When tactics collide: Counter effects between an adjunct map and prequestions

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Abstract:

Eighty-five undergraduates read a 1,399-word story using computer programs that differed in the types of learning aids provided: either prequestions only (PO) viewed prior to the reading, a related map that was first reviewed feature by feature (MR), prequestions plus an unreviewed map (PM), or prequestions with a reviewed map (PMR). During reading, subjects accessed the map as desired by depressing the mouse button, at which time the computer recorded how often they viewed the display and for how long. Analyses of scores on a 20-item constructed-response test on the story showed significantly higher recall by PO and PM groups compared to subjects receiving only a map. The MR group accessed the map significantly more often than did the PM group, while subjects given a reviewed map (MR and PMR groups) rated it significantly more useful for learning the story than did those who received both prequestions and a map that was not reviewed. All three groups receiving prequestions rated the text itself more useful than did the map-only group. These findings provide partial evidence that graphic and verbally based instructional tactics can, in certain circumstances, "collide" with one another when used concurrently. Because both adjunct displays and adjunct questions rely on mental rehearsal during initial processing, they potentially compete for the limited resources of working memory leading to, in some cases, attenuation of their benefits during learning.

Article:

Instructional design can generally be thought of as a strategic activity that determines the best route for achieving a specific learning outcome. Much attention has been given to the strategic side of instructional technology. This interest can be seen, for example, in the educational technology literature that deals with differences among various instructional design models (Andrews & Goodson, 1995; Reigeluth, 1983, 1986). Of similar importance, though, is the tactical aspect of instruction (Leshin, Pollock, & Reigeluth, 1992; West, Farmer, & Wolff, 1991) that addresses the question, "What is the most effective method for carrying out an instructional design?" Yet, learners have had surprisingly little formal classroom experience with instructional tactics such as mnemonics, underlining, and questioning, and educational researchers have often confused learning tactics with learning strategies (Snowman, 1986). Hence, there is good reason to believe that the tactical side of learning represents an aspect of instructional design that has received relatively little attention. Accordingly, instructional tactics is the focus of this article and, in particular, the unexpected effects that may arise when combining two or more methods for assisting learners.

Specifically, an assumption for this study was that the effectiveness of an instructional adjunct may sometimes be undermined when used concurrently with another instructional intervention, method, or tool. Underlying this thesis is the assumption that any given adjunct can elicit several different types of mental processes. For example, the effect of an adjunct prequestion may be to activate the prior knowledge of readers (Gagne, 1988) or to direct their processing attention to the text information that follows (Anderson, 1982). Presumably, there may be instances where it would be difficult or impossible for two cognitive processes to operate simultaneously because of the limitations of working memory (Kulhavy, Schwartz, & Peterson; 1986). Even so, when an adjunct prompts two mental processes, they can operate in tandem to support the same learning objective; to use the present example, an adjunct prequestion may first activate a context for interpreting a text and then draw the reader's attention to key sections in the prose. A difficulty arises, however, when two or more instructional aids are used, since the odds are greater that the cognitive functions activated by one may conflict with those triggered by another. Hypothetically, in instances where the concurrent use of two adjuncts invokes competing cognitive processes, learners may choose to ignore one aid entirely. Hence, the benefits anticipated from the tactical use of multiple adjuncts might not be fully realized.

Given standard instructional design practices, it is conceivable that designers who specify the use of multiple adjuncts may, in doing so, inadvertently set off competing mental processes among learners. Typically, instructional design progresses from broad strategic considerations to tactical ones that are narrower in scope and more removed from the psychological principles on which instructional strategy is based. Hence, decisions on the selection of tactics are not driven by the possible psychological impact they may have but rather by requirements indicated in the design model, such as the characteristics of the learner or the planned learning outcome (Dick & Carey, 1990; Gagne, 1988; Moore & Scevak, 1988). Consequently, instructional designers may not normally consider the prospect that two proven instructional approaches-such as adjunct questions and maps-might compete with one another.

Competition Between Adjunct Tactics

The notion of two instructional aids counteracting one another when provided at the same time emerged unexpectedly during a study we conducted on map prior knowledge and its effect on learning from a related text. In the study, 69 eighth graders read a story on a computer while accessing either a familiar or unknown map at any time by holding down the mouse button. As they did so, the program surreptitiously recorded both the frequency and duration of their map viewing.

Both pilot testing and the readability of the text (9.5 grade level on the Flesch-Kincaid index) suggested the experimental prose would be challenging for subjects. Hence, adjunct prequestions were added to the treatments whereby subjects viewed the 20 short-answer criterion questions at a rate of 5 sec per question prior to reading the text.

During the experimental session, subjects rarely consulted the accompanying map despite periodic reminders that it could be viewed at any time. The validity of this observation was confirmed during data analysis revealing the same paucity of map-viewing behavior by subjects in all four experimental conditions: On the average, subjects viewed the map for a little more than 2 sec during the entire 10-min reading task.

Initially, it was thought that subjects might have refrained from viewing the map to avoid losing their place in the text. However, analysis of subjects' ratings on the relative usefulness of the map, the adjunct questions, and the feature-by-feature review of the map indicated that subjects in all four experimental conditions found prequestions to be significantly more useful in recalling the text. This evidence strongly suggested that, after viewing prequestions, subjects intentionally refrained from accessing the map during reading. Feasibly, subjects may have considered the map to be superfluous information or that it interfered with the mental processes activated by prequestions.

Research by Ho (1989) on the use of multiple text adjuncts-in this instance, adjunct questions and simple illustrations-offers a counterargument to the position of the current study that the joint use of visual and verbal adjuncts may elicit processing interference. Fourth graders participating in Ho's study learned significantly more from a text that was accompanied by both adjunct questions and line drawings than from texts containing either adjunct alone. An important difference, however, between this study and the experiment reported herein is that subjects in the former instance made overt responses to postquestions interspersed throughout a text along with different illustrations, whereas those in the latter study made covert responses to massed prequestions, and viewed just one display.

An interesting finding of the Ho study (1989) was that the questions-only group took roughly 40% longer to complete the lesson than did the pictures-only group, with no between-group differences in recall performance. Therefore, in terms of savings, both in instructional time and in development costs related to producing many drawings, the possibility of achieving even moderate success with prequestions and a single map display was worth investigating.

Characteristics of Adjunct Maps

The benefits of maps for aiding recall of related texts are well documented (Kulhavy, Stock, & Kealy, 1993; Winn, 1991). When a map supplements a related text, the result is not merely an improvement in recall for the text mirrored by the map labels. Rather, the map enhances memory for parts of the text that, while semantically related to map features, is information that one could not glean from looking at the map alone. Imagine, for instance, a map with the labeled feature PLAZA that accompanies a text containing the following two sentences: "It was at the plaza that the elders of the town met to cast votes for their mayor. Voting was accomplished by having each person drop either a red or brown bean in a basket." In this case, the value of the map is not just that it improves the reader's chances of recalling where the elders met (i.e., the plaza), but rather that facts related to the town voting procedure are more memorable. Therefore, adjunct maps work for reasons other than simply because they provide redundant information.

By the same token, the positive effects of maps on text recall cannot be fully explained by the theory that map labels selectively cue the reader to corresponding portions of the text. A number of researchers (Abel & Kulhavy, 1986, 1989; Griffin & Robinson, 2000; Kulhavy, Schwartz, & Shaha, 1983; Mastropieri & Peters, 1987; Schwartz & Kulhavy, 1981) have discounted this idea by showing that subjects viewing maps with features listed along the border (whether depicted by labels or mimetic icons) recall significantly less from accompanying texts than those viewing maps with features that are spatially dispersed. If maps do, in fact, aid text recall through selective cueing, there should have been no difference between groups since both displays contained identical linguistic and graphic elements.

A widely accepted explanation for why a map enhances recall of an accompanying text is that the two stimulus formats are mentally processed through separate encoding channels, one imaginal and spatial and the other linguistic, respectively (Paivio, 1986). In this manner, map and text information are conjointly retained in separate, but mutually accessible, areas of mental long-term storage. According to the conjoint retention hypothesis (Kulhavy, Lee, & Caterino, 1985), during recall an initial attempt is made to retrieve propositional data from verbal storage. If this effort fails, the map image is mentally generated as a simple intact image that is held in working memory and scanned. Any map features recalled in this manner then serve as secondary retrieval cues for associated propositions in verbal storage.

Maps serve this mnemonic function particularly well compared to other types of visual displays, such as illustrations and photographs, for a couple of reasons. First, the structure of a map, namely, its spatial properties (e.g., distance and direction) and supporting visual elements (e.g., its boundary), constitute a spatial framework that facilitates the encoding and retrieval of embedded map features. This means the map framework, once encoded in long-term memory, allows for the rapid recall of its component features (Rittschof, Stock, Kulhavy, Verdi, & Doran, 1994; Verdi & Kulhavy, 2002). second, like diagrams, maps are "computationally efficient" displays that exert far less demand on working memory than would an equivalent number of sentences (Larkin & Simon, 1987). Consequently, when learners attempt to remember what they read, they are able to form a mental image of the map, direct their attention to its various features, and search associated verbal storage-all without exceeding the capacity of working memory (Kulhavy et al, 1993).

Learning from maps and text may be thought of as a special case within the broader realm of how people learn from multimedia. According to Mayer (1999), when learners encounter multimedia instruction consisting of coordinated images and text, they first select visual and verbal information for further processing based on its perceived relevance and importance. They then organize the selected material within working memory to form corresponding visual and verbal mental models. Finally, they attempt to make meaningful connections between the two models while trying to integrate this with prior knowledge retrieved from long-term storage.

From the perspective of this model of multimedia learning, subjects in the prototypical research study on the effects of an adjunct map would initially select the map elements and features on which to allocate their processing attention. One way that subjects might be guided in this task is through the schemata acquired from years of experience in using maps (Schwartz, Ellsworth, Graham, & Knight, 1998). Subjects would then attempt to mentally organize this information, possibly by spatially partitioning the map area into a more simplified geometry (Thorndyke & Stasz, 1980) before the map is removed and replaced by the experimental text. Though the map is gone at this point, it is conjectured that subjects would continue to refresh its image in working memory as they attend to the text, mentally organize what they read, and periodically integrate this with what they see in their mind's eye.

At first glance, this scenario may appear to contradict Mayer's (2002) contiguity principle, which states that a simultaneous presentation of verbal and visual material yields better learning than when the two information sources are presented separately. Theoretically, however, the mental processing of a map imposes, because of its structural attributes, a relatively small demand on short-term memory compared to other more visually complex displays (Kulhavy et al, 1993; Verdi & Kulhavy, 2002). Assuming this is true, subjects may be able to mentally image a map as they concurrently process and integrate a related text without exceeding working memory limitations. Hence, even though a map is processed before a text, plausibly it could facilitate a "virtual" simultaneous presentation of visual and verbal information through the map's availability in working memory.

By contrast, when the text is encountered before the map, only a limited number of propositions can be rehearsed, with attention, selection, and mental organization probably guided, in part, by what the text's semantic structure may cue as important (Meyer & McConkie, 1973). When, in this situation, the text is finally replaced by the map, subjects would find themselves in a dilemma: should they choose to study the display and lose whatever propositions have been brought from long-term storage into working memory, or continue rehearsing the verbal information in working memory and lose the computational advantage gained by using the map (Verdi, Johnson, & Stock, 1997)? In either case, it seems unlikely that subjects would be able to engage in the mental integration of verbal and visual information that is so central to Mayer's (2002) notion of multimedia learning.

Characteristics of Adjunct Questions

Adjunct questions, like maps and other types of graphic displays, have been a longstanding feature of instructional texts. When adjunct questions precede a relevant prose passage (i.e., prequestions), readers target more of their processing attention to text material dealing directly with the prequestions (Anderson & Biddle, 1975). Consequently, these readers are able to recall significantly more of the text-albeit, parts of the text only related to the questions-than those who do not see prequestions. By contrast, adjunct questions that follow text (i.e., postquestions) invoke more global allocation of attentional resources by readers. Postquestions not only aid recall of the question-related text, but also produce an indirect effect that helps readers remember text material not directly related to the questions (Anderson & Biddle, 1975; Kealy & Sullivan, 1991; Kulhavy et al., 1986).

Adjunct prequestions tend to focus processing attention more narrowly than do postquestions (Hamaker, 1986); the former yields superior recall of text information that is directly related to questions, but at the expense of less learning for other material. In the study with eighth graders mentioned earlier, readers viewed prequestions knowing that they would again appear as criterion questions after the text passage was completed. Given their expectations of the task to be performed, subjects may have focused their processing attention entirely on the prequestions, rehearsing them in working memory and ignoring the map as extraneous material.

Though this conclusion about the interaction between adjunct prequestions and adjunct maps may be reasonable, it is not definitive, because the aforementioned study was neither intended nor designed to gauge the effect of prequestions (e.g., it did not include a nonprequestion group). Consequently, the current study was initiated to investigate the impact of using prequestions and maps concurrently. This was not a replication, in the true sense of the word, of the previous experiment since the design, purpose, treatments, and subjects of the two studies were quite different. Rather, the current study was an attempt to reproduce the unexplained learning behavior demonstrated by subjects in the earlier experiment and to study this phenomenon in a scientifically controlled manner. The experiment reported herein, therefore, was exploratory research into the relative effectiveness of different instructional tactics, consisting of prequestions or a map or both, for text acquisition. For this study, as in the previous research, verbal recall served as the primary criterion measure1. Unlike the earlier work, however, the present investigation also examined learner motivation for accessing and studying an adjunct map under various conditions-with and without the presence of prequestions and whether or not subjects were required to process the map.

Although the present study was not designed to examine the relative efficacy of prequestions versus maps as learning aids, it nevertheless seemed likely that prequestions, either alone or in conjunction with an adjunct map, would prove to be more facilitative than a map alone in recalling the experimental text. Our prediction was based on the belief that a preview of the actual criterion questions would likely heighten both subjects' task expectancy and processing attention of the experimental text more than would the map. Additionally, we estimated that prequestions would aid text recall better than a map would because the former, but not the latter, constitutes the same type of processing as the type of task subjects expected-a phenomenon known as transfer appropriate processing. Researchers in this area (Meier & Graf, 2000) generally find that higher test performance results when the type of processing the test involves matches that of the prospective memory task (e.g., perceptual-perceptual or semantic-semantic versus perceptual-semantic or semantic-perceptual). In other words, learners may be more successful in verbal recall when the prospective task is cued verbally, such as with prequestions, rather than spatially, such as with a map.

Of greater interest to us, however, was how subjects would respond to and learn from the presence of multiple adjuncts relative to use of a single adjunct. In terms of Mayer's (1999) model of multimedia learning, we especially questioned how the combined use of prequestions and an adjunct map might influence the ability and motivation of subjects to allocate their processing attention to the critical information in both adjuncts.

While adjunct questions elicit processing attention by their very presence, adjunct maps require an event that induces viewers to actively process the map in order for it to facilitate recall of an accompanying text. To be specific, past research (Dean & Kulhavy, 1981) has shown that such forced processing (e.g., labeling the map, tracing its outline, reviewing it feature by feature) increases its effectiveness as an adjunct for learning related text. In the current study, however, just the opposite effect was predicted when active processing of the map is preceded by prequestions. Here, we surmised that people would find it difficult to mentally rehearse prequestions in short-term memory when their appearance was immediately followed by a feature-by-feature review of the map. Moreover, it seemed conceivable that this review would heighten the perceived importance of the map, thereby compelling subjects to split working memory resources between rehearsal of prequestion and map information.

An entirely different outcome, on the other hand, was predicted when subjects are given prequestions followed by a map that they are not forced to process. In this case, it seemed likely that subjects would devote virtually all working memory assets to question rehearsal. For this reason, we believed people who are given both prequestions and an adjunct map would show better recall for a related text when they are not directed to actively process the map than those for whom map processing is forced. Despite the lower recall performance expected among the latter group, it was hypothesized that they would nevertheless give the map higher ratings on its usefulness for learning the text than those who did not review the map after seeing prequestions.

An important characteristic of adjunct maps is that these displays only enhance recall for the parts of the accompanying text that are semantically related to map features (Abel & Kulhavy, 1986; Amlund, Gafney, & Kulhavy, 1985; Schwartz & Kulhavy, 1981). Accordingly, we predicted significant differences between recall of text that was related to the map features compared with recall of parts of the story unrelated to features-but only among subjects who actively reviewed a map prior to reading and who did not view prequestions. On the contrary, no distinction between feature- and nonfeature-related recall was anticipated among subjects receiving either prequestions alone or prequestions with a map-regardless of whether or not the map was actively reviewed.

Active review of a map following exposure to prequestions, we reasoned, would split subjects' attention between the two sources of information. In all likelihood, these participants would neither develop a strongly organized visual mental model of the map information nor be able to integrate this knowledge with feature-related material in the text. Meanwhile, those who briefly saw the map (to learn of its availability during reading) without reviewing it in detail would conceivably forego rehearsing the map in working memory. Instead, once participants were shown the prequestions they would try to retain this material in working memory, intentionally not accessing the map to minimize the interference it might have on prequestion rehearsal. In this situation, no differences were expected in how much text information subjects recalled that was either related or unrelated to map features, since the prequestions reflected both types of information in equal numbers.

To summarize, the following outcomes were predicted for the current study:

1. Subjects will exhibit greater verbal recall when a text they study is accompanied by adjunct prequestions than when it is supplemented with a related adjunct map.

2. Subjects receiving both an adjunct map and adjunct prequestions will access the map more frequently-yet show poorer verbal recall-when, after seeing prequestions, they perform a feature-byfeature review of the map compared to those without a map review.

3. Subjects given both prequestions and a map will be less motivated to access the display than those receiving a map alone.

4. Participants will recall more story information related to map features than parts unrelated to features when a map is their sole adjunct for learning a text. These differences in text recall will disappear when prequestions are provided.

5. Subjects receiving both prequestions and an adjunct map will rate the former more useful for recalling part of the text. Such differences, however, in the perceived usefulness of the two adjuncts will be smaller among those who actively review the map's features.

METHOD

Subjects and Design

Research participants were 85 (67 female, 18 male) students attending undergraduate classes at a public university in the southern United States. Of the volunteers, 58 (44 female, 14 male) were recruited from lower-standing psychology classes and represented a wide variety of academic majors (e.g., psychology, preengineering, premedicine science, business). In order to raise the number of experimental subjects, 27 additional subjects were recruited at the same university three months later from a 2000-level introductory course in instructional technology within the college of education. Participants from the two subject pools were assigned to the four experimental groups in roughly the same proportion (15:7, 15:7, 15:5, and 13:8, respectively). Female participants accounted for 86, 73, 75, and 81% of the total subject population, respectively, within the four groups. All subjects in the experiment received credit toward their course grade in exchange for their participation.

Subjects read the same 1,399-word passage as that used in the experiment mentioned earlier involving eighth graders. The current study also used the same 20 criterion questions: 10 questions were related to features on the map, and 10 were not. Computer programs were developed using Authorware (1997), which presented subjects with the experimental text and one of four adjunct conditions: (a) prequestions only (PO), (b) prequestions plus a map (PM), (c) prequestions plus a map that was first reviewed, feature-by-feature (PMR), and (d) a map that included a review of the features it contained (MR). Hence, the base design for the study was a 4 Adjunct (PO vs. PM vs. PMR vs. MR) x 2 Recall (feature vs. nonfeature questions) factorial with the type of adjunct varied between subject- and question-type acting as a repeated measure.

Materials

Experimental map. The computer display used in the three treatments with a map (i.e., PM, PMR, and MR) depicted the international border of the United States formed by its 48 contiguous states and rendered, by a trained cartographer, as a textured light green shape on a medium blue background. After being imported into the Authorware application, the map was annotated to show the location of the five tribes mentioned in the story by labeling each position with the tribal name printed in white 14-point Times Roman lettering. To limit the influence of subjects' prior knowledge, both the map and experimental text substituted the actual tribal names (Makah, Cahokian, Onondaga, Chaco, and Calusa) with the nonsense words or "paralogs" (Noble, 1952) Kupod, Latuk, Gokem, Polef, and Tarop, respectively.

Immediately above and below each tribal name was labeled a geographical feature printed in yellow eight-point Arial typeface. Through a norming procedure (Kealy & Sivo, 1993), the five tribal locations were each assigned two unique features from a list of 37 geographical settings. The ten features assigned were: peak, forest, hill, woods, meadow, plains, swamp, marsh, canyon, and desert. Figure 1 is an outlined version of the experimental map showing the spatial distribution of the tribal locations and their associated geographical features.

Experimental text. The experimental text was a 1,399-word passage adapted from an essay in Smithsonian (MacLeish, 1991) on five pre-Columbian settlements within what is now the United States. The story, retitled "How Ancient Tribes Survived," discussed the types of food each tribe ate, the kinds of dwellings they built, their culture, and so forth. Two paragraphs, each roughly the same length and consisting of five sentences, were written for each tribe. Additionally, two paragraphs were written to precede and introduce material about the tribes and one paragraph was created to conclude the story. When incorporated in the Authorware program, each paragraph of the story, rendered in black 18-point Times New Roman typeface, filled most of the screen area of a 15-in (38.1 cm) computer monitor set at 600 x 800 dots-per-inch resolution. The entire story appeared on 13 numbered screens of the computer program.

Figure 1 ☐ Display viewed by subjects in the three adjunct map conditions within the study.

Figure 1 [white square] Display viewed by subjects in the three adjunct map conditions within the study.

The structure of the five-sentence paragraphs took one of two formats. In one case, the first sentence mentioned the name of the tribe, the second presented target information not related to map features, the third stated one of the two map features where the tribe was located, the fourth contained target information related to this feature, and the fifth sentence consisted of "filler" information. For the second paragraph format, the first sentence contained both the name of the tribe and the remaining geographical feature associated with the tribe's location, while the second sentence included target information related to this map feature. The third sentence contained filler information that served as a buffer between the second sentence and the fourth sentence, which presented target material unrelated to map features. Like the first paragraph format, the fifth sentence of this format was composed of filler information. A paragraph from the experimental text follows exemplifying the first format:

Many tribes living in tropical climates find, as the Tarop did, that nature provides an abundant supply of different foods. As a result, the tribe never tried to grow food but instead just ate a type of wild potato that grew in the seagrass. Their favorite food, however, was the shellfish caught in a saltwater SWAMP where several rivers emptied into the sea. We know about their diet by the remains of 20-ft-high mounds formed from the shells the tribe threw away after eating. Besides decorating the walls of their homes with shells, the tribe also used this material to create crude hand axes. [The map feature, shown in capital letters, was written in lowercase in the study.]

For each tribe mentioned in the story, the first paragraph used one format while the other paragraph followed the alternative format. Further, each paragraph was written to be semantically independent of preceding and succeeding paragraphs. Therefore, the two paragraphs devoted to a given tribe could be presented in any order, as could each of the two-paragraph sections dealing with a particular tribe. This permitted development of two different versions of the experimental text by switching the paragraph order of a passage on a particular tribe and changing the order in which the tribes appeared in the story.

With this strategy, we sought to control for any unintentional selective cueing that might arise from the semantic structure of how the text was written (Meyer & McConkie, 1973). In one text version, tribes were discussed in the order: Latuk, Kupod, Tarop, Polef, and Gokem. The passage about the Latuk began with the first type of paragraph format; each tribe mentioned thereafter alternated in the paragraph format initially used. The second version of the experimental text reordered presentation of the tribes: Tarop, Polef, Gokem, Kupod, and Latuk. The passage on the first tribe initially used the second paragraph format, the second tribe began with the first format, the third tribe started with the second, and so on.

To test verbal recall, 20 short-answer questions were formed (4 on each of the five tribes). In this way, half of the questions dealt with story information that was related to features on the map while the remaining items were unrelated to map features. An example of a feature-related question on the paragraph from the experimental text shown earlier was "How do we know about the diet of the Tarop?" (related to shellfish caught in the swamp). By contrast, a nonfeature-related question on material from the same paragraph was "Instead of growing their own crops, what did the Tarop eat?" The computer-based treatments were designed so that all questions, whether functioning as the criterion measure or as adjunct prequestions, were presented to subjects in random order.

Procedures

Computer programs were installed on the hard drives of 16 classroom computers so that the four experimental treatments were distributed in equal numbers. In order to limit the chance of a subject's inadvertent exposure to a treatment other than the one assigned, at least one unused computer was positioned between any two computers used in the study. Further, treatments were distributed with the PO condition represented in the first row of seating, the PM treatment in the third row, the PMR programs in the fifth row, and the MR treatment in the seventh row. Hence, subjects accidentally glancing at a distant computer in front of them would not gain any more information than what was already available on their own computer.

As participants arrived for an experimental session, they were randomly assigned to computers that were disabled, showing only a blank blue screen. After introductory remarks by the experimenter and an overview of the task they would perform, the volunteers were given the opportunity to quit the study and reminded they could do so at any time without penalty (no students left during any of the experimental sessions). Subjects were told to attend to just the material shown on their screen and to raise their hand any time during the course of the study if they had a question or a computer malfunction.

Once everyone in the room was ready to begin, subjects were told to press the TAB key to start the program. Subjects were then prompted by the computer to enter their first and last name and press the ENTER key when finished. The next screen reminded subjects that they would be studying a story about five ancient tribes, consisting of roughly 1,400 words shown on 13 computer screens. Included in the story, they were told, were FORWARD and BACK buttons located, respectively, on the lower left and right corners of each screen to let them navigate through the text. The appearance and location of the buttons was illustrated on the instructional screen. Subjects then clicked the CLICK TO CONTINUE button at the bottom center of the screen and read the next set of instructions, informing them that they would have 10 min to read the story. The text stated that a timer, like the one illustrated on their screen, would appear in the upper-right corner of each screen in the story, counting backward from 600 sec to disclose how much reading time remained. Subjects also read that if they reached the end of the story before the time period expired, they were to use the BACK button to go over earlier parts of the text.

When subjects finished reading this information, they clicked the CONTINUE button and proceeded to the next screen. Here, they were informed that after the reading period they would complete 20 short-answer questions about the text. The directions repeated the earlier instruction for them to raise their hand anytime during the session if either a procedural question or a computer malfunction arose, and to do so now if there was a question about anything covered thus far. At this point, the computer program became locked and subjects could not proceed any further. Once it was clear that they had no procedural questions, the experimenter told the participants to click on the word raise on the screen to continue to the next set of instructions. The purpose of this "holding" screen was to ensure that all subjects were at the same place in the program before beginning parts of the treatment that varied between groups.

Subjects in the PO group then viewed a new screen informing them that they would now see a preview of the 20 questions presented after completion of the story. The preview questions, they were told, would automatically appear on the screen, one at a time, for about 3 sec each. Below these directions was a button marked CLICK TO BEGIN that, when clicked, started the question preview. The 20 prequestions then appeared one by one, in random order, at the top one third of the screen in 18-point white New Times Roman lettering.

After the last prequestion had finished being displayed, a new screen stated, "Click the button below to begin reading the story." Once subjects clicked this button, the entire screen was replaced by the first paragraph of the experimental text, the story's title, "How Ancient Tribes Survived" above it, the timer, and the navigation buttons (the BACK button was disabled on the first screen of the story).

In the case of the three experimental groups that received an adjunct map (i.e., the PM, PMR, and MR), once subjects clicked on the word raise (on the holding screen mentioned earlier) a new screen informed them that a map showing the land of the five tribes was included with the story. Subjects were instructed that they could examine the map at any time during the story by placing the cursor over the text and holding down the mouse button. When they did this, they were told, a map would replace the text and remain on the screen for as long as the mouse button was depressed. Once the mouse button was released, the story text would reappear, replacing the map. On-screen instructions directed subjects to practice accessing the map and, after retrieving the map twice, a CLICK TO CONTINUE button appeared.

Upon clicking the button, subjects in the PM and PMR groups that received both the map and adjunct questions viewed the same prequestions as those in the PO group. Participants first read that they would now be presented with the 20 questions to be answered after the story was read and then clicked the CLICK TO BEGIN button to start viewing the prequestions. Immediately after the last question was presented, those in the PM group saw a new screen stating, "Click the button below to begin reading the story" and, after clicking it, began reading the experimental text.

Meanwhile, after seeing the last question, subjects in the PMR group were shown a screen containing the same U.S. map viewed earlier, but with a few minor differences. Above the border of this map appeared, "To help familiarize yourself with the map, click on each of the features as its name appears in the box above this sentence." Additionally, centered immediately above this text was a dark blue rectangle and, centered at the base of the screen, a rectangular button labeled CLICK TO BEGIN. When subjects clicked this button, it and the sentence above the map disappeared. Simultaneously, the program randomly selected one of the map's 15 labels (i.e., 5 tribe names plus 10 geographical features), displaying it within the dark blue rectangle in 17-point light blue Arial capital letters. When subjects clicked on the map's identical label, a bright orange dot about 1/8 inch (0.3 cm) in diameter appeared to the left of the map label. At the same time, its duplicate in the dark blue rectangle was replaced by another word, randomly chosen from the total set of labels, which had not yet been used.

Subjects continued this procedure of locating and clicking the label on the map that was identified in the blue box until all geographical features and tribe names were annotated with an orange dot. As the last map label was clicked, the display was replaced by a blue screen stating "Click the button below to begin reading the story," and a button below it labeled CLICK TO CONTINUE. After this button was clicked, the first screen of the story appeared. The MR group received an experimental treatment that was, in every respect, identical to that of the PMR group, but minus the prequestions.

Once the reading task was completed, three addition problems appeared on the screen, each consisting of four 2-digit numbers with the solution provided. Instructions at the top of the screen directed subjects to type either Y or N in the space provided below each sum to indicate, respectively, whether the addition shown was correct or incorrect. This procedure was designed to limit subjects' rehearsal of story material in working memory so that their responses to subsequent cued recall questions would be made from information in long-term mental storage.

As soon as the last addition problem was answered, a new screen informed subjects that they would now complete 20 short-answer questions about what they had read. They were told that, for each question, they would have 15 sec to type their response in the space provided. The amount of response time available was limited to control for time on task as well as to prevent construction of unnecessarily lengthy responses to the short-answer questions that were presented.

Immediately below the instructions was a button marked CLICK TO BEGIN and, directly below that, a rectangle with seven horizontal lines for subjects to type their answers on. Positioned on the midpoint of the seventh horizontal line was a timer, represented as a clock-shaped icon, which graphically indicated the passage of the 15-sec period allowed for each question. Once subjects clicked the button to begin, the instructions were replaced by the first of 20 cued-recall questions presented in a separate random order for each subject. The program prevented subjects from entering an answer before the timer was finished in order to quickly move on to the next question. Instead, the program automatically accepted whatever was typed in the answer space after the allotted time period was over.

Once the last cued-recall question was completed, a new screen informed subjects that they would be rating the helpfulness of certain parts of their learning experience. They were told to make their rating by using the mouse to drag a short vertical bar (the slider) to the left or right of a rectangular box (the slide) that was almost as wide as the screen. The slide was designed to allow rating of how helpful the program's components were (e.g., prequestions, text, and map) on a scale of 0 (unhelpful) to 5 (helpful). Unlike a typical unlabeled semantic differential scale, however, no interval points for rating appeared on the scale. Rather, as the slider was moved, the computer registered continuous mathematical values to the 11th decimal place corresponding with the slider's position along the slide.

Several factors drove the decision to gather the rating data as a continuous variable. First, it was determined that judgment on the usefulness of an aid to learning, like many other human behaviors, is probably continuous in nature. Second, assuming judgment is a continuous variable, partitioning the semantic distance between unhelpful and helpful into a small fixed number of data points (a dichotomy being an extreme case) would limit the ability to represent the variability existing in the domain (Cudeck & Hulin, 2001). Third, obtaining data at the interval scale of measurement legitimized use of analysis of variance (ANOVA) and Pearson product correlation to determine, respectively, (a) the influence forced processing of a map has on its rated usefulness relative to a map where forced processing does not occur, and (b) the relationship between map usefulness ratings, map accessing behavior, and verbal recall. A chi-square analysis, on the contrary, would be more appropriate for examining the categorical data (Ross & Morrison, 1996) gathered from the use of a standard semantic differential scale.

A set of instructions at the top of the first screen directed subjects to place the cursor over the vertical slider, and with the mouse button depressed, practice moving the slider left and right. The instructions stated that, during the actual rating activity, the computer would accept a rating based on the slider's position at the moment the mouse button was released. Below this text was an example of the slide and slider, with the words Helpful and Unhelpful immediately below the slide at its respective left and right-hand edges. The short vertical slider, located at the slide's midpoint, was operable and, following the on-screen instructions, subjects practiced moving the slider without making a rating. A button labeled CLICK TO BEGIN, centered just below the horizontal slide, started the rating procedure.

Instructions on the use of the slider disappeared from the screen as soon as the button was clicked to begin rating. The vertical slider bar, the horizontal slide, and the bipolar descriptors at its terminal points remained on the screen. Centered immediately above the slider appeared a question that prompted a rating from subjects. Those receiving both an adjunct map and adjunct questions (i.e., groups PM and PMR) saw three such questions: (a) "How helpful were the preview questions in learning the story?" (b) "How helpful was the text in learning the story?" and (c) "How helpful was the map in learning the story?" Meanwhile, because of the nature of their experimental treatments, subjects in the PO and MR groups saw, respectively, just the first two or the last two of the three questions. The computer programs presented all rating questions to each subject in random order.

As subjects completed their last rating, the computer displayed a new screen with the instructions, "Please briefly describe any mental strategy or trick you may have used to recall details from the story you read. Press the ENTER key when done." Below the directions was a rectangle with seven ruled horizontal lines where subjects typed their responses, taking as long as they wished to do so. Upon pressing the ENTER key, subjects saw a screen of text thanking them for their participation and providing contact information for the experimenter if questions arose about the study. As subjects read this, the computer recorded information to the data diskette, including the subject's name, time and date of session, experimental condition, frequency and duration of map viewing, responses to cued recall questions, helpfulness ratings, and self-report on mental strategy used. After the second or two it took to complete this operation, subjects logged off the computer and were excused from the room. Following the last experimental session, subjects' responses were printed on paper, one sheet per subject, for scoring.

RESULTS

Scoring of the Cued-recall Task

Using printed copies of the experimental text and questions, two graduate student assistants determined the correct answer for each of the 20 criterion questions. They then separately scored the same eight data sheets randomly selected and representing all experimental treatments and text versions. Scored sheets were then compared with scoring differences resolved in conference. Another round of scoring followed, using different protocols, which resulted in a 92% agreement between judges. After the remaining data sheets were scored, the data were input into a statistical program for further analysis; an alpha level of .05 was used for all statistical tests.

Cued-recall data from subjects using the two versions of the experimental text were compared to ensure that the order of text presentation did not have an intervening influence on subjects' recall performance. The total scores of all participants were partitioned into two groups based on text version and entered in a one-way ANOVA. Results showed no significant difference, $F(1,84) = .06$, $p = .81$, between subjects based on the particular version of the text studied. These scores were also partitioned according to the experimental session in which they were obtained (i.e., the initial sessions or those three months later) to determine if differences in recall performance between treatment groups could be attributed to variability among participants based on the session attended. Neither the main effects nor the interaction yielded by a 2 x 4 (Session x Adjunct) ANOVA were significant. All data were therefore pooled, eliminating text version and experimental session as variables in the remaining analyses.

Table 1 ☐ Mean cued recall for text related or unrelated to features on an accompanying map by subjects receiving different types of instructional adjuncts.

Adjunct condition		Mean Cued Recall: Feature		Mean Cued Recall: Nonfeature	
Prequestions alone (n = 22) (PO)	*M*	4.32		3.73	
	SD	2.40		2.14	
	Skew[a]	.18		.17	
	Kurtosis	−1.02		−.58	
Prequestions plus unreviewed map (n = 22) (PM)	*M*	4.27		4.00	
	SD	2.37		2.20	
	Skew	−.15		−.26	
	Kurtosis	−.22		−.66	
Prequestions plus reviewed map (n = 20) (PMR)	*M*	3.80		3.60	
	SD	2.31		2.82	
	Skew	.58		.57	
	Kurtosis	.18		−.20	
Reviewed map alone (n = 21) (MR)	*M*	3.38	[2.67]	2.62	[2.22]
	SD	2.25	[1.41]	1.56	[1.26]
	Skew	.93	[−.03]	.45	[.32]
	Kurtosis	.72	[−.61]	−.30	[-.08]

Note. Figures in brackets are values derived following removal of three outlying cases within the group receiving only a reviewed map (n = 18). [a] Skew and kurtosis = 0 for an exactly normal distribution while positive values indicate, respectively, positively skewed and leptokurtic (i.e., peaked) distributions.

Table 1 [white square] Mean cued recall for text related or unrelated to features on an accompanying map by subjects receiving different types of instructional adjuncts.

Cued Recall Performance

A 4 x 2 (Adjunct x Recall) repeated measures ANOVA of raw data for all 85 subjects showed no significant differences in cued recall between treatment groups, F(3, 81) = 1.29, p = .29. The adjunct variable accounted for 5% of the variability in scores ([eta]^sup 2^=.05). The main effect for recall, on the contrary, was significant, F(1, 81) = 5.21, p = .03, with subjects exhibiting better cued recall for feature-related questions than for questions dealing with parts of the text not related to map features ([eta]^sup 2^ = .06). There was no significant two-way interaction between the adjunct and recall variables, F(3, 81) = .43, p = .73.

Boxplot displays of the analysis revealed three outliers: cases with values between 1.5 and 3 times the interquartile range-the distribution of scores between the 75th and 25th percentile-from either end of the interquartile range. All three outliers were from the map-only group and had respective scores of 7, 7, and 9 (out of a possible score of 10) on feature-related questions and scores of 5, 4, and 6 (only the last score was outlying) on questions not related to map features. As Table 1 shows, eliminating the three outlying cases lowered MR subjects' mean feature-related recall from 3.38 to 2.67 and nonfeature-related recall from 2.62 to 2.22. By contrast, removing outliers had little effect on median values for the MR group: The median score for feature-related recall remained 3.0 while the median for recall of text unrelated to features dropped from 3.0 to 2.5. This relative stability of the median compared to the mean reflects the positively skewed distribution of MR scores, especially for feature-related recall, indicated in Table 1. The distribution for feature-related MR scores is also relatively more leptokurtic (i.e., peaked), making the outlier scores particularly abnormal in light of the group's tighter distribution of scores compared to other groups (cf. MR standard deviations with those of other groups). Hence, the three outliers were distinctive not only because their scores were high relative to others in their treatment group but also because of the uniformity of the poor performance by the nonoutliers.

Characteristics of the outliers were examined to understand why their recall performance was so extraordinary. One of the outliers, it was discovered, was a math education major and an exceptional student who had scored 31 on the 2000 ACT exam (98th percentile nationwide) and had a GPA of 3.94 for 115 credit hours at the time of the experiment. Another outlier was a graduate student in psychology and the only nonundergraduate among the entire subject population. No detailed information was available on the third outlier, a female psychology major. Evidence on the mental aptitude and academic experience of two of the three outliers, however, supports the boxplot analysis that they differed substantially from others in their treatment group.

Using the revised dataset, a 4 x 2 (Adjunct x Recall) repeated measures ANOVA was again executed revealing a significant main effect for adjunct, F(3, 78) = 2.89, p = .04. This accounted for 10% of the variability in recall performance ([eta]^sup 2^ = .10). In terms of statistical power, somewhere between a moderate and large probability (d = .67) existed for finding significant differences in performance based on the type of adjunct used, assuming the hypothesis was true that such differences existed. Mean cued recall for each between-subjects group followed the prediction that subjects with prequestions would outperform those whose text study was aided by just a map (see Figure 2). Once the three outliers were removed from the dataset, the main effect for type of recall was no longer significant, F(1, 78) = 3.46, p = .07. As in the initial analysis containing the outliers, no Adjunct x Recall interaction, F(3, 78) = .19, p = .90, was noted. Using the MR group as a reference category, an analysis of simple contrasts among the remaining between-subjects factors showed those receiving only a map had significantly lower recall scores than either the PO group, t(78) = 2.49, p = .01 (two-tailed), d = .69, or the PM group, t(78) = 2.67, p = .01 (two-tailed), d = .75. Differences in recall scores between the MR and PMR groups, however, fell just short of statistical significance, t(78) = 1.94, p = .06 (two-tailed), d = .48.

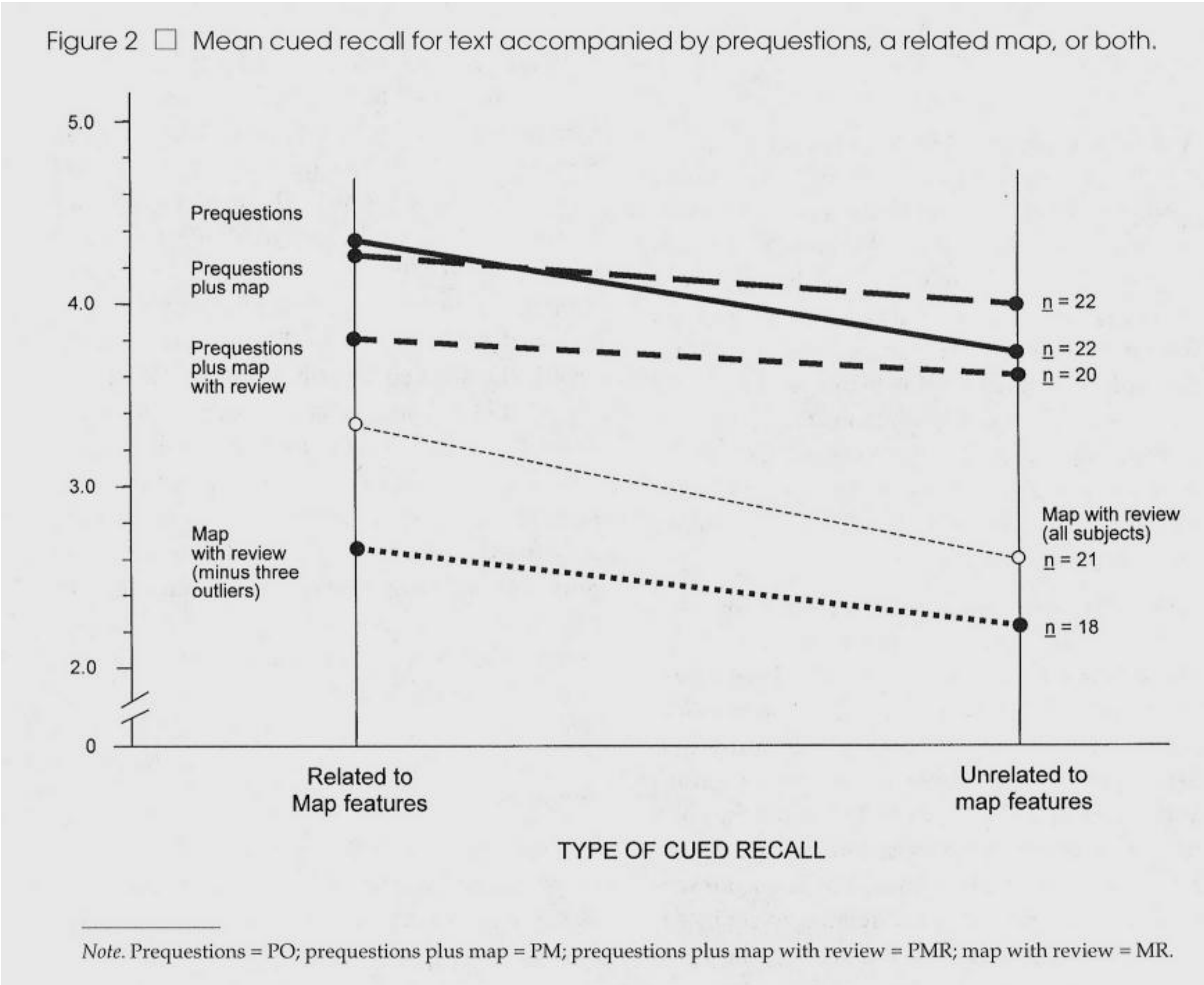

Figure 2 [white square] Mean cued recall for text accompanied by prequestions, a related map, or both.

Frequency of Map Use

One aim of the study was to examine how motivation to access an adjunct map may be influenced by either the presence of preview questions or by a systematic review of features on the map. This aim was achieved by having the computer-based treatments record the frequency and duration of access by subjects of the adjunct map while reading. These data were entered into a one-way ANOVA revealing, as Table 2 portrays, a significant difference among the three map treatments, $F(2, 59) = 4.49$, $p = .02$.

Table 2 ☐ Mean frequency and duration of map accessing during reading of a text preceded by prequestions, a map review, or both.

Adjunct condition[a]		Degree of Map Access: Frequency	Degree of Map Access: Duration
Prequestions plus unreviewed map (22)	*M*	3.73*	12.87
	SD	4.43	21.78
Prequestions map (20)	*M*	5.70	13.25
	SD	7.32	16.80
Reviewed map alone (18)	*M*	9.17*	25.09
	SD	5.12	17.36

Note. Means with asterisks differ significantly ($p < .01$) according to a Newman-Keuls post hoc test.
[a] Number of subjects for each condition is shown in parenthesis.

Table 2 [white square] Mean frequency and duration of map accessing during reading of a text preceded by prequestions, a map review, or both.

Differences among the three adjunct conditions were further examined in a Newman-Keuls post hoc test. Since the three groups differed in sample size, n was replaced by the harmonic mean (n") of the sample sizes for the two means being compared (see Howell, 1982, p. 302). Results indicated that those who received prequestions plus a map that was not reviewed accessed the map significantly fewer times while reading the story than subjects who received a reviewed map as their sole instructional adjunct. Subjects receiving both prequestions and a reviewed map, on the other hand, did not significantly differ from either the PO or the MR groups in how frequently they accessed the map as they read.

In terms of the total time subjects viewed the adjunct map while reading, a one-way ANOVA showed that differences among the map conditions were not significant, $F(2, 59) = 2.55$, $p = .09$. Nevertheless, the means for viewing duration closely corresponded with frequency of map access by each group. Indeed, subjects who viewed a map, but not prequestions, studied the map for roughly twice as long as subjects in the two map-plus-prequestions groups.

Ratings on Perceived Usefulness of Adjuncts

Only 6 out of the 212 ratings made by the entire subject pool for all rated items were exactly 2.5 (on a 0 to 5 scale), suggesting that subjects moved the slider from its original position and understood the rating procedure. Moreover, during the research study sessions, the experimenter observed that virtually all subjects performed the computer-based rating task with ease and fluidity.

Separate one-way ANOVAs were performed for ratings on the usefulness of the text, map, and prequestions. Only in the two treatment groups, PM and PMR, where subjects received both a map and prequestions, did they rate all three items. In the PO group, usefulness ratings of just the prequestions and the text were obtained while those in the MR group rated only the map and text. Hence, each ANOVA involved a different sample depending on whether the rating involved was for text (n = 81), prequestions (n = 64), or map (n = 60). Figure 3 depicts results from the three analyses.

Groups provided with a map to aid in their reading differed significantly in how useful they rated the adjunct for recalling the story, $F(2, 59) = 6.22$, $p < .01$. Through a Newman-Keuls post hoc test it was determined that subjects receiving a feature-by-feature review of the map (i.e., PMR and MR groups) rated it significantly higher in its usefulness than those (in the PM group) who viewed questions followed by a map that was not reviewed (PM < PMR = MR).

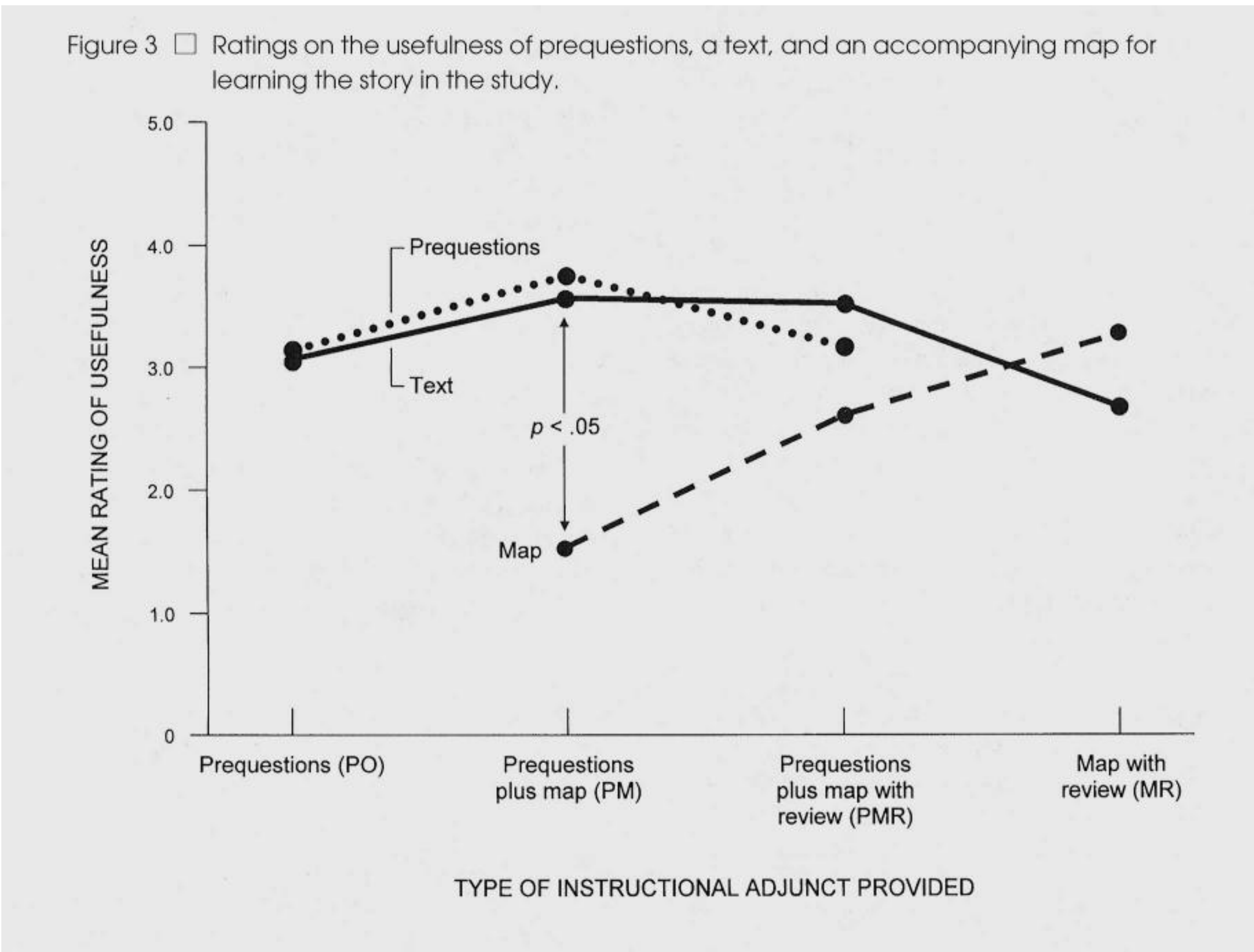

Figure 3 [white square] Ratings on the usefulness of prequestions, a text, and an accompanying map for learning the story in the study.

One-way ANOVA did not reveal any significant differences in how subjects rated the usefulness of either the prequestions, $F(2, 63) = 1.55$, $p = .22$, or the text, $F(3, 81) = 2.47$, $p = .07$, for learning the story. Though not significant by standards, the differences in ratings for text were nevertheless of interest; the relatively higher ratings on the usefulness of the text among those viewing prequestions was in line with the study's general position regarding reading with prequestions and a map.

As Figure 3 suggests, larger differences in ratings were observed between the linguistic components (i.e., prequestions and text) of a treatment and its visuospatial element (i.e., the map) for the PM group compared to the PMR group. This pattern was confirmed by a 2 x 3 (Adjunct x Type Rating) repeated measures ANOVA in which a significant main effect was found for type of rating, $F(2, 80) = 16.44$, $p < .01$, but not for type of adjunct, $F(1, 40) = .38$, $p = .54$. Additionally, the analysis revealed a significant Adjunct x Type Rating interaction, $F(2, 80) = 4.17$, $p = .02$. Subsequently, a simple effects analysis showed that only PM subjects receiving an unreviewed map produced significantly different, $F(2,80) = 18.91$, $p < .01$, ratings on the usefulness of the map, prequestions, and text. A simple contrast of ratings by this group indicated, as Figure 3 clearly shows, that both the prequestions and the text were rated higher than the map, but roughly equivalent to one another, in perceived usefulness.

Intercorrelations Between Ratings, Map Accessing, and Recall Performance

Plausibly, a relationship might exist between the ratings of a map's usefulness and the amount of time spent accessing it during reading, particularly when the map's role is emphasized through a review. This possibility was examined by calculating, for each of the three treatment groups, Pearson product-moment correlations between the usefulness ratings of the map, pre-questions, and text, the amount and frequency of map access, and recall of text that was either related or unrelated to map features.

Table 3 ☐ Intercorrelations between recall, map access, and usefulness ratings by subjects reading a text with adjunct maps and/or prequestions.

	1	2	3	4	5	6	7
Prequestions with unreviewed map (PM) (n = 22)							
1. Feature items[1]		.73**	–.17	–.25	.32	.34	.24
2. Non-feature items			–.12	–.28	.22	.20	.03
3. Map access frequency				.90**	.39	.02	–.22
4. Map access duration					.25	–.02	–.13
5. Map usefulness rating						.31	–.38
6. Prequestion usefulness rating							.04
7. Text usefulness rating							
Prequestions with reviewed map (PMR) (n = 20)							
1. Feature items		.76**	.54*	.24	.30	.19	.34
2. Non-feature items			.49*	.19	.43	.09	.50*
3. Map access frequency				.64**	.43	–.13	.29
4. Map access duration					.52*	–.41	.08
5. Map usefulness rating						.04	.14
6. Prequestion usefulness rating							.01
7. Text usefulness rating							
Reviewed map (no prequestions) (MR) (n = 18)							
1. Feature items		.31	.15	.34	.09	[2]	.14
2. Non-feature items			–.09	.21	.02		.03
3. Map access frequency				.53*	.47*		.14
4. Map access duration					.71**		.30
5. Map usefulness rating						.18	
6. Prequestion usefulness rating							
7. Text usefulness rating							

Note. Figures represent Pearson *r* correlations. * $p < .05$ ** $p < .01$.

[1] Indicates recall of text related to map features. [2] Cell entry not applicable.

Table 3 [white square] Intercorrelations between recall, map access, and usefulness ratings by subjects reading a text with adjunct maps and/or prequestions.

Results validated our speculation that map-viewing behavior is related to its perceived usefulness. Significant correlations were found (see Table 3) between how often a map was accessed during reading and its usefulness rating among subjects having either a reviewed map with prequestions, $r = .52$, $p = .02$, or a reviewed map alone, $r = .47$, $p = .05$. Additionally, within the latter condition ratings were very highly and significantly correlated, $r = .71$, $p < .01$, with the total duration of map viewing activity. By contrast, no significant relationship was noted between map usefulness ratings and either the frequency or duration of map viewing among subjects receiving prequestions plus a map that was not reviewed.

Among the groups receiving prequestions (PO, PM, and PMR), a significant ($p < .01$) and high correlation ($r = .57$, $r = .73$, and $r = .76$, respectively) was found between recall test items that were related to map features and those unrelated to map features. No comparable association was evident among subjects in the MR for the two types of recall test items ($r = .31$, $p = .22$). However, reanalysis of the data with responses from the three outliers included resulted in significant correlations, $r = .67$, $p < .01$, for feature and nonfeature recall for the map-only group as well. The only other association in the MR group that was significantly affected by including outlier data was the rated usefulness of the map and its frequency of access, whereby the correlation was no longer significant ($r = .37$, $p = .10$).

Self-report on Metacognitive Strategies Used

After subjects completed the usefulness ratings, they were asked to describe any "mental trick or strategy used to recall details of the story." Responses by subjects were examined to identify patterns or trends in the kinds of metacognitive strategies used, particularly within a given experimental group. These statements were first listed on several sheets of paper with a line for each entry. Next, they were given to a researcher experienced in qualitative methods who was briefed on the procedures, but not the hypotheses, of the study. A thematic analysis of the statements (Miles & Huberman, 1994) identified nine primary categories of mental strategies used by subjects.

Table 4 ☐ Mental strategies reported by subjects to aid in learning a text while using different instructional adjuncts.

Memory strategy	Instructional Adjunct Condition PO	PM	PMR	MR
1. Using prequestions to direct reading attention	6 (4)	7 (4)	6 (4)	[1]
2. Associating aspects of a tribe with map attributes	[1]	7 (5)	4 (3)	5 (5)
3. Using word features to form acronyms & rhymes	4 (4)	3 (2)	3 (2)	1 (0)
4. Attending to map characteristics and features	[1]	0	3 (2)	7 (6)
5. Associating aspects of the tribes with one another	4 (3)	2 (2)	2 (2)	0
6. Identifying key terms & information in the story	2 (1)	3 (1)	3 (2)	0
7. Noting the order and sequence of story material	2 (2)	1 (1)	0	0
8. Rereading or reviewing the entire text or parts	2 (0)	0	1 (0)	0
9. Trying to remain mentally focused while reading	1 (1)	2 (2)	0	0
No strategy used[2]	0	0	1	4
One strategy used	15	17	15	11
Multiple strategies used	3	4	3	1

Note. PO = Prequestions only, PM = Prequestions & map, PMR = Prequestions & reviewed map, MR = Reviewed map. Numbers reflect the total subjects reporting use of the strategy indicated. This figure may include subjects counted in more than one category who reported using a mixed strategy.
Numbers in parentheses, by contrast, indicate only those subjects who used only the strategy shown.
[1] Entry not applicable. [2] Numbers in this section of the table reflect the absolute, non-repetitive totals of subjects who used multiple, singular, or no mental strategies. Excluded from the data are four subjects, two each in the PO and MR conditions, who made irrelevant comments and three subjects, one in each of the prequestions treatments, who made no response.

Table 4 [white square] Mental strategies reported by subjects to aid in learning a text while using different instructional adjuncts.

A second researcher then resorted subjects' responses into these categories, sometimes assigning a response to more than one category because it incorporated two or more basic strategies. During this "retranslation" process the decision was made to combine two categories that were semantically similar and individually contained few responses. Conversely, a new category was created to represent the large number of subjects who reported trying to associate text information and aspects of the map. Table 4 shows the resulting set of categories and the distribution of recall strategies within each for every treatment group. The table also indicates, for each Strategy x Treatment group cell, the number of subjects using a particular strategy, whether alone or in conjunction with other approaches and, in parentheses, how many of that number used only that strategy.

Use of prequestions was the most widely reported strategy for recalling text information when the same questions were presented after the reading passage; this approach was represented within the three relevant treatment groups in roughly the same numbers. The second most popular mental strategy reported was that of associating aspects of the text with the map. Subjects in the three map conditions employed this approach in roughly equal numbers. Those in the MR group, however, distinguished themselves from subjects in the PM and PMR groups by their greater attempts to use their prior knowledge about the United States to connect regional characteristics (e.g., extensive swamplands are found in southern Florida) with text information. The MR group also had the greatest number of subjects who reported not using any mental strategy at all. If subjects in this group did report using a strategy, it involved using the map. By contrast, every verbally based mental strategy, minus the one involving a map, was represented in the reporting of the prequestions-only treatment group.

DISCUSSION

A chief aim of the current study was to address issues raised by previous research on how subjects make use of an adjunct map when it is accompanied by prequestions on the reading material. The wide variety of data obtained in the current study-recall performance, frequency and duration of map access, usefulness ratings, and self-report of mental strategy used-all suggest that subjects make less use of adjunct maps when they are preceded by prequestions. Although conclusions from the study are tempered by the removal of three outliers from the map-only group, scores within this condition were nevertheless uniformly low relative to the other experimental groups. Further, subjects in this group behaved significantly different than those in other groups in terms of how their map was accessed, rated, and employed in their mental strategies for learning the text.

Subjects given prequestions prior to reading the text recalled more details from the story than subjects who received only an adjunct map. This was true not only for cases where prequestions served as the sole adjunct but also in instances where prequestions were supplemented by an adjunct map that was either not reviewed or, to a lesser degree of confidence, ($p = .06$), one that was thoroughly reviewed prior to reading the text.

When a reviewed map served as the only adjunct during reading it was accessed significantly more often by subjects and rated significantly more useful than when it was preceded by questions-as long as the map accompanying prequestions was not reviewed. In cases where the map was reviewed immediately after the presentation of prequestions (i.e., PMR subjects), both the number of times it was accessed and its rated usefulness fell about halfway between what was observed for MR subjects given only the reviewed map and PM subjects receiving prequestions and an unreviewed map. This apparent effect of map review on its perceived usefulness by subjects and their motivation to access it during reading is consistent with past research (Dean & Kulhavy, 1981) that shows that thoroughly reviewing a map prior to reading a related text increases its effectiveness as an adjunct for prose learning.

Conceivably, people who are exposed to prequestions and then an extensive map review may experience a higher level of processing interference than those provided prequestions and map that is not reviewed. This explanation could account for the differences between the PMR and PM groups in terms of their map ratings, map access, and text recall. Both groups probably tried to retain as much of the prequestions information as possible in working memory once the questions disappeared from the screen. In the case of the PM group, subjects were able to continue mentally rehearsing the prequestions as they looked for related target material in the text while, as the data show, ignoring the map. Those in the PMR group, however, who actively went over each map feature, were faced with the decision either to quit rehearsal of prequestions in working memory or to attempt to retain this information while minimizing the mental disruption of the map review task.

It is difficult to say what the outcome would have been on the recall performance, map ratings, and map access of the PMR group had the review activity occurred before the prequestions. Based on research showing that adjunct maps are most effective when studied before versus after a text (Rittschof et al., 1994; Verdi et al., 1997), one could argue that placing the map review before prequestions should yield better recall. This is an interesting possibility that should be explored in future research on multiple adjuncts.

An interesting outcome of the study was the difference in recall for text information that was either related or unrelated to the map features. Prior to removal of the outliers, a significant main effect was observed for type of recall; short-answer questions loosely related to map features were answered more correctly than questions unrelated to features. While the removal of outliers lowered the main effect for type of recall to just below the commonly accepted level of significance ($p = .07$), this nevertheless represents an important finding. The relatively higher recall for feature-related text was, in itself, not surprising since this is a common finding in research on adjunct maps (Abel & Kulhavy, 1986; Amlund et al., 1985; Schwartz & Kulhavy, 1981). What was unusual in the current study, however, was that this outcome was extended even to subjects who did not study a map. Given the great care taken in designing the different versions of the experimental prose, it seems unlikely that the text structure itself might have made feature-related content more salient than material not related to map features.

One hypothetical explanation for the better recall for feature-related text by subjects in the prequestions-only group is that adjunct questions based on feature-related text may activate dual coding better than questions unrelated to map features. Some dual coding theorists argue that words for concrete objects are easier to image mentally than relatively abstract verbal concepts and are, hence, processed differently (Sadoski & Paivio, 2001). For example, Sadoski, Kealy, Goetz, and Paivio (1997) found that subjects produced lengthier definitions in less time when the words being defined stood for items that were relatively more concrete. Since the natural and man-made landmarks that typically serve as map features are characteristically concrete, they may be especially easy to image mentally and encode in visual storage, even when encountered only in prose. Therefore, whether or not a map is present, adjunct questions that are semantically related to map features may promote dual processing more and be remembered better than text not related to features.

Because adjunct questions direct what learners attend to in a text, when such questions are semantically related to map features they may perform, to some degree, the same attention allocation function that maps and diagrams theoretically carry out when initially viewed (Mayer, 1999). Though nonfeature adjunct questions also direct processing attention, their lower potential for visual imagery (e.g., "What eliminated much of the Kupod tribe's population?") makes them less likely candidates for dual processing than feature-related questions (e.g., "How were the houses of the Kupod designed?"). Regrettably, the present study did not incorporate a text-only treatment (i.e., neither map nor prequestions) that could have been compared with the prequestions-only group to examine the effect of the latter on the differential recall for feature versus nonfeature prose. The possibility that verbally-based orienting devices such as prequestions, objectives, titles, and subheadings can be used to activate dual coding in a text-only learning environment is an exciting prospect that warrants further study.

Incorporating a text-only treatment in the current study could also have helped determine whether the learning achievement of the MR group was typical of map-only conditions in other studies. We suspect it was not, based partly on the fact that this was the only experimental group for which recall of feature-related text was not significantly correlated with recall of text unrelated to map features. Theoretically, when a map and text are dually encoded, the additional access to feature-related verbal information that is afforded by its semantic connection to visual storage should be available to all learners. However, if only a few persons within the group are dually-encoding the adjunct map and text, their ability to remember feature-related information will be disproportionably higher than others in the group, resulting in a lower correlation among the group between feature and nonfeature recall.

The thesis that the MR subjects may not have fully exploited the dual coding potential afforded by the map and text appears more feasible in light of the nearly perfect noncorrelation (whether or not outliers are considered) between their degree of map access and their recall performance. Further, this seemingly random behavior in accessing the map appears consistent with the mental strategies the MR group reported for learning the text. More than any other group in the study, those with only a map displayed a limited repertoire of metacognitive strategies. Essentially, the only approaches they used were either associating the text and map or simply noting map locations. The latter strategy was the one used most often by subjects in the map-only group while rarely used, if at all, by other groups having access to a map during reading. From this we conclude that, despite the feature-by-feature review, only a few subjects in the MR group used the map in a way that might have resulted in a cross-connection between imaginally and linguistically stored information-a key element in both the conjoint retention (Kulhavy et al., 1985) and multimedia processing (Mayer; 1999, 2001) models that accounts for the facilitative effect of visual displays on text recall.

Given the possibility that subjects may not have profited from the adjunct map, we ask what might have been done to make it more effective for promoting dual processing. For instance, depicting map features with mimetic images instead of verbal labels might have resulted in better recall by those in the map-only group. Alternatively, instead of giving participants the anticipation that they would be recalling what they read, they could have been told to expect a task involving some form of geospatial problem solving (e.g., terrain navigation, route planning). This approach may have encouraged more focused initial processing of the map, greater effort in transforming it into a distinct mental model, and increased mindfulness toward making semantic connections between the map and the accompanying text. Our current research addresses this possibility and, in particular, the influence that task expectancy may have on learner motivation to process some types of graphic adjuncts over others.

The matter of when learners are motivated to access and use instructional adjuncts, particularly graphic displays, is one that has formerly received little research attention, in part because of the difficulty in determining what subjects are viewing at any given time. Previous attempts to identify when subjects attend to specific components of an instructional program have usually relied on either the self-reporting of subjects or complex eye-tracking technology. In many instances, data from the former have proven unreliable while that from the latter are often difficult to interpret. However, the computer technology employed in our study offers an attractive alternative for pinpointing the exact times and durations that subjects view an adjunct display. This method for obtaining a direct and reliable measure of subjects' motivation to view an adjunct display offers numerous research possibilities such as the study of display preference under varying conditions of task expectancy mentioned earlier.

Given the potential of computer-based treatments for measuring where and when subjects want to view an adjunct display in a text, one can begin to explore questions related to the temporal and spatial contiguity of texts and images. For instance, where should adjunct questions be included, if at all, in an illustrated instructional text? The results of this study suggest that brief presentation of questions at the very beginning of a text increases the chance that learners will not attend to an adjunct graphic-at least when the expected criterion task involves recall of what was read. However, placing adjunct questions periodically throughout a text and immediately following related target prose may heighten processing attention without focusing it so narrowly that adjunct graphics are ignored. Such an approach by itself, however, is not likely to enhance dual processing of text unless, as Ho's (1989) study suggests, each adjunct question is spatially contiguous to a semantically related graphic.

In this regard, perhaps the best solution to the problem of where to place adjunct questions is one proposed by Fleming (1987) several years ago: Incorporate questions directly in the captions of figures. In theory, such an instructional approach would compel readers to make meaningful connections between the information in a display and the corresponding material in an adjacent text. Hopefully, this would enable graphic and text-based adjuncts to be used so that they complement instead of hinder one another. Ideally, this tactic will also maximize the potential that multiple adjuncts offer for dual coding to occur. It remains for further research to determine whether such expectations are justified.

1 Verbal recall was selected as the main criterion measure in this study chiefly because this continues to be the primary behavioral outcome-obtained most frequently through free recall or constructed-response tasks-used in research on learning from adjunct maps. Conceivably, this is the case because the vast majority of studies dealing with use of adjunct maps have been conducted by educational psychologists whose primary interest has been the understanding of how human memory functions, especially where it concerns visuospatial processing. To a certain degree, the current experiment continues in this research paradigm in its attempt to understand the mental processes at work when two proven instructional adjuncts are used concurrently.
Of greater and more fundamental importance, however, is the fact that the study of verbal learning remains especially useful for examining learning processes that entail dual coding mechanisms. While of limited use for constructivist learning environments, data on verbal learning that is facilitated through the use of semantically related graphics provides a vitally important "window" for understanding the complex interplay between knowledge that is conjointly retained in imaginal and linguistically-based mental stores.

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