ ] Once there was a group of men who were traveling in a country called Canada. The men had decided to spend one year walking across the whole country. They took a tent with them, and they camped everywhere that they went [ ]. Throughout their journey, they walked and camped by rivers, lakes, and creeks, and they saw many different kinds of living creatures. One day, the men were walking beside a river [ ]. Suddenly they stopped and looked upstream and saw some bears [ ].

The bears also saw the men. The bears wanted to get away from the men. So the bears ran through the grass to the top of a hill, far away from the river.

3. [ ] One day, a duck named Donald took some money out of his purse [ ]. He gave the money to his three nephews [ ], which made them very happy [ ]. The three nephews wanted to go to the store to spend their money, so they started to run out of the house [ ]. But Donald stood in front of the front door and stopped them [ ]. He made them put their money into a bank, that was shaped like a little house [ ]. Then Donald went to sleep on the couch, holding the bank on his stomach [ ]. The three nephews wanted to get the bank without waking Donald up. They tiptoed upstairs, where they could look down at Donald [ ]. One of the nephews had a fishing rod with a hook on a string [ ]. He lowered the hook and the string down to the bank [ ], and lifted up the bank with the hook [ ]. Before any of them could get a good hold on the bank, the bank fell off the hook [ ]! The bank fell down right towards Donald's head. One of the nephews raced downstairs to try to catch the bank before it hit Donald in the head [ ].

The nephew caught the bank. But then the door to the bank fell open, and the coins fell out of the bank and fell right on Donald's nose! And that woke Donald up!