Educational Psychology Review, Vol. 14, No. 1, March 2002 (© 2002)

Pictorial Illustrations *Still* Improve Students' Learning From Text

Russell N. Carney[1,3] and Joel R. Levin[2]

Research conducted primarily during the 1970s and 1980s supported the assertion that carefully constructed text illustrations generally enhance learners' performance on a variety of text-dependent cognitive outcomes. Research conducted throughout the 1990s still *strongly supports that assertion. The more recent research has extended pictures-in-text conclusions to alternative media and technological formats and has begun to explore more systematically the "whys," "whens," and "for whoms" of picture facilitation, in addition to the "whethers" and "how muchs." Consideration is given here to both more and less conventional types of textbook illustration, with several "tenets for teachers" provided in relation to each type.*

KEY WORDS: pictorial illustrations; pictures; illustrations; pictorial mnemonic strategies; text illustrations; adjunct pictures.

In 1994, elaborate cave art was discovered in Chauvet Cave, in France, art that is thought to be 35,000 years old. Far from being primitive, these animal paintings, engravings, and drawings were skillfully executed (Clottes, 2001; Cutting and Massironi, 1998). As this find illustrates, from very early on people have created pictures. Perhaps these early paintings served as "adjunct aids" to storytellers, playing a role in humankind's development. Similarly, illustrations have been a part of our more recent development via the picture storybooks of our childhoods.

Although the empirical research evidence strongly indicates that storybook pictures may interfere with "learning to read" (i.e., the initial stages

[1]Department of Psychology, Southwest Missouri State University, Springfield, Missouri.
[2]Department of Educational Psychology, University of Arizona, Arizona.
[3]Correspondence should be addressed to Russell N. Carney, Department of Psychology, Southwest Missouri State University, Springfield, Missouri 65804; e-mail: russellcarney@smsu.edu.

1040-726X/02/0300-0005/0 © 2002 Plenum Publishing Corporation

of extracting words and meaning from text—see, e.g., Levie, 1987; Levin, 1983; Samuels, 1970), Fang (1996, p. 136) suggests that "the contributions of pictures to the overall development of children's literate behavior seems to be overwhelmingly greater than its potential dangers." In this regard, Fang (1996) lists six roles that pictures play in storybooks. Pictures may serve to help (a) establish the setting, (b) define/develop the characters, (c) extend/develop the plot, (d) provide a different viewpoint, (e) contribute to the text's coherence, and (f) reinforce the text. Fang goes on to list several benefits that pictures provide, including such things as motivating the reader, promoting creativity, serving as mental scaffolds, fostering aesthetic appreciation, and promoting children's language and literacy. Also supportive of pictures in children's storybooks, Goodman *et al.* (1994) decry the way in which illustrations have been altered in order to force them into a basal format. Describing storybooks as both "an art form and a genre of literature" (p. 20), they argue against such alteration and advocate the use of storybooks in their original format as part of the reading curriculum.

Picture storybooks are sometimes called "twice-told tales" because both mediums, verbal and pictorial, may tell the story. Such pictures are representational in nature, illustrating what is described in the text. Further, the pictures in storybooks may go beyond this role by adding additional details (e.g., Stewig, 1992). As Patricia Gauch, an author of children's books, has observed, "Art, when it's really good, doesn't imitate or mirror the text. Rather, it adds a new dimension that goes way beyond the words" (Raymond, 1995, p. 64). Using Maurice Sendak's *Where the Wild Things Are* as an example, Sipe (1998) suggests that the child constructs meaning through the interplay of text and image, which vary somewhat in content.

Although pictures in storybooks may go beyond text content, our focus in this review is on the contributions that pictures make in complementing the text—serving as adjunct aids for "reading to learn" (i.e., the processing of—which includes perceiving, understanding, and remembering—text information). More than ever in our society, written prose is accompanied by illustration (e.g., David, 1998). In our schools, and in contrast to the densely worded textbooks of the past, modern undergraduate texts are richly appointed with pictorial illustrations, diagrams, photos, and the like. Even 15 years ago, this trend was apparent. Smith and Elifson (1986) compared history textbooks of the 1960s with those of the 1980s and found a tremendous increase in the number of pictures. On university campuses, many instructors make use of software programs such as *Powerpoint* to include relevant pictures (and video) in their classroom presentations. Computer software and internet sites routinely provide pictures and illustrations as adjuncts to text content.

Given the ever-increasing use of pictures in connection with text in these and other contexts, it is timely to review recent pictorial research. In that regard, we focus here on empirical research studies that have appeared in the professional literature primarily from the 1990s through the present. As a preview of what is to come, it is clear from that literature that pictures (at least, well-selected or well-constructed pictures) reliably improve the reading-to-learn process—just as had been concluded on the basis of the pictures-in-text research literature through the 1980s (e.g., Levie, 1987; Levie and Lentz, 1982; Levin *et al.*, 1987; Levin and Mayer, 1993; Mandl and Levin, 1989; Schallert, 1980).

FUNCTIONS OF PICTURES IN TEXT

As was just noted, reviews of the effects of pictures on students' text processing conducted in the 1980s examined reading-to-learn studies and found advantages for pictures as text adjuncts. In particular, we (Levin *et al.*, 1987) structured our meta-analytic review in terms of Levin's five functions (Levin, 1981) that pictures serve in text processing—four conventional functions (decorational, representational, organizational, interpretational) and one more unconventional one (transformational). Briefly, decorational pictures simply decorate the page, bearing little or no relationship to the text content. For example, a generic drawing of a pine tree adjacent to a description of a hiking trail would be decorational in nature. In contrast, representational pictures mirror part or all of the text content and are by far the most commonly used type of illustration. For example, a picture that accurately portrays a scene described in a Harry Potter book would be deemed representational. Organizational pictures provide a useful structural framework for the text content (e.g., an illustrated map of a hiking trail, or an illustration showing the series of steps involved in performing cardiopulmonary resuscitation). Interpretational pictures help to clarify difficult text (e.g., representing blood pressure in terms of a pump system). Finally, transformational pictures include systematic mnemonic (memory enhancing) components that are designed to improve a reader's recall of text information. Here, information is often recoded to make it more concrete and then related by way of a meaningful, interactive illustration. Take, for example, a passage about a fictitious town called Belleview (which is described in more detail later in this chapter). The name, *Belleview*, is first recoded as a more concrete keyword, such as *bell*. Then, information about the town is combined pictorially in an interactive image involving a *bell*. Thus encoded, the name of the town, *Belleview*, prompts recall of the keyword, *bell*. This, in turn, brings back the interactive image that yields details about the town. Our meta-analysis of the available empirical studies yielded the effect sizes

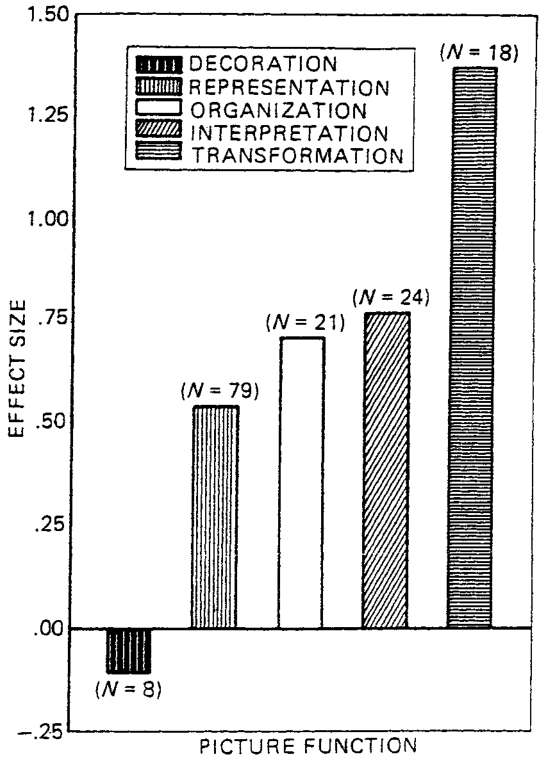

Fig. 1. Average effect size by picture function, across all units (from Levin *et al.*, 1987, p. 68).

that are presented in Fig. 1. Purely decorational pictures exhibited virtually no beneficial text-learning effects, whereas the remaining effect sizes ranged from moderate benefits (for representational pictures) to quite substantial benefits (for transformational pictures).[4]

We concluded our review with a light-hearted list that was dubbed the "ten commandments of picture facilitation" (Levin *et al.*, 1987, pp. 73–77). The commandments were as follows:

1. Pictures shalt be judiciously applied to text, to remember it wholly.
2. Pictures shalt honor the text. That is, the picture needs to correspond to the text. As we have seen, purely decorational pictures do not improve students' learning of text content.

[4]The effect sizes and interpretations are based on Cohen's *d*, or the standardized-difference between an experimental (here, picture) and control (here, no picture) condition (Cohen, 1988).

3. Pictures shalt not bear false fitness to the text. Conflicting pictures are most likely not helpful and may even hinder learning.
4. Pictures shalt not be used in the presence of "heavenly" bodies of prose. If the text is highly memorable to begin with, there is no need to add pictures.
5. Pictures shalt not be used with text cravin' for images. That is, if the text content directly elicits useful mental images in students (as is often the case with engaging concrete narrative texts), providing pictures or instructing students to generate their own text-related imagery is often superfluous.
6. Pictures shalt not be prepared in vain. A reader's possession of basic reading skills is required for picture benefits to emerge. Pictures are intended as text supplements rather than as text substitutes.
7. Pictures shalt be faithfully created from generation to generation. As an analog to Commandment 6, this means that for a learner to generate beneficial internal pictorial representations of the text (i.e., visual images), the learner must similarly possess adequate basic reading skills.
8. Pictures shalt not be adulterated. This emphasizes the need to design good-quality pictures.
9. Pictures shalt be appreciated for the art they art. Veridical "pictorial" representations should be distinguished from "figural" representations, such as graphs or flow charts.
10. Pictures shalt be made to perform their appropriate functions. The amount and type of prose-learning facilitation are related to the type of picture selected.

As an addendum to pictures-in-text commandments, Levin and Mayer (1993) proposed seven "C" principles for explaining the "whys" of picture facilitation. In particular, they suggest that pictures improve students' learning from text because they make the text more concentrated (focused, with respect to directing a reader's attention), compact/concise ("a picture is worth a thousand words"), concrete (the representation function), coherent (the organization function), comprehensible (the interpretation function), correspondent (relating unfamiliar text to a reader's prior knowledge), and codable (the mnemonic transformation function). Further, Levin and Mayer adapt Bransford's version (Bransford, 1979) of Jenkins' tetrahedral model (Jenkins, 1979) to argue that four variables must be taken into account when considering the "whys," "whens," and "for whoms" of picture facilitation: desired performance outcomes (e.g., comprehension, memory, transfer), the nature of the illustrations (e.g., that they must be related to the text content), the nature of the text (e.g., the more difficult the text is to understand, the more that pictures help), and learner characteristics (e.g., learners lacking domain-relevant background knowledge benefit more from illustrations)—see also Mayer (1992) and Gyselinck and Tardieu (1999).

In a related review, Peeck (1993) lists a number of reasons why pictures should facilitate learning, including increasing motivation, focusing attention, depth of processing, clarification of text content, dual-coding theory, distinctive encoding, decreasing interference/decay, processing support for the type of information typically extracted from a specific type of text (e.g., Waddill *et al.*, 1988; Waddill and McDaniel, 1992), and serving as mental models (e.g., Glenberg and Langston, 1992; Gyselinck and Tardieu, 1994). Nevertheless, Peeck goes on to doubt that pictures contribute much to text processing in real-life situations. As Weidenmann (1989) argued, for a variety of reasons "good pictures fail." For example, pictures are often viewed as "easy" material and may be examined only superficially by learners.

Peeck also describes picture effects in relation to the tetrahedral model. In contrast to the Levin and Mayer (1993) review, which focused largely on illustration–text characteristics and correspondence, Peeck's paper emphasizes the latter part of Bransford's model: learner characteristics and learning activities. Learner characteristics of importance are the age of the learner, the learner's reading ability, and the learner's "visual literacy" (i.e., one's ability to "read" pictures). Peeck describes several attempts to teach such literacy, including approaches by Constable *et al.* (1988) and Higgins (1979). He recommends teaching visual literacy in the context of teaching reading comprehension (e.g., Palincsar and Brown, 1984). Shifting to learning activities, Peeck asserts that simply asking students to pay more attention to pictures is not likely to increase students' processing of them. He cites three studies (Bernard, 1990; Reinking *et al.*, 1988; Weidenmann, 1989) suggesting that the effect of text illustrations is enhanced when explicit instructions or cues are provided (Peeck, 1993, p. 234).

Peeck concludes with a helpful summary table. Here, his recommendation for the optimal processing of adjunct pictures is to "tell the student to do something with the illustration" and require a "controllable" product (p. 235). For example, one might ask students to label features of illustrations accompanying text—analogous to Dean and Kulhavy's findings with respect to labeling maps (Dean and Kulhavy, 1981).

RECENT RESEARCH

We now briefly review several pictures-in-text studies published in the last decade. This review is grouped according to the posited Levin *et al.* (1987) functions of the particular pictures examined: representational, organizational, interpretational, and transformational. Because of space limitations, our summary is selective (although, we hope, representative), rather than comprehensive. In addition, we include here only research findings based on "pictures" as *text-provided visual illustrations* (on the page, or on the computer screen) and not findings based on "pictures" as *learner-generated visual imagery* (in the head)—see Levin *et al.* (1987) for both the distinction and a meta-analytic summary of both literatures through the 1980s.[5]

Representational Pictures

Recall that representational pictures literally depict or overlap (part or all of) the text content. They are undoubtedly the most common and pervasive type of pictorial text adjunct. Adler's dissertation (Adler, 1993) looked at how different directions for processing representational pictures affected students' recall of text information dealing with water safety and rescue in emergency situations. College undergraduates were randomly assigned to one of four picture-processing conditions: no explicit processing directions, explicit processing (e.g., "How many objects are in the picture? Write your answer below."), semantic elaboration (e.g., "Specifically, how does the picture relate to the text? Write your answer below."), and interrogative elaboration (e.g., answer a "why" or "what" question, such as "What other things are thrown the way this is thrown?"). Adler found a statistical advantage for the interrogative elaboration treatment.

Using Paivio's dual-coding theory (Paivio, 1971, 1986) as a theoretical backdrop, David (1998) conducted several experiments concerning the usefulness of incorporating a representational picture into a news item. As David (1998, p. 182) notes, "Because the basic purpose of the representation function is to make the story concrete, it provides an ideal framework to test the interaction between news story concreteness and the facilitative role of pictures." In Experiment 1, for example, undergraduates read a randomized set of 30 news stories dealing with celebrities. The 30 stories were presented via computer, and of these, half included a representative photograph. Following a 30-min filler task, students were asked to recall the names of the celebrities. David found a recall advantage for the text/picture condition relative to the text-only condition (corroborating conclusions of Levin and Berry [1980] that were derived from children *listening* to news stories with

[5] As an aside that is especially apropos for present purposes, we note that (1) professional journal articles typically consist of densely worded technical text; (2) such text often can benefit from clarifying pictorial accompaniments; but (3) pictures, diagrams, and figures take up precious journal space, adding to the cost of an already costly enterprise. Nevertheless, it is ironic that one often reads research articles focusing on the effects of text-accompanying illustrations without encountering even a single illustration of the illustration used in the research.

and without pictorial accompaniments). Additional experiments replicated this basic finding, and also supported the notion that concrete news in general was better remembered than abstract news. Moreover, in one experiment (Experiment 3) David found that adding a picture to a concrete news story was more beneficial than adding a picture to an abstract news story.

Many of the representational pictures studies reviewed through the 1980s consisted of children processing narrative passages. A recently reported study by Rubman and Waters (2000) extended Lesgold *et al.*'s earlier work on young children's (first graders') cumulative construction of a picture (through the use of illustrated cutout figures and backgrounds) while listenting to a story (Lesgold *et al.*, 1975). In the Rubman and Waters study, third and sixth graders engaged in a similar picture-construction task while reading a passage on their own. In addition to replicating the Lesgold *et al.* (1975) finding of increased story recall by picture-constructing children (relative to no-picture control children), Rubman and Waters reported that the children who constructed pictures of the story were better able to detect inconsistencies embedded in the stories (i.e., contradictions with either preceding text information or common knowledge). The latter result was assumed by the authors to reflect superior comprehension monitoring (e.g., Markman, 1979) on the part of children who were provided with the pictorial accompaniments.

Organizational Pictures

As stated earlier, organizational pictures provide a structural framework for the text content. Betrancourt and Bisseret (1998) wanted to know how best to present the text information in conjunction with an organizational picture.[6] Toward that end, they presented pictorial information on a computer through pop-up windows. Three displays on the computer screen were compared: a "split" display, in which the text and picture appeared in separate parts of the screen; an "integrated" display, in which the text and picture appeared in close proximity; and a "pop-up" display, in which the pictorial elements appeared when the user clicked a link on the screen. The authors summarize their findings as follows:

> The integration of text information via pop-up fields increased the learning efficiency compared with a split format, but this advantage is significant only with regard to the integration of text-picture information, as opposed to either pictorial or textual information alone. Second, the information was more quickly retrieved from memory when the material was integrated (spatially or in pop-up fields) as compared to a

[6]Our characterizing Betrancourt and Bisseret's pictures as "organizational" (Betrancourt and Bisseret, 1998) is based on the illustration provided in the published paper.

> split display. These results support the hypothesis that an integrated display (either spatially or in pop-up windows) improves subjects' performance in memorizing a labeled schema. (Betrancourt and Bisseret, 1998, p. 268)

The authors go on to list three "pragmatic" reasons why the pop-up approach might be preferred: (a) it saves screen space and, hence, improves legibility; (b) it allows either text or picture to appear in the foreground (e.g., Levie and Lentz, 1982; Peeck, 1993); and (c) it is more interactive for the learner and, thus, improves motivation and performance.

Betrancourt and Bisseret (1998, p. 272) additionally speculate that

> the integrated format helps the learners mentally integrate the two sources of information and allows the learners to avoid splitting their attention between the two media. Therefore, fewer cognitive resources would be required to process the document, thus increasing the remaining working-memory capacity allocated to learning.

Such interpretations mesh well with those offered by other researchers with respect to the function of integrated pictures in learning science and mathematics concepts and skills (e.g., Marcus *et al.*, 1996; Mayer and Anderson, 1992; Mayer and Moreno, 1998; Mousavi *et al.*, 1995)—as becomes apparent in the immediately following section.

Interpretational Pictures

By far, the greatest number of research studies during the decade of the 1990s have examined interpretational pictures as clarifiers of difficult-to-understand material (often scientific or other technical concepts). In that regard, Richard Mayer and his colleagues have extensively investigated the use of adjunct illustrations in facilitating students' understanding of scientific explanations (see also Mayer's paper in this issue). Mayer (1989) suggested that four conditions must be met for pictorial illustrations to be helpful: (1) the text must describe a cause-and-effect system; (2) the illustrations must reasonably depict the system or process under consideration; (3) appropriate outcome measures must be selected; and (4) the learners must be inexperienced with respect to the targeted content domain. As a representative example, Mayer and Gallini (1990) conducted three experiments dealing with scientific devices (see Fig. 2). In these studies, a no-illustration (control) condition was compared to two illustration conditions. One presented static pictures of a machine (e.g., a braking system), with labels for each step ("steps" pictures), and the second displayed the "on" and "off" states of the machine, with labels for each part and step ("parts-and-steps" pictures). It was found that parts-and-steps pictures improved students' conceptual information recall and problem solving, particularly for low prior-knowledge students. Mayer and Gallini refer to parts-and-steps pictures as "explanative" illustrations and suggest that such illustrations serve as "runnable mental

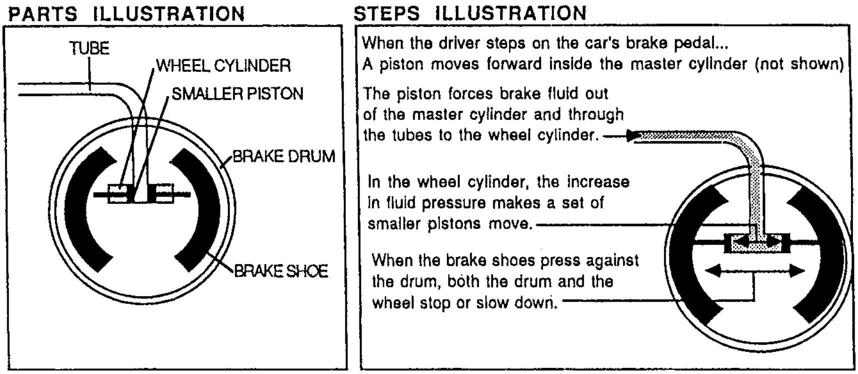

Fig. 2. Illustration of a brake system (from Mayer and Gallini, 1990, p. 716).

models" for the learner (see also Glenberg and Langston, 1992; Gyselinck and Tardieu, 1994, 1999). More recently, Mayer and Moreno (1998) compared on-screen text with concurrent narration as adjuncts to a computer-generated animation that presented the process of lightning formation. They found performance advantages for the concurrent narration and offered a "split-attention" account in the context of Paivio's dual-processing model of working memory (Paivio, 1986).

Reid and Beveridge (1990) conducted a computer-based experiment dealing with illustrated science texts.[7] One hundred eighty 14-year-olds were directed to study three illustrated science topics presented by computer: "transport of sugar in plants," "exchange of gases in the leaf," and "conduction of the nerve" (p. 77). The length of the text ran from 232 to 245 words. The computer recorded the time that students spent on the sentences and pictures. Additionally, it recorded at which point in the sentences the student first looked at the picture. General findings were that (a) more difficult topics were associated with more time looking at pictures (consistent with assumptions by Levin and Mayer [1993] and Mayer [1989]) and (b) "less successful" students spent more time looking at the pictures than did their "more successful" counterparts. Note, however, that although the first finding is relatively interpretable (because "text difficulty" levels were defined on an a priori basis), the second finding is not (because "success" levels were defined post hoc on the basis of students' learning of the experimental texts and, therefore, there is no clear separation of the effects of student characteristics, picture looking, and text learning).

[7]Although this paper included six tables and three figures, no examples of the pictures under study were provided. Inasmuch as the texts addressed science (biology) concepts, we have included the study under the "interpretational" heading.

Riding and Douglas (1993) examined students' "cognitive style" in relation to their learning about car brake systems under two computerized presentation formats. Secondary students were assigned randomly to one of two experimental conditions: (1) text plus accompanying verbal descriptions and (2) text plus accompanying pictorial illustrations. Completion of the computer activity and the test was followed by a cognitive-style assessment, with the focal style being the verbal-imagery dimension. In brief, "imagers" performed better (learned more) than "verbalizers" with the pictures format, whereas verbalizers performed better than imagers with the descriptions format.

Prompted, in part, by the findings of an assessment team that concluded that "few texts and their accompanying illustrations [are] . . . even marginally clear and easy to comprehend" (Benson, 1995, p. 2; see also Blystone and Dettling, 1990), Benson (1995) conducted an interesting dissertation investigation titled "Problems in picturing text." In that study, 15 experts from three disciplines (textbook illustration design, editing, and biology) were asked to diagnose and solve problems related to three high-school level biology topics that were accompanied by illustrations. One illustration (which we would characterize as "representational") depicted the flow of ice in New England during a particular ice age. A second illustration (characterized as "organizational") illustrated the life cycle of a fern. The third illustration (characterized as "interpretational") displayed the life cycle of black bread mold.[8] The three text/illustration combinations were also read and interpreted by 14 first-year undergraduate biology students.

Perhaps surprisingly, the experts were unable to predict the undergraduates' misinterpretations of the illustrations, and some did not even notice problems in the text/illustration combinations themselves. Benson suggests that such problems may happen for two reasons. First, they may occur because the various experts producing text/illustration combinations are not working face-to-face. Second, and relatedly, problems may occur because experts working independently may "advocate their own problem solving frameworks rather than synthesize their perspectives with those of other experts" (Benson, 1995, p. vi).

Balluerka (1995) compared adjunct instructional aids in the context of a relatively long scientific passage dealing with the photocopying process (1,336 words). The four conditions provided either (a) no adjunct aids (control); (b) written instructions that provided an overview; (c) the same written instructions plus directions to form a study outline; and (d) an illustration (which we would characterize as an "interpretational" picture) that depicted

[8]We have placed this research under the "interpretational" heading because one of the illustrations is regarded as "interpretational" and all illustrations focused on science concepts.

the systems described in the text. Students were allowed 22 min to study the text and the corresponding adjunct aids. Dependent measures include a 5-item application test, and a 24-item true/false recognition test, administered either immediately or after 24 hr. Balluerka's results (based on both the immediate and delayed tests) indicated that all three adjunct aids facilitated performance in comparison to the no-aids control group.

Iding (1997) conducted three experiments in which questions were designed to facilitate the processing of scientific diagrams in textbooks. In these studies, questions either (a) replaced traditional figure captions on the illustrations (Experiment 1); or (b) were placed directly in the text (Experiments 2 and 3). Based on her research, Iding concluded that the use of questions did not facilitate learning. She explained her findings in terms of previous "cognitive load" theorizing (e.g., Mousavi *et al.*, 1995). That is, "questions about illustrations might cause cognitive resources to be unnecessarily and deleteriously expended in the text-diagram integration process" (Iding, 1997, p. 22).

Ollerenshaw *et al.* (1997) compared the performance of undergraduates under four study conditions, in a passage dealing with the operation of pumps: text only, text plus diagram with labels, text plus diagram illustrating major operating stages, or "full multimedia" (text and an animated simulation were computer projected in a darkened room). In the initial session, students completed a test of prior knowledge, similar to that of Mayer and Gallini (1990). In a second session, students completed a measure of learning style (the "Study Process Questionnaire"), and, following study of the pumps passage in their respective conditions for 10 min, they took a text comprehension test. In general, the authors found that students provided with computer-simulated multimedia diagrams outperformed students in the other three conditions. Moreover, from a student-differences perspective (and in accord with findings of both Mayer and Gallini [1990] and resultant assumptions of Levin and Mayer [1993]), the authors found that ". . . students with low prior knowledge profited most from comprehensive, informative visual illustrations" (Ollerenshaw *et al.*, 1997, p. 235).

Two computer experiments involving the structuring and sequencing of interpretational illustrations were conducted by Weidenmann *et al.* (1999). The learning material dealt with three topics: the awarding of "quality badges," solar energy, and the effect of stress on hormones. Three different picture formats were compared: (a) a top-down, "zoom" presentation; (b) a step-by-step presentation; and (c) a static picture. Learning via these presentations was followed by an unrelated activity and then a test over the content. Participants also assessed their strategy's effectiveness and stated the order of their preferences for the three picture formats. In the latter instance, students tended to prefer the "zoom" presentation. Interestingly, however, students' preferences for particular strategies was not related to how well they learned the material. The authors concluded that the particular strategy students use is less important than the amount of time spent processing the pictures.

Transformational (Mnemonic) Pictures

Levin and his colleagues have examined adjunct transformational (mnemonic) pictures as aids to students' learning from text (for earlier reviews, see Levin, 1982; McCormick and Levin, 1987). During the past decade, Dretzke (1993) examined the effects of mnemonic illustrations on the prose recall of younger (17–29 years), middle-aged (40–50 years), and older (60–84 years) adults. Within each age group, participants were assigned randomly to one of three conditions, two of which are relevant to this review: mnemonic illustration and text-only control. Based on the earlier work of Levin *et al.* (1983), the text material consisted of six passages describing fictitious cities and five associated concrete attributes, as, for example:

> Belleview is attractively situated at the base on an *inactive volcano*, which last erupted in the eighteenth century. *Hot air balloon rides* provide a thrilling way for visitors to take in the lovely surroundings. A large *automobile museum* in the city boasts to have the best collection of turn-of-the-century classics that can be found in this part of the country. This is also the home of skilled craftsmen known for their *handmade musical instruments*. Every summer, thousands of folks from all over the world come here to compete against the best in an Olympic-style *marathon*. (Dretzke, 1993, pp. 493–494)

In the mnemonic condition, the cities' names were represented as illustrated "keywords" (e.g., a bell for Belleview), along with the pictured city attributes (see Fig. 3). Dretzke found that mnemonic illustrations were useful in facilitating both younger and middle-aged adults' recall of concrete text material (relative to the text-only control condition).[9] Keyword illustrations served to organize participants' subsequent recall of the text information (i.e., attribute clustering) at all three age levels. Further, Dretzke found a relationship between verbal ability and recall performance for older adults in both the mnemonic and control conditions, suggesting that "... with increasing age it becomes more difficult for adults of relatively lower verbal ability to process effectively the information presented in complex pictorial interactions" (p. 499).

Levin and Levin (1990) reported a series of experimental studies (including those of Levin *et al.*, 1988, and Rosenheck *et al.*, 1989) in which a pictorial mnemonic taxonomy, or "mnemonomy," was constructed to organize the content from a botany passage (see Fig. 4). Of particular interest

[9] Recall performance in the older adult sample was relatively low across the board.

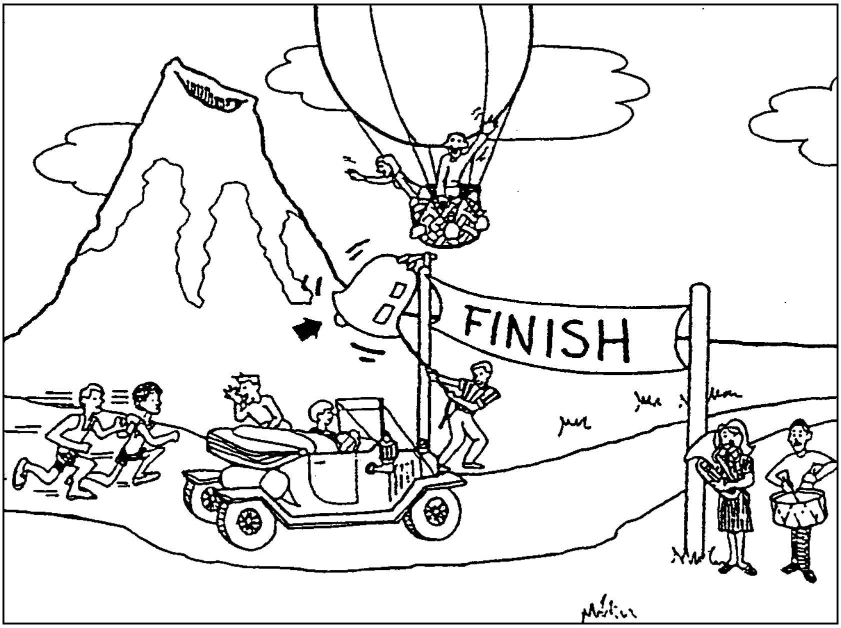

Fig. 3. Transformational illustration designed to represent details about the ficticious city of Belleview (from Dretzke, 1993, p. 494).

to these investigators was whether mnemonic illustrations could enable students go “beyond the information given” (e.g., Bruner, 1966) and assist them in performing “higher order” cognitive application tasks (Levin, 1986), such as those involving inference, problem solving, and analogical and syllogistic reasoning based on the botany content. Combined with separate mnemonic illustrations for solidifying unfamiliar terminology and definitions, the pictorial mnemonomy was found to be a potent facilitator of students’ information reconstruction and application performance (relative to performance in a free-study condition), both on immediate tests and on delayed tests up to 2 months later.

More recently, Levin’s research group has extended their positive higher order mnemonic findings to other learning-from-text tasks. For example, Atkinson *et al.* (1999) conducted three experiments in which the text-processing benefits of rows-and-columns matrix structures, mnemonic illustrations, and their combination (in a mnemonic matrix, or “mnematrix”) were examined. A central conclusion of these studies was that the memorial benefits of mnemonic illustrations and mnematrices may be more critical than the “. . . computational-efficiency properties of [conventional] matrices

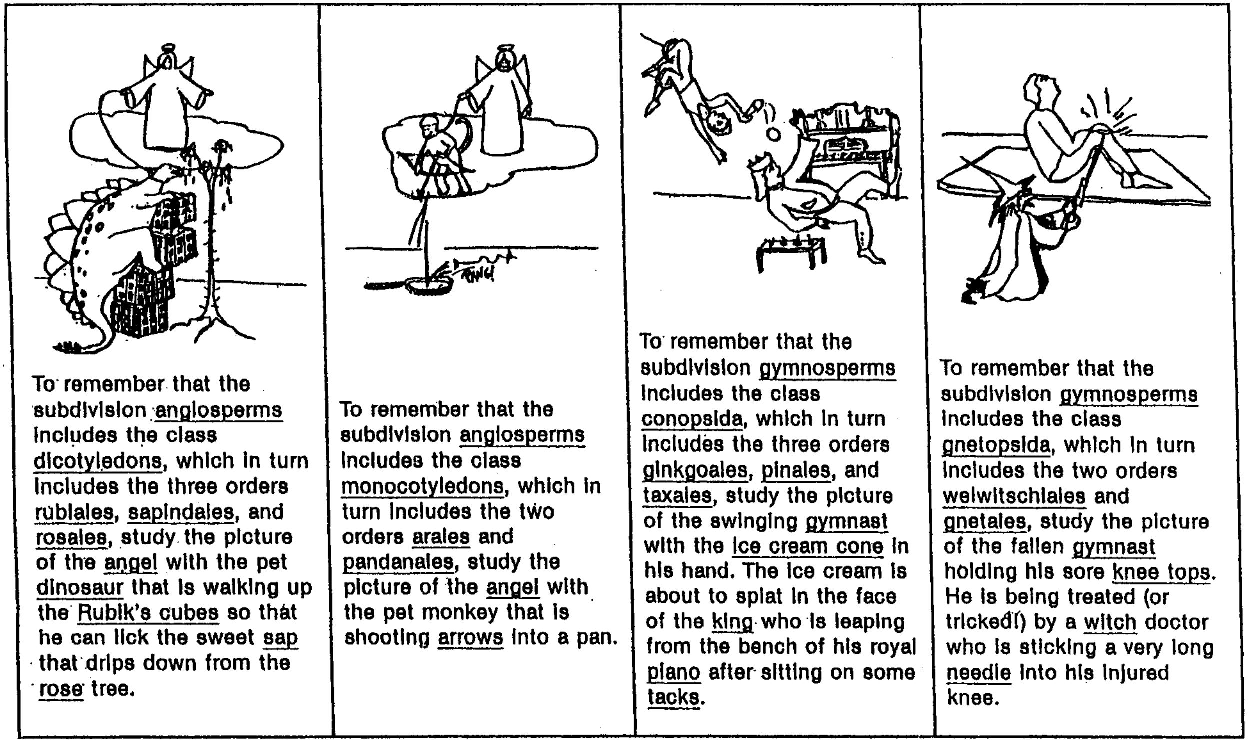

Fig. 4. Pictorial "mnemonomy" designed to promote students' higher order learning (from Levin and Levin, 1990, p. 305).

with respect to performing well on tasks . . . requiring memory for previously studied factual information, including the organization and manipulation of that information" (Atkinson *et al.*, 1999, p. 356). The authors argue that the ready access to information that mnemonic strategies afford can facilitate students' acquisition of higher order concepts and skills. Additional recent research (e.g., Atkinson *et al.*, 1999) has replicated and extended the initial Atkinson *et al.* findings.

As a final transformational-illustration example, Rummel *et al.* (2001) recently constructed a lengthy two-topic text passage in which was presented a variety of theoretical (Topic 1) and psychometric (Topic 2) conceptions of intelligence. The passage was given to 40 college students under one of two conditions, mnemonic and free study. In the mnemonic condition, illustrations relating people's names (e.g., a thirsty person for *Thurstone*, a gardener for *Gardner*) to both their associated topic (theory or measurement) and their specific contributions. For both factual memory (a relatively "lower level" name-fact matching task) and essay writing (a relatively "higher level" critical-information production task), students in the mnemonic condition outperformed their free-study counterparts.

GUIDELINES FOR EDUCATORS CONSIDERING TEXT-ACCOMPANYING ILLUSTRATIONS

We conclude this pictures-in-text review with a list of 10 practical suggestions for educators, or what might be called "10 tenets for teachers." The first four tenets are derived from our earlier "ten commandments" of pictorial facilitation of text information (Levin *et al.*, 1987).

1. Select pictures that overlap with text content. Learning benefits occur when pictures and text provide congruent, or supporting, information. Decorational illustrations may help to make the text more attractive or more marketable, but they are unlikely to enhance desired outcomes related to understanding, remembering, or applying the text content. As a corollary related to the pervasive use of pictures in teaching children beginning reading skills (i.e., phonemic awareness, word decoding, and word recognition): With precious few exceptions (e.g., Levin, 1983, pp. 219–223), the bulk of the research literature suggests that this is not a good idea.
2. Easy-to-follow texts that are highly concrete and engaging (e.g., interesting narrative passages) readily elicit visual imagery in students and therefore are unlikely to yield additional cognitive benefits from the inclusion of pictures.

3. Prerequisite basic reading skills are required on the part of the student for positive effects of pictures to emerge. At the same time, young children or other students lacking such skills can improve their *listening* comprehension and recall with well-selected pictorial accompaniments.
4. Choose pictures with an eye toward the desired functions they are to play, namely—and applying earlier-presented terminology—representational (to make the text more concrete), organizational (to make the text more coherent), interpretational (to make the text more comprehensible), or transformational (to make the text more codable—and more memorable), in light of the desired learning outcomes.

   The remaining six tenets are derived from our review of some of the more recent pictures-in-text literature.
5. In general, the more complex the text, the more likely that pictures are helpful (Levin and Mayer, 1993). In particular, explanative (or interpretational) pictures function as useful mental models if (a) the text describes a cause-and-effect system or complex process (e.g., Mayer and Gallini, 1990) and (b) the learners are relatively inexperienced in the content domain (Mayer and Gallini, 1990; Ollerenshaw *et al.*, 1997).
6. To yield the maximum benefits from pictures as text adjuncts, direct students to do something with the picture that yields a controllable product, such as labeling the features of the illustration (Peeck, 1993) or structuring the process so that students are certain to be constructing veridical pictorial representation of the passage (e.g., Rubman and Waters, 2000). Adler (1993) found that asking “why” or “what” questions about pictures was useful, although it should be noted that Iding (1997) did not find question benefits in another context.
7. Computer software that uses integrated or pop-up displays may be more effective than those using split displays in which the picture and text appear in separated locations on the screen (Betrancourt and Bisseret, 1998). This picture-text adjacency principle is consistent with Mayer’s conclusions from his multimedia investigations (see, Mayer, this issue). Simply put, adjunct aids need to be proximally adjunct!
8. You may also want/need to consider students’ individual learning styles. For example, Riding and Douglas (1993) found that students displaying an “imager” cognitive style profited more from animated pictorial adjuncts than did students displaying a “verbalizer” style. In a complementary vein two decades earlier, Levin *et al.* (1974,

Experiment 2) reported that students who were adept at remembering pictured objects benefitted more from instructions to generate text-related visual images while they read (relative to students who were not as adept at remembering pictured objects).

9. Realize that even professionally designed pictures and illustrations in textbooks are not necessarily perfect, nor easy for students to comprehend or remember (e.g., Benson, 1995; see also Guri, 1985). Thus, even though a particular textbook illustration may be *designed* to be cognitively useful, it may turn out to be functionally useless unless the learner perceives the illustrated content or process in the intended manner.
10. Finally—and of special significance to the present authors—consider the use of transformational (mnemonic) pictures as pictorial adjunct aids to text. Although mnemonic illustrations are rarely encountered in current textbooks (see, e.g., Mayer, 1992), teachers can learn how to develop creative and powerful illustrations of this kind. Nontechnical accounts of mnemonic principles and procedures targeted at educators, students, and just regular folks have been provided by Carney and Levin (1998), Carney *et al.* (1993), Higbee (1988), and Levin (1980, 1998), among others. Mnemonic illustrations have been associated with impressive memory-for-text gains in a large number of experimental studies dealing with a variety of text topics and genres (e.g., Levin, 1995; McCormick and Levin, 1987), with such illustrations producing higher order application gains as well (e.g., Atkinson *et al.*, 1999; Levin and Levin, 1990). At the same time, with the numerous mnemonic text-learning successes have come selected mnemonic text-learning failures (e.g., Ho, 1999; Renandya *et al.*, 1993). An important research priority is to identify the situational characteristics that distinguish between the successes and failures so that more specifically "useful" mnemonic illustration guidelines can be developed.

CONCLUSION

Although our 10 commandments of pictures-in-text facilitation (Levin *et al.*, 1987) were not chiseled in stone, they nonetheless have stood the test of more than a decade's worth of time. Indeed, the first four of our current 10 tenets for teachers were derived from those commandments. Our additional six teacher-directed suggestions come from research conducted throughout the decade of the 1990s—research that, as we move into the new millennium, increasingly involves "pictures" as encapsulated in computer displays involving image maps, animations, video clips, hypermedia, and beyond. Indeed, the ease with which instructors can add pictorial elements to Web-based course presentations will likely lead to their proliferation in the future. In that regard, it has been noted that novice PowerPoint users often present too much verbal information on the screen. Complementarily, we caution instructors of the future not to flood learners with adjunct computer graphics, but rather to deploy them judiciously. An interesting, yet-to-be addressed, empirical question is whether the "cyberstudents" (Wang and Newlin, 2000) of the new millennium will differ from the book-learned "liberstudents" of the century past in their ability to process picture and text information comprehensively, and with comprehension.

In many ways, pictures—and guidelines for their effective use—transcend the medium. Whether ancient cave painting or computer screen icon, pictures are part of the human experience. Based on our review of the empirical literature, carefully constructed illustrations continue to receive high marks as text adjuncts. Accordingly, and with an appreciative wink at Paul Simon, the closing tribute is in order: Pictures, we still praise thee after all these years!

REFERENCES

Adler, C. (1993). Directed picture processing: The effects for learners on recall of related text. *Diss. Abstr. Int.* 54(3-A): 863.

Atkinson, R. K., Levin, J. R., Beitzel, B. D., and Glover, T. A. (1999). In search of the unique cognitive benefits of mnemonic matrices. Paper presented at *the Annual Meeting of the American Educational Research Association*, Montreal, April 1999.

Atkinson, R. K., Levin, J. R., Kiewra, K. A., Meyers, T., Kim, S., Atkinson, L. A., Renandya, W. A., and Hwang, Y. (1999). Matrix and mnemonic text-processing adjuncts: Comparing and combining their components. *J. Educ. Psychol.* 91: 342–357.

Balluerka, N. (1995). The influence of instructions, outlines, and illustrations on the comprehension and recall of scientific texts. *Contemp. Educ. Psychol.* 20: 369–375.

Benson, P. J. (1995). Problems in picturing text. *Diss. Abstr. Int. Sec. A: Humanities Soc. Sci.* 55(11-A): 3357.

Bernard, R. M. (1990). Using extended captions to improve learning from instructional illustrations. *Br. J. Educ. Technol.* 21: 215–225.

Betrancourt, M., and Bisseret, A. (1998). Integrating textual and pictorial information via pop-up windows: An experimental study. *Behav. Inf. Technol.* 17: 263–273.

Blystone, R., and Dettling, B. (1990). Visual literacy in science textbooks. In Rowe, M. B. (ed.), *What Research Says to the Science Teacher: The Process of Knowing, Vol. 6*, National Science Teachers Association, Washington, DC, pp. 19–40.

Bransford, J. D. (1979). *Human Cognition: Learning, Understanding, and Remembering*, Wadsworth, Belmont, CA.

Bruner, J. S. (1966). *Toward a Theory of Instruction*, Norton, New York.

Carney, R. N., and Levin, J. R. (1998). Coming to terms with the keyword method in introductory psychology: A "neuromnemonic" example. *Teaching Psychol.* 25: 132–134.

Carney, R. N., Levin, M. E., and Levin, J. R. (1993). Mnemonic strategies: Instructional techniques worth remembering. *Teaching Except. Child.* 25(4): 24–30.

Clottes, J. (2001). France's magical ice age art: Chauvet cave. *Nat. Geogr.* 200(2): 104–121.

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences*, Rev. edn., Erlbaum, Hillsdale, NJ.

Constable, H., Cambell, B., and Brown, R. (1988). Sectional drawings from science textbooks: An experimental investigation into pupils' understanding. *Br. J. Educ. Psychol.* 58: 89–102.

Cutting, J. E., and Massironi, M. (1998). Pictures and their special status in perceptual and cognitive inquiry. In Hochberg, J., Carterette, E., and Friedman, M. (eds.), *Perception and Cognition at the Century's End: Handbook of Perception and Cognition*, 2nd edn., Academic Press, San Diego, pp. 137–168.

David, P. (1998). News concreteness and visual-verbal association: Do news pictures narrow the recall gap between concrete and abstract news? *Hum. Comm. Res.* 25: 180–201.

Dean, R. S., and Kulhavy, R. W. (1981). The influence of spatial organization in prose learning. *J. Educ. Psychol.* 73: 57–64.

Dretzke, B. J. (1993). Effects of pictorial mnemonic strategy usage on prose recall of young, middle-aged, and older adults. *Educ. Gerontol.* 19: 489–502.

Fang, Z. (1996). Illustrations, text, and the child reader. What are pictures in children's storybooks for? *Read. Horizons* 37: 130–142.

Glenberg, A. M., and Langston, W. E. (1992). Comprehension of illustrated text: Pictures help to build mental models. *J. Mem. Lang.* 31: 129–151.

Goodman, K., Maras, L., and Birdseye, D. (1994). Look! Look! Who stole the pictures from the picture books? The basalization of picture books. *New Advocate* 7(1): 1–24.

Guri, S. (1985). The function of diagrams in learning from social science self-study texts. Paper presented at *the Annual Meeting of the American Educational Research Association*, Chicago, March–April 1985.

Gyselinck, V., and Tardieu, H. (1994). Illustrations, mental models, and comprehension of instructional text. In Schnotz, W., and Kulhavy, R. W. (eds.), *Comprehension and Graphics*, North-Holland, Amsterdam.

Gyselinck, V., and Tardieu, H. (1999). The role of illustrations in text comprehension: What, when, for whom, and why? In van Oostendorp, H., and Goldman, S. R. (eds.), *The Construction of Mental Operations During Reading*, Erlbaum, Mahwah, NJ.

Higbee, K. L. (1988). *Your Memory: How It Works and How to Improve It*, 2nd edn., Prentice Hall, New York.

Higgins, L. C. (1979). Effects of strategy-oriented training on children's inference from pictures. *Educ. Comm. Technol. J.* 27: 265–280.

Ho, E. (1999). *The Heart of the Matter: The Use of Mnemonics and Analogies in Learning Science Text*, Unpublished Masters Thesis, University of Wisconsin, Madison.

Iding, M. K. (1997). Can questions facilitate learning from illustrated science texts? *Read. Psychol.* 18: 1–29.

Jenkins, J. J. (1979). Four points to remember: A tetrahedral model of memory explanations. In Cermak, L. S., and Craik, F. I. M. (eds.), *Levels of Processing in Human Memory*, Erlbaum, Hillsdale, NJ, pp. 429–446.

Lesgold, A. M., Levin, J. R., Shimron, J., and Guttman, J. (1975). Pictures and young children's learning from oral prose. *J. Educ. Psychol.* 67: 636–642.

Levie, W. H. (1987). Research on pictures: A guide to the literature. In Willows, D. M., and Houghton, H. A. (eds.), *The Psychology of Illustration: I. Basic Research*, Springer, New York, pp. 1–50.

Levie, W. H., and Lentz, R. (1982). Effects of text illustrations: A review of research. *Educ. Comm. Technol. J.* 30: 195–232.

Levin, J. R. (1980). Try a new method of vocabulary instruction. *Weekly Reader* (Teacher's Edition 4) 61(25): 1–3.

Levin, J. R. (1981). On functions of pictures in prose. In Pirozzolo, F. J., and Wittrock, M. C. (eds.), *Neuropsychological and Cognitive Processes in Reading*, Academic Press, New York, pp. 203–228.

Levin, J. R. (1982). Pictures as prose-learning devices. In Flammer, A., and Kintsch, W. (eds.), *Discourse Processing*, North-Holland, Amsterdam, pp. 412–444.

Levin, J. R. (1983). Pictorial strategies for school learning: Practical illustrations. In Pressley, M., and Levin, J. R. (eds.), *Cognitive Strategy Research: Educational Applications*, Springer, New York, pp. 213–237.
Levin, J. R. (1986). Four cognitive principles of learning-strategy instruction. *Educ. Psychol.* 21: 3–17.
Levin, J. R. (1995). Stalking the wild mnemos: Research that's easy to remember. In Brannigan, G. G. (ed.), *The Enlightened Educator: Research Adventures in the Schools*, McGraw-Hill, New York, pp. 85–108.
Levin, J. R. (1998). How to remember (almost) everything. In Suid, M. (ed.), *The Kids' How to Do (Almost) Everything Guide*, Monday Morning Books, Palo Alto, CA, pp. 126–128.
Levin, J. R., Anglin, G. J., and Carney, R. N. (1987). On empirically validating functions of pictures in prose. In Willows, D. M., and Houghton, H. A. (eds.), *The Psychology of Illustration: I. Basic Research*, Springer, New York, pp. 51–85.
Levin, J. R., and Berry, J. K. (1980). Children's learning of all the news that's fit to picture. *Educ. Comm. Technol. J.* 28: 177–185.
Levin, J. R., Divine-Hawkins, P., Kerst, S. M., and Guttmann, J. (1974). Individual differences in learning from pictures and words: The development and application of an instrument. *J. Educ. Psychol.* 66: 296–303.
Levin, J. R., and Mayer, R. E. (1993). Understanding illustrations in text. In Britton, B. K., Woodward, A., and Brinkley, M. (eds.), *Learning from Textbooks*, Erlbaum, Hillsdale, NJ, pp. 95–113.
Levin, J. R., Shriberg, L. K., and Berry, J. K. (1983). A concrete strategy for remembering abstract prose. *Am. Educ. Res. J.* 20: 277–290.
Levin, M. E., and Levin, J. R. (1990). Scientific mnemonomies: Methods for maximizing more than memory. *Am. Educ. Res. J.* 27: 301–321.
Levin, M. E., Rosenheck, M. B., and Levin, J. R. (1988). Mnemonic text-processing strategies: A teaching science for science teaching. *Read. Psychol.* 9: 343–363.
Mandl, H., and Levin, J. R. (eds.) (1989). *Knowledge Acquisition from Text and Pictures*, Elsevier, Amsterdam.
Marcus, N., Cooper, M., and Sweller, J. (1996). Understanding instructions. *J. Educ. Psychol.* 88: 49–63.
Markman, E. M. (1979). Realizing that you don't understand: Elementary school children's awareness of inconsistencies. *Child Dev.* 50: 643–655.
Mayer, R. E. (1989). Systematic thinking fostered by illustrations in scientific text. *J. Educ. Psychol.* 81: 240–246.
Mayer, R. E. (1992). Illustrations that instruct. In Glaser, R. (ed.), *Advances in Instructional Psychology, Vol. 4*, Erlbaum, Hillsdale, NJ, pp. 253–284.
Mayer, R. E., and Anderson, R. (1992). The instructive animation: Helping students build connections between words and pictures in multimedia learning. *J. Educ. Psychol.* 84: 444–452.
Mayer, R. E., and Gallini, J. K. (1990). When is an illustration worth ten thousand words? *J. Educ. Psychol.* 82: 715–726.
Mayer, R. E., and Moreno, R. (1998). A split-attention effect in multimedia learning: Evidence for dual processing systems in working memory. *J. Educ. Psychol.* 90: 312–320.
McCormick, C. B., and Levin, J. R. (1987). Mnemonic prose-learning strategies. In McDaniel, M. A., and Pressley, M. (eds.), *Imagery and Related Mnemonic Processes: Theories, Individual Differences, and Applications*, Springer, New York, pp. 392–406.
Mousavi, S. Y., Low, R., and Sweller, J. (1995). Reducing cognitive load by mixing auditory and visual presentation modes. *J. Educ. Psychol.* 87: 319–334.
Ollerenshaw, A., Aidman, E., and Kidd, G. (1997). Is an illustration always worth ten thousand words? Effects of prior knowledge, learning style, and multimedia illustrations on text comprehension. *Int. J. Instruct. Media* 24: 227–238.
Paivio, A. (1971). *Imagery and Verbal Processes*, Holt, Rinehart, & Co., New York.
Paivio, A. (1986). *Mental Representations: A Dual-Coding Approach*, Oxford University Press, New York.

Palincsar, A. S., and Brown, A. L. (1984). Reciprocal teaching of comprehension fostering and monitoring activities. *Cogn. Instruct.* 1: 117–175.
Peeck, J. (1993). Increasing picture effects in learning from illustrated text. *Learn. Instruct.* 3: 227–238.
Raymond, A. (1995). Author, editor-in-chief, teacher: Patricia Lee Gauch. *Teaching Pre K-8* 26(1): 62–64.
Reid, D. J., and Beveridge, M. (1990). Reading illustrated science texts: A micro-computer investigation of children's strategies. *Br. J. Educ. Psychol.* 60: 76–87.
Reinking, D. R., Hayes, D. A., and McEneaney, J. E. (1988). Good and poor readers' use of explicitly cued graphic aids. *J. Read. Behav.* 20: 229–243.
Renandya, W. A., Hwang, Y., Rich, J. D., Ruffalo, S. L., Levin, M. E., and Levin, J. R. (1993). Explorations in mnemonic mythology. Paper presented at *the Annual Meeting of the American Educational Research Association*, Atlanta, April 1993.
Riding, R. J., and Douglas, G. (1993). The effect of cognitive style and mode of presentation on learning performance. *Br. J. Educ. Psychol.* 63: 297–307.
Rosenheck, M. B., Levin, M. E., and Levin, J. R. (1989). Learning botany concepts mnemonically: Seeing the forest and the trees. *J. Educ. Psychol.* 81: 196–203.
Rubman, C. N., and Waters, H. S. (2000). A, B seeing: The role of reconstructive processes in children's comprehension monitoring. *J. Educ. Psychol.* 92: 503–514.
Rummel, N., Levin, J. R., and Beitzel, B. D. (2001). Can mnemonic strategies enhance students, processing and recall of integrated text? Unpublished manuscript.
Samuels, S. J. (1970). Effects of pictures on learning to read, comprehension and attitudes. *Rev. Educ. Res.* 40: 397–407.
Schallert, D. L. (1980). The role of illustrations in reading comprehension. In Spiro, R. J., Bruce, B. C., and Brewer, W. F. (eds.), *Theoretical Issues in Reading Comprehension: Perspectives from Cognitive Psychology, Linguistics, Artificial Intelligence, and Education*, Erlbaum, Hillsdale, NJ, pp. 503–524.
Sipe, L. R. (1998). How picture books work: A semiotically framed theory of text-picture relationships. *Children's Lit. Educ.* 29: 97–108.
Smith, B. D., and Elifson, J. M. (1986). Do pictures make a difference in college textbooks? *Read. Horizons* 26: 270–277.
Stewig, J. W. (1992). Reading pictures, reading text: Some similarities. *New Advocate* 5(1): 11–22.
Waddill, P. J., and McDaniel, M. A. (1992). Pictorial enhancement of text memory: Limitations imposed by picture type and comprehension skill. *Mem. Cogn.* 20: 472–482.
Waddill, P. J., McDaniel, M. A., and Einstein, G. O. (1988). Illustrations as adjuncts to prose: A test-appropriate processing approach. *J. Educ. Psychol.* 80: 457–464.
Wang, A. Y., and Newlin, M. H. (2000). Characteristics of students who enroll and succeed in psychology web-based classes. *J. Educ. Psychol.* 92: 137–143.
Weidenmann, B. (1989). When good pictures fail: An information-processing approach to the effect of illustrations. In Mandl, H., and Levin, J. R. (eds.), *Knowledge Acquisition from Text and Pictures*, Elsevier, Amsterdam, pp. 157–171.
Weidenmann, B., Paechter, M., and Hartmannsgruber, K. (1999). Structuring and sequencing of comples text-picture combinations. *Europ. J. Psychol. Educ.* 14: 185–202.