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Memory for *Star Trek*: The Role of Prior Knowledge in Recognition Revisited

Debra L. Long and Chantel S. Prat
University of California, Davis

Prior studies have found robust knowledge effects on recall of text ideas but have seldom found comparable effects on recognition. This inconsistency was examined in light of recent research on the component processes that underlie recognition memory. Using the remember/know paradigm, the authors found that experts made more remember judgments than novices, but only in response to text ideas relevant to their domain of expertise. Using the process-dissociation procedure, the authors found knowledge effects on recollection estimates, but not on familiarity estimates. The authors contend that knowledge effects have been difficult to detect in recognition because knowledge primarily affects recollection, whereas familiarity gives rise to good performance even among novices.

In 1972, Bransford and Johnson published a now classic study showing that the presence of contextual knowledge during reading greatly facilitated memory for a text. Subsequent research confirmed the memory advantage associated with domain knowledge but also showed that it depended on the nature of the task. Knowledge effects have been large in studies using recall (Anderson, 1981; Anderson & Pitchert, 1978; Bower, Black, & Turner, 1979; Fass & Schumacher, 1981; Johnson & Kieras, 1983; Schneider, Körkel, & Weinert, 1990; Spilich, Vesonder, Chiesi, & Voss, 1979; Sulin & Dooling, 1974) but small or nonexistent in studies using recognition (Alba, Alexander, Hasher, & Caniglia, 1981; Alba & Hasher, 1983; Moravcsik & Kintsch, 1993; Schneider et al., 1990; Summers, Horton, & Diehl, 1985).

Our goal in this study was to revisit the relation between prior knowledge and recognition of text ideas in light of recent research on the memory processes that affect recognition performance. Many memory researchers argue that recognition involves at least two distinct processing components: one is influenced by the retrieval of specific, meaningful information about a studied item and one is influenced by an assessment of the global similarity between an item at test and information stored in memory (Jacoby, 1991; Mandler, 1980; Yonelinas, 1994). In this study, we asked whether prior knowledge had different effects on these two memory processes. Before describing the details of our study, we briefly review relevant research on the relation between prior knowledge and memory performance and then discuss what is currently known about the memory processes that are involved in the recognition task.

Knowledge Effects on Recall and Recognition

The recall advantage associated with knowledge has been well documented in two different paradigms. In the first paradigm, participants read texts that contain numerous vague referring expressions. Recall for the text improves when readers are given relevant contextual knowledge, such as a title that denotes the topic of the passage (e.g., "Washing Clothes").

In the second paradigm, participants read coherent texts that contain information about a specific domain. Those who are knowledgeable about the domain recall more information from the text than do those who are less knowledgeable. For example, Spilich et al. (1979) found that "baseball experts" recalled more information from baseball texts than did "novices." Moreover, experts recalled more propositions relating to actions and events that were closely associated with the goal structure of a baseball game than did novices. Schneider et al. (1990) reported similar results using soccer as the knowledge domain.

Although robust knowledge effects have been found in recall, comparable effects have seldom been found in recognition. Indeed, several studies have reported absolutely no knowledge effects on recognition performance. For example, Alba et al. (1981) examined both recall and recognition of the passages used by Bransford and Johnson (1972). They replicated Bransford and Johnson's recall effect but found no influence of knowledge on recognition performance. Moravcsik and Kintsch (1993) examined the influence of knowledge, writing style, and reading skill on narrative and found no effects of reading skill or prior knowledge on recognition. Finally, Schneider et al. (1990) observed knowledge effects on several memory measures—including free recall—in the absence of any effects on recognition.

Other studies have reported knowledge effects on particular aspects of recognition performance. Summers et al. (1985) used Bransford and Johnson's (1972) paradigm and found an effect of title condition, but only when participants were explicitly told prior to reading that they would receive a recognition test and the number of distractor sentences was increased sevenfold. The primary effect of knowledge was found on responses to the distractor sentences. Similarly, Arkes and Freedman (1984) found that knowledge effects on recognition depended on the type of distractors that were used. When distractors were paraphrases or inferences that high-knowledge participants were likely to make, knowledge impaired recognition performance. Graesser, Gordon, and Sawyer (1979) also found a negative effect of knowledge on

Debra L. Long and Chantel S. Prat, Department of Psychology, University of California, Davis.

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Correspondence concerning this article should be addressed to Debra L. Long, Department of Psychology, One Shields Avenue, University of California, Davis, California 95616. E-mail: dllong@ucdavis.edu

recognition. Readers with access to a relevant schema during reading had greater difficulty rejecting schema-related distractors than did readers with no access to the schema. Finally, Chiesi, Spilich, and Voss (1979) found that baseball experts and novices were equally likely to recognize a baseball passage that they had heard previously, but experts needed to listen to fewer sentences before making a recognition judgment.

Schustack and Anderson (1979) are among the few researchers to report a clear knowledge advantage. They found that recognition of biographical statements about fictional characters was facilitated when the statements were presented with information that highlighted the similarity between the character and a famous person. It is worth noting that they used a cued-recognition task. Participants made recognition judgments and decided whether a statement had been presented in a set associated with a specific character, a procedure reminiscent of source-memory judgment.

Failure to find robust knowledge effects on recognition memory for text ideas is somewhat surprising in light of evidence that elaborative processing appears to benefit both recognition and free recall of individual words (Craik & Tulving, 1975; Jacoby & Craik, 1979; Jacoby & Dallas, 1981). If knowledge-related processes involved in the encoding and retrieval of text propositions facilitate recall, then it seems reasonable to assume that recognition should be similarly affected. It is difficult, however, to assess the extent to which superior recall performance results from better encoding and retrieval of information or from experts' superior ability to reconstruct text ideas. High-knowledge readers may produce statements at recall that are similar to statements that appeared in the text; however, these statements may actually be memory intrusions that were produced from preexisting knowledge about the domain. High- and low-knowledge participants may have equivalent memory for the text, but only high-knowledge readers can use domain knowledge during recall to retrieve information similar to that contained in the text. This reconstruction advantage is eliminated during recognition. The fact that knowledge effects, when they are found in recognition, primarily involve responses to distractor items is consistent with a reconstruction explanation.

A second explanation is that prior knowledge facilitates the comprehension and retrieval of information from a text, but the recognition task is insensitive to its influence. Several researchers have argued that recognition items provide direct access to memory traces in the reader's text representation, eliminating the need to engage in an elaborate search of the representation. Knowledge effects are found in recall, and not recognition, because prior knowledge primarily affects the search process (Moravcsik & Kintsch, 1993; Schneider et al., 1990). In this study, we examined a variation of this explanation that is consistent with recent research on the component memory processes that underlie recognition. In the next section, we describe these processes and ask whether they might be differentially affected by prior knowledge.

Dual-Process Models of Recognition

Recent research on recognition memory has been primarily concerned with two questions: How many processes underlie performance on recognition tasks, and what does each process accomplish? Most memory researchers now believe that recognition involves at least two distinct processes (Hintzman & Curran, 1994; Jacoby, 1991; Mandler, 1980; Yonelinas, 1994). According to proponents of dual-process models, one of these processes, often called *recollection,* involves retrieval of specific information about a studied item, such as information about the context in which the item appeared (Clark, 1992; Hintzman & Caulton, 1997; Hintzman & Curran, 1994; Humphreys, 1978; Jacoby, 1991; Mandler, 1980; Yonelinas, 1994, 1997). This process may involve discrete, all-or-none retrieval of qualitative information associated with the target item. A distinguishing characteristic of recollection is that it is accompanied by the conscious remembrance of the studied item. The second process, usually called *familiarity,* involves an assessment of the similarity between a test item and a memory trace. A test item will elicit feelings of familiarity to the extent that it shares features, perceptual and conceptual, with an item in memory (Clark & Gronlund, 1996; Gillund & Shiffrin, 1984; Hintzman, 1988; Humphreys, Bain, & Pike, 1989; Murdock, 1982). Familiarity may be a matter of degree and may not be accompanied by the conscious remembrance of the studied event.

Although many researchers agree that both recollection and familiarity are involved in recognition, they disagree about how these processes should be assessed (Jacoby, 1991; Gardiner & Java, 1993; Hintzman & Caulton, 1997; Hintzman & Curran, 1994; Rajaram & Roediger, 1997). Tulving (1985) proposed one method for separating the two components (see also Gardiner, 1988; Gardiner & Java, 1991; Gardiner & Parkin, 1990; Rajaram, 1993). He asked participants to make judgments concerning the nature of their memory for recognized items, to respond "remember" to those items that were accompanied by recollection of details of the item's prior occurrence, and to respond "know" to those items that were recognized from the study episode, but were not accompanied by recollection. Remember and know judgments frequently show the same types of functional dissociations as do explicit and implicit memory tasks: (a) divided attention at study reduces the number of remember responses at test, whereas know responses are relatively unaffected (Gardiner & Parkin, 1990); (b) remember and know responses have different forgetting curves; remember responses are more frequent than know responses initially but decline rapidly, dropping to the level of know responses within a few days whereas know responses show little decline in the first week after study and decline only gradually thereafter (Gardiner & Java, 1991; Hockley & Consoli, 1999); (c) age reduces the number of remember responses but not know responses (Mäntylä, 1993; Parkin & Walter, 1991); (d) remember and know judgments are differentially affected by levels of processing; remember responses increase as a function of levels-of-processing manipulations, whereas know responses decrease (Gardiner, 1988; Rajaram, 1993); and (e) words elicit more remember responses than do nonwords, whereas the opposite is true for know responses (Gardiner & Java, 1990).

The relation between these factors and remember judgments is reminiscent of the relation between these same factors and recall performance. Both remember and recall responses appear to result from processes specific to a distinct episodic memory system (Gardiner & Parkin, 1990; Tulving, 1985; but cf. Strack & Förster, 1995). Situations that encourage conceptual processing appear to increase the likelihood of a remember response. For example, Horton, Pavlick, and Moulin-Julian (1993) found that remember responses to studied word pairs increased as a function of the associative relationship between the individual words in a pair. In contrast, they found a negative relation between know judgments and associative information.

Dual-process models suggest why knowledge effects on recognition may be difficult to detect. Consider the paradigm in which readers are asked to comprehend vague passages in the presence or absence of a disambiguating title. Prior knowledge may have little effect on many of the component processes involved in comprehending a sentence (e.g., word recognition, syntactic analysis); therefore, the likelihood of a recognition judgment resulting from familiarity may be quite good and equivalent in the title and no-title conditions. In contrast, prior knowledge may affect the reader's ability to establish conceptual relations among propositions and to make knowledge-based inferences. These types of relations may support a conscious recollective experience at test. Thus, knowledge effects on recognition may be found only when readers are asked to discriminate recognition judgments that are based on recollection of information associated with an item (remember responses) from judgments that are based on the familiarity of the item (know responses).

We examined the influence of prior knowledge on recognition performance in two experiments. We identified participants who were either high or low knowledge about the domain of *Star Trek.* These participants read texts in the *Star Trek* domain or in an unrelated one (texts about psychology) and then received a subsequent recognition test. In Experiment 1, we used the remember/know paradigm to examine the extent to which these judgments were differentially affected by domain-relevant knowledge. In Experiment 2, we used a different paradigm, process-dissociation, to examine the influence of knowledge on the familiarity and recollective components of recognition.

Experiment 1

In this experiment, we used the remember/know paradigm to examine recognition performance among high- and low-knowledge readers in a popular domain, knowledge about the science-fiction saga, *Star Trek.* We chose the *Star Trek* domain for several reasons. First, *Star Trek* enjoys such widespread popularity that almost everyone has at least some knowledge about the characters and story settings. Second, knowledge about *Star Trek* varies widely among college students. Some students have only passing knowledge about the domain; other students have considerable expertise. Finally, dozens of short stories, novels, and reference materials about *Star Trek* have been published and were suitable for use as experimental materials.

We assessed participants' levels of *Star Trek* knowledge by means of a two-part recognition test: a character test and a life-form test. Experts and novices were identified according to their performance on the test. Participants then read a short story about *Star Trek* and received a recognition test consisting of sentences from the story that they read as well as distractor sentences from a *Star Trek* story that they did not read. In addition to the *Star Trek* story, participants also read a chapter from an introductory psychology textbook and responded to sentences selected from it. The purpose of the psychology chapter was to determine whether differences between experts and novices were restricted to the relevant knowledge domain (i.e., knowledge about *Star Trek*).

We expected both experts and novices to exhibit somewhat better recognition of test items from the *Star Trek* story than from the psychology chapter. Comprehension of narrative text tends to be better than comprehension of expository text (Haberlandt & Graesser, 1985; Kieras, 1982, 1985). Our primary interest concerned the pattern of remember and know judgments for items from the *Star Trek* story. If experts construct more integrated and elaborated text representations than do novices, then they may be more likely than novices to have a recollective experience at test.

Method

Participants. Participants were 96 undergraduate psychology students at the University of California, Davis. They received course credit for their participation.

Materials. We constructed a *Star Trek* knowledge test, consisting of two parts: a character test and a life-form test (see the Appendix). The test was modeled after the Author Recognition Test (ART), a test of readers' exposure to print (Stanovich & West, 1989; West & Stanovich, 1991). The ART consists of a checklist of names; half of the names are authors of popular fiction and nonfiction books, and half are foils. The *Star Trek* character and life-form tests, like the ART, were checklists. The character test consisted of 50 names of characters selected from *Star Trek* television episodes and movies interleaved with 50 names of characters selected from other science fiction television and movie sources (e.g., *Battlestar Galactica, Aliens, Dune*). The life-form test consisted of 25 names of life-forms that appeared on *Star Trek* interweaved with 25 names of life-forms selected from other science-fiction sources. All *Star Trek* character names and life-forms were obtained from a book of *Star Trek* trivia (Okuda & Okuda, 1996).

The texts used in the experiment were two *Star Trek* short stories and two chapters from introductory psychology textbooks. The *Star Trek* stories were selected from a published anthology of short stories (Marshak & Culbreath, 1996). One story, "The Enchanted Pool" (Ericson, 1996), was 6,320 words long; the other story, "Intersection Point" (Coulson, 1996), was 6,090 words long. The psychology chapters were selected from two introductory psychology textbooks not currently in use at the University of California, Davis. Chapter 1 of *Psychology: Mind, brain, & culture* (Westen, 1996) was 6,546 words long and chapter 1 of *Psychology* (Santrock, 2000) was 6,013 words long. Four text sets were constructed; each *Star Trek* story was paired with each psychology chapter.

The recognition test consisted of both *Star Trek* and psychology items. The *Star Trek* items were 50 sentences consisting of 25 items from each story. Psychology items were also 50 sentences consisting of 25 items from each chapter. All of the sentences were chosen randomly with the proviso that each test sentence was at least six words long.

Procedure. We conducted the experiment in two sessions. In Session 1, participants received the *Star Trek* knowledge test. The test and instructions for it appear in the Appendix. In Session 2, participants were assigned to one of the text sets. To ensure that we had approximately equal numbers of experts and novices assigned to each text set, we used the following procedure. We scored the knowledge tests and ranked participants according to their performance, highest to lowest. We then proceeded through the ranking, top to bottom, selecting participants in groups of four. Each member of the group was randomly assigned to a text set.

Participants read two texts, one *Star Trek* story and one psychology chapter. The texts were presented in random order, one screen of text at a time. Participants pressed the space bar to proceed from one screen to the next. They were told to read the texts carefully and that their memory for information in the texts would be tested later.

After reading the two texts, participants were asked whether they had read either text before the experiment and then they received the recognition test. Recognition items were presented in two randomized blocks: One block contained the *Star Trek* items and the other block contained the psychology items. Target and distractor items within a block were presented randomly, one at a time, in the center of the screen. Instructions preceding the block of *Star Trek* items asked participants to decide whether or not each item had appeared in the *Star Trek* story that they had read. If the item was not in the story, they were asked to press a key labeled *no.* If they recognized an item from the story, they were asked to decide whether they had a vivid conscious awareness of having read the sentence in the passage; if so, they were asked to press a key labeled *R* (for remember). If they did not have a conscious recollection of reading the sentence, but they still believed that the sentence had been in the story, they were asked to press a key labeled *K* (for know). Similar instructions preceded the block of psychology test items.

Results and Discussion

The knowledge test was scored by calculating hits minus false alarms. The maximum possible score was 75. The top-third of the distribution ($n = 32$) was classified as expert ($M = 58.75$, range = 52 to 73); the bottom-third of the distribution ($n = 32$) was classified as novice ($M = 23.01$, range = 4 to 44). We included in our analyses only those data from participants classified as expert or novice.

Mean proportions of remember and know responses appear in Table 1. We analyzed remember and know responses separately. All analyses were conducted twice, once with participants as a random factor (F_1) and once with items as a random factor (F_2). The analyses were 2 (knowledge) × 2 (text) analyses of variance (ANOVAs). Knowledge (expert vs. novice) was a between–participants and between–items factor, and text (*Star Trek* vs. psychology) was a within–participants and between–items factor. All effects were reliable at $p < .05$, unless otherwise indicated. Statistical tests are reported only for effects that were reliable in both the participants and items analyses.

Remember responses. We had predicted that experts would provide more remember responses than would novices, but only in response to *Star Trek* items. Our analyses of remember responses to old items (hits) revealed the predicted interaction between knowledge and text, $F_1(1, 62) = 4.02$, $MSE = 0.02$; $F_2(1, 99) = 5.04$, $MSE = 0.02$. Experts responded “remember” more often than did novices in response to *Star Trek* items, $F_1(1, 62) = 4.60$, $F_2(1, 99) = 7.83$, whereas the two groups did not differ in response to psychology items. The analysis also yielded a main effect of text, $F_1(1, 62) = 11.54$, $MSE = 0.02$; $F_2(1, 99) = 6.73$, $MSE = 0.023$. Our analyses of remember responses to new items (false alarms) revealed no reliable effects.

Table 1
Mean Proportions of Hits and False Alarms as a Function of Judgment Type, Domain Knowledge, and Text in Experiment 1

	Star Trek		Psychology	
Knowledge	Hits	False alarms	Hits	False alarms
Expert				
Remember	.60 (.19)	.08 (.12)	.47 (.22)	.07 (.10)
Know	.09 (.09)	.09 (.09)	.24 (.15)	.19 (.19)
Novice				
Remember	.48 (.18)	.10 (.18)	.46 (.17)	.10 (.13)
Know	.19 (.18)	.12 (.14)	.25 (.15)	.19 (.21)

Note. Standard deviations are in parentheses.

We conducted an analysis to determine whether knowledge differences in remember judgments might reflect differences in the criteria used by experts and novices rather than differences in the nature of their memory for *Star Trek* information. Donaldson (1996) has argued that the remember/know paradigm may involve two response criteria. One criterion is used to discriminate between old and new items; a second criterion is used to divide old responses into remember and know judgments. Items that lie above the second criterion receive a remember response, those that lie between the first and second criterion receive a know response. If experts and novices differ in the placement of this second criterion, then they may exhibit differences in remember judgments even if the nature of their memory for old information is similar. Donaldson has recommended testing this possibility by comparing A' scores for remember responses to A' scores for all old judgments. The scores should be similar if remember responses are nothing more than conservative old judgments. We conducted this analysis and found that remember A’s were reliably different from old A’s (Ms = .81 and .84, remember and old, respectively), $F_1(1, 62) = 8.87$, $MSE = 0.01$, $F_2(1, 99) = 6.00$, $MSE = .02$. This difference was primarily due to the fact that experts showed a difference in the *Star Trek* condition (Ms = .75 and .80, remember and old, respectively), whereas novices showed no difference in this condition (Ms = .82 and .81, remember and old, respectively). Thus, these results suggest that something other than a criteria difference may underlie the pattern of remember judgments exhibited by the experts and novices (but see Dobbins, 2001, for a discussion of problems in using the A' metric to discriminate between single-process signal detection and dual-process accounts of recognition memory).

Know responses. Our analyses of know judgments to old items mirrored the remember results. We found a Knowledge × Text interaction, $F_1(1, 62) = 6.40$, $MSE = 0.01$; $F_2(1, 99) = 6.53$, $MSE = 0.01$. Experts made fewer know responses than did novices, but only for *Star Trek* items, $F_1(1, 62) = 14.40$; $F_2(1, 62) = 16.14$; we found no effect of knowledge on know responses to psychology items. The analysis also yielded a reliable effect of text, $F_1(1, 62) = 42.69$, $MSE = 0.01$; $F_2(1, 99) = 43.55$, $MSE = 0.01$. Our analyses of know responses to new items revealed no effects that were reliable in both the participants and items analyses.

Overall recognition. We conducted analyses to determine whether experts and novices differed in their overall recognition accuracy. We computed d' scores, collapsing across remember and know responses. Recognition accuracy was somewhat higher for the *Star Trek* items than for the psychology items (Ms = 1.43 and 1.32, respectively). However, neither this effect nor any other in the analysis was reliable. We conducted a power analysis to determine the sample size needed to detect a reliable effect of knowledge on d' scores. We used as our measure of expected effect size, the difference in remember responses for experts and novices. We set alpha to .05, and our desired power level was set to .80. The analysis yielded a required sample size of 245, suggesting that the effect of knowledge on overall recognition in this experiment was quite small.

Our results are consistent with previous studies that failed to find knowledge effects on overall recognition accuracy (Alba et al., 1981; Moravcsik & Kintsch, 1993; Schneider et al., 1990; Summers et al., 1985). We did find such effects, however, when we examined remember and know responses. Experts produced more remember and fewer know responses than did novices, but only for items in the relevant knowledge domain. Experts were more likely to report a vivid, conscious experience of recollection in response to sentences from the *Star Trek* story than were novices. *Star Trek* knowledge had no effect on remember judgments to items from the psychology chapter.

Our focus in this experiment was on the influence of domain-relevant knowledge on remember responses. We found that remember judgments about sentences in a text increased as a function of domain expertise. If we assume that remember responses reflect an underlying recollective process, our results suggest that domain knowledge affects recollection by increasing the probability that the reader retrieves context-specific information about an item at test.

What about the influence of domain knowledge on familiarity? In this experiment, we found that know responses decreased as a function of prior knowledge. Does this mean that domain knowledge affects recollection and familiarity in opposite ways, increasing recollection, but decreasing familiarity? The answer to this question depends on how one views the relation between familiarity and recollection. According to one view, the two processes are mutually exclusive (Gardiner & Parkin, 1990; Jones, 1987; Nelson, Schreiber, & McEvoy, 1992). Recognition memory results from either recollection, involving retrieval of context-specific information about the item, or from familiarity, an assessment that a tested item is similar to a studied one. Support for the exclusivity assumption can be seen in the convergence of results from remember/know studies and results from studies of direct and indirect tests (for a review, see Roediger & McDermott, 1993). For example, levels-of-processing manipulations have large effects on direct tasks (e.g., free recall) and remember judgments but have little effect on indirect tests (e.g., word–fragment completion) and know judgments.

An alternative view of the relation between familiarity and recollection is that the processes are independent (Jacoby & Dallas, 1981; Jacoby, Toth, & Yonelinas, 1993; Jones, 1987; Mandler, 1980). Recognition may be accompanied by recollection, by familiarity, or by some combination of the two. In the context of the remember/know paradigm, recognition resulting from familiarity alone leads to know judgments, whereas recognition resulting from recollection alone or some combination of the two leads to remember judgments. The independence assumption is supported in studies examining dissociations between recollection and familiarity. A number of variables, such as amnesia, aging, divided attention, list length, appear to affect recollection, but not familiarity (Jacoby, 1991; Jennings & Jacoby, 1993; Verfaellie & Treadwell, 1993; Yonelinas & Jacoby, 1995). Similarly, increases in familiarity, but not recollection, can be found under conditions in which response criteria are relaxed (Yonelinas, 1994).

Two different procedures have been used to obtain estimates of recollection and familiarity assuming independence between the two processes. One procedure involves calculating recollection and familiarity estimates from remember and know judgments, the independence remember/know procedure (see Yonelinas & Jacoby, 1995, for details). We applied this procedure to the data in this experiment to examine the effect of knowledge on recollection and familiarity. Mean recollection and familiarity estimates appear in Table 2. Our analysis of the recollection estimates yielded the

Table 2
Recollection and Familiarity Estimates Obtained From the Independence Remember/Know Procedure in Experiment 1

Knowledge and estimate	Text: *Star Trek*	Text: Psychology
Expert		
Recollection	.51 (.26)	.23 (.34)
Familiarity	.24 (.20)	.35 (.22)
Novice		
Recollection	.29 (.29)	.20 (.28)
Familiarity	.26 (.25)	.34 (.23)

Note. Standard deviations are in parentheses.

same pattern of results as did our analysis of remember judgments. Knowledge and text interacted such that experts had higher recollection judgments than did novices, but only for information from the *Star Trek* story, $F_1(1, 64) = 6.20$, $MSE = 0.04$; $F_2(1, 99) = 4.99$, $MSE = 0.02$. In contrast, we found no reliable effects in our analyses of the familiarity estimates. Thus, when this procedure is used, it appears that knowledge has a large effect on recollection but little effect on familiarity.

The second procedure for obtaining estimates of recollection and familiarity under the independence assumption is the process-dissociation procedure (Jacoby, 1991; Jacoby et al., 1993; Yonelinas & Jacoby, 1995). We used this procedure in Experiment 2 to obtain converging evidence about the influence of expertise on recognition.

Experiment 2

Jacoby (1991) developed the process-dissociation procedure as a means of assessing the relative contribution of automatic and intentional memory processes to recognition performance. Recognition memory for studied words is compared in two conditions: the inclusion condition, in which participants are asked to respond "old" to studied items on the basis of either recollection or familiarity, and the exclusion condition, in which participants are asked to reject studied items whenever they can recollect them as old. Exclusion and inclusion probabilities are then used to obtain estimates of recollection and familiarity (see Yonelinas & Jacoby, 1995, for details). In Experiment 2, we used this procedure to examine the effect of knowledge on recollection and familiarity. Experts and novices read two *Star Trek* stories or two psychology chapters. They then received a recognition test under both inclusion and exclusion instructions. On the basis of our previous study, we expected experts to have higher recollection estimates than novices, but only for *Star Trek* items. Our primary interest was in the extent to which domain knowledge affected estimates of familiarity.

Method

Participants. Participants were 72 undergraduates at the University of California, Davis. They received course credit for their participation.

Materials. We used the same set of texts and recognition items as we did in Experiment 1 (25 *Star Trek* items from each story and 25 Psychology items from each story). In addition, we selected a third *Star Trek* story, "The Hunting" (Beetem, 1996), from the same anthology used in Experiment 1 and a third psychology chapter (Baron, 1998, chap. 1). We selected 50 recognition items from each of these additional texts.

The texts were paired to create six text sets. Each set contained either two *Star Trek* stories or two psychology chapters, counterbalanced across sets. A recognition test was constructed for the *Star Trek* stories by creating two blocks of items. Each block contained 25 items from each of the *Star Trek* stories that participants read. In addition, each contained 25 new *Star Trek* items from a story that participants did not read. A recognition test was constructed similarly for the psychology chapters. In both recognition tests, inclusion instructions preceded one block and exclusion instructions preceded the other block. Block order was counterbalanced across material sets.

Procedure. Participants completed the *Star Trek* knowledge test in Session 1 and were randomly assigned to a text set in Session 2, using the procedure described in Experiment 1. Each text set contained either two *Star Trek* stories or two psychology chapters. The experimental session consisted of four study–test conditions. In two conditions, participants read the texts and then received the recognition test in two counterbalanced instructional blocks. In one block, participants were told to respond "yes" if the sentence appeared in the first text that they had read or to respond "yes" if they recognized the sentence but could not remember in which text it had appeared. They were told to respond "no" to any new item. In the other block, they received exclusion instructions asking them to respond "yes" only if the sentence was in the second text that they had read. They were told to respond "no" if they recognized the item from the first text or if the item was new. In the other two study–test conditions, the inclusion and exclusion instructions were reversed and participants were told to respond "yes" if the sentence appeared in the second text that they had read.

Results and Discussion

Scores on the knowledge test were used to classify participants as expert or novice, as we described previously. Experts had scores that ranged from 47 to 70 ($M = 59.11$, $n = 24$); novices had scores that ranged from -2 to 41 ($M = 24.41$, $n = 24$).

We calculated inclusion and exclusion probabilities for each participant.[1] Both probabilities reflect yes responses to sentences from the first text that participants read. Thus, inclusion probabilities are *hits,* whereas exclusion probabilities are *false alarms.* These probabilities appear in Table 3. The inclusion and exclusion scores were used to calculate estimates of recollection and familiarity for each participant. These estimates also appear in Table 3. We performed separate 2 (knowledge) × 2 (text) ANOVAs on these estimates. Knowledge (expert vs. novice) and text (*Star Trek* vs. psychology) were between–participants and between–items factors.

Table 3
Inclusion and Exclusion Probabilities and Recollection and Familiarity Estimates as a Function of Domain Knowledge and Text in Experiment 2

	Text	
Knowledge and estimate	*Star Trek*	Psychology
Expert		
Inclusion	.77 (.22)	.53 (.18)
Exclusion	.23 (.16)	.47 (.21)
Recollection	.54 (.35)	.05 (.34)
Familiarity	.54 (.17)	.52 (.19)
Novice		
Inclusion	.61 (.31)	.61 (.20)
Exclusion	.53 (.23)	.52 (.25)
Recollection	.08 (.48)	.09 (.38)
Familiarity	.58 (.22)	.60 (.15)

Note. Standard deviations are in parentheses.

Recollection and familiarity estimates. Our analysis of the recollection estimates revealed the predicted Knowledge × Text interaction, $F_1(1, 44) = 4.65$, $MSE = 0.16$; $F_2(1, 96) = 23.20$, $MSE = 0.07$. Experts had higher estimates of recollection than did novices, but only in the *Star Trek* condition, $F_1(1, 44) = 9.13$; $F_2(1, 96) = 43.46$. The two groups had similar recollection estimates in the psychology condition. We also found a reliable effect of text, $F_1(1, 44) = 4.40$, $MSE = 0.16$; $F_2(1, 96) = 21.35$, $MSE = 0.07$. Our analyses of the familiarity estimates revealed no reliable effects.

Responses to new items. Our analyses of "yes" responses to new items (false alarms) revealed no reliable effects.

Our primary goal in this experiment was to investigate the influence of domain knowledge on the familiarity component of recognition memory. If we assume that recollection and familiarity are independent processes, our results suggest that domain knowledge has no effect on familiarity. Experts and novices had comparable familiarity estimates in response to *Star Trek* items. These results are consistent with our findings from Experiment 1. Domain knowledge appears to have a reliable and robust effect on recollection. Experts were more accurate than were novices when they were asked to recognize items that had been in either text (inclusion instructions). More importantly, experts were more accurate than were novices at linking an item with the specific text in which it appeared (exclusion instructions). These effects appeared, however, only in response to *Star Trek* items (items from the relevant knowledge domain).

General Discussion

Our goal in this study was to reconcile two somewhat disparate findings concerning the effects of prior knowledge on memory for text: prior knowledge has a large effect on readers' recall of text information, but only a small effect on readers' recognition performance. We hypothesized that failure to detect clear effects of knowledge on recognition might result from the dual nature of recognition memory. Our results were consistent with this hypothesis. In particular, recollection appears to play a significant role in the recognition performance of high-knowledge individuals. Thus, in Experiment 1, we observed more remember responses among *Star Trek* experts than among *Star Trek* novices; and, in Experiment 2, the process-dissociation procedure yielded larger estimates of recollection among experts than among novices. It is important to note that differences among experts and novices were found

[1] Our primary interest was in the effects of knowledge on recollection and familiarity; however, we did analyze the inclusion and exclusion probabilities. Our analyses of the inclusion probabilities revealed no effects that were reliable in both the participants and items analyses. Our analyses of the exclusion probabilities revealed a reliable Knowledge × Text interaction, $F_1(1, 44) = 4.01$, $MSE = .06$; $F_2(1, 96) = 13.57$, $MSE = .03$, and a reliable effect of knowledge, $F_1(1, 44) = 7.56$, $MSE = .06$; $F_2(1, 96) = 25.59$, $MSE = .03$.

only in response to *Star Trek* items. We found no differences in the groups' responses to psychology items. Thus, the two experiments provide converging evidence that expertise has a large influence on the recollective component of recognition.

Prior studies of knowledge effects on recognition memory, like those reported here, have failed to find robust knowledge effects on overall recognition accuracy, but there have been a few notable exceptions. Our results have implications for resolving these inconsistencies. For example, Schustack and Anderson (1979) found knowledge effects using a cued-recognition procedure. Participants in their study were required to decide whether a test item had occurred in a set of statements that was associated with a specific character during study. All of the test items had been presented previously in the study episode; thus, familiarity could not be used as the sole criterion for making a response. A correct response required the recollection of relevant information about the context in which the item occurred. This task is similar to the one that we used in Experiment 2 in that it emphasizes retrieval-based recognition. A correct response requires retrieval of information about the specific context in which a target item appeared.

How does prior knowledge improve a reader's ability to recollect text ideas? Current models of discourse comprehension suggest two possibilities. According to these models, readers construct and store in memory at least two interrelated representations when they comprehend a text: a propositional representation and a discourse model (Gernsbacher, 1990; Graesser, Singer, & Trabasso, 1994; Greene, McKoon, & Ratcliff, 1992; Kintsch, 1988; Kintsch & van Dijk; 1978; McKoon & Ratcliff, 1990, 1992, 1998). The propositional representation contains the individual ideas that are derived from each sentence and the relations among them. The relations among propositions are primarily referential (Kintsch, 1974; McKoon & Ratcliff, 1980; Ratcliff & McKoon, 1978). The ability to establish referential connections among propositions is affected by text-relevant knowledge. For example, knowing that "Worf is a Klingon" enables a reader to establish a referential connection between propositions containing the concepts "Worf" and "Klingon." Such connections are likely to enhance retrieval of text ideas, leading to a conscious recollective experience at test.

The propositional representation serves as a foundation for the discourse model (Graesser et al., 1994; Greene et al., 1992; McKoon & Ratcliff, 1990, 1992, 1998). The discourse model is a representation of the context or situation to which the text refers. The discourse model is constructed by integrating text ideas with relevant world knowledge. This often requires making inferences about the causes and consequences of events, the spatial arrangement of objects, the procedure for performing a task, or the goals of individuals. In the context of narrative understanding, prior knowledge about characters in a story may be particularly important in constructing the discourse model. Knowledge about the personalities of characters and their typical responses to various situations can provide the basis for elaborating the actions and events in a story. These elaborations may involve subtle aspects of meaning. For example, knowing about Klingons' stoic nature may allow the reader to make inferences in response to the sentence *Lieutenant Worf remained silent* that could not be made by readers without such knowledge. These inferences are likely to translate into differences in experts' and novices' retrieval experiences during recognition.

Our focus in this study was primarily on the relation between domain knowledge and recollection in recognition memory. Dual-process models of recognition memory offer relatively clear predictions about how the recollective process should be affected by domain expertise. Predictions with respect to how domain knowledge should affect familiarity are less straightforward and depend on assumptions about the relation between familiarity and recollection. If we assume that familiarity and recollection are mutually exclusive, then our results suggest that domain expertise reduces the contribution of familiarity to recognition memory performance. If we assume, however, that the two processes are independent, then our results suggest that familiarity is unaffected by expertise. This latter finding is somewhat surprising given previous research on the influence of levels-of-processing manipulations on estimates of recollection and familiarity. Such research has usually found that both estimates increase as a function of levels of processing (Jacoby, 1991; Toth, 1996).

In summary, the involvement of two distinct processing components in recognition provides an explanation for previous failures to find knowledge differences in recognition memory for text ideas. Knowledge effects are difficult to detect in overall recognition performance because familiarity-based processing gives rise to good recognition memory even among novices. Robust knowledge effects emerge, however, when recognition is partitioned into its familiarity and recollective components. Prior knowledge about a text has a large effect on recollection, increasing the likelihood that readers report a vivid, conscious experience of recollection in response to text ideas.

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Appendix
Star Trek Knowledge Test

Star Trek Character Recognition Test

Below you will see a list of fictional characters. Some of these characters were selected from *Star Trek* television episodes or movies; some were selected from other science fiction sources. Many of the characters from *Star Trek* are rather obscure in that they may have appeared in only a single episode or movie. Please read the names and place a check mark next to those that you know come from *Star Trek*. DO NOT GUESS. Remember, many of the characters come from other science fiction sources. Check only those you are sure appeared in at least one *Star Trek* episode or movie.

____ Rom
____ Dr. von Braun
____ Melzi
____ Salia
____ Commissioner Bele
____ Ripley
____ Uhura
____ Captain Vince
____ Tanya Kirbuk
____ Jean Luc Picard
____ Lavender Giovio
____ Balok
____ Nakedei Toshida
____ Major Lawrence Hall
____ Carol Marcus
____ Charleroi
____ Khan Noonien Singh
____ Terr
____ Commodore Matt Decker
____ Calvin Hardwell
____ Gowron
____ William T. Riker
____ Mr. Reeves
____ Miles O'Brien
____ Sybok
____ Harcourt Fenton Mudd
____ Hiharu Sulu
____ Ro Laren
____ Dr. Simon Gelder
____ Thol
____ DiaMon Tog
____ Captain Pike
____ Zefram Cochrane
____ Kamala
____ Saavik
____ Erin Morgan
____ Captain Garth
____ Natasha Yar
____ Zaidie
____ Lwaxana Troi
____ Dr. Katherine Pulaski
____ Kevin O'Donnell
____ Deanna Troi
____ Ambassador Detrich
____ Anan 7
____ Thayn Marden
____ Tyree
____ Boothby
____ Leila Habib
____ Flint
____ Dr. Randel Steffington
____ Geordi La Forge
____ Reginald Barclay
____ Sador
____ Gary Seven
____ Commander Morrison
____ Lewis Armatrading
____ Paul Altreides
____ Edith Keeler
____ Brion
____ Surak
____ Dr. Mendel
____ Dr. Beverly Crusher
____ Dr. Josh Ward
____ Pavel Chekov
____ Dr. Richard Daystrom
____ David Habrin
____ Ocpetis Marn
____ Keiko Ishikawa
____ Mr. Homm
____ David Marcus
____ Dr. Noonien Soong
____ Tarl Brent
____ Commander Dave Bowman
____ Dr. Sevrin
____ Penkawr
____ Calder
____ Captain Maltby
____ Arturo Gerli
____ Commodore Robert Wesley
____ Jon Westerley
____ Guinan
____ Leonard McCoy
____ Leila Smithers
____ Mary Tshona
____ Commander Straker
____ Nengle
____ Ben Finney
____ Rab Quobba
____ Orr
____ Wesley Crusher
____ Gul Macet
____ Corporal Hendricks
____ Alexander Rozhenko
____ Dr. Zach
____ Tammas
____ T'Pring
____ Morbius
____ Montgomery Scott
____ General Muller

(*Appendix continues*)

Appendix (*continued*)

Star Trek Life-Form Recognition Test

Below is a list of life-forms (races or individual creatures). Some of these life-forms were selected from *Star Trek,* and some were selected from other science fiction sources. Place a check mark next to those that come from *Star Trek.* DO NOT GUESS. Check only those you are sure appeared in at least one *Star Trek* episode or movie.

____ Vasopod	____ Tellarite	____ Thermosian	____ Metron
____ Tamarian	____ Space amoeba	____ Malmori	____ Astronef
____ Mitr	____ Vulcan	____ Borg	____ Tarellian
____ Ferengi	____ Romulan	____ Jerrodian	____ Lupov
____ Human	____ Carse	____ Kelvan	____ Tholian
____ Sunmen	____ J'naii	____ Tribble	____ Q
____ Coeurl	____ Bynar	____ Horta	____ Mengenth
____ Aldeans	____ Vramen	____ Mentats	____ Trill
____ Ewoks	____ Krel	____ Jenghik	____ Gorgan
____ Klingon	____ Cardassian	____ Bajorans	____ Gomtuu
____ Panglic	____ Triffids	____ Oms	____ Cylon
____ Quiru	____ Dellian	____ Melkot	
____ Troodontid	____ Betazoid	____ Croc	

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