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Exploring Encoding and Retrieval Effects of Background Information on Text Memory

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Two experiments were conducted (a) to evaluate how providing background information at test may benefit retrieval and (b) to further examine how providing background information prior to study influences encoding. Half of the participants read background information prior to study, and the other half did not. In each group, half were presented with background information at test. Background information at test improved recall for those who did not read information prior to study. Results from Experiment 2 suggested that this improvement was due to background information providing content cues to retrieve specific ideas from the text rather than topic cues to support top-down recall. Concerning encoding effects, secondary measures and construction-integration modeling of free recall support the hypothesis that background information presented prior to study influences the effectiveness of organizational processing during encoding.

In many educational and professional training environments, instruction within a domain often begins with the presentation of background information. In general, background information involves the presentation of material prior to study of the to-be-learned content that provides information related to but not necessarily contained within that content. For example, background information may explicitly state new facts or ideas relevant to the text content (e.g., informational outlines, definitions, or instructed theories). Some forms of background information may support the activation of a reader's prior knowledge relevant to the text content (e.g., thematic titles, reading perspectives, or advanced organizers that provide

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conceptual analogies). The intent of presenting background information is usually to provide a foundation for subsequent learning of relevant content. Indeed, previous research has shown that various forms of background information can improve memory for subsequently presented text material (e.g., Anderson & Pichert, 1978; Bransford & Johnson, 1973; Corkill, 1992; Dinnel & Glover, 1985; Dooling & Lachman, 1971; Mannes & Kintsch, 1987; Mayer, 1983; Mishra & Brewer, 2003; Rawson & Kintsch, 2002; Slater, Graves, & Piché, 1985; Wiley & Rayner, 2000). However, although a sizeable amount of research has demonstrated that background information can improve memory for text material, many fewer studies have investigated how it is that presenting background information brings about these improvements in memory. Accordingly, our goal in this research was to further explore the underlying mechanisms by which background information benefits text memory.

We begin with the assumption that memory for any given idea unit within a text depends on at least three factors: (a) whether the information within that idea unit is encoded, (b) the extent to which connections between that idea unit and other related ideas or topics are encoded, and (c) whether retrieval cues for accessing that idea unit are available at time of test. Most important for these purposes, background information may influence any or all of these factors. Specifically, background information may improve text memory by supporting the encoding of more idea units and/or the encoding of more connections. Note that each of these represents an "encoding effect." In addition to any encoding effects, background information may also improve text memory by influencing the retrieval cues used to access encoded idea units, which represents one form of "retrieval effect." In the following, we consider both encoding and retrieval effects in turn.

EFFECTS OF BACKGROUND INFORMATION ON ENCODING

An increasing amount of research has supported the widely held assumption that background information influences the encoding of text information. For example, Wiley and Rayner (2000) reported that providing readers with topical information for texts that are otherwise ambiguous thematically influences the pattern of eye movements during reading (e.g., fewer regressive fixations and shorter gaze durations at sentence wrap-up points). Kaakinen, Hyönä, and Keenan (2002) similarly showed that reading perspectives influence online eye movements. Rawson and Kintsch (2002) provided further examination of the nature of encoding effects. Participants read several short texts that discussed the advantages and disadvantages of various government policies. Prior to reading the texts, half of the participants read relevant background information (e.g., definitional information about the policies), whereas the other half did not. All participants completed a free re-

call test after studying the texts. Across experiments, participants who read background information recalled significantly more than those who did not. Based on the pattern of results across several secondary measures, we concluded that this memory advantage was due to the encoding of more connections between idea units and topical information rather than to the encoding of more idea units per se. Specifically, cued recall for specific idea units did not differ between the two groups, suggesting a minimal influence of background information on the number of idea units encoded (see also Kardash, Royer, & Greene, 1988). In contrast, several measures suggested greater interconnectedness between those idea units and topic superordinates in the background information group. For example, readers in the background information group were more likely to output idea units related to the same topic together (i.e., greater clustering), and they were better able to identify which topic was being discussed when presented with a particular idea unit.

In this research, we provide further evidence to support the conclusion that the primary encoding effect of background information involves the encoding of more connections between idea units and topical information rather than the encoding of more idea units. First, we replicate the pattern of results in the secondary measures originally reported in Rawson and Kintsch (2002). Second, to provide converging evidence for the claim that background information promotes the encoding of more connections, we performed computational modeling based on the construction-integration (CI) theory of text comprehension (Kintsch, 1988, 1998) to simulate the patterns of free recall in this research. These simulations are described in detail in a section following presentation of Experiments 1 and 2.

EFFECTS OF BACKGROUND INFORMATION ON RETRIEVAL

Although background information is typically presented prior to study of related text content, background information may also be provided at time of test with the intent of further promoting recall of the text material. Much less research has examined the influence of background information at retrieval than has examined its effects at encoding. Furthermore, the extant research has yielded mixed results. For example, Dooling and Mullet (1973) used short texts that were topically ambiguous unless accompanied by a title that explicitly stated the theme of the text (e.g., "Christopher Columbus Discovering America"). The text title was either presented prior to the text, after the text but prior to test, or not at all. Free recall was greater when the title was read prior to the text than when it was read after the text or not at all. Free recall for these latter two groups did not significantly differ, suggesting a minimal influence at retrieval (see also Corkill, Glover, Bruning, & Krug, 1988).

In contrast, other research has suggested that background information can exert an influence at retrieval (e.g., Alba & Hasher, 1983; Anderson & Pichert, 1978; Fass & Schumacher, 1981; Kardash et al., 1988). For example, Anderson and Pichert presented all participants with a story about two boys who skip school and spend the day at one of the boy's homes. The home and its contents are described at various points throughout the story. Prior to reading the story, participants were instructed to take the perspective of either a burglar or a home buyer as they read. After reading, an initial recall test was given. Then participants were given a second recall test in which they were instructed to take either the same perspective they were given before study or the alternative perspective. The critical results concern recall for the content that was relevant to only one of the two perspectives (e.g., a leaky roof would be relevant to a home buyer but not to a burglar). On the initial recall test, participants recalled more perspective-relevant information than perspective-irrelevant information. More important, on the second recall test, participants who changed perspectives now recalled significantly more of the information that was previously irrelevant than did those who maintained the same perspective. Results from a postexperimental interview provided converging support for an influence of perspectives on the retrieval cues used at time of test. Forty-four percent of the participants "expressly stated that considering superordinate categories of information significant in the light of the perspective caused them to recall particular items of information from these categories" (Anderson & Pichert, 1978, p. 9). Another 38% of the participants reported that "the new perspective 'jogged' their memories" or brought additional information to mind (Anderson & Pichert, 1978, p. 9).

To revisit, the form of retrieval effect under consideration here concerns an influence of background information on the cues used to access encoded information at time of test. The retrospective reports described by Anderson and Pichert (1978) have suggested that background information may influence the use of two different kinds of retrieval cue. First, background information may encourage the use of "topic cues" to retrieve information at time of test. Specifically, background information may promote the use of topic superordinates at time of test as cues for retrieving the related text content connected to those topics. By this account, any recall advantage for those reading background information would be attributable to greater use of a "top-down" (i.e., topic to content) retrieval strategy. Participants who do not read background information may be less likely to use topics as cues at time of test, particularly to the extent that their representation of the topical structure is not well developed (and thus not readily accessible). Instead, they may rely on a "bottom-up" retrieval strategy by attempting to access text content directly, which presumably would be less effective than also using topics as cues to retrieve content in a top-down fashion.

To evaluate the *topic cue hypothesis* (i.e., that background information can improve recall of text content by promoting the use of topics as retrieval cues at time

of test), in Experiment 1, we replicated and extended our earlier research (Rawson & Kintsch, 2002). As in Rawson and Kintsch, one group of participants read background information prior to reading text material, and another group did not. Importantly, in this research, half of the participants in each group were presented with the background information at time of test and half were not. The idea here is that presenting background information at test will activate topic superordinates, which will in turn encourage the use of those topics as cues to retrieve related content. To the extent that readers do not spontaneously use topic cues to retrieve text content, presenting background information at time of test would be expected to promote recall.

In addition to topic cues, providing background information at test may also influence the use of a second kind of retrieval cue referred to here as "content cues." Specifically, background information may contain particular content words or concepts that can directly cue the retrieval of idea units from the text that also contain those words or concepts regardless of their topical relations (cf. the resonance-based retrieval accounts of the activation of information during online text processing discussed by Gerrig & McKoon, 1998, and Myers & O'Brien, 1998). We consider the *content cue hypothesis* (i.e., background information at time of test may encourage readers to use the specific content words contained therein to retrieve text content) further in Experiments 1 and 2.

EXPERIMENT 1

Method

Participants and design. One hundred twelve undergraduates from the University of Colorado participated to partially satisfy course requirements in Introductory Psychology. Twenty-eight participants were randomly assigned to each of four groups defined by two between-subject variables, study information (background information or none) and test information (background information or none).

Materials. All instructions and materials were presented by computer. The materials used in this research were based on those developed by Rawson and Kintsch (2002), with minor modifications. Briefly, the text materials were adapted from a political science textbook and centered around the general topic of government intervention in the labor market. Each of four texts discussed one policy *issue,* or one specific way in which the government can intervene in the labor market (i.e., benefit mandates, labor laws, training programs, or minimum wage). A background information item was written for each issue describing what that form of government intervention entailed (e.g., benefit mandates are government regula-

tions that require large businesses to provide benefits for full-time employees). Each of the texts contained four content statements. Each content statement contained a quoted argument either for or against that particular form of government intervention, with two prointervention and two anti-intervention arguments in each text. Each content statement was attributed to one of four *sources* or fictional persons to whom the argument was attributed. Each source was briefly introduced by full name and title in the first text (e.g., Lloyd Jones, a professor of economics and public affairs at Stanford University) and then referred to by abbreviated title and last name in subsequent texts (e.g., Professor Jones). Within each text, the four content statements were presented in the same random order to all participants, with short transitional phrases or sentences in between each so that the texts read more naturally. Additionally, the four texts were presented in the same random order for all participants. (Fixed random orders within and between texts were adopted to allow the CI models to simulate processing of texts in the same order of presentation for all participants.) A sample background information item and a sample text are presented in the Appendix.

Cued recall prompts were developed from each of the 16 content statements (see the Appendix for sample prompts). Each prompt consisted of one of the two sentences comprising a quoted argument. For each prompt, participants were asked to recall the other half of the quoted argument, the source who said it, and the issue they were discussing when they said it. Results from the cued recall test were relevant to exploring the effect of background information at encoding but did not bear on the question concerning potential effects at retrieval. Accordingly, we discuss these results in the section following Experiments 1 and 2.

Procedure. Participants were informed that they were going to be given four short, argumentative texts on the general topic of government intervention to study for later recall. Participants who were to receive background information prior to study were told that information pertaining to the issues would be presented prior to each text. They were told that they would not be tested on this information but were encouraged to read the descriptions carefully to help them remember the text material. Participants who were to receive background information at time of test were not informed of this in advance.

Participants who received background information prior to study were presented with the background information item for the first text for self-paced study. When the participant terminated study with a key press, the information was replaced with the corresponding text for self-paced study and so on until all four background information items and texts had been presented. After reading all of the materials once, each participant was then given a second study trial to avoid potential floor effects in free recall. For participants who did not receive background information prior to study, the procedure was exactly the same except that each text

was preceded by a numerical text title (e.g., "Text One") instead of background information.

After study was completed, participants were told that they would next be tested on their memory for the material. Participants who were to receive background information at test were also shown one of the two prompts shown following, which were worded to appropriately reflect whether they had also seen background information prior to study or not:

> As an aid for remembering the text information, the four background sentences you saw prior to each text will also appear on the screen. You should not include these in the recall that you type in, but you can read them again to help you remember the texts.

> As an aid for remembering the texts, four sentences providing you with some background information will also appear on the screen. The background information in each sentence will explain a particular way that the government intervenes in the labor market. You should not include these in the recall that you type in, but you can read the them to help you remember the texts.

On the recall screen, all participants were presented with an empty text field and a prompt to type in as much as she or he could recall from all of the texts. For those participants who received background information at test, the four background information items appeared at the top of the screen above the recall field. The amount of time permitted for recall was not restricted. After the participant made a key press to indicate she or he had finished recalling the texts, the cued recall test was administered, with prompts presented one at a time in random order.

Results and Discussion

The quoted argument portion of each content statement in each text was segmented into propositions (Bovair & Kieras, 1985; Kintsch, 1998). For example, the propositional analysis for the following sentence (taken from a content statement about labor laws) is shown following: "If you can breathe, you can sue for unlawful termination, and if you can't, then you qualify as disabled":

P1 IF[P3,P2]
P2 BREATHE[YOU]
P3 SUE-FOR[YOU,TERMINATION]
P4 UNLAWFUL[TERMINATION]
P5 IF[P7,P6]
P6 NOT-BREATHE[YOU]
P7 QUALIFY-AS[YOU,DISABLED]

The percentage of propositions recalled was then computed for each participant. Verbatim recall or close paraphrases were scored as correct. Recall of transitional sentences between content statements was not scored.

Mean free recall across participants in each group is reported in Figure 1. In subsequent analyses, all effects declared as significant have $p < .05$. A 2 × 2 analysis of variance (ANOVA) revealed a significant main effect of study information, $F(1, 106) = 4.93$, $MSE = 109.05$, replicating the basic finding of previous research that reading background information prior to studying text material can improve subsequent recall of that material. The main effect of test information approached significance, $F(1, 106) = 2.79$, $p < .10$. Finally, the interaction was significant, $F(1, 106) = 4.46$. For participants who read background information prior to studying the texts, presentation of background information at time of test did not influence recall performance, $t(54) = 0.21$, a finding we consider further later. In contrast, for participants who did not read background information prior to studying the texts, recall was significantly greater for those who read background information at time of test than for who did not, $t(54) = 3.16$.

Thus, this research demonstrates that providing background information at test can improve free recall. However, what is the nature of this retrieval effect? To what extent did background information promote the use of topic cues to retrieve related text content or the use of content cues to access specific idea units? Although the background information items did not contain any of the complete idea units contained in the text, several of the key content words in the background in-

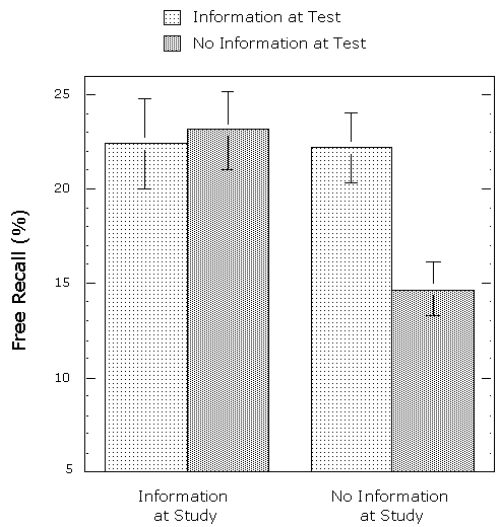

FIGURE 1 Mean free recall (in percentage) as a function of whether participants read background information prior to study and whether participants read background information at time of test. Error bars represent standard errors of the means.

formation items appeared in various ideas expressed in the text. For example, the background information item for benefit mandates explains that large businesses must provide benefits for full-time employees. The term *full-time* appears in two other ideas in the corresponding text (e.g., "by hiring temporary rather than full-time workers") and once in another of the texts ("An employee working full-time, year-round still has an income well below the poverty level"). The closely related term *part-time* similarly appears in three different ideas across texts. Thus, terms included in the background information item could cue recall of these text ideas without relying on relations between those ideas and the topics.

A post hoc analysis of recall for specific text ideas provides some support for the content cue hypothesis. For each participant, we computed the number of propositional elements (i.e., words denoting the constituent concepts and relations) recalled from each of the 36 complex propositions comprising the scored argument content of the texts. For each of the 36 complex propositions, we then computed the mean number of elements recalled across participants within each group. Using data from the two groups of participants who did not read background information prior to study, we computed a difference score for each of the 36 complex propositions by subtracting the mean for the group who did not read background information at test from the mean for those who did. Thus, a positive difference score indicated that recall of a particular complex proposition was greater for those who read information at test than for those who did not.

Of the 36 complex propositions, 25 shared zero to one content words with the background information items. Again, for participants who did not read background information prior to study, the mean difference score for these propositions was .47 (standard error of the means [*SEM*] = .11). The remaining 11 complex propositions each shared two to three content words with background information items and showed a greater mean difference score of .90 elements (*SEM* = .21), $t(34) = 2.00$, $p = .05$. Thus, the recall advantage for participants who received background information at test was particularly pronounced for text content that shared key content words with those informational items.[1] This outcome supports the idea that for those readers who did not receive background information prior to study,

[1]To what extent can the content cue hypothesis account for the recall advantage for readers who did read background information prior to study relative to those who did not? That is, participants who read background information prior to study may have retrieved the information at time of test and then used the content words to cue specific pieces of content. A post hoc analysis of recall by item (as previously) weighed against this account. Specifically, we computed difference scores using the two groups of participants who did not receive background information at test. Thus, in this analysis, a higher difference score meant that recall of a particular complex proposition was greater for participants who only read background information prior to study than for those who did not read background information at either study or test (the two groups conventionally used to demonstrate background information effects). Mean difference score for the 25 complex propositions sharing zero to one content words with background information (.61; *SEM* = .13) did not significantly differ from the mean difference score for the 11 complex propositions sharing two to three content words (.55; *SEM* = .12), $t(34) = 0.06$. In fact, the trend was in the opposite direction than that predicted by the content cue hypothesis.

presentation of background information at time of test provided content words that were used as cues to retrieve specific idea units from the text content. Of course, this support for the content cue hypothesis rests on post hoc analyses. Accordingly, we conducted Experiment 2 to provide a stronger test of both the topic cue and content cue hypotheses and their accounts of the elevated recall observed when background information was provided at test.

EXPERIMENT 2

As in Experiment 1, half of the participants read background information prior to study, and half did not. However, instead of background information at time of test, half of the participants in each group were provided with *topic labels* or the names of the issues that served as the topics of the text material. The logic here is that presenting topic labels at time of test will provide topic cues for retrieving text material without providing key content words that would cue retrieval of specific idea units. To the extent that providing background information at test improved recall in Experiment 1 (for those who did not read information prior to study) by encouraging the use of topic cues to retrieve content, providing topic labels at test will also improve recall. However, to the extent that background information at test improved recall in Experiment 1 by providing specific content cues, providing only topic labels at test will not improve recall.

Method

One hundred eight undergraduates from the University of Colorado participated to partially satisfy course requirements in Introductory Psychology. Twenty-seven participants were randomly assigned to each of the four groups defined by two between-subject variables, study information (background information or none) and test information (topic labels or none). The materials and procedure were the same as in Experiment 1 except that the names of the four topics replaced the background information items at the top of the recall screen. The wording of the instructions to participants prior to recall was also changed slightly to accurately describe the topic labels that would appear on the screen.

Results

In Figure 2, we report mean free recall across participants within each group. A 2 × 2 ANOVA revealed only a significant main effect of study condition, $F(1, 104) = 6.25$, $MSE = 94.02$. Neither the main effect of test condition nor the interaction was significant, Fs < 1. These results suggest that the background information provided at test in Experiment 1 did not improve recall by influencing the use of topic cues

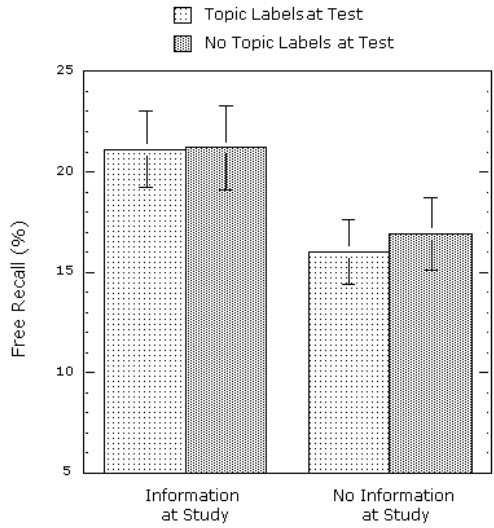

FIGURE 2 Mean free recall (in percentage) as a function of whether participants read background information prior to study and whether participants read topic labels at time of test. Error bars represent standard errors of the means.

to retrieve text content but rather by providing content cues to retrieve specific idea units that contained those key content words.

Discussion of the Effects of Background Information at Retrieval

Taken together, the results of Experiments 1 and 2 suggest that background information presented at retrieval can improve memory for text content but primarily by providing specific content cues for accessing particular idea units from the text. Providing only topic cues at time of test did not improve recall. One possibility is that the failure of topic cues to improve recall may be due to the fact that topics were ineffective cues for readers who did not read background information prior to study. That is, topics would have only cued retrieval of text content to the extent that links between the topics and related text ideas have been represented (and can thus be used as retrieval routes). Results from both our previous work (Rawson & Kintsch, 2002) and from this research (discussed following) suggest that readers who were not provided with background information prior to study were less likely to form connections between topics and text content than were those who read information prior to study, which supports the idea that topic cues would be less effective for the prior group.

Given the evidence for greater interconnectivity between topics and text content when background information is read prior to study, why then did topic cues not improve recall in this group in this study? We argue that presenting topic cues to this group provided no further benefit because the cues were redundant with the retrieval strategy that readers in this group were already using. Specifically, based on previous research and further results presented later, we propose that readers who received background information prior to study developed relatively strong representations of the topic structure of the texts and the connections between those topics and text content. At time of test, these readers then spontaneously accessed this topic structure and exploited the links between topics and text content to guide retrieval. We now turn to results that support this contention and that also provide evidence concerning the nature of encoding effects of background information.

EFFECTS OF BACKGROUND INFORMATION AT ENCODING

Empirical Evidence

The research reported in Rawson and Kintsch (2002) was designed to evaluate the nature of the effects of background information on encoding of text material. In brief, we evaluated three hypotheses: According to the quantitative hypothesis, background information influences the amount of text content encoded. According to the organizational-likelihood hypothesis, background information influences whether or not readers attempt to organize text content at encoding. According to the organizational-effectiveness hypothesis, given that readers attempt to organize text content at encoding, background information influences how effectively they are able to do so.

To evaluate these nonexclusive hypotheses, we examined several secondary measures of performance including cued recall and measures of representational organization. The pattern of results across the secondary measures yielded strongest support for the organizational-effectiveness hypothesis. For a detailed discussion of the relation between each of the secondary measures and the three hypotheses outlined previously, we refer readers to Rawson and Kintsch (2002). In brief, counter to the prediction of the quantitative hypothesis, cued recall of text content did not differ for those who read background information prior to study and those who did not, suggesting that background information had not promoted the encoding of more text content (see also Kardash et al., 1988). Counter to the organizational-likelihood hypothesis, clustering in recall (i.e., the extent to which idea units dealing with the same topic appeared together in recall) was well above chance regardless of whether background information was provided prior to study or not,

suggesting that readers in both groups attempted to form connections between topics and related idea units. However, consistent with the organizational-effectiveness hypothesis, clustering in recall was greater for those who read background information prior to study than for those who did not, suggesting that the former group of readers was more successful in establishing connections between topics and text content. Other secondary measures provided converging evidence for the organizational-effectiveness hypothesis. For example, when cued with a segment of content, recall of the particular topic associated with that content was greater for readers who read background information, further suggesting a greater degree of linking between topics and text content.

To establish the reliability of these findings, we computed the same set of secondary measures reported in Rawson and Kintsch (2002). These measures were calculated for the two groups providing a replication of those used in this earlier research. Namely, participants who read background information prior to study (but who did not receive any form of information at test) in Experiments 1 and 2 were combined to form the background information group. Participants who did not read background information at study or test in Experiments 1 and 2 were combined to form the control group. The results of these secondary measures for these two groups are reported in Table 1 along with corresponding inferential statistics. The results were consistent with the pattern of results from Rawson and Kintsch and further strengthened the evidence supporting the organizational-effectiveness hypothesis.

TABLE 1
Means for Secondary Dependent Measures
Across Replication Groups in Experiments 1 and 2

	Background Information		*Control*		
	M	*SD*	*M*	*SD*	*t*
Cued recall for content	13.10	1.20	12.6	1.20	$t(105) = 0.30$
Cued recall for issues	66.70	4.80	26.1	3.80	$t(53) = 6.63$**
Cued recall for sources	8.30	2.20	12.9	2.70	$t(53) = 1.30$
ARC	0.92	0.03	0.7	0.06	$t(101) = 3.45$**
Category access	3.60	0.10	3.3	0.10	$t(103) = 1.72$*
Statements per category	2.50	0.10	2.0	0.10	$t(103) = 3.90$**

Note. Results are reported for the two groups that did not receive background information at test (across Experiments 1 and 2), as these two groups replicate the original experiments reported by Rawson and Kintsch (2002). Thus, the Background information group includes participants who read background information prior to study only, and the control group includes participants who did not read background information at any point. Cued recall scores are reported in percentages (cued recall for issues and sources was not collected in Experiment 2). ARC = adjusted ratio of clustering from –1 to 1. Category access (i.e., number of categories for which at least one statement was recalled) and statements per category (i.e., number of statements recalled per category recalled) are out of a possible four.

*$p < .10$. **$p < .01$.

Simulations Using CI Theory

Based on the overall pattern of empirical results in this study as well as in the previous research (Rawson & Kintsch, 2002), we argue that providing readers with background information prior to study promotes the effectiveness with which they are able to represent links between topics and related content. Readers who do not read background information prior to study also attempt to form links between topics and content but are less successful at doing so. Thus, our central claim with respect to encoding effects is that the critical difference between the two groups is the extent of the connections between topics and related content (as stated by the organizational-effectiveness hypothesis). If so, then a model that captures this critical representational difference should be predictive not only of overall levels of recall but also of differences in recall between the two groups.

To further evaluate the plausibility of the organizational-effectiveness hypothesis, we investigated how differences in free recall could result from the different text representations in the two groups that this hypothesis assumes, using computational models based on the CI theory of text comprehension (Kintsch, 1988, 1998). In the following, we first briefly describe the central tenets of the CI theory, and then we describe the particular model instantiations used for these simulations.

According to CI theory, text processing involves a promiscuous construction phase followed by a winnowing integration process that yields a coherent network of nodes with weighted links between them. During the construction phase, nodes are created to represent the propositions explicitly stated in the text as well as related information from long-term memory that gets activated by the explicit content. Links between nodes are formed based on various factors, but one prominent factor is argument overlap (i.e., when propositions share one or more constituent arguments).

During the integration phase, the network created during the construction phase undergoes a spreading activation process. Highly interconnected nodes will accumulate activation, whereas less well-connected or weaker nodes will lose activation and may drop from the network altogether. A given text is processed in cycles in which construction and integration processes operate on one segment of text at a time, with a segment roughly corresponding to about one sentence. To maintain coherence across segments, a subset of the most highly weighted nodes at the end of integration are held over to participate in the next processing cycle.

After processing of a text has been completed, subsequent recall of any given proposition is assumed to be a function of the activation that the proposition accrued during the cycles in which it participated. Once a proposition has been recalled, it may act as a cue for retrieval of any content with which it shares a connection. The likelihood that a recalled proposition retrieves another text proposition is assumed to be a function of the strength of the connection between those propositions.

CI modeling. We instantiated the basic principles of CI theory in two computational models. Each model consisted of a network of linked nodes. To preview, the two models were highly similar except for the extent of linking between nodes in the network (as described in more detail later). The links in one model were intended to reflect the assumptions that the organizational-effectiveness hypothesis makes about the nature of the representation constructed when background information is presented prior to study. The links in the other model were intended to reflect the assumptions that the hypothesis makes about the representation when background information is not presented.

The four experimental texts were parsed into propositions as described in the Results and Discussion section of Experiment 1. In both models, a content node was created for each proposition. For the content nodes denoting propositions that were contained within the same sentence, links were formed based on argument overlap. Links between content nodes in different sentences were also formed based on argument overlap but only if those nodes participated in the same processing cycle (i.e., for those most highly activated nodes from the previous sentence that were carried over to participate during the processing of the next sentence).

Each model also contained a topic node corresponding to the topic of the text. However, the rule used to form links between content nodes and the topic nodes was different in the two models to reflect the differences assumed by the organizational-effectiveness hypothesis. Namely, in the model for the control group, one link was formed between the topic node and the one content node that expressed the main idea in each clause of a sentence (resulting in one to two content nodes linked to the topic node in each sentence). In the model for the background information group, a link was formed between the topic node and every content node in the sentence except for nodes expressing low-level modifying information (resulting in two to five content nodes linked to the topic node in each sentence). Thus, the connections between content nodes and the topic node were more dense in the model for the background information group than in the model for the control group to reflect the theoretical claim that more content was linked to topic superordinates in the background information group.

Each model was processed using the CI simulation program (Mross & Roberts, 1992; available from W. Kintsch on request). In brief, each model was submitted to the program one segment (usually corresponding to one sentence) at a time in the order in which they had been presented to participants. On each cycle, the program implemented spreading activation across the network segment. At the end of the cycle, the topic node and the two strongest content nodes (three in the case of a tie) were carried over to the next processing cycle.

Modeling results. Using these two models, we predicted patterns of recall in the two experimental groups that represent the standard background information design; that is, participants who only read background information prior to study in Experiments 1 and 2 were combined to form the background information group,

whereas participants who did not read background information at study or test in Experiments 1 and 2 were combined to form the control group. For purposes of predicting recall in the two experimental groups, two variables from the CI model are of interest: *node strength* or the activation a node accrued from the processing cycle(s) in which it participated and *link strength* or the strength of connection between two nodes in the network at the end of processing. These two variables were used to predict two aspects of recall: (a) the differences in level of recall for particular text items within a group, often referred to as the "landscape of recall," and (b) the differences between groups in the level of recall for each of these items.

First, consider the landscape of recall for each experimental group plotted in Figure 3. Each item corresponds to a complex proposition. Item recall was plotted as the mean number of propositional elements recalled from that item across participants within a group. Visual inspection of Figure 3 reveals that the landscape of recall in the two groups was highly similar—the Pearson correlation between item recall in the two groups was .95. Second, visual inspection of Figure 3 also reveals that the advantage in overall recall for the background information group was not due to a consistent elevation in recall across all items. Rather, the differences in item recall for particular items ranged from –.2 to 2.41.

To what extent does the CI modeling capture both the landscape of recall within each group as well as the item-specific differences in recall between groups? To evaluate the extent to which the model predicted the landscape of recall, we con-

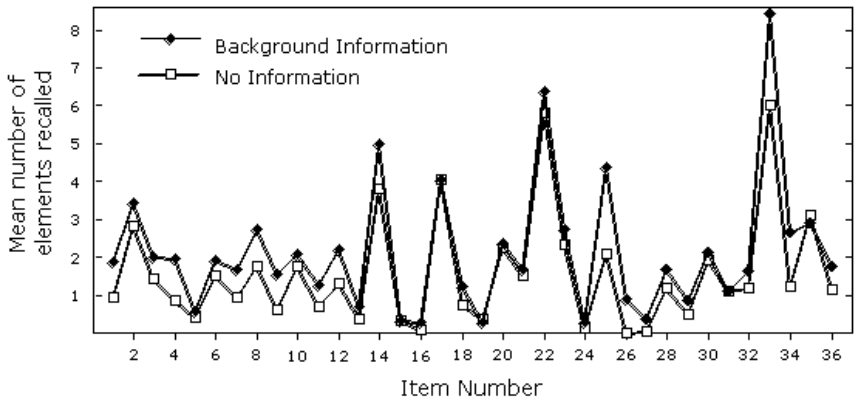

FIGURE 3 Free recall for each content item from the texts plotted as the mean number of propositional elements recalled for that item. Recall is plotted separately for participants who read background information prior to study only and for participants who did not read background information at any point across Experiments 1 to 2. Items 1 through 9 correspond to Text 1 (benefit mandates), Items 10 through 18 correspond to Text 2 (labor laws), Items 19 through 27 correspond to Text 3 (training programs), and Items 28 through 36 correspond to Text 4 (minimum wage).

ducted two multiple regression analyses, one for each of the experimental groups using the predictor variables derived from the model constructed for that group. Specifically, each regression included a node strength variable (i.e., the sum of the strengths for the nodes corresponding to the atomic propositions contained in an item) and a link strength variable (i.e., the sum of the link strengths between the topic superordinate node and any of the content nodes from that item) for the 36 items that comprised the substantive content of the texts.

On inspection of initial results, we realized that the predictiveness of the CI variables was particularly low for items in one of the four texts. Specifically, the CI variables were unrelated to item recall for the text on minimum wage. In retrospect, this result was not surprising given that most college undergraduates were likely to have considerable prior knowledge about minimum wage from personal work experience. Note that the CI networks only contained nodes corresponding to explicit text content and did not contain any nodes corresponding to prior knowledge. The power of the CI model to predict recall for this text would thus be severely compromised given that it was not provided with all of the information that participants were presumably processing while reading this text. In contrast, undergraduates' knowledge of the other three topics was likely quite low as reflected by the power of the CI model to predict recall for these texts based only on input of explicit text content. Thus, given that the patterns of results were qualitatively the same but stronger without the minimum wage items, all subsequent analyses are reported based on exclusion of minimum wage items.

For the background information group, the resulting standardized regression coefficients were .15 for node strength and .58 for link strength. The predictor variables from the corresponding CI model accounted for 51% of the variance in item recall, $F(2, 24) = 12.53$, $p < .001$. For the no-information group, the resulting standardized regression coefficients were .51 for node strength and .30 for link strength. The predictor variables from the corresponding model accounted for 52% of the variance in item recall, $F(2, 24) = 12.83$, $p < .001$. Thus, the CI models reflected the overall landscape of recall in each group, which established the appropriateness of the models.

To evaluate the extent to which the model predicted differences between the groups in item recall, we conducted a second series of regression analyses. According to the organizational-effectiveness hypothesis, the difference in recall between the two groups is due to a differential degree of interconnectivity between text content and topic superordinates. Thus, this account would predict that differences in link strengths would be most predictive of the differences in item recall between groups. By way of comparison, the quantitative hypothesis described previously would predict that differences in node strengths would be most predictive of differences in item recall. The quantitative hypothesis assumes that background information influences the amount of content encoded. Node strength in the model represents the degree of encoding of a given piece of content.

To evaluate these predictions, we created a difference variable by subtracting mean item recall in the no-information group from mean item recall in the background information group for each of the items. We then performed a multiple regression analysis with the difference score as the dependent variable. The four predictor variables included the link strength variable and the node strength variable from the model for each of the two groups. Together, these four variables accounted for 40% of the variance in the difference score, $F(4, 22) = 3.73$, $p < .02$. However, the unique variance associated with link strength from the background information model was the only significant individual predictor (standard coefficient = .92, $p < .03$). We also conducted a second multiple regression analysis in which difference scores for node and link strengths were entered into the regression instead of the four separate predictor variables. The node strength difference score was computed by subtracting the node strength in the control model from node strength in the background information model for each item. The link strength difference score was computed by subtracting the link strength in the control model from the link strength in the background information model for each item. The resulting standardized regression coefficients are .04 and .57 for the node strength difference and link strength difference variables, respectively, with link strength difference being the only significant predictor of differences in recall ($p < .01$). These findings are consistent with the claims of the organizational-effectiveness hypothesis given that they reflect a recall advantage for those items that shared links with topic superordinates above and beyond those formed in the absence of background information.

GENERAL DISCUSSION

This research adds to the body of evidence that has demonstrated that presenting readers with background information prior to studying related text material can improve memory for that material. More important, this research further illuminated the nature of the effect and extended the scope of potential effects of background information to include retrieval in addition to the effects at encoding. Specifically, Experiment 1 showed that presenting background information at time of test improved recall for individuals who had not read the information prior to study. Two hypotheses concerning the nature of this retrieval effect were considered. Results from both Experiments 1 and 2 supported the content cue hypothesis, suggesting that background information presented at test improved recall by providing key content words that could be used as retrieval cues to access specific idea units that also contained those content words (cf. Britton, Meyer, Hodge, & Glynn, 1980). In contrast, minimal evidence was found for the topic cue hypothesis given that the presentation of topic information alone was insufficient to boost recall.

Why were topic cues presented at test not effective for increasing recall? For individuals who read background information prior to study, we argue that presenting topic cues at time of test provided no further benefit because these readers were already accessing a relatively well-represented topical structure of the text to guide retrieval, and thus the topic cues were redundant. What about individuals who did not read background information prior to study? For this group, we consider two possible reasons why topic cues at test were ineffective. First, if readers in this group did not spontaneously use topic cues to retrieve related content (i.e., providing topic cues would not be redundant with their retrieval strategy), these readers may not have been able to use explicitly provided topic cues to retrieve content if no links were formed between the topics and that content during encoding. Second, if readers in this group were already using topic cues spontaneously to retrieve related content, providing topic cues at test would have been redundant. The pattern of results across the secondary measures reported in Table 1 (and in Rawson & Kintsch, 2002) appears to favor the second of these two accounts. For example, the relatively high degree of clustering in recall observed in the control group suggests that even in the absence of background information prior to study, readers were attempting to use the topic structure to guide retrieval.

In sum, these results support the general conclusion that background information presented at time of test can improve recall to the extent that it provides retrieval cues that are not already being used by readers. This conclusion is consistent with results concerning the effect of presenting background information at test that has been reported in previous research (e.g., Anderson & Pichert, 1978; Corkill et al., 1988). For example, Corkill et al. reported that for readers who studied an advance organizer prior to study, presenting the organizer at test did not yield a performance advantage on an immediate test. Corkill et al. argued that because "the encoding context was not 'lost,' rereading the organizer at retrieval was not effective because this procedure was redundant with an already appropriate retrieval context" (p. 306). In support of this claim, subsequent experiments showed that presenting an organizer at test could improve recall for those who had studied the organizer prior to study when the test was administered after a delay, presumably because it provided retrieval cues that had been lost over the interval. However, we should note an important boundary condition to the claim that background information at test will improve recall when it provides retrieval cues that are otherwise unavailable. Providing new retrieval cues is not enough; those cues must be meaningfully related to the to-be-retrieved content to be effective. Corkill et al. found that providing the advance organizer at test to individuals who had not read it prior to studying the text produced no benefit on either an immediate or a delayed test. Presumably, the organizer did not provide any useful retrieval cues because no links between the concepts in the organizer and those in the text were available (see also Dooling & Mullet, 1973).

This point highlights one of the critical functions of presenting background information prior to studying related text material. It supports the claim that the representation of links between text content and higher order concepts or topics can subsequently facilitate recall. With respect to such encoding effects, we argue that regardless of whether background information is provided prior to study, readers attempt to develop topic superordinates and to link related content to those superordinates. The critical role of reading background information prior to study is to promote the linking of text content to topic superordinates. Readers in both groups appeared to use the resulting topic structures to retrieve text content at time of test. Individuals who read background information prior to study exhibited a recall advantage because more connections to topic superordinates resulted in the retrieval of more text content.

The conclusion that background information primarily influences the effectiveness of organizational processing during encoding was further supported by the results of secondary measures (as in Rawson & Kintsch, 2002) and by the results from computational models of the pattern of free recall. These simulations, based on the CI theory of text comprehension, contributed a different form of converging evidence for the plausibility of the organizational-effectiveness hypothesis. These simulations also represent an advance in the use of CI models to predict human recall performance. Although CI models have been used in previous research to predict the overall landscape of recall (e.g., Goldman & Varma, 1995; Kintsch, 1998), they have seldom been used to predict differences in the landscape of recall between experimental groups (cf. Singer & Kintsch, 2001). Thus, the success of these CI models in predicting group differences not only provided evidence bearing on the way in which background information supports text memory, it also provided further support for the central theoretical tenets of CI theory.

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APPENDIX
Sample Background Information, Text, and Cued Recall Prompts

Background Information

Text 1 is about benefit mandates, which are government regulations that require large businesses to provide benefits for full-time employees.

Text Material

Martin Knox, a public policy researcher with the Norton Institute, argues that benefit mandates will negatively impact U.S. employment. "The cost is too much for many companies to support full-time employees. Employers must use part-time workers, send jobs overseas, or automate to stay in business," contends Knox. However, Frank O'Connor, legal director for the National Association of Manufacturers, advocates benefit mandates. "Many 'small' businesses stay below the magic number that exempts them from these regulations by hiring temporary rather than full-time workers. All employees of so-called 'small' businesses should be covered."

But, says Jeff Thompson, a policy analyst at the Labor Policy Association in Washington DC, "Many businesses stay small because going over the employee limit requiring them to participate would cost more than any profits from expansion. As most job growth comes from small business, we shouldn't discourage small businesses from taking on employees." Supporters of benefit mandates raise other concerns, however. "National Bank put thousands of employees on part-time status the same year it posted $1.4 billion in profits. Extending coverage to part-time workers would discourage such corporate greed," argues Lloyd Jones, a professor of economics and public affairs at Stanford University.

Cued Recall Prompts

"The cost is too much for many companies to support full-time employees."

"All employees of so-called "small" businesses should be covered."

"As most job growth comes from small business, we shouldn't discourage small businesses from taking on employees."

"National Bank put thousands of employees on part-time status the same year it posted $1.4 billion in profits."