

Elaborative Interrogation Facilitates Adult Learning of Factual Paragraphs

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The authors evaluated the potency of elaborative interrogation for promoting acquisition of facts in paragraphs. University students studied 6-sentence factual paragraphs about 5 universities (1 fact per sentence). In general, elaborative interrogation facilitated learning better than did self-reference (Experiment 1 only) and reading-control conditions; performances in the elaborative-interrogation conditions equaled performances in the imagery conditions. The elaborative interrogation over control advantage was obtained for both intentional and incidental learning (Experiment 2) and both when subjects processed sentences individually and when they generated answers for each new sentence in a paragraph by considering information presented earlier in the paragraph (Experiment 2). Even when elaborative-interrogation subjects could not recall facts in their entirety, they were more likely than control subjects to have learned the associations between the university and the factual attribute.

Sometimes students lack prior knowledge that might make obvious the significance and meaning of to-be-acquired facts (e.g., Bransford et al., 1982). If so, fact learning reduces to rote learning of arbitrary associations, a process known to be difficult (e.g., Rohwer, 1973). Alternatively, even when people possess relevant prior knowledge that can be used to elaborate novel facts to make them more meaningful and memorable, they may fail to activate such knowledge (Pressley, McDaniel, Turnure, Wood, & Ahmad, 1987; Pressley, Symons, McDaniel, Snyder, & Turnure, 1988). One purpose of our studies was to evaluate one mechanism that can encourage students to activate relevant prior knowledge in response to novel facts and, in turn, facilitate acquisition of those facts.

Bransford and his associates (e.g., Stein & Bransford, 1979; Stein, Littlefield, Bransford, & Persampieri, 1984) presented learners with information about types of men: specifically, statements about actions that were arbitrarily associated with a number of man types (e.g., "The tall man bought the crackers," "The hungry man got into the car"). They found that when adults and children were provided elaborations for arbitrary facts that made the significance of the man-action pairings more obvious (i.e., precise elaborations, to use Bransford et al.'s 1982 terminology), arbitrary facts were more memorable. Thus "The tall man bought the crackers *that were on the top shelf*" was more memorable than "The tall man bought the crackers." Bransford et al. (1982) argued that provision of precise elaborations helps to activate the learner's

prior knowledge and promotes integration of seemingly arbitrary information with previous experience, making the novel facts more comprehensible and memorable. Unfortunately, memory gains produced by *providing* precise elaborations to adults are often small.

More optimistically, Pressley et al. (1987) identified another procedure designed to encourage learners to make connections between arbitrary facts and their prior knowledge. Pressley et al. instructed their subjects to generate an answer to a "why" question (e.g., "Why did that particular man do that?") when presented man statements. Pressley et al. found that this approach (elaborative interrogation) produced larger learning gains than did provision of precise elaborations. One reason why the self-generated elaborations may be more effective than experimenter-provided ones is that they are more likely to be consistent with the learner's prior knowledge. Alternatively, elaborative interrogation may involve more conscious and effortful memory processes than does provision of elaborations (Hasher & Zacks, 1979; Jacoby, 1978), and the resulting memory trace may be more distinctive (e.g., Slamecka & Graf, 1978). The elaborative-interrogation effect seems consistent with other demonstrations that learning is better when study includes active generation of information (e.g., Jacoby, 1978; Schwartz, 1971; Slamecka & Fevrieski, 1983; Slamecka & Graf, 1978).

In addition to enhancing acquisition of essentially random associations (i.e., man sentences), Pressley et al. (1988) also demonstrated that elaborative interrogation promotes learning of more educationally relevant content. Canadian university students were presented facts about Canadian geography, history, economics, and sociology. If, during study, students answered "why" questions about the facts (e.g., "Why would it make sense that British Columbia is the province with the highest percentage of its population in unions?"), retention of

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the facts was greater than if they read and reread the same information with the goal of comprehending it. The same result was obtained when students were presented statements about gender differences: Adult students learned better when they answered "why" questions (e.g., "Why would it make sense that the fact was true of males?"). Overall, the effects produced by elaborative interrogation have been large, generally between one and two standard deviations in magnitude (e.g., Hedges & Olkin, 1985).

Experiment 1

There were two important differences in the encoding and retrieval demands of Experiment 1 in comparison with those of previous research: (a) In all previous investigations, the to-be-learned materials were isolated pieces of information presented in random order. Events and attributes were linked to concepts already familiar to the learners (e.g., types of men, Canadian provinces, men and women). The memory test usually required recall of the familiar concept when the subject was given the corresponding event or attribute, as in the following examples: "Which man bought the crackers?" "Which province produces the most fox fur?" "Who is more likely to get the flu, males, females, or they're equally likely?" In contrast, the students in Experiment 1 were given five sets of six facts, each about a different university. The six statements in each set were presented in succession and were written so that they formed a coherent narrative about the university. Thus the to-be-learned content was more organized in Experiment 1 than in previous research. (b) Our main interest in Experiment 1 was whether students' cued recall of the six facts associated with each university would be enhanced if they attempted to answer a "why" question for each fact. At testing, subjects were required to recall all six facts when given the name of the university, a more demanding retrieval task than those of previous studies, in which each test question had only one answer (i.e., associative matching).

An incidental learning paradigm was used to maximize adherence to instructions (e.g., Craik & Lockhart, 1972; Craik & Tulving, 1975). In keeping with much of the previous research on elaborative interrogation, subjects were not told of the upcoming memory tests (Pressley et al., 1987; Pressley et al., 1988). Performance in the elaborative-interrogation condition was evaluated in relation to performance in a reading-control condition, in which subjects were explicitly instructed to read each statement with the goal of understanding factual content. The reading-control participants were actively engaged in reading and processing the material for the entire period of time that it was presented. Thus this was a demanding control condition in the sense that total study time was at least equal to, if not greater than, that in the elaborative-interrogation condition.

In addition, elaborative-interrogation performance was evaluated in relation to two other conditions that involved elaborative encoding of the text content: an imagery condition and a self-reference condition. Representational imagery is a strategy familiar to most readers of this journal. There are many demonstrations that imagery generation enhances the learning of arbitrary facts, often by a large amount (e.g.,

Anderson & Hidde, 1971; Anderson & Kulhavy, 1972; Giesen & Peeck, 1984; Paivio, 1971, 1986; Pressley et al., 1988; Rasco, Tennyson, & Boutwell, 1975). Subjects in the self-reference condition decided and explained whether each to-be-learned fact would influence their decision to attend the particular university being discussed. This condition was designed in light of demonstrations that elaborating to-be-learned content with self-knowledge promotes learning (Bellevza, 1984; Rogers, Kuiper, & Kirker, 1977). For instance, when people evaluate whether passage information accurately describes themselves, they remember more of the passage than if they decide whether the passage describes someone else (Reeder, McCormick, & Esselman, 1987). By directly comparing elaborative interrogation with imagery and self-referencing, we could evaluate whether elaborative interrogation is as powerful as other elaborative methods being recommended to the educational community. Such information is important in determining whether to continue development of elaborative interrogation procedures or to divert research resources to other learning strategies.

Method

Subjects and Design

The participants were 80 English-speaking undergraduates (28 female and 52 male) enrolled in an introductory psychology course at the University of Western Ontario. Because the task involved learning information about Canadian universities, participation was restricted to those who had never been enrolled in another Canadian university. Twenty subjects were randomly assigned to each of the four experimental conditions. Three conditions (elaborative interrogation, imagery, and self-reference) required subjects to elaborate information about the schools; the fourth was a reading-control condition.

Materials

A set of 43 slides was constructed for each experimental condition. A single factual statement about a Canadian university was typed in the middle of each slide in upper- and lowercase letters; there were six consecutive slides for each university. The statements were constructed from information in Yale Daily News (1987) and *U-Choose: A Guide to Canadian Universities* (1987), two volumes providing "insider" information about universities. We assumed that the facts that were selected were not well known to people not attending the schools in question; this assumption was verified in a pilot study in which potential statements were presented as part of eight alternative multiple-choice questions (i.e., subjects attempted to match facts to eight universities). The correct responses (for items used in our study) were selected by less than 20% of these pilot subjects. Appendix A contains the practice sentence about McMaster University, one of the two six-sentence practice sets, and one of the five six-sentence sets constituting the critical to-be-learned information in this study.

Slides varied by condition with respect to the processing prompt printed in capital letters underneath each fact. The prompt in the elaborative-interrogation condition was the "why" question, "Why would that fact be true of that particular university?" Imagery subjects were reminded to "create an image of this fact and that particular university." Self-reference subjects were to "explain if this fact would influence your decision to attend that particular university." Reading-

control subjects were reminded to "read the sentence out loud at a rate that allows you to understand that fact is true of that particular university."

Procedure

The session consisted of four phases: instructions, study, tests, and posttest interview.

Instructions. Instructions varied by condition. Elaborative-interrogation subjects were instructed to read each sentence silently but to answer aloud the "why" question printed below it: "Why would that fact be true of that particular university?" They were told that the purpose of the experiment was to investigate how people answer questions about sentences they read. The subjects were informed that they would be shown several sets of true facts, each set about a particular Canadian university. They were instructed to respond to the "why" question after each fact was presented: It was emphasized that their answer should state why the fact was true of the specific university being discussed and not another similar university (e.g., by referring to the school's location). The 15-s rate of presentation was explained. Subjects were urged several times to attempt to generate an answer for every sentence presented.

Imagery subjects were instructed similarly to construct imaginal representations for each fact as part of an investigation of the ease with which people can generate mental images. Each subject was to depict clearly (e.g., by creating an image of the factual relation in the school's geographical setting) the fact as presented, imagining it as true of the specific university being discussed and not another, similar university. Subjects were told to keep the image in mind for as long as the sentence was presented. Subjects were led to believe they would be asked subsequently to rate how easy or hard it was to create images for the sentences.

Self-reference subjects were to decide and explain whether each fact would influence their decision to attend the university (i.e., positively, negatively, or not at all). The directions in this condition were otherwise as similar as possible to the directions in the elaborative-interrogation condition.

Reading-control subjects were asked to read each sentence out loud at a rate that permitted them to understand that the fact was true for the specific university being discussed. They were told to continue reading the sentence aloud for the entire time that the slide was presented. (This produced an average of 2.3 readings of each sentence in this experiment.)

Before study, subjects practiced with the single practice sentence and two practice sets of six sentences. Subjects were required to demonstrate how they would process the statements; feedback about their practice responses was provided; and an example of an appropriate response for each statement was provided by the experimenter. (Appendix B contains experimenter-provided sample responses for each elaboration condition.)

Study. Immediately after the practice session, five sets of six to-be-learned sentences were presented to the subjects. Twenty random orderings of the five sets were used, so that each subject in each of the four conditions experienced a unique order of presentation. The sentences within sets were presented in a constant order. Immediately before the presentation of each sentence set, the experimenter stated the name of the university and the province in which the school is located and placed in front of the subject a stand-up cue card bearing the name of the school. Before each sentence set, subjects were reminded of the processing instructions for their condition.

Tests. Two memory tests were administered immediately after study. Subjects were first cued with the names of the five schools (the province where the school is located was also provided when requested) and were required to recall the facts about each school (fact

recall). The school names were presented one at a time in a random order, except that the last school presented during study was never recalled first. Subjects were told to make the best possible guesses if they were unsure and were prompted to use the strategies that they had employed during study to aid in the recall of the facts. For example, subjects in the elaborative-interrogation condition were told that trying to remember how they answered the "why" questions might aid their recall of the presented facts. When a subject indicated that nothing more could be recalled, the name of another school was presented. No time limits were imposed on recall.

The second memory test consisted of presenting the 30 target facts and five target school names; subjects were required to indicate which university went with each fact (associative matching). The 30 test questions were presented in a different random order to each subject. Subjects were permitted about 10 s to begin responding to each item. Subjects were encouraged to attempt an answer to each question, even if the response was only a best guess.

Posttest interview. A posttest interview similar to one used by Pressley et al. (1988) followed testing. It was designed to provide information about whether subjects followed the instructions that were given to them, whether they suspected that they would be given the memory tests, and whether they had prior knowledge about the target schools. Subjects in all conditions were asked to describe their processing of five statements presented during the study phase. All subjects were asked whether they had anticipated the memory tests. Subjects were also asked to rate the difficulty of the assigned processing task, providing a rating from 1 (*easy*) to 10 (*difficult*) for each school. Finally, subjects were asked to indicate how much they had known about each school before the study on a scale of 1 (*a lot*) to 10 (*very little*).

Results

The fact recall data (i.e., facts recalled given the university names) was scored with 98% interrater agreement. Both the fact recall and associative matching data are summarized in Table 1 as a function of experimental condition. For both dependent variables, we evaluated the four condition means by making all six pairwise comparisons, using a set of Dunn-Bonferroni contrasts (Kirk, 1982, here and for all other ref-

Table 1
Fact Recall and Associative Matching As a Function of
Experimental Condition in Experiment 1

Condition	Fact recall		Associative matching	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Elaborative interrogation	10.65 _a	3.10	23.85 _a	2.80
Imagery				
Unadjusted	10.80 _a	5.75	22.20 _a	4.57
Adjusted	10.00 _{a,b}	5.59	21.47 _a	4.63
Self-reference	7.10 _{b,c}	3.54	20.40 _a	3.98
Reading control				
Unadjusted	5.70 _c	2.81	15.35 _b	5.24
Adjusted	5.43 _c	2.94	14.94 _b	5.31
<i>MS_e</i> (unadjusted)		15.775		18.006
<i>MS_e</i> (adjusted)		14.744		17.507

Note. Maximum score = 30 for both fact recall and associative matching. Means within columns that share the same subscripts do not differ significantly at $p < .0083$ per comparison (i.e., $p < .05$ for the set of six possible pairwise comparisons). Adjusted means and standard deviations were calculated by eliminating subjects who had anticipated an upcoming test.

erences to hypotheses-testing procedures). The overall Type I error rate for each set of contrasts was set at $p < .05$, and thus the per comparison error rate was $p < .0083$. The cutoff was $t(76) = 2.73$ with this setup. Significant differences are summarized in Table 1. In general, elaborative interrogation and imagery were more potent than the reading control procedure. Although self-reference subjects did significantly better than control subjects on the associative matching task, there was only a trend favoring self-reference subjects over reading-control participants on the fact recall task. There were no significant differences between elaborative interrogation and imagery for either task.

In general, participants in the study did not anticipate the memory tests. Only 9 subjects (5 imagery and 4 reading control) said that they expected a test. The data were reanalyzed without the data of these subjects, and the adjusted data are summarized in Table 1. There was only one change in the significant differences: The fact recall difference between imagery and self-reference conditions was no longer significant.

Even when fact recall proved impossible, subjects in the three elaboration conditions were more likely to have learned at least the association between the fact and the university than were the reading-control participants. The probabilities for making the match if the fact was not recalled were .74 (elaborative interrogation), .65 (imagery), .61 (self-reference), and .45 (reading control); each of the elaboration probabilities differed significantly from the reading-control probability, smallest $t(76) = 3.43$, $p < .001$ ($MS_e = .0218$). The elaborative interrogation probability was significantly greater than the self-reference probability, $t(76) = 2.78$, $p < .01$. The imagery probability did not differ significantly from either the elaborative-interrogation or the self-reference probabilities, larger $t(76) = 1.93$, $p > .05$.

Errors

There was some concern that elaborative interrogation might produce more fact recall errors than would the other procedures, because elaborative interrogation directs attention during study to information not stated in the passage. This fear was unfounded. *Intrusion errors* were facts presented during study but recalled in response to the wrong school; *incorrect statements* were facts recalled at testing that did not correspond with information presented during study. Both types of errors were rare (mean numbers per subject = 1.10 and 2.01, respectively). There were no between-condition differences for either type of error, largest relevant pairwise $t(76) = 1.74$, $p > .05$. These error analyses made it clear that the between-condition differences in correct factual recall were not artifacts of more attempts at recall. If that had been the case, error rates would have covaried positively with recall.

Relations Between Responses During Study and Subsequent Memory Performances

All of the responses to "why" questions in the elaborative interrogation condition were scored by two independent raters. Responses scored as adequate reflected some background

knowledge possessed by the subject that made clearer why the stated fact was true of the particular university and not another school. All other responses were classified as inadequate. There was 96% interrater agreement in classification of the responses, and disagreements were resolved by discussion. Adequate elaborations, inadequate elaborations, and failures to respond occurred for 71.83%, 14.17%, and 14.00% of the items, respectively. The conditional probabilities of fact recall and associative matching for items as a function of the type of response given during study are recorded in Table 2. Because not every subject provided responses for all three answer categories, the Spjotvoll and Stoline modified Honestly Significant Difference (HSD) procedure (overall $p < .05$ for each set of comparisons) for unequal sample sizes was used to assess differences between categories; the significant differences are summarized in Table 2.

In the adequate responses to questions in the self-reference condition, subjects included a statement of how the fact would influence the subject's attendance decision (positively, negatively, or neutrally) and used some background knowledge to explain why the decision was specific to that university and not another school (scored with 89% interrater agreement; disagreements were resolved by discussion). All other responses were classified as "inadequate." Adequate responses occurred for 58% of the items; inadequate responses were provided for 41% of the items. Subjects failed to respond to only 1% of the self-reference items. Table 2 summarizes the conditional probabilities for the two memory tests as a function of study-answer adequacy. None of the differences were significant.

Posttest Interview

In general, reported adherence to the instructed strategies was high: 75% ($SD = 34\%$) in the self-reference condition, 80% ($SD = 22\%$) in the elaborative-interrogation condition, and 90% ($SD = 20\%$) in the imagery condition. Rated task difficulty and rated prior knowledge data are summarized in Table 3; both variables were analyzed with the same approach used to analyze the recall data. The prior knowledge ratings did not differ as a function of condition; rated prior knowledge

Table 2
Mean Conditional Probabilities of Fact Recall and Associative Matching As a Function of Adequacy of Answers to Why Questions in the Elaborative Interrogation and Self-Reference Conditions

Condition	<i>n</i>	Fact recall	Matching
Elaborative interrogation			
Adequate response	20	.395 _a	.811 _a
Inadequate response	20	.212 _b	.799 _a
No response	13	.176 _b	.735 _a
Self-reference			
Adequate response	20	.265 _a	.730 _a
Inadequate response	20	.207 _a	.641 _a
No response	6	.000*	.500*

Note. Means within each column in each condition that share the same subscript do not differ significantly, except where noted.

* A probability that was not analyzed because it was based on a very small number of subjects.

Table 3
Task Difficulty and Prior Knowledge Ratings As a Function of Experimental Condition in Experiment 1

Condition	Task difficulty		Prior knowledge	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Elaborative interrogation	6.14 _a	1.17	8.80 _a	0.77
Imagery	4.72 _{b,c}	1.18	8.44 _a	1.58
Self-reference	5.75 _{a,b}	1.09	7.69 _a	1.56
Reading control	3.94 _c	1.41	8.12 _a	1.62
<i>MS_e</i>	1.484		2.037	

Note. Each mean based on each subject's mean rating averaged over the five schools. Maximum rating = 10. Means within columns that share the same subscripts do not differ significantly at $p < .0083$ per comparison (i.e., $p < .05$ per set of all pairwise comparisons within the column).

was very low in all conditions. Task difficulty ratings varied between conditions. Elaborative-interrogation and self-reference strategies were reported as more difficult to execute than the imagery and reading-aloud procedures.

Discussion

Given a cue (i.e., a university name), subjects in the elaborative-interrogation condition recalled novel facts better than did subjects in the reading-control condition. Even when subjects in the elaborative-interrogation condition had not learned a fact so well that they could recall it, they were much more likely than reading-control subjects to be able to match facts and universities. What was just as critical, however, was that elaborative interrogation proved at least as potent as imagery or self-reference processing on all memory measures. Moreover, any fears that elaborative-interrogation subjects might give more incorrect statements during the memory tests were unfounded.

This study provided illuminating data about two other potential problems with elaborative interrogation. Failures to generate adequate responses to elaborative interrogations might be expected to impair learning of an item, inasmuch as most attention during study would have been devoted to the unsuccessful effort to discover a mediator rather than learning the fact. Potentially even worse would have been the discovery of a mediator based on irrelevant prior knowledge. As in previous research, however, the differences in conditional probabilities of recall within the elaborative-interrogation condition were small in absolute value as a function of the quality of answer generated in response to "why" questions, although the probability of recalling a fact was significantly higher for items that had been answered adequately than it was for other items.

Pressley et al. (1988) suggested that one factor accounting for the effectiveness of elaborative interrogation was that elaborative-interrogation subjects rarely spend time disconfirming or challenging the facts as given, a behavioral pattern that was observed in this study. In contrast, the reading-control subjects expressed surprise or doubt about almost a quarter of the probed items (21%), making no attempt to

reconcile these prior beliefs with the facts as presented. Simply activating inconsistent prior knowledge should, if anything, interfere with new learning; that is, activation of inconsistent information may actually undermine rather than support the learning of novel facts.

The self-reference intervention produced a clearly significant improvement in associative matching, but only a trend toward better fact recall than did the reading control condition. Brown, Keenan, and Potts (1986) cautioned that self-reference processing might be beneficial only if the to-be-learned material was capable of being associated with the self-schema. In the past, most investigations of self-reference processing involved learning of adjectives describing personality traits, information that presumably could be readily associated with the self-schema. Arbitrary facts, however, may not be so easily related to self. In keeping with this interpretation, self-reference subjects reported their task as difficult. Given that the self-reference strategy did not produce especially impressive gains in Experiment 1, there was no motivation to study it further in Experiment 2.

Experiment 2

The results of Experiment 1 confirmed that elaborative interrogation would enhance cued recall of several related facts. Nonetheless, because subjects were not informed of the upcoming memory tests (i.e., learning was incidental rather than intentional), the reading-control subjects may not have been doing all they could have done to learn the materials. Given that real-world learning is often intentional, Experiment 2 included both intentional and incidental learning conditions.

In addition, because text is rarely presented sentence by sentence, it made sense to begin studying the use of elaborative interrogation when paragraphs are presented as wholes. Thus in the whole-paragraph conditions of Experiment 2, subjects were presented six facts about each school simultaneously and were told to consider information presented earlier in the paragraph as they processed each subsequent sentence.

Method

Subjects and Design

The course that supplied subjects for Experiment 1 provided 141 female and 99 male participants for Experiment 2 a year later. These students' ages ranged between 17 and 46 years ($M = 19$ years, 8 months; $SD = 3$ years, 4 months). The screening criteria applied in Experiment 1 were also used in Experiment 2.

The design could be conceptualized as a 3 Instructional Condition (reading control, imagery, elaborative interrogation) \times 2 Test Awareness (incidental, intentional learning) \times 2 Formats of Presentation (sentences, paragraphs) factorial design. All were between-subject manipulations; $n = 20$ for each of the 12 cells. The three incidental/sentence conditions in Experiment 2 were very similar to the elaborative-interrogation, imagery, and reading-control conditions in Experiment 1. The three intentional/sentence conditions were identical to corresponding incidental conditions except that subjects were given intentional learning instructions: They were explicitly told about and practiced taking the memory tests. The whole-paragraph conditions

(three incidental and three intentional) were like the sentence-by-sentence conditions except that subjects were presented all six sentences for each school simultaneously and were urged to process the six sentences in a wholistic fashion. Specifically, subjects were told to use previous statements about a particular school when processing subsequent facts about the same school.

There were three experimenters. One tested 6 subjects in each condition. The other two each tested 7 subjects in each condition.

Materials

Three sets of 30 slides (6 sentences for each of 5 schools) were used in the sentence conditions to present the to-be-learned information. These slides were identical to the ones used in Experiment 1 (except for slight modifications in two statements). Two sets of 30 slides were used in the elaborative-interrogation/paragraph and imagery/paragraph conditions. Each slide in the set contained the entire paragraph for the school: In the first slide in the set, the first sentence was highlighted in boldface; in the second slide, the second sentence was highlighted; and so forth. (The subject was instructed to attend only to the boldface sentence in each slide.) One set of five slides (one slide for each school) was used in the reading control/paragraph condition. Processing reminders were typed in capital letters below each paragraph; the instruction varied as a function of experimental condition. Reading-control subjects were directed to "read the paragraph out loud at a rate that allows you to understand that the facts are true of that particular university"; imagery subjects were instructed to "create one image for these facts and that particular university"; elaborative-interrogation condition participants were to answer the question "Why would these facts be true of that particular university?"

Two sets of six practice sentences (one describing the University of Western Ontario, the other describing McGill University) were used to give directions to sentence-condition participants; the formats of these slides were identical to the formats of the practice slides used in corresponding conditions of Experiment 1. A set of two slides (one containing the paragraph for Western Ontario and one containing the paragraph for McGill) was used to provide directions in the paragraph conditions.

Procedure

As in Experiment 1, participation occurred in four phases:

Instructions. The instructions in the three incidental/sentence conditions were about the same as those used in corresponding cells of Experiment 1. Incidental subjects were told that the experiment was about rate of reading in the reading-control condition, making up images in the imagery condition, or answering questions in the elaborative-interrogation condition. Instructions in the intentional/sentence conditions varied from those in the corresponding incidental/sentence conditions only in that subjects were told from the onset that the goal was to prepare for memory tests.

The directions in the paragraph conditions were as comparable as possible with those in the sentence conditions except that subjects were informed that they would be given entire paragraphs and were provided instructions about how to process the paragraphs as a unit. Reading-control/paragraph subjects were told to read each sentence of the paragraph aloud until they reached the end of the paragraph. They were to reread the paragraph aloud until it was time to move to the next slide. (They did so an average of 2.6 times.) They were urged to think about the meaning of the whole paragraph as they processed each sentence, making certain they understood the paragraph as a whole.

Imagery/paragraph subjects were told to read each sentence in the paragraph and to create one image for all the stated facts. They were

instructed to read the first sentence in the paragraph and make an image of that fact and the particular university being discussed. Then they were to read the next sentence, creating a new image that contained both the school and the new fact, as well as some part of the previous image. They were specifically instructed not to make a separate image for each new fact about the same school or to combine images of the different schools.

Elaborative-interrogation/paragraph subjects were made aware that they would be answering out loud a series of "why" questions about each paragraph. After each sentence in the paragraph, subjects were told to try to tell why the fact in question was true of the university being discussed. Subjects were urged to incorporate answers from previous questions into subsequent answers about the same school, but not to combine answers from different schools.

All subjects practiced with the Western Ontario and McGill materials; each subject was required to demonstrate their processing overtly. Subjects were provided feedback about the adequacy of their practice responses, including exemplary experimenter-provided sample responses (see Appendix C for two example feedback responses). Participants in the intentional memory conditions also practiced the memory tests. First, they were asked to recall all six facts about each of the two sample schools without being given the school names. Then, they were given the names of the two universities and were required to recall the information associated with each school. Finally, they were given the 12 facts and were asked to match them to either McGill or Western Ontario.

Study. The five critical to-be-learned sets were then presented, generally in keeping with the procedures used in Experiment 1. In the sentence conditions, each of the six sentences was presented every 15 s. For the elaborative-interrogation/paragraph and imagery/paragraph conditions, each paragraph was presented for 90 s; each sentence was highlighted with boldface for 15 s. In the reading-control/paragraph conditions, the paragraph was presented for 90 s. Two random orders of presenting the five universities were used; approximately half of the subjects in each condition were assigned to each order.

Tests. Three memory tests were administered after presentation of the five to-be-learned sets of sentences. The first (henceforth referred to as the *free-recall test*) required recall of both the university names and the corresponding facts about each school; subjects were permitted as much time as they needed to complete this task. This measure was included because it required more retrieval by learners than fact recall, thus permitting assessment of the elaborative-interrogation effect with an even more demanding memory task than those used in Experiment 1 or in previous studies. The second and third tasks were identical to fact recall and associative matching in Experiment 1. Subjects were urged to recall as much as possible for all tasks; they were prompted to think back to the mediators created during study (e.g., imagery subjects were told to recall their images).

Posttest interview. After subjects completed the associative matching task, a posttest interview, similar to the one used in Experiment 1, was administered.

Results

The primary analyses involved the free-recall, fact-recall, and associative-matching data. The maximum score for each of these tests was 30.

Memory

Three raters scored 30% of the free and fact recall data with better than 95% agreement, and thus the remainder of the

data was scored by only one person. The memory performance data are summarized in Table 4.

The free-recall, fact-recall, and associative-matching data were analyzed in parallel analyses. The three instructional condition means within each of the four test-awareness/format combinations were compared in the three possible pairwise comparisons (elaborative interrogation vs. imagery, elaborative interrogation vs. reading control, and imagery vs. reading control); each comparison was conducted at $p < .01$, cutoff $t(228) = 2.62$. The significant differences in these analyses are detailed in Table 4. In general, elaborative interrogation and/or imagery were more potent strategies than the reading-control procedures.

In addition, we contrasted each incidental mean with its corresponding intentional mean by using six comparisons per memory variable, each conducted at $p < .01$. Only one of these comparisons was significant, although 14 of the 18 comparisons descriptively favored the intentional means. For fact recall, intentional/imagery/sentence subjects significantly outperformed incidental/imagery/sentence subjects.

We also contrasted each sentence condition mean with its corresponding paragraph condition mean by using six pairwise contrasts, each conducted at $p < .01$. Only one of these comparisons was significant, although 13 of the 18 comparisons descriptively favored memory in the paragraph conditions. For fact recall, incidental/imagery/paragraph subjects recalled significantly more than incidental/imagery/sentence subjects.

The overall Type I error rate per variable for all of the analyses summarized in this subsection thus far was .24; that is, $.01 \times 12 = .12$ for the 12 comparisons within the test awareness/format combinations plus $.01 \times 6 = .06$ for the six intentional versus incidental comparisons plus $.01 \times 6 = .06$ for the six sentence versus paragraph comparisons. This rate compares favorably with Type I error rates associated with alternative analyses, such as $3 \times 2 \times 2$ analyses of variance with Type I error rate $< .05$ per effect; in that case, the overall Type I error rate is .35 per variable.

In general, incidental condition subjects did not anticipate the memory tests; only 14 subjects did so (3 imagery/para-

Table 4
Free Recall, Fact Recall, and Associative Matching Performances in Experiment 2
As a Function of Test Awareness, Presentation Format, and Instructional Conditions

Condition	Free recall		Fact recall		Associative matching	
	M	SD	M	SD	M	SD
Incidental learning: Sentence format						
Elaborative interrogation	8.75 _a	3.49	9.55 _a	4.07	23.40 _a	3.99
Imagery	7.60 _{ab}	4.78	8.30 _{ab}	3.76	18.90 _b	5.13
Reading control						
Unadjusted	4.45 _b	4.15	5.50 _b	5.07	14.25 _c	6.71
Adjusted	4.57 _b	4.57	5.50 _a	5.45	14.64 _b	6.34
Incidental learning: Paragraph format						
Elaborative interrogation						
Unadjusted	10.05 _a	4.22	11.30 _a	4.14	22.95 _a	3.83
Adjusted	10.21 _a	4.28	11.47 _a	4.18	23.21 _a	3.75
Imagery						
Unadjusted	10.35 _a	5.70	12.25 _a	5.77	20.75 _a	6.19
Adjusted	9.88 _a	6.01	11.88 _a	6.16	20.06 _a	6.25
Reading control						
Unadjusted	4.60 _b	3.82	5.95 _b	3.59	13.45 _b	5.92
Adjusted	4.69 _b	4.19	6.25 _b	3.82	14.19 _b	6.34
Intentional learning: Sentence format						
Elaborative interrogation	7.80 _{ab}	4.07	11.20 _a	4.05	24.60 _a	3.07
Imagery	11.00 _a	3.97	12.45 _a	5.05	22.20 _a	4.77
Reading control	6.60 _b	4.69	7.15 _b	4.88	16.35 _b	5.97
Intentional learning: Paragraph format						
Elaborative interrogation	9.20 _b	5.32	11.20 _{ab}	4.64	21.85 _a	4.78
Imagery	13.35 _a	4.45	14.50 _a	4.29	22.75 _a	4.25
Reading control	7.05 _b	3.79	9.15 _b	4.15	16.25 _b	5.49
Mean squared error						
Unadjusted	19.494		20.217		26.180	
Adjusted	19.997		20.771		25.442	

Note. Maximum score = 30 for each task. $n = 20$ per condition. Means within columns within each test awareness/format combination that share the same subscripts do not differ significantly, $p < .01$ per comparison. Adjusted means and standard deviations were calculated by eliminating subjects who had anticipated an upcoming test.

graph, 1 elaborative-interrogation/paragraph, 4 reading-control/paragraph, and 6 reading-control/sentence). When the data were reanalyzed without data from test-suspicious incidental subjects (see adjusted means in Table 4), there were some slight changes in the pattern of significance, most of which are summarized in Table 4. In addition, the one-sentence versus paragraph comparison that was significant in the unadjusted analyses (involving the imagery/fact-recall means) was no longer significant according to the criteria applied in the unadjusted analyses, $t(214) = 2.38, p > .01$.

As in Experiment 1, when the more demanding memory tasks could not be performed (i.e., free and fact recall in Experiment 2), elaborative-interrogation and imagery subjects were more likely than reading-control subjects to be able to do the associative matching task. Because the general pattern of differences between instructional conditions did not differ as a function of test awareness or format, the most efficient way to summarize the analyses was to collapse across conditions. The probabilities that elaborative-interrogation subjects could make an associative match was .71 when they could not achieve free recall and .68 when they could not achieve fact recall. Both of these probabilities were significantly greater than the corresponding imagery values of .61 and .57 and the corresponding reading-control values of .44 and .42, smallest $t(228) = 3.82, p < .001$ (MS_e s = 0.028 for free recall and 0.030 for fact recall). Both of the imagery probabilities were significantly greater than the reading control values, smaller $t(228) = 5.75, p < .001$. In short, associative learning was facilitated across the board by the imagery and elaborative interrogation instructions.

Free Recall Organization Data: Sentence Versus Paragraph Format

We measured organization of subject's free recall by using an index of contiguous recall (i.e., category clustering), in this case the tendency to recall facts about the same university together. These repetition ratios (RRs; Begg, 1978; Murphy, 1979) were calculated only for those subjects who achieved free recall of items from more than one categorical group (i.e., university). The value of the RR could range from 0 for chance clustering to 1 for maximum possible clustering; the actual mean in this study was .50 when data were collapsed across conditions. The RR data were analyzed by the same approach employed to analyze each of the memory dependent variables. No significant effects were detected in these comparisons, although in every case the paragraph value was slightly greater than the corresponding sentence value.

Errors

As in Experiment 1, intrusion errors and incorrect statements were scored. These errors were analyzed in procedures exactly paralleling the free- and fact-recall analyses; a total of 24 pairwise comparisons were made, each at .01 per comparison.

The mean number of incorrect statements ranged from 0.35 to 1.90 per condition. When data from all 12 conditions

were considered, the mean numbers of incorrect statements per subject were 0.88 for free recall and 1.20 for fact recall. Three pairwise comparisons were significant in the analyses of incorrect statements. For free recall, the intentional/imagery/paragraph mean of 1.80 was greater than the incidental/imagery/paragraph mean of 0.70, $t(228) = 2.80$ ($MS_e = 1.54$) and the intentional/reading-control/paragraph mean of 0.55, $t(228) = 3.19$. For fact recall, the incidental/elaborative-interrogation/paragraph mean of 1.90 was significantly greater than the incidental/reading-control/paragraph mean of 0.55, $t(228) = 3.49$ ($MS_e = 1.498$).

The mean number of intrusion errors ranged from 0.65 to 2.90 per condition, with an overall mean per subject of 2.00. Two pairwise differences were significant for intrusions during fact recall. The intentional/reading-control/sentence mean of 2.90 was greater than the intentional/elaborative-interrogation/sentence mean of 0.90, $t(228) = 3.37$ ($MS_e = 3.52$). The intentional/reading-control/sentence mean was also greater than the intentional/imagery/sentence mean, $t(228) = 3.20$.

Effects of Various Types of Responses to Elaborative Interrogations

When data were collapsed across the four elaborative-interrogation cells, adequate elaborations were given in response to "why" questions presented 69.37% of the time, inadequate elaborations were provided for 22.88% of the items, and failures to respond occurred for 7.74% of the items. There was very little variability in these rates between the four elaborative-interrogation conditions (e.g., the range of the four elaborative-interrogation means for adequate elaborations was 66.1%–71.9%). In short, subjects were able to come up with adequate responses a high proportion of the time.

The conditional probabilities of free recall, fact recall, and associative matching as a function of adequacy of response to "why" questions were calculated for each subject. These conditional probabilities of correctness varied little as a function of the adequacy of responses to the "why" questions. The only significant difference to emerge, in a number of different analyses performed, was on the associative-matching task. Items answered adequately at study were matched significantly more often (i.e., 80% of the time) than items answered inadequately at study (i.e., 69% of the time), $t(202) = 4.38$ ($MS_e = 0.051$).

Posttest Interviews

Between-condition differences for rated task difficulty and rated prior knowledge are presented in Table 5; these data were analyzed in 24 pairwise comparisons that paralleled the ones used to analyze the memory data. The significant differences for these variables also are summarized in Table 5. Most notable was that elaborative interrogation and imagery were always rated as more difficult than the reading-control procedure.

As in Experiment 1, reported adherence to the elaborative-interrogation and imagery instructions was high, (81% and 87% adherence, respectively); there were only small differences in adherence as a function of test awareness and format

Table 5
Task Difficulty and Prior Knowledge Ratings As a Function of Experimental Condition in Experiment 2

Format/condition	Task difficulty ($MS_e = 1.481$)		Prior knowledge ($MS_e = 1.658$)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Incidental learning				
Sentences				
Elaborative interrogation	6.22 _a	1.05	7.90 _a	1.40
Imagery	4.17 _b	1.12	8.72 _a	1.46
Reading control	2.67 _c	1.55	8.60 _a	1.38
Paragraphs				
Elaborative interrogation	5.45 _a	0.98	8.51 _a	1.29
Imagery	4.83 _a	1.34	9.21 _a	0.96
Reading control	2.59 _b	1.26	9.18 _a	0.99
Intentional learning				
Sentences				
Elaborative interrogation	5.88 _a	1.21	8.54 _a	1.77
Imagery	4.53 _b	0.98	9.02 _a	0.86
Reading control	2.44 _c	1.19	8.95 _a	1.24
Paragraphs				
Elaborative interrogation	5.89 _a	0.96	8.97 _a	1.18
Imagery	4.43 _b	1.31	9.06 _a	1.51
Reading control	2.76 _c	1.48	8.92 _a	1.12

Note. Each mean based on subject's mean rating averaged over the five schools. The maximum rating for both measures was 10. $N = 20$ per condition.

conditions. In addition, subjects were asked whether they would use the assigned strategy again. In general, the answer was yes in the elaborative-interrogation and imagery conditions (65% and 74% of subjects, respectively). Both of these rates of endorsement exceeded the 45% endorsement rate in the reading-control condition, $\chi^2(1-20) = 6.47, p < .03$.

Discussion

Elaborative interrogation produced better incidental learning than did the reading-control procedure. Elaborative interrogation facilitated intentional learning of the school-fact associations across the board and fact recall in the sentence-format conditions. The remaining three intentional elaborative-interrogation versus reading-control comparisons were not significant, although in each case there was a trend favoring elaborative interrogation. As in Experiment 1, performances in the elaborative-interrogation and imagery conditions were generally comparable, statistically so 10 of 12 times. Again, the benefits of elaborative interrogation on free and fact recall were obtained without concomitant increases in incorrect statements and intrusions, and failing to generate an answer to an elaborative interrogation during study was not associated with dramatically lower memory for the item.

Elaborative interrogation was viewed once again as more difficult to execute than imagery, which was considered more difficult than reading. Nonetheless, the majority of both elaborative-interrogation and imagery subjects in Experiment 2 endorsed continued use of their respective strategies. Reading-

control subjects were less willing to endorse continued reading. Elaborative-interrogation and imagery subjects seemed to recognize that the learning gains produced by elaborative interrogation and imagery warranted the extra efforts required to execute these strategies.

Summary and General Discussion

Every relevant descriptive comparison reported here favored elaborative interrogation over the reading-control condition, which was a demanding contrast in that reading-control subjects were required to process the materials for the entire presentation time. In general, these were large effects; 7 of the 12 elaborative-interrogation versus reading-control differences were greater than one standard deviation in magnitude (i.e., in relation to the reading-control standard deviation; Hedges & Olkin, 1985). Just as critical was that elaborative interrogation was generally at least as effective as the other elaborative procedures studied here.

Other aspects of the data also suggest that elaborative interrogation is a promising procedure for learning of factually dense prose. Although elaborative interrogation was perceived as more demanding to execute than the reading-control procedure, these perceptions did not seem to deter elaborative-interrogation subjects from indicating that they would use the strategy in the future. The possibilities that elaborative interrogation would produce intrusions and incorrect statements did not occur. It also mattered little whether elaborative-interrogation subjects succeeded in generating adequate answers to "why" questions, an important finding given that students were not always able to generate adequate responses. Attempting to generate a response probably activates a network of information related to to-be-learned facts, even when learners cannot retrieve or construct information so that adequate answers to "why" questions are produced (see Slamecka & Fevrieski, 1983).

An important next step is to determine whether students can be taught to use elaborative interrogation in a self-regulated fashion. That it may be possible to do so is supported by a recent report by King (1989), who taught Grade 9 students to question themselves as they listened to lectures. Although substantial practice was required before students understood fully how to generate questions in reaction to lecture content and to attempt answers to them, there were very striking memory differences favoring the self-questioning groups over nontrained control subjects. Research on self-regulated use of elaborative interrogation should also be aimed at generating information about whether the procedure can be used with ecologically valid materials. The operations used here only roughly approximated naturalistic reading and studying. Students are rarely required to pause after every sentence. Chapter-, article-, and book-length pieces are the usual units of prose processing, rather than paragraphs. Much work remains to be done to determine whether students can be taught to use elaborative interrogation in a flexibly adaptive fashion as they confront realistic educational tasks, such as attempting to learn from the factually dense texts used to convey science and social studies content to elementary and secondary school students.

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Appendix A

Sample Practice and To-Be-Learned Materials

Practice Sentence

1. The campus at McMaster University is full of wild life.

Practice Sentence Set (McGill University)

1. The land on which McGill University stands was donated by a fur trader.
2. The university's first faculty was a medical faculty.
3. The university is also recognized for establishing the first medical faculty in Canada.
4. The Psychology Department at the school is internationally acclaimed.
5. The school has an extensive puppet collection.
6. Many students consider the university's athletic and recreational facilities to be old and small.

Target Sentence Set (University of New Brunswick)

1. The University of New Brunswick was the first Canadian university to offer a degree in engineering.
2. The school's Chemistry program is reputed as one of the best in Canada.
3. The oldest building of any Canadian university is located on the school's main campus.
4. The school was also one of the first to bring resident artists to campus to enhance programs in Literature, Drama, and Art.
5. One of the university's campuses has residential facilities for males only.
6. Male students who live on campus also have access to special photographic equipment.

Appendix B

Experimenter-Provided Responses:
 "The Campus at McMaster University is Full of Wild Life"

Elaborative Interrogation Condition

My answer is that McMaster University is located on the edge of a bird sanctuary. Therefore, there would be a lot of animals that would enter the campus from the sanctuary. Also, the students would leave leftover food on the ground which would encourage the animals to come on campus. This answer is exclusive to McMaster University because it is the only school located by a bird sanctuary. It is very important that your answers be specific to the university being discussed.

Imagery Condition

I imagined a lot of rabbits and squirrels sitting on one of the walkways at McMaster. In the background I pictured the tops of industrial

furnaces with lots of smoke blowing out of them. The smokey sky and tops of the industrial furnaces make the image unique to McMaster University as two major steel factories are located in Hamilton and that is where McMaster is located.

Self-Reference Condition

This fact would positively influence my decision to attend the university. It is very important that I feel relaxed at school and enjoy the school's campus. The presence of small wild animals would help me feel like this. Because McMaster University is the only university located beside a bird sanctuary, and this is where many of the animals would come from, I know my answer is specific to McMaster University.

Appendix C

Experimenter-Provided Responses

Elaborative Interrogation Condition

"The Land on Which McGill University Stands Was Donated by a Fur Trader"

My answer is that when Canada was still a young country, many fur traders lived in Quebec. Most of these fur traders were businessmen who owned large amounts of property. The fur traders were so well off that they could afford to donate large pieces of land. Because many fur traders lived in Quebec, and because McGill University is in Quebec, I know my answer is specific to McGill University. Make

sure to think of an answer that is specific to McGill when you are answering the questions. Remember that you can also use your previous answers to help answer subsequent questions.

"The University's First Faculty Was a Medical Faculty"

Using my first answer that many fur traders lived in one of the first established provinces with one of the largest populations, I know that there was a high demand for doctors and medical facilities. Therefore, one of the first things McGill University would be encouraged to do would be to teach and train doctors.

(Appendix C continues on next page)

Imagery Condition

"The Land on Which McGill University Stands Was Donated by a Fur Trader"

I imagined a fur trader dressed in furs showing a section of vacant land to a friend of mine who goes to McGill. They're standing on Mount Royal. The image of Mount Royal helps me to distinguish this fact as true of McGill because both Mount Royal and McGill University are in Quebec.

"The University's First Faculty Was a Medical Faculty"

To integrate this new fact, I saw a picture of vacant land and a fur trader, but this time the well-dressed men are showing the fur trader a brand new building. Although the building is new, its structure is quite old. Inside the building, I see doctors running around in white lab coats and green surgeon outfits, with name tags written in French attached to their clothes.

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