Elaborative-Interrogation and Prior-Knowledge Effects on Learning of Facts

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Canadian and West German adults were presented facts about Canadian provinces and West German states (at the time of the study, West Germany was a separate nation of what is now the Federal Republic of Germany). Participants in the elaborative-interrogation condition rationalized why each fact was sensible. Reading-to-understand participants read the facts with the goal of comprehending each one. After presentation of all facts, subjects were asked to match provinces and states to facts associated with them. These performances were compared with matching in a no-exposure-control condition. Prior knowledge had a striking effect on learning in both the elaborative-interrogation and reading-to-understand conditions. Elaborative interrogation also promoted learning of all facts for all participants, although when learners lacked prior knowledge, elaborative interrogation did not produce the high levels of performance that were obtained when subjects possessing high prior knowledge simply read the facts. Both strategies and prior knowledge are critical to efficient learning.

Students often need to learn facts. As are many associative learning tasks, the acquisition of factual content can be challenging. Asking students to explain why facts are sensible facilitates memory of the facts (Martin & Pressley, 1991; Pressley, McDaniel, Turnure, Wood, & Ahmad, 1987; Pressley, Symons, McDaniel, Snyder, & Turnure, 1988; Woloshyn, Willoughby, Wood, & Pressley, 1990; Wood, Pressley, & Winne, 1990). For example, given the statement, "Baseball in Canada was first played in Ontario," Canadian students can generate rationales about the proximity of Ontario to New York, where baseball started in the United States. Alternatively, they might rationalize that Ontario imports innovations from the United States more often than do other provinces. In studies to date, the process of attempting to explain why facts are sensible has greatly enhanced fact learning relative to the process of reading for understanding (i.e., more than a 1 SD advantage; for a review see Pressley, Wood, Woloshyn, Martin, King, & Menke, in press). Because this question-answering approach is intended to stimulate for-

mulation of elaborations and inferences about information to be learned, it is referred to as *elaborative interrogation*.

In previous research on elaborative interrogation, participants have been asked to study facts from domains for which they possessed substantial prior knowledge. Thus, Canadian adults have been asked to learn information about Canadian provinces (Martin & Pressley, 1991; Pressley et al., 1988), children have learned facts about familiar animals (Wood et al., 1990), and Canadian university students have studied information about institutions in their home country (Woloshyn et al., 1990). The assumption in these studies was that elaborative interrogation would promote learning, at least in part, by increasing learners' attention to, and processing of, prior knowledge that was related to the critical information. Martin and Pressley (1991) produced data consistent with this interpretation (see also Bransford et al., 1982), demonstrating that "why" questioning improved learning of facts proportional to the extent that why questions oriented learners to relevant prior knowledge. Thus, learning the fact, "The first Canadian-based farm protest organization was formed in Manitoba," was facilitated by answering the question, "Why does that make sense given what you know about that particular province?," which explicitly directed attention to information supporting the fact as stated. In contrast, when questions oriented learners to prior knowledge that did not support the facts as stated, there were no learning gains. Thus, no improvement in acquisition occurred when participants answered questions such as, "Why is that unexpected given what you know about other provinces?"

Yet what if learners do not possess relevant prior knowledge that can be activated during the construction of explanatory rationales? This is an important issue because students are often domain novices, who lack extensive prior knowledge about what they are studying. One obvious possibility is that

elaborative interrogation would no longer facilitate learning. If why questioning promotes acquisition only by stimulating prior knowledge and if there were no prior knowledge that could be related to the new facts, then elaborative interrogation would not be expected to facilitate learning. Alternatively, elaborative interrogation might still enhance learning because question answering can initiate a variety of mechanisms besides activation of prior knowledge. For instance, it should increase conscious processing of to-be-learned materials (i.e., cognitive effort) as well as meaningful analyses of them (i.e., deep processing, which is often associated with enhanced learning; e.g., Jacoby, 1978; Slamecka & Graf, 1978; Tyler, Hertel, McCallum, & Ellis, 1979).

The participants in this experiment were from two countries, Canada and the Federal Republic of Germany (West Germany at the time of the study). In two conditions of the study, students of both nationalities were presented information about provinces/states in their own nation as well as information about the provinces/states of the other country. In one of these conditions (elaborative interrogation), students answered why questions about the facts. Participants in a second condition were instructed to read the same facts very carefully, making certain that they understood each one (reading-to-understand condition). After presentation of the facts, elaborative-interrogation and reading-to-understand subjects were required to match the names of West German states and Canadian provinces to facts associated with them. Matching performances in both the elaborative-interrogation and reading-to-understand conditions were compared to performance in a third condition, a no-exposure control. Because performance in the no-exposure condition reflected how well participants could perform the task without an opportunity to learn the facts, it provided an appropriate baseline for evaluating whether, and to what extent, learning occurred in the elaborative-interrogation and reading-to-understand conditions.

We expected that with familiar domain materials elaborative interrogation would be more beneficial than reading for understanding which, in turn, would be more helpful than no exposure (e.g., Kuhara-Kojima & Hatano, 1991; Woloshyn et al., 1990). We were less certain how large the corresponding effects would be for materials from an unfamiliar domain. Thus, the primary purpose of our study was to determine the size of the differences between elaborative-interrogation, reading-to-understand, and no-exposure-control conditions with domain-familiar materials in relation to the corresponding differences with domain-unfamiliar content. By examining learning in elaborative-interrogation and reading-to-understand conditions with materials from both familiar and unfamiliar domains, we were able to evaluate some theoretically important issues. Most critically, we were able to compare learning mediated by the elaborative-interrogation strategy in relation to learning mediated by the activation of prior knowledge that was associated with simply reading materials in order to understand them. This comparison is important given contemporary debates about the potential roles of consciously applied strategies, including strategies designed to activate relevant prior knowledge not accessed by instructions to read material (e.g., Bjorklund, Muir-Broaddus, & Schneider, 1990).

Method

Subjects and Design

The participants in this study were 100 undergraduate students. Fifty students were from the University of Western Ontario, London, Ontario, Canada: 36 female students, 14 male students; mean age = 20.4 years; age range = 18 to 46 years. Fifty students were from the University of Munich, Munich, Bavaria, Federal Republic of Germany (West Germany at the time of the study): 24 female students, 26 male students; mean age = 25.4 years; age range = 18 to 34 years. The Canadians were students in an introductory psychology course. The West Germans were at various points in their degree programs, all enrolled in a summer session.

All participants had resided in their home country for at least 15 years and thus were assumed to possess sufficient background knowledge to answer many of the why questions posed during presentation of the facts pertaining to their own country. No participants were enrolled or had been enrolled in academic programs focusing on the "foreign" country (i.e., West Germany for Canadian students; Canada for the West Germans). Hence, it was assumed that the West German students possessed only very general knowledge about Canada and that the Canadians possessed only very general knowledge about Germany. In fact, when asked how much they knew about the two countries, every participant in the study indicated that he or she knew more about their home country than about the foreign country. On a scale ranging from *knew a lot* (1) to *knew little* (10), the Canadians rated their knowledge of Canada as 4.38 on average and their knowledge of West Germany as 9.00. The West Germans rated their knowledge of West Germany as 5.68 on average and their knowledge of Canada as 8.28.

Twenty subjects from each country were assigned randomly to one of the two incidental learning conditions, elaborative interrogation or reading to understand. The remaining 10 subjects from each country participated in the no-exposure-control condition (i.e., they took the criterion test without opportunity to study the facts). The decision to have 20 participants from each country in each of the two conditions that provided an opportunity to learn the facts and only 10 in the no-exposure-control condition was based on information obtained during pilot testing. This preliminary work suggested that performance in the no-exposure-control condition would be at about chance levels, with little variability. We believed that this would be obvious even with only a few subjects. In contrast, greater variability was expected in the elaborative-interrogation and reading-to-understand conditions, and thus there was a need for larger numbers of subjects in these conditions to estimate reliably their mean levels of performance.

Materials

We constructed a set of 66 factual statements for the study. Both English-language and German-language versions of this set were prepared. Thirty-three of the statements contained true facts about Canada, with 3 statements for each of 11 of the 12 Canadian provinces/territories. The remaining 33 statements were about West Germany, with 3 statements for each of the 11 West German states. We constructed six additional statements, 3 pertaining to Canada and 3 pertaining to West Germany, for use during practice.

The Canadian facts were identical to those used by Pressley, McDaniel, Turnure, Wood, and Ahmad (1987) and Martin and Pressley (1991) and were based on information from the *Canadian Yearbook* (Statistics Canada, 1988), *The Canadian Encyclopedia* (1985), and *The Collins Dictionary of Canadian History* (Bercuson

& Granatstein, 1988). The West German facts were based on information from *Fodor's Germany* (1988), *Statistisches Jahrbuch für die Bundesrepublik Deutschland* (Statistisches Bundesant Herausgeber, 1989), and *The Europa Year Book* (1988). The Canadian statements averaged 11 words in length (range = 6 to 17 words); the West German statements averaged 9 words (range = 5 to 21). For about half of the facts, the name of the province/state appeared at the beginning of the sentence. For the remaining facts, the name of the province/state appeared at the end. The factual statements (English versions) used in this study are presented in the Appendix.

The factual statements were typed in upper and lower case letters and photographed to produce slides. Two sets of orienting instructions were typed in upper case letters and mounted on stand-up cue cards. These prompts varied as a function of instructional condition, with elaborative-interrogation subjects instructed to answer the question, "Why would this fact be true of that particular province/state?" and reading-to-understand control subjects instructed to "Read the sentence out loud at a rate that allows you to understand that this fact is true of that particular state/province."

Procedure

All subjects were tested individually in a laboratory room. The session took place in their home country and lasted about 45 min for elaborative-interrogation and reading-to-understand subjects and about 20 min for students in the no-exposure-control condition. Laboratory rooms were arranged so that the subjects sat at a table facing a screen on which the to-be-learned materials were projected. West German participants were tested by one of two West German experimenters, such that each experimenter tested half the subjects in each of the two instructional conditions and the no-exposure-control group. All Canadian subjects were tested by one experimenter who had observed the testing of the West German participants.

Instructions before study. The incidental-learning instructions provided to subjects in the study varied as a function of instructional condition. (An incidental-learning paradigm was used to maximize adherence to the instructions in each condition; e.g., Craik & Lockhart, 1972; Craik & Tulving, 1975). Subjects in the elaborative-interrogation condition were instructed to indicate aloud why each fact was true:

> The purpose of this study is to investigate how people answer questions about sentences that they read. I will show you true facts about the Canadian provinces and West German states. Your task is to answer a why question about each sentence— Why would that fact be true of that particular province/state? It is very important that your answer clearly states why the fact is true of the particular province/state being discussed and not another similar province/state. In order to help you make your answers specific, you will want to include information that you already know about Canada/Germany, or even better, about the particular province/state being discussed. For example, information about its history, geography, industry, people, etc. ... You will be given 10 seconds to answer each question. It is very important that you attempt to answer each question, even if you are not sure your answer is correct. Because we are interested in how people answer these questions, I will tape record your responses.

Subjects assigned to the reading-to-understand group were instructed to read each statement aloud at a rate that allowed them to understand that each fact was true. Specifically, these subjects were given the following instructions:

> The purpose of this experiment is to investigate the rate at which

people read sentences in order to understand them. I will show you several sentences that contain true facts about the Canadian provinces and West German states. Your task is to read each sentence aloud at a rate that allows you to understand each fact as true. You are to keep reading each sentence at that rate for the entire time that it is presented. It is very important that you read each sentence at a rate that allows you to understand that the stated fact is true of the particular province/state being discussed and not another province/state. If you do not understand that fact is true, you are probably reading too fast and need to slow down. Because we are interested in reading rates that permit people to understand sentences, I will tape record your responses.

Prior to viewing the critical materials about each country, subjects were given three practice statements. Subjects were required to demonstrate how they would process these statements and were provided feedback about their responses and an example of an acceptable response.

Presentation of to-be-learned materials. Prior to presentation of the critical materials, the experimenter informed the subjects which country would be presented first and presented them with the stand-up cue card bearing the appropriate orienting instructions. After presentation of these first 33 statements, processing instructions were reiterated, the name of the second country was announced, and the remaining factual statements were presented. Half of the subjects in each condition and country studied facts about their home country first, and half studied facts about the foreign country first. Two different orderings of both the Canadian and West German facts were constructed. Half the participants in each condition and each country received one ordering of the Canadian facts and one ordering of the West German facts, with the other participants receiving the remaining orderings.

The 66 statements were presented at a rate of 10 s per item. Pilot testing had determined that this rate permitted processing of each sentence without producing ceiling or floor effects on the province/state fact-matching task. All of the subjects were told that they would be shown true facts about the 11 Canadian provinces and the 11 West German states and that all the information about one country would be presented before the other country was discussed. Subjects were presented facts from both countries before retention was assessed so that incidental learning was tested for both sets of facts.

Testing. The test followed presentation of the facts for the students in the two instructional conditions (i.e., in the elaborative-interrogation and reading-to-understand conditions). To provide an estimate of performance on the matching task based on prior knowledge alone, no-exposure-control subjects took this test without previous viewing of the facts (e.g., see Kuhara-Kojima & Hatano, 1991, Experiment 2, for a similar condition serving the same purpose).

During the test, subjects were asked to complete 66 questions by providing the name of the province or state that corresponded with each of the studied facts. Subjects were provided with the names of the 11 provinces and the 11 states at this time; hence, this was a matching task rather than a completion task, the latter of which would have required recall of the names. A matching test was used because it is an especially sensitive indicator of effects on associative learning (e.g., Kee & Rohwer, 1974; Pressley, Levin, Kuiper, Bryant, & Michener, 1982), which presumably is the locus of greatest effect for elaborative interrogation and other strategies with an elaboration component (e.g., see Pressley, 1977, 1982).

The test questions were presented in a different random order to each participant, one question at a time. Questions about countries were presented in the same sequence as the study format. The subjects were encouraged to answer each test question, making their best guess when unsure of the correct response.

Results and Discussion

The mean number of Canadian and German facts correctly matched with their provinces or states is recorded in Table 1 as a function of (a) nationality of the participant and (b) condition. The results with Canadian and West German facts were strikingly comparable, with the six corresponding condition means (e.g., 26.25 and 23.40, 3.00 and 3.50) for the Canadian and West German facts correlating with one another at $r = .97$.

Analyses of Matching Performance Data

We analyzed the means in Table 1 using 26 planned comparisons conducted at an overall error rate of less than .30. This is comparable to the overall Type I rate if a 2 (set of facts) × 3 (instructional condition) × 2 (level of prior knowledge) analysis of variance (ANOVA) had been used to analyze the data, with a probability level of .05 for each main effect and interaction (Kirk, 1982). Thus, the per-comparison error rate was $p < .012$. The comparisons, summarized in Table 2, were used instead of alternatives, such as omnibus ANOVA, in order to match the statistical tests exactly to the main issues addressed in the study.

Because of heterogeneous variances in the 12 cells in Table 1, the Welch–Aspin procedure was carried out for each comparison, with an error term based only on the cells involved in the comparison (Marascuilo & Serlin, 1988, Chapter 31; Maxwell & Delaney, 1990, Chapter 4). Because the Welch–Aspin procedure involves t tests with reduced degrees of freedom relative to regular t tests, the degrees of freedom for each test are recorded in Table 2.

For the first 24 comparisons summarized in Table 2, the hypothesis was directional, and hence we conducted one-tailed tests. The final two comparisons reported in Table 2 tested nondirectional hypotheses and were evaluated with two-tailed tests.

Was matching in the elaborative-interrogation condition better than in each of the other two instructional conditions? Comparisons 1 through 8 in Table 2 addressed the question of the relative matching performance in the elaborative-interrogation condition. All 8 comparisons testing the superiority of matching performance in the elaborative-interrogation condition relative to the reading-to-understand and no-exposure-control comparisons were significant.

Did reading-to-understand participants make more correct matches than no-exposure-control participants? Comparisons 9 through 12 in Table 2 were concerned with the reading-to-understand versus no-exposure-control differences. When prior knowledge was high (i.e., when Canadian subjects were presented with Canadian facts or when West German subjects were presented with West German facts), there were differences in performance favoring reading-to-understand subjects. When prior knowledge was low for West Germans subjects (i.e., when they were presented with Canadian facts), there was a significant advantage for reading-to-understand over no-exposure-control participants. The corresponding difference for Canadian participants when presented with West German facts, however, was not significant.

Did high prior knowledge produce better matching than low prior knowledge? Comparisons 13 through 18 in Table 2 assessed the effects of prior knowledge on matching. In 5 of the 6 tests, the answer was "yes." The exception occurred with the no-exposure-control condition. Canadians in this condition made only slightly more matches for Canadian facts than did West German participants.[1]

Were the differences between instructional conditions greater when prior knowledge was high as compared to when prior knowledge was low? The interactions of instructional condition and level of prior knowledge were tested in Comparisons 19 through 24 in Table 2. The elaborative-interrogation versus reading-to-understand differences were not significantly greater when prior knowledge was high than when prior knowledge was low. The elaborative-interrogation versus no-exposure-control comparisons and the reading-to-understand versus no-exposure-control comparisons were greater when prior knowledge was high than when it was low. That Comparisons 21 through 24 were significant was the strongest evidence in this study of the dependency of learning on prior knowledge, both learning that is strategically mediated and learning that occurs as a function of reading facts.

Can elaborative interrogation make up for lack of a knowledge base? Strategies are often taught to people with low domain knowledge in the hope that use of strategies can facilitate learning of materials. Although the results presented thus far permit the conclusion that elaborative interrogation can increase learning in an unfamiliar domain over learning without use of the strategy, elaborative interrogation did not produce especially high levels of performance for domain novices. The design used in this study permitted two comparisons of learning based on elaborative interrogation when prior knowledge was low and learning based on the prior knowledge activation that accompanies reading facts from a familiar domain to understand them: When the Canadian facts were processed by West German students who were using elaborative interrogation, their performance was significantly lower than that of Canadian students who read the facts and attempted to understand them (Comparison 25 in Table 2). When the West German facts were processed by Canadian students who were using elaborative interrogation, their performance was significantly lower than that of West German students who read to understand (Comparison 26 in

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[1] The tests of prior knowledge and interactions involving prior knowledge are reported here as between-subjects comparisons in order to compare tests that involve learning of the same facts. If the corresponding contrasts are made within subjects, thus confounding materials learned and prior knowledge status, the results are identical as those produced with the between-subjects tests with one exception: The size of the elaborative interrogation versus reading-to-understand difference varied within the Canadian sample as a function of prior knowledge (as defined by fact type). Canadians benefited more from elaborative interrogation for Canadian facts (26.25 − 17.10 = 9.15) than West German facts (7.05 − 4.60 = 2.45), $t (35) = 3.70, p < .001$. In contrast, neither of the between-subjects interaction contrasts, (26.25 − 17.10) versus (11.10 − 5.80) and (23.40 − 17.20) versus (7.05 − 4.60), which tested the relative size of the elaborative-interrogation versus reading-to-understand difference as a function of prior knowledge (defined by subject nationality), was significant.

Table 1

Mean Number of Canadian and West German Facts Matched Correctly as a Function of the Nationality of the Participants and Experimental Condition

Facts/subjects	Elaborative interrogation			Reading to understand			No-exposure control		
	M	SD	mean P	M	SD	mean P	M	SD	mean P
Canadian facts									
Canadian subjects (high prior knowledge)	26.25	4.23	.80	17.10	7.15	.52	4.10	2.23	.12
West German subjects (low prior knowledge)	11.10	5.40	.34	5.80	3.07	.18	3.00	1.83	.09
West German facts									
West German subjects (high prior knowledge)	23.40	4.54	.71	17.20	6.71	.52	8.20	5.05	.25
Canadian subjects (low prior knowledge)	7.05	3.79	.21	4.60	2.19	.14	3.50	2.07	.11

Note. *M* and *SD* are raw scores; *P* = proportion; *n* = 20 for the elaborative-interrogation and reading-to-understanding conditions at each nationality level; *n* = 10 for the no-exposure-control condition; maximum matching score = 33.

Table 2). As is clear from inspection of Table 1 means, use of elaborative interrogation by domain novices did not produce learning that was even close in degree to the learning produced by reading facts that could be related to extensive prior knowledge about one's home country.

However, we emphasize that it is not reasonable to conceive of this study as only a "horse race" between prior knowledge and elaborative interrogation. Instead, this study was designed to determine whether both processes can play important and complementary roles in the acquisition of facts. They can, and this point is emphasized by a consideration of the results in terms of regression analyses: Prior knowledge status (coded as 1 = high for home country; −1 = low for foreign country) entered first as the largest predictor of performance on the matching task, with strategy status (coded as 1 = elaborative interrogation and −1 = reading to understand) entering subsequently (all *p*s < .001) for both the Canadian and West German facts. Prior knowledge status and instructional condition in combination accounted for a total of 68% of the variability in the learning of Canadian facts and 73% of the variability in the learning of West German facts. These regression analyses underscore that optimum learning occurred when participants high in prior knowledge used the elaborative-interrogation strategy.

Learner Activities During Presentation of the Facts

Reading-to-understand subjects read each sentence an average of 1.85 times. West German subjects read each statement about West Germany 1.59 times and each statement about Canada about 1.85 times; Canadians read each statement about West Germany 1.69 times and each statement about Canada 2.04 times. In short, the reading-to-understand participants read aloud, as they were instructed to do.

The answers to why questions that were provided by elaborative-interrogation subjects were analyzed for adequacy

with a scoring procedure used in our previous research: Some subjects provided no responses to some why questions. To other questions, the subjects' responses were inadequate in that the answer did not make clear the reason the fact would pertain to the state or province in question rather than to other states or provinces. For example, given the statement, "Bavaria is the state with the largest hop harvest," inadequate responses included answers such as "Germans like beer," and "It is easy to grow hops." In contrast, adequate responses clearly conveyed the reason the fact was particularly pertinent to the state or province in question. For example, adequate responses for the same fact included, "Bavaria is the most southern state and enjoys a warm climate relative to other states," and "Bavaria is surrounded by mountains, providing a sheltered environment for growing hops." The percentages of answers falling into each category and the conditional probabilities of recall associated with each type of response are recorded in Table 3.

There are several noteworthy features of the data in Table 3. First, for the situation most similar to our previous work (i.e., subjects constructing explanations about facts from a familiar domain), the outcomes in this study are similar to previous outcomes: Subjects were able to generate adequate responses most of the time. In previous work (e.g., Woloshyn et al., 1990), the conditional probabilities of recall differed descriptively such that adequately answered items were remembered better than inadequately answered items, which were remembered better than no-response items. However, these descriptive differences were not very great. That was the pattern obtained in this study as well, with the exception that for Canadian subjects learning Canadian facts, the conditional probabilities of recall did not differ for adequately and inadequately answered items.

Consistent with previous research, all of the conditional probabilities of recall in the elaborative-interrogation condition were descriptively greater than the corresponding prob-

Table 2
Summary of the 26 Planned Comparisons Used to Analyze the Matching Data

Comparison	Comparison values	Answer	t test	
			t	df
Did elaborative interrogation produce better matching than reading to understand?				
1. With Canadians on Canadian facts	26.25 vs. 17.10	Yes	4.93	30
2. With West Germans on Canadian facts	11.10 vs. 5.80	Yes	3.82	30
3. With West Germans on West German facts	23.40 vs. 17.20	Yes	3.42	33
4. With Canadians on West German facts	7.05 vs. 4.60	Yes	2.50	30
Did elaborative interrogation produce better matching than no-exposure control?				
5. With Canadians on Canadian facts	26.25 vs. 4.10	Yes	15.43	28
6. With West Germans on Canadian facts	11.10 vs. 3.00	Yes	4.58	25
7. With West Germans on West German facts	23.40 vs. 8.20	Yes	8.33	16
8. With Canadians on West German facts	7.05 vs. 3.50	Yes	2.75	28
Did reading to understand produce better matching than no-exposure control?				
9. With Canadians on Canadian facts	17.10 vs. 4.10	Yes	5.57	25
10. With West Germans on Canadian facts	5.80 vs. 3.00	Yes	2.64	27
11. With West Germans on West German facts	17.20 vs. 8.20	Yes	3.73	23
12. With Canadians on West German facts	4.60 vs. 3.50	No	1.32	19
Did high prior knowledge produce better matching than low prior knowledge in the elaborative-interrogation condition?				
13. Canadian facts, Canadian versus West German participants	26.25 vs. 11.10	Yes	9.88	35
14. West German facts, West German versus Canadian participants?	23.40 vs. 7.05	Yes	12.36	36
Did high prior knowledge produce better matching than low prior knowledge in the reading-to-understand condition?				
15. Canadian facts, Canadian versus West German participants	17.10 vs. 5.80	Yes	6.49	25
16. West German facts, West German versus Canadian participants	17.20 vs. 4.60	Yes	7.98	23
Did high prior knowledge produce better matching than low prior knowledge in the no-exposure-control condition?				
17. Canadian facts, Canadian versus West German participants	4.10 vs. 3.00	No	1.21	17
18. West German facts, West German versus Canadian participants	8.50 vs. 3.50	Yes	2.72	11
Were differences between instructional conditions greater when prior knowledge was high for elaborative-interrogation versus reading-to-understand comparisons?				
19. Canadian facts, Canadian versus West German participants	26.25–17.10 vs. 11.10–5.80	No	1.66	56
20. West German facts, West German versus Canadian participants	23.40–17.20 vs. 7.05–4.60	No	1.82	50
Were differences between instructional conditions greater when prior knowledge was high for elaborative-interrogation versus no-exposure-control comparisons?				
21. Canadian facts, Canadian versus West German participants	26.25–4.10 vs. 11.10–3.00	Yes	6.16	52
22. West German facts, West German versus Canadian participants	23.40–8.20 vs. 7.05–3.50	Yes	5.21	27
Were differences between instructional conditions greater when prior knowledge was high for reading-to-understand versus no-exposure-control comparisons?				
23. Canadian facts, Canadian versus West German participants	17.10–4.10 vs. 5.80–3.00	Yes	3.98	37
24. West German facts, West German versus Canadian participants	17.20–8.20 vs. 4.60–3.50	Yes	3.10	29
Can elaborative interrogation make up for a lack of prior knowledge (How does elaborative interrogation when prior knowledge is low compare with reading to understand when prior knowledge is high?				
25. Canadian facts, Canadian participants reading to understand versus West German participants using elaborative interrogation	17.10 vs. 11.10	No[a]	2.99	35

Table 2 *(continued)*

| Comparison | Comparison values | Answer | t test | |
			t	*df*
26. West German facts, West German participants reading to understand versus Canadian participants using elaborative interrogation	17.20 vs. 7.05	No[a]	5.89	30

Note. Type 1 error rate <.012 for each comparison. The first 24 comparisons were tested with a one-tailed criterion; Comparisons 25 and 26 were two-tailed tests. The degrees of freedom with the Welch–Aspin procedure were calculated with the following formula, figured separately for each comparison: $df = (\sum c^2 s^2/n)^2/\sum[(c^2 s^2/n)^2/(n-1)]$, including only the means involved in the comparison. The c is the weighting of the mean in the contrast, s is the standard deviation for the cell, and n is the number of participants in the cell.

[a] Reading with high prior knowledge produced better matching than elaborative interrogation with low prior knowledge.

abilities of recall in the reading-to-understand condition (i.e., the recall proportions in Table 1 for the reading-to-understand condition). That is, for Canadians presented with Canadian facts, the lowest conditional probability of recall in Table 3 of .75 exceeded the .52 probability of recall in the reading-to-understand condition (from Table 1); and for West Germans presented with Canadian facts, the conditional probability of .30 (Table 3) exceeded the .18 probability of recall in the reading-to-understand condition. For West Germans presented with West German facts, the .63 (Table 3) conditional probability exceeded the .52 probability of recall in the reading-to-understand condition; and for Canadians presented with West German facts, the lowest conditional probability of recall in Table 3 of .18 was descriptively greater than the .14 probability in the reading-to-understand condition. Thus, the process of searching for an explanation (i.e., an answer to the why question) promoted performance. Our interpretation

of these results is that when prior knowledge was high, the search for responses to the why questions probably stimulated the activation of knowledge related to the to-be-learned fact, even when an adequate response to the why question was not located (reported) by the subject (Slamecka & Fevreiski, 1983). Thus, matching was high even in the absence of an answer to the why question during study.

The mechanisms mediating the elaborative-interrogation effects when prior knowledge is low are probably different, a point which is supported by the low adequate response rates to the why questions that occurred when the participants were processing foreign facts. Our hypothesis is that when prior knowledge is low, the general factors such as increased arousal, attention, and cognitive effort (e.g., Slamecka & Graf, 1978; Tyler et al., 1979), which accompany attempts to answer questions, probably account for the positive effects of elaborative interrogation.

Table 3

Proportions of Response Types to "Why" Questions During Original Presentation of Facts in the Elaborative-Interrogation Condition and Subsequent Probability of Correct Matching for Each Response Type

| | Canadian facts | | German facts | |
Response type/measure	Canadian subjects	West German subjects	West German subjects	Canadian subjects
Adequate				
Proportion of all responses	.56	.01	.66	.02
Conditional probability of correct test response	.82	.68	.73	.38
Inadequate				
Proportion of all responses	.28	.86	.21	.80
Conditional probability of correct test response	.82	.33	.69	.20
No response				
Proportion of all responses	.16	.13	.13	.18
Conditional probability of correct test response	.75	.30	.63	.18

Note. Canadian subjects had high prior knowledge of Canadian facts and low prior knowledge of West German facts. West German subjects had high prior knowledge of West German facts and low prior knowledge of Canadian facts.

Summary and Conclusion

Virtually all contemporary models of learning and memory (e.g., Baker & Brown, 1984; Bjorklund, 1987; Bjorklund et al., 1990; Chi, 1985; Pressley, Borkowski, & Schneider, 1987, 1989) posit that strategies and knowledge make independent contributions to performance. These same models also presume that prior knowledge and strategies can operate in combination to produce especially good memory. This study provided evidence of simple effects of both elaborative interrogation and prior knowledge on learning, as well as information on the ways in which the two factors can operate together to increase performance to a level higher than that produced by either factor operating alone.

Elaborative interrogation promoted learning regardless of students' prior knowledge for the domain of learning: (a) There was significantly better matching in the elaborative-interrogation condition than in the no-exposure condition, when knowledge was both high and low; and (b) elaborative interrogation enhanced learning even after the facilitative effects of prior knowledge were taken into account. Relative to the reading-to-understand condition, there was significantly better learning in the elaborative-interrogation condition, regardless of whether participants possessed high or low prior knowledge.

We had predicted that prior knowledge would be a particularly important determinant of learning in the reading-to-understand condition (consistent with Kuhara-Kojima & Hatano, 1991), as participants in that condition would presumably be relying on reading to mediate learning. That the difference between reading to understand and the no exposure control was greater when prior knowledge was high than when it was low is consistent with this perspective. Arguably, there was greater support for this difference in the Canadian sample than in the West German sample, as the reading-to-understand versus no-exposure difference was significant in that sample only when prior knowledge was high. In contrast, West German participants in the reading-to-understand condition matched more facts than did no-exposure control participants regardless of prior knowledge status.

The findings of this study help resolve an interpretive dilemma present in our earlier experiments on elaborative interrogation: The effects of elaborative interrogation on learning of familiar facts could be due in part or whole either to activation of prior knowledge not activated by reading alone or to more general factors (i.e., increased attention and arousal, deeper and more meaningful processing of facts). The case in favor of prior-knowledge mediation when elaborative interrogation is used to process facts from a familiar domain has been bolstered by recent work (Martin & Pressley, 1991). The theoretical analysis of elaborative-interrogation effects that is most compatible with the present data, as well as with the results reported by Martin and Pressley, is that when learners possess high prior knowledge related to target facts, why questions facilitate performance to the degree that they orient the learner to prior knowledge that is related to the to-be-learned facts. That is, the why questions in this study produced greater attention to relevant prior knowledge when prior knowledge was high than would have occurred other-

wise. When prior knowledge was low, attempting to answer why questions probably facilitated performance because it increased general arousal, attention to the facts, and efforts to learn them.

In summary, elaborative-interrogation effects are pervasive because elaborative interrogation stimulates a variety of mechanisms that can increase learning. This learning procedure works (a) both when prior knowledge is high and when it is low, (b) both when learning is incidental and when it is intentional (Woloshyn et al., 1990), and (c) when the facts to be learned are disconnected and when they are connected (Woloshyn et al., 1990). Such a procedure has much to recommend it, enough so that students should be encouraged to use elaborative interrogation during their day-to-day contact with academic content. Thus, a principal direction that we plan to pursue is to teach students to use elaborative interrogation in a self-regulated fashion. Establishing that the procedure produces reliable effects when students are under strong instructional control was prerequisite to work on self-controlled use of the strategy (see Pressley et al., 1990), a prerequisite that has been met by this study and previous related research.

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(Appendix follows on next page)

Appendix

Canadian and German Study Facts

Canadian Facts

1. Nova Scotia spends the greatest amount of money per person for national defense in Canada.
2. The first steel bars cast in Canada were produced in Nova Scotia.
3. Apples in Canada were first cultivated in Nova Scotia.
4. Ontario is the province with the highest percentage of people declaring bankruptcy.
5. The province with the largest number of native people is Ontario.
6. Ontario is the Canadian province that produces the most mushrooms.
7. British Columbia is the province with the highest percentage of its population in unions.
8. The province with the most number of different types of lizards is British Columbia.
9. Judo was first introduced in the province of British Columbia.
10. Newfoundland was the first province to be mapped.
11. The province with the highest percentage of single detached houses is Newfoundland.
12. Newfoundland has the highest provincial tax rates.
13. The first choir music was written in the province of Quebec.
14. The province of Quebec established the first schools for deaf children.
15. The first humane society was founded in the province of Quebec.
16. Prince Edward Island is the province with the highest percentage of its budget for the performing arts.
17. The province with the highest percentage of telephone party lines is Prince Edward Island.
18. Prince Edward Island is the province with the highest proportion of its population of British ancestry.
19. Saskatchewan has Canada's lowest unemployment rate.
20. The highest temperature in Canadian history was recorded in Saskatchewan.
21. The province with the longest total distance of roads is Saskatchewan.
22. Yukon is the province with the highest percentage of vehicles that are trucks.
23. Yukon is the province with the lowest minimum wage.
24. The earliest site occupied by man in Canada is in the Yukon.
25. The province producing the most fox fur is New Brunswick.
26. New Brunswick was the first officially bilingual Canadian province.
27. The first province to establish a Department of Health was New Brunswick.
28. Manitoba has the highest cancer rate in Canada.
29. The most ducks and geese are raised for food in the province of Manitoba.
30. The province of Manitoba published the most recent directory of peace organizations.
31. The province of Alberta had the worst tornado in Canada.
32. Alberta was the first province with an educational radio station.
33. The first nature trails in Canada that had signs to explain the natural features were in Alberta.

West German Facts

1. Bavaria is the state with the largest hop harvest.
2. The highest percentage of persons leaving the state was registered in Bavaria.

3. The highest percentage of hotel beds is in the state of Bavaria.
4. Baden-Württemberg is the state with the highest degree of industrial concentration.
5. Baden-Württemberg is the state with the lowest unemployment rate.
6. The region with the greatest number of sunny days per year lies in the state of Baden-Württemberg.
7. Hamburg is the state with the lowest percentage of registered trucks.
8. Hamburg (City-State) has the highest percentage of per capita gross domestic product.
9. The highest wages for work in industry are paid in the state of Hamburg.
10. The state with the highest percentage of Catholics is Saarland.
11. Saarland is the youngest state in the Federal Republic of Germany.
12. The state with the densest railway network is Saarland.
13. Berlin state has the highest number of inhabitants per square kilometer.
14. The lowest percentage of employees of the German Federal Railroads work in Berlin.
15. Berlin is the state with the highest proportion of Turkish workers.
16. The state that employs the highest proportion of foreign workers is North Rhine Westphalia.
17. The state with the most university teachers is North Rhine Westphalia.
18. North Rhine Westphalia is the state registering the most people moving in and settling.
19. The state with the lowest percentage of people declaring bankruptcy is Bremen (City-State).
20. In the last Federal elections, the Green Party made its best showing in Bremen (City-State).
21. Bremen (City-State) registered the highest unemployment rate.
22. The state with the highest percentage of Lutherans is Schleswig-Holstein.
23. The highest percentage of Germans employed in shipbuilding work [are] in Schleswig-Holstein.
24. Schleswig-Holstein is the state with the most popular of the Baltic holiday spots.
25. Hessen is the most densely wooded state.
26. Hessen is the German state that grows the largest amount of wheat.
27. Some of the best white wines in the world are from the state of Hessen.
28. The state with the largest potato harvest is Lower Saxony.
29. The largest amount of crude oil is produced in the state of Lower Saxony.
30. Lower Saxony is the second largest state as measured in square kilometers.
31. Rhineland Palatinate is the state with the lowest air-passenger traffic.
32. Rhineland Palatinate is the German state that rates lowest in fodder cultivation.
33. The most wine is produced in the state of Rhineland Palatinate.