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The Role of Schemas in Reading Text: A Real-Time Examination

EDWARD E. SMITH
University of Michigan

DAVID A. SWINNEY
City University of New York

This article is concerned with how people process text in the presence or absence of a relevant schema. In particular, we focus on the effects of schema availability and concept repetition on *both* on-line integration and memory for text. Subjects were required to read "vague" texts (like Bransford and Johnson's, 1972, well-known "washing clothes" story) and their reading time for each sentence in each text was recorded. Half the texts were preceded by a title that activated a relevant schema, whereas the other half were presented without relevant schemas. Overall, reading time per sentence was substantially longer when reading without a schema than with one. The amount of extra time needed to read a sentence when no schema was available was the same at all points in the story. Also, when no schema was available reading time per sentence decreased with the number of repeated concepts in the sentence, whereas when a schema was available concept repetition had little effect. These results, along with the finding that schemas facilitated recall, indicate that: (a) schemas affect on-line comprehension, not just recall; and (b) reading without a schema involves the use of repeated concepts to connect propositions and perhaps the use of an abstract default schema to aid integration.

Proposals about how people understand text often give central stage to schemas. Typically, a schema is assumed to be a description of a recurrent action or situation. The description consists of a set of attributes, or "slots," and their interrelations, where each slot can be instantiated by information from the text or default information that is part of the schema (see, e.g., Rumelhart & Ortony, 1977; Schank & Abelson, 1977). The defaults are what allow a reader to understand vague texts. We can illustrate this with the schema for *washing clothes,* which can be used to understand the following "vague vignette" of Bransford and Johnson (1972, p. 722):

> The procedure is actually quite simple. First you arrange things into different groups. Of course one pile may be sufficient depending on how much there is to do. If you have to go somewhere else due to a lack of facilities, that is the next step ...

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Correspondence and requests for reprints should be sent to Edward E. Smith, Department of Psychology, University of Michigan, 330 Packard Road, Ann Arbor. MI 48104.

Presumably, a reader who knew that this text was about *washing clothes* would use defaults (such as that clothes are separated into piles and that these piles are inserted into washing and drying machines) to instantiate "procedure" with "the process of washing clothes," "things" with "clothes," "pile" with "pile of clothes," and "facilities" with "washing and drying machines." The reader would also use the *washing clothes* schema to determine the relations between the various propositions, such as that the procedure referred to in the first sentence includes the operations described in successive sentences.

Although the schema-based approach to text processing has yielded important insights, we are concerned here with two limitations of the approach, one methodological, the other conceptual. The methodological problem is that virtually all evidence for the use of schemas involves memory measures, which reflect more the products than the processes of text understanding. The conceptual problem is that the schema account needs to be augmented by an explanation of how people understand text when no schema is accessible. We consider these problems in turn.

MEMORY VERSUS ON-LINE MEASURES

One source of evidence for the hypothesis that text understanding is based on schemas is that recall of a vague story-like the washing clothes vignette-is better when a schema is provided than when it is not (e.g., Bransford & Johnson, 1972, 1973; Sulin & Dooling, 1974). Another kind of evidence for the hypothesis is that when given a recall or recognition test on some previously read text, subjects erroneously recall or recognize information that was not presented but is part of the relevant schema (e.g., Bower, Black, & Turner, 1979). Studies like these (see Alba & Hasher, 1983, and Brewer & Nakamura, 1984, for reviews) provide strong evidence that schemas play a role in remembering text, but the critical issue of *when* schemas have their effect-during comprehension or only during the memory test-is not addressed in this work. It therefore remains possible that schemas may play little role in understanding text and instead function primarily to guide retrieval in recall tasks (e.g., "Think of activities related to washing clothes."), or to aid decisions in recognition tasks (e.g., "Is this item related to washing clothes?").

The reason why memory measures are not diagnostic between comprehension and recall is that they are taken "off-line," after the comprehension processes of interest have been completed. These measures therefore need to be supplemented with "on-line" measures, such as the time to read each unit of text. Such measures are temporally closer to, and more directly reflect, the comprehension process. Accordingly, in the present experiment we compared vague texts read with or without schemas, for which we recorded reading times per sentence as well as subsequent recall of the texts.

READING WITHOUT SCHEMAS

Understanding without schemas clearly is a frequent occurrence in casual conversation where topic switches are common and often unannounced. A similar situation can arise in reading text, and this situation provides the focus of our investigation. Given a situation where no schema is available, how can one interrelate propositions and determine the referents of vague terms?

In trying to generate potential answers to this question, a useful starting point is to note that there are two basic approaches to text understanding: the top-down approach, in which the reader starts with a preexistent structure like a schema and tries to fit the text proposition into it, and the bottom-up approach, in which the reader starts with the text propositions and tries to create a new structure for them. According to the top-down approach, when no schema is explicitly given and the reader needs to determine referents and interrelate propositions, he uses whatever information he has garnered from the text to generate or guess a schema. The reader may try to guess a schema at the same level of detail as that of "washing clothes" (see example given earlier); alternatively, he may use some abstract default schema to relate propositions (e.g., Person . . . Performs .. . Action ... on ... Object). We will refer to these two instances of the top-down approach as the "guessing" and "default schema" strategies, respectively.[1] With regard to the bottom-up approach to text understanding, when the reader needs to determine referents or interrelate propositions, presumably he does this by using concepts that have been repeated within and between propositions. This "concept repetition" strategy is probably the best-known instance of the bottom-up approach (e.g., Kintsch & van Dijk, 1978). In what follows, we provide a more detailed account of the three strategies we have just introduced.

Consider first the guessing strategy, in the context of a vague text like:

> The procedure is actually quite simple. First you sort things into different groups ...

A reader using this strategy would try to guess a schema at the same level of detail as that of *washing clothes.* We will refer to such detailed schemas as "basic level" schemas because the objects and actions specified in the schema are generally at the basic level (see Rosch, Mervis, Gray, Johnson, & Boyes-Braehm, 1976, for a discussion of basic level objects, and Rifkin, 1985, for an extension of Rosch et al.'s ideas to basic level actions). Once a basic level schema has been guessed, its defaults will be used to instantiate vague terms in

[1]Another possible instance of a top-down approach is that the reader simply delays determining referents and interconnecting propositions until a schema is made available. Although there are cases where this "delay" strategy is plausible, we are concerned here with the situation where a schema may never be made available, and consequently we will not consider the delay strategy further.

the text, such as "procedure" and "groups." However, any particular basic-level guess is very likely to be wrong, in as much as one can think of dozens of basic-level schemas consistent with the first line of our sample vignette. Thus, if upon reading, "The procedure is quite simple," the reader guesses the schema for *driving a car,* upon reading the second sentence he will have to surrender his original hypothesis and guess another basic-level schema. This switch in guesses will cause extra computation. Specifically, the reader must undo the instantiations he has made (e.g., *procedure* cannot be instantiated with "driving"), as well as retrieve the proposition underlying the first sentence to see if it is covered by the newly guessed schema. And if this new guess fails, the reader has to make still another guess, undo more instantiations, and retrieve the propositions underlying the first couple of sentences.

There is evidence that these extra computations place an additional load on working memory; protocols obtained from readers who are forced to switch schemas reveal that they engage in conscious deliberations to change one instantiation to another (Collins, Brown, & Larkin, 1978). The guessing strategy is therefore very likely to incur a working-memory load that increases as the reader moves through a continuously vague story (particularly in the first part of the story, where the reader is motivated to guess and the probability of a correct guess is very low). Because reading times increase with the size of the working-memory load (cf. Just & Carpenter, 1987, pp. 472-474), reading times should be longer without a schema than with one, and should increase as one moves through the story relative to any increase found when a schema is operative.

The default schema strategy assumes that rather than guessing a schema at a basic level, the reader guesses a more superordinate-level schema. Such a schema might include general slots like *actor, manipulative action,* and *object,* along with general defaults like *adult person, move implement,* and *machine.* Hence, this schema is very likely to be compatible with our sample story. Although it may be of some help in relating propositions (e.g., one proposition describes the objects to be acted upon, another describes the action itself), the strategy is of little use in determining the referents of vague terms.

With regard to predicted effects of this strategy, there is reason to believe that reading times should be longer when guided by a superordinate-level schema than by a basic-level one. Specifically, analogous to the findings with object schemas where people are faster at categorizing at a basic level than at an abstract one (Rosch et al., 1976), we suspect that people will be faster at instantiating story information at a basic-level schema like *washing clothes* than at a superordinate-level schema like *doing a routine procedure.* Such an effect should arise because the defaults of a schema like *washing clothes* denote basic-level objects, whereas the defaults of *doing a routine procedure* denote more superordinate objects, and instantiating a default with story information amounts to categorizing that information. There is, however, no reason to expect the relative disadvantage of using a default schema to increase as the reader goes further into the story.

Finally, consider the concept repetition strategy (e.g., Kintsch & van Dijk, 1978), again in the context of understanding our sample story:

> The procedure is quite simple. First you arrange things into different groups. Of course one pile may be sufficient depending on how much there is to do...

In processing the last sentence the reader might note that "piles" refers to the same concept as "groups" does in the previous sentence, and use this repeated concept to link the propositions underlying the two sentences. By repeatedly applying this strategy to successive lines of a story, a reader can often interrelate the propositions without ever considering larger units of meanings. Also, the reader can occasionally determine the referent of a vague term if linguistic cues indicate that the term refers to the same concept as does a more specific term (e.g., "The person entered the room ... the doctor had never seen such a mess."). This strategy leads to the distinct prediction that it should take less time to read a story line that shares more concepts with previous lines. There is a bit of support for this prediction in the work of Kintsch, Kozminsky, Streby, McKoon, and Keenan (1975), who found that people took less time to read a paragraph that contained a few often-repeated concepts than one that contained numerous rarely repeated concepts. Note that this strategy offers no reason to expect reading times to increase as the reader goes through the story, unless there are decreases in concept repetition as the story progresses.

Concept repetition differs qualitatively from the other strategies we considered (including whatever strategy one uses when a schema is available). Concept repetition operates at the level of individual concepts, not propositions or larger meaning units. Furthermore, concept repetition does not even require that the reader use the contents of a concept; all that is required of the reader is a decision that two concepts are the same. For these reasons, concept repetition seems semantically barren compared to schema-based strategies, and is less a competitor to schema-based strategies than a possible auxiliary to them.

Our predictions about reading times for the various strategies are summarized in Table 1 (p. 308). The guessing strategy predicts that reading times should be longer when a vague text is read without a schema than with one, and that the schema advantage in reading time will increase as the story progresses. The default schema strategy also predicts a lengthening of reading times when a schema is not available, but does not predict that the schema advantage will grow as one moves through the story. Finally, the concept repetition strategy predicts that the time to read a sentence depends only on the number of repeated concepts contained in the sentences. Whereas the predictions for the guessing versus default schema strategies form a true contrast (i.e., only one set of predictions can be correct), those for concept repetition versus the schema-based strategies are more complementary (e.g., predictions for both concept repetition and default schema could be jointly supported). Of course, these strategies do not exhaust all possibilities for reading without a schema. For example, people might

TABLE 1
Summary of Predictions About Reading Times for the Three Strategies

	Strategies		
	Guessing	**Default**	**Concept Repetition**
Schema faster than no-schema (schema advantage)	X	X	—
Schema advantage increases as reader moves through text	X	Y	—
Repeated concepts faster than non-repeated concepts	—	—	X

Note. — = strategy makes no prediction; X = strategy makes prediction; Y = strategy makes opposite prediction.

employ a bottom-up strategy that is more content-based than simple concept repetition. However, there are no existing proposals along these lines that are explicit enough to generate predictions in the manner in which the three strategies we have presented do.

METHOD

Overview

Subjects read eight vague texts, half of them preceded by a title that provided explicit information about the relevant schema, the other half presented without such information. Across subjects, the same story was read equally often with and without a schema. In addition to this schema manipulation, the lines of each story varied naturally in the amount of concept repetition they manifested, thereby making it possible to determine the relative contributions of schema guidance and concept repetition from the time it took a subject to read each sentence. In addition, after the subjects finished reading each story they answered two true-false questions about it. After they answered the questions for the final story they tried to recall it verbatim. Verbatim recall provided a conventional off-line measure of schema effects.

Materials

The materials consisted of eight sets of vague stories (modeled after Bransford & Johnson's classic *washing clothes* story). Each set itself consisted of eight different versions of a "matrix story." Each matrix story was approximately 16 sentences long (range = 14-18), which included approximately 160 words or 400 syllables. Each matrix story was created by using vague references and neutral descriptors (e.g., "thing," "item," "object"), rather than naming the referred-to items at the basic level. As a consequence, if one did not know the story's topic beforehand it was difficult to discern it from reading the story. However, if the topic was known beforehand (as when presented with a title triggering the schema), the story appeared to "make sense" and was perceived as being a "good story" about a topic as well as being constructed in a reasonable fashion (within the vagueness constraint). As support for these claims, the matrix stories were unanimously judged by four raters to: (a) fulfill the requirements of conforming to good story structure within the constraint of vague reference; (b) be criterially vague, in that the topic of the story was very difficult to discern from a single reading of the story; and(c) be considered to be a good story about the topic, once the topic was given to the judge. The Appendix contains two of our matrix stories.

Four natural variants of each matrix story were created by either systematically replacing open class words (nouns, verbs, and adjectives) with pronouns or by systematically repeating identical referents in the stories.[2] Each of these versions could either be preceded by a title that activated a relevant schema or not, yielding a total of eight versions for each of the eight matrix stories. The 64 stories were combined into eight separate "scripts," a script consisting of exactly one version of each matrix story. Each script was presented to 5 subjects, with half the stories being preceded by a title or schema, and the other half not. For half of the scripts, the four stories without a schema were presented before the four with a schema, whereas for the other half of the scripts the reverse was the case. In addition, for each script a practice story of the same general nature and makeup as the experimental stories was presented first. This story, which was the same in all scripts, was presented without a schema. The eight scripts constituted a between-subjects factor, the schema versus no-schema variation a within-subject factor.

Procedure

Subjects were each presented with a script on a CRT controlled by a DEC LSI 11/23 microcomputer. Each subject sat in front of the CRT in a sound-attenuated booth that contained a button-press device. Each line of text was displayed on the screen and subjects pressed a button as soon as they finished reading the line. Upon pressing a button they would immediately see the subsequent line of text, and so on throughout a story. Reading times were recorded by the computer.

[2] Please note that when we originally began this study we had been interested in the relative role of pronominal,reference versus identity reference as a factor in discourse representation and processing. Similarly, we had wished to systematically study the effects of amount of concept repetition on such processing. However, in designing this study we discovered that variation of *either* the number of pronominal referents or identity repetitions could not be done without confounding it with variations in the *other* factor or with syntactic complexity and sentence length. Thus, we gave up the idea of studying these effects independently in light of the more important major issues we were pursuing. However, simply as a technique to provide natural variation in story structure and style, we decided to employ pronominal reference and identity repetition to create paragraph variations with similar semantic content.

Subjects had been instructed that their task was to both read and understand the incoming information because they would be asked questions about it at the end of each story. At the end of each story, two questions were presented in succession. Each question required subjects to combine information from two sentences in the story and required a true-false decision, which the subject indicated by pressing one of two appropriately labeled buttons. Following the answering of the two questions for the final story in the script, subjects were immediately and unexpectedly asked to provide written verbatim recall of the last story they heard. Because of the design, across-subject groups (corresponding to the eight different scripts), verbatim recall was required for each matrix story type, half with a schema and half without. True-false decisions were recorded by the computer, whereas recall protocols were analyzed by hand.

Subjects

Forty college students participated in the experiment in partial fulfillment of a course requirement.

RESULTS

Reading Times

The average reading time for a sentence was substantially less when reading with a schema than when reading without one, 2,879 ms versus 3,180 ms, respectively. This difference proved significant in analyses of variance, both for subjects, $F_1(1, 32) = 35.02$, $p < .01$, and for items, $F_2(1, 244) = 40.20$, $p < .01$. Analyses for subjects also showed that reading times different for different stories, $F_1(7, 32) = 3.46$, $p < .01$; though not for different scripts, $F_1(7, 32) = 1.02$. (Analyses for items showed no hint of an effect for stories or scripts.) There were no significant interactions among the three factors (schema, stories, and scripts) nor of concept repetition (see the following), nor of whether subjects experienced the schema condition before the no-schema condition, or vice versa.

The beneficial effect of schema on reading time is consistent with both the guessing and default schema strategies. To distinguish between these hypotheses, we needed to analyze schema and no-schema reading times as a function of story line (first line, second line, etc.). To make this a sensitive analysis, first we normalized each reading time by the number of syllables in the sentence (because the number of syllables differed across sentences), and then we averaged the reading times across stories, scripts, and subjects. The results are presented in Figure 1. Reading times are faster with a schema than without for 17 of 18 lines. More diagnostically, the schema effect on reading time does not increase as one goes through the story; instead, the effect is largest for the first line, and thereafter appears to be relatively constant. These results support the default schema strategy over the guessing strategy.

Consider now the effects of concept repetition. Recall that the lines of each

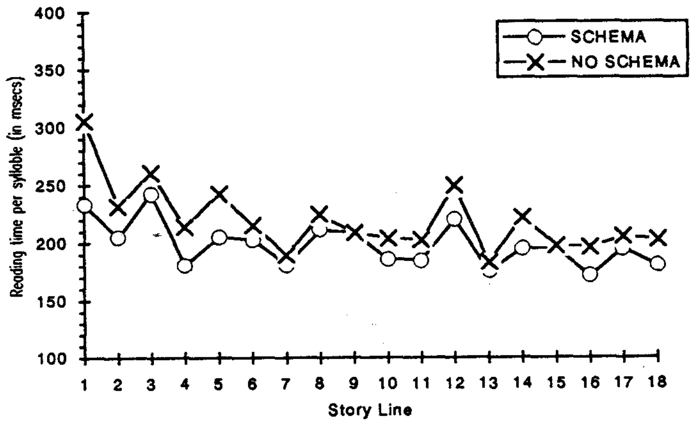

Figure 1. Reading time per syllable as a function of story line, separately for schema and no-schema conditions.

story varied naturally in amount of concept repetition. To measure this amount, a linguist (unfamiliar with the hypotheses of this study) determined the total number of concept repetitions for each line of each story of each script. Total concept repetition per line was calculated as the sum of (a) the number of identical repetitions of words previously occurring in the story (or identical root-lexical items with different suffixes); (b) the number of occurrences of a synonym of a word occurring earlier in the story; and (c) the number of occurrences of anaphora, where the antecedent was clearly determined by syntactic or semantic constraints in the sentence (in cases where the antecedent was not clear, the items were not counted as instances of concept repetitions.) Based on this analysis, we divided the sentences of each story into a "high-repetition" and a "low-repetition" group, where the eight sentences in the high group exceeded the median amount of concept repetition for that story, whereas the eight sentences in the low group fell below that median.

Reading time per syllable could now be portrayed as a function of both schema and concept-repetition factors, as shown in Table 2 (p. 312; ignore the entries in parentheses for now). Reading times are faster to sentences with more repeated concepts (the high-repetition group), at least when no schema is available. This claim was supported by analyses of variance employing subjects and stories as random factors. In these analyses, there was a significant effect of schema, $F_1(1, 39) = 31.8$, $p < .01$, and $F_2(1, 7) = 17.43$, $p < .01$. In addition, there was an effect of concept repetition that was significant in the subjects analysis, $F_1(1, 39) = 74.09$, $p < .01$; but only marginal in the item's analysis, $F_2(1, 7) = 2.86$, $p = .14$; and an interaction between the schema and concept repetition factors that was significant in the items analysis, $F_2(1, 7) = 10.20$, $p < .01$; and marginal in the subjects analysis, $F_1(1, 39) = 2.11$, $p = .15$.

TABLE 2
Mean Reading Time per Syllable (in ms) as a Function of Schema and Concept Repetition Factors

	Concept Repetition	
	High	**Low**
Schema	193 (191)	203 (206)
No schema	210 (209)	233 (230)

Note. The entries in parentheses give the data when responses to the first line of text are omitted.

Independent examination of the factors in the interaction revealed that concept repetition significantly facilitated reading times when no schema was available, $t(39) = 3.87$, $p < .01$; but not when a schema was present, $t(39) = 1.11$, $p > .05$. These data, then, support the concept repetition strategy.

The preceding conclusions remain roughly intact even if we exclude from our analysis the first line (which produced an extremely long reading time-see Figure 1-and which was always low in concept repetition). The retabulated data are given in parentheses in Table 2 (the median-split analysis was adjusted accordingly). Analyses of variance on these data (again employing subjects and stories as random factors) showed a significant effect of schemas, $F_1(1, 39) = 24.9$, $p < .01$, and $F_2(1, 7) = 11.79$, $p < .01$; a significant effect of concept repetition only in the subjects analysis, $F_1(1, 39) = 53.2$, $p < .01$, and $F_2(1, 7) = 1.1$, $p > .10$; and nonsignificant interaction between schema and concept repetition factors, $F_1(1, 39) < 1$, and $F_2(1, 7) = 2.81$, $p > .10$. Subsequent analysis of the interaction again showed that concept repetition significantly facilitated reading times when no schema was available, $t(39) = 3.20$, $p < .05$; but not when one was available, $t(39) = 1.04$, $p > .10$.

Recall Accuracy

Subject's recalls of the final story were analyzed by two judges in a two-step procedure. First, the judges determined if a recalled sentence corresponded to a proposition in the story. Then, for each corresponding sentence, the judges counted the number of open class words that were identical or synonymous to a word in the' story-call these "correct" words. The total number of correct words was greater when a schema was available than when it was not, 533 versus 402, respectively, $t(38) = 2.88$, $p < .01$. This replicates the well-known finding that schemas facilitate recall of vague stories (e.g., Bransford & Johnson, 1972).

The two judges also scored recall intrusions, characterizing each as either consistent or inconsistent with the lines of the story. Across all 40 subjects, there were only three inconsistent intrusions, all of them occurring when no schema was available. In contrast, there was a total of 44 consistent intrusions, with the majority of them, 25, occurring when a schema was available. Although these numbers are too sparse to support statistical tests, they are at least in agreement with previous reports of schemas inducing consistent recall intrusions (e.g., Alba & Hasher, 1983).[3] It is worth noting that in no case of an intrusion in a no-schema condition did the intrusion indicate a knowledge or "sense" of the actual schema. For example, for the "playing the piano" story under the no-schema condition, not a single subject ever intruded anything about either a piano or about playing an instrument.

DISCUSSION

The finding that schemas facilitated reading times indicates that schemas have their effect on text understanding during comprehension, not just during recall. Furthermore, the fact that the aforementioned schema advantage did not increase with story line, coupled with the findings about concept repetition, suggests that readers deprived of schemas use both the default schema and concept repetition strategies. These conclusions are amplified in the following.

Memory Versus On-Line Measures

We mentioned at the outset that virtually all previous evidence for the use of schemas rests on memory measures, leaving open the possibility that schemas play no role in comprehension. That possibility, to a large extent, is squashed by our reading-time results. Having a schema speeded reading times for 17 of 18 story lines, a strikingly robust effect, which indicates that schemas affect the comprehension processes that precede recall. Indeed, in light of the present results it is possible that the usual schema effect on recall of vague stories (replicated here) is itself derivative from the schema effect on comprehension. That is, schemas enable the reader to relate different propositions in the text, which results in a more interrelated representation than had no schema been available, and the additional interrelations function as extra retrieval paths during recall (e.g., Anderson, 1983; Smith, Adams, & Schorr, 1978). This interpretation fits with the finding that schemas have no effect on recognition memory of vague stories (Alba, Alexander, Hasher, & Caniglia, 1981), because recognition, unlike recall, may not depend on multiple retrieval routes.

Our reading time results, however, are not analytic enough to document which processes in comprehension are benefited by schemas. Finer grained on-line measures may be needed for this purpose.

[3] We also examined subjects' responses to the true-false questions asked at the end of each story. There were a total of 640 such responses (2 questions x 8 stories x 40 subjects). The mean accuracy was 84% when a schema was available, compared to 78% when no schema was available. Although this difference failed to reach significance, it is in line with a beneficial effect of schemas on comprehension and recall.

Reading Without Schemas

The following findings characterize reading without a schema: (a) Reading time is slowed, compared to the case in which a schema is available; (b) this decrement remains relatively constant (after the first line) throughout the story; and (c) reading time is speeded to the extent the story line repeats concepts from previous lines. This package of findings is inconsistent with the hypothesis that readers repeatedly try to guess a basic-level schema (if this were so, the decrement due to lack of a schema would increase through the story), and instead suggests that readers used a combination of the default schema and concept repetition strategies. Thus, a reader might: (a) insure that each proposition in the text is compatible with the slots of some abstract schema (e.g., *actor*, *manipulative action*, and *object),* (b) use the relations between these slots to occasionally correct story propositions, (c) use concept repetition to relate other story propositions, and (d) use concept repetition to occasionally determine the referents of vague terms.

To the extent this characterization is correct, the memory representation that results from reading without a schema should be relatively sparse. Only rarely will the basic-level referents of vague terms be determined. And relations between propositions will center on vague concepts or on the mere fact that a concept has been repeated. This superficial level of text processing seems qualitatively different from what transpires when the reader has a schema available.

REFERENCES

Alba, J. W., Alexander, S. G., Hasher, L., & Caniglia, K. (1981). The role of context in the encoding of information. *Journal of Experimental Psychology: Human Learning and Memory, 7,* 283-292.

Alba, J. W., & Hasher, L. (1983). Is memory schematic? *Psychological Bulletin, 93*, 203-231.

Anderson, J. R. (1983). *The architecture of cognition.* Cambridge, MA: Harvard University Press.

Bower, G. H., Black, J. B., & Turner, T. J. (1979). Scripts in memory for text. *Cognitive Psychology, 11,* 177-220.

Bransford, J. D., & Johnson, M. K. (1972). Contextual prerequisites for understanding: Some investigations of comprehension and recall. *Journal of Verbal Learning and Verbal Behavior, 11*, 717-726.

Bransford, J. D., & Johnson, M. K. (1973). Considerations of some problems of comprehension. In W. G. Chase (Ed.), *Verbal information processing* (pp. 383-438). New York: Academic.

Brewer, W. F.,. & Nakamura, G. V. (1984). The nature and function of schemas. In R. S. Wyer & T. K. Scull (Eds.), *Handbook of social cognition* (*Vol. 1,* pp. 119-160). Hillsdale, NJ: Erlbaum.

Collins, A., Brown, J. S., & Larkin, K. M. (1978). Inference in text understanding. In R. J. Spiro, B. C. Bruce, & W. F. Brewer (Eds.), *Theoretical issues in reading comprehension.* Hillsdale, NJ: Erlbaum.

Just, M. A., & Carpenter, P. A. (1987). *The psychology of reading and language comprehension.* Boston, MA: Allyn & Bacon.

Kintsch, W., Kozminsky, E., Streby, G., McKoon, G., & Keenan, J. M. (1975). Comprehension and recall of text as a function of content variables. *Journal of Verbal Learning and Verbal Behavior, 14,* 196-214.

Kintsch, W., & van Dijk, T. A. (1978). Toward a model of text comprehension and production. *Psychological Review, 85,* 363-394.
Rifkin, A. (1985). Evidence for a basic level in event taxonomies. *Memory and Cognition, 13,* 538-556.
Rosch, E., Mervis, C. B., Gray, W., Johnson, D., & Boyes-Braehm, P. (1976). Basic objects in natural categories. *Cognitive Psychology, 8,* 382-439.
Rumelhart, D. E., & Ortony, A. (1977). The representation of knowledge in memory. In R. C. Anderson, R. J. Spiro, & W. E. Montague (Eds.), *Schooling and the acquisition of knowledge* (pp. 99-135). Hillsdale, NJ: Erlbaum.
Schank, R. C., & Abelson, R. (1977). *Scripts, plans, goals, and understanding.* Hillsdale, NJ: Erlbaum.
Smith, E. E., Adams, N., & Schorr, D. (1978). Fact retrieval and the paradox of interference. *Cognitive Psychology, 10,* 438-464.
Sulin, R. A., & Sooling, D. J. (1974). Intrusion of a thematic idea in retention of prose. *Journal of Experimental Psychology, 103,* 255-262.

APPENDIX: SAMPLE MATRIX STORIES

Playing the Piano

Begin by looking at the arrangement of items in front of you.
At first, this arrangement may look rather random.
However, you will see that there is a pattern to the arrangement.
Note that the pattern is repeated.
This pattern is central to the organizing principle of the arrangement.
In time this arrangement will become second nature to you.
If you are confused, it is always helpful to experiment a little.
Try to discover similarities among items in the arrangement.
These sizes can vary from object to object.
Besides, you will rarely have the opportunity to use all of the items.
For the clearest understanding, begin in the middle of the arrangement.
Starting at the middle, pick out every other item.
Then, with as many items as possible, try these items simultaneously.
Maintaining this strategy, work your way through the system.

Building a Snowman

This process is as easy as it is enjoyable.
This process can take anywhere from about 1 hr to all day.
The length of time depends on the elaborateness of the final product.
Only one substance is necessary for this process.
However, the substance must be quite abundant and of suitable consistency.
The substance is best used when it is fresh, as its lifespan can vary.
Its lifespan varies depending on where the substance is located.
If one waits too long before using it, the substance may disappear.
This process is such that almost anyone can do it.

The easiest method is to compress the substance into a denser mass than it held in its original state.
This process gives a previously amorphous substance some structure.
Other substances can be introduced near the end of the process to add to the complexity of the final product.
These substances are not necessary.
However, many people find that they add to the desired effect.
At the end of the process, the substance is usually in a pleasing form.