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ABSTRACT

A study was conducted to determine how a reader identifies and represents the major topics in a text and their interrelationships. Subjects, 56 college students, read two texts one sentence at a time. Each text contained 12 paragraphs that discussed six attributes of two major topics. The paragraphs on one text were organized by attribute, while the topics of the other text were randomly organized. Reading times were recorded for the initial, topic-introducing sentences of each paragraph, and for matched, nontopic sentences. Results showed that reading times for topic sentences depended upon text organization, while reading times for nontopic sentences did not, and that topic sentences were read faster if the new topic was predictable as opposed to unpredictable from the preceding text topics. The findings suggest that when readers encounter a new text topic, they integrate it into a representation of the topic structure of the text. (Author/FL)

On-line Processing of Text Organization

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Abstract

Do experienced readers represent the relationships among a text's major topics immediately upon encountering the topics while reading? Fifty-six subjects read two texts a sentence at a time. Both texts contained twelve paragraphs discussing six attributes of each of two major topics. The paragraphs of one text were organized by attributes, while the topics of the other text were randomly organized. Reading times were recorded for the initial, topic-introducing sentences of each paragraph, and for matched, nontopic sentences. The major finding was that reading times to topic sentences depended upon text organization, while reading times to nontopic sentences did not. Topic sentences were read faster if the new topic was predictable as opposed to unpredictable from the preceding text topics. The findings suggest that when readers encounter a new text topic, they integrate it into a representation of the topic structure of the text.

On-line Processing of Text Organization

One important attribute of a good reader is the ability to comprehend the gist, or macrostructure of a text. Although only one aspect of reading, macroprocessing is a complex ability consisting of many subprocesses. This study is concerned with one component of a reader's processing of the macrostructure of a text. Specifically, it focuses on how a reader identifies and represents the major topics in a text and their interrelationships.

Kintsch and van Dijk (1978; van Dijk, 1980) have characterized reading as consisting of two independent but complementary levels of processing, microprocessing and macroprocessing. Microprocessing refers to a local level of processing, while macroprocessing refers to a more global level. Locally, text comprehension requires that the reader process the relations among the individual propositions conveyed in a text. More globally, readers must identify the most important ideas in a text and represent how those macropropositions are related to one another and to the subordinate propositions they dominate.

According to current formulations, macroprocesses are active, on-line processes that are applied in a systematic fashion during reading (Kintsch & van Dijk, 1978; Kintsch & Vipond, 1979; Spilich, Vesonder, Chiesi, & Voss, 1979; Vipond, 1980). All proposals suggest that the macrostructure representation is revised regularly during reading. For example, Kintsch and Vipond

(1979) hypothesize that the contents of a "macrobuffer" are updated whenever readers encounter a paragraph boundary. It is possible, however, that readers are much less active and systematic macroprocessors than most theorists have supposed. An alternative perspective is that readers are typically "lazy" processors who do not systematically process a text's macrostructure unless forced to do so by task demands. Instead, readers are satisfied if they comprehend the local coherence of a text, so they rely primarily upon microprocesses when reading.

According to the lazy macroprocessor model, readers seek to connect the currently processed proposition into their existing representations of the text. This <u>may</u> occasionally require the application of a macro-operation, but it will usually involve only the processing of local coherence relations (e.g., determining referents for pronouns). The model does not claim that readers are incapable of macroprocessing, only that macroprocessing is not done in a systematic, on-line fashion as a matter of course. Rather, systematic macroprocessing will be done only when task demands require such processing. For example, if asked to outline a text, readers will do on-line macroprocessing; if instructed after reading to summarize a text, readers at that point retrieve their representations of the text and apply the macro-operators needed to produce a summary.

There is no conclusive evidence demonstrating systematic, on-line macroprocessing. Although there are findings consistent with Kintsch and van Dijk's proposals about macroprocessing, most studies have not utilized on-line measures of macroprocessing (Brown and Day, 1983; Brown, Day, & Jones, 1983; Graesser, Hoffman, & Clark, 1980; Kintsch & Yarbrough, 1982; Kintsch & Vipond, 1979; Vipond, 1980). Those studies which do allow evaluation of on-line processing demands during reading have not been designed to test the issue of whether macroprocessing occurs on-line (Cirilo, 1981; Cirilo & Foss, 1980; Fletcher, 1981).

What would constitute a clear demonstration of systematic, on-line macroprocessing? One approach would be to identify a specific text event that should trigger macroprocessing, then demonstrate that processing demands increase at that point. That is the approach taken in this study.

One task that must be performed in order to construct a representation of a text's macrostructure is the identification of the major topics and their relationships. An important clue readers have to aid in topic identification is a shift of topic. The importance of this information to the reading process is emphasized by the fact that under normal conditions topic shifts are physically marked by paragraph structure and headings. If readers are on-line macroprocessors, we would expect them to do some macroprocessing whenever there is a major topic shift in a text. Specifically, the on-line macroprocessor model proposes that readers construct representations of the topic structure of a text. Whenever there is a major topic shift, they update their representations. A representation of the topic structure includes not only a list of topics (Kieras, 1981), but also information about the relationships among the topics. According to this hypothesis, processing load will be heavy whenever there is a shift of topic. Further, the processing load will depend upon how difficult it is to relate the new topic to the preceding topics.

To test these claims, subjects read two expository texts while their reading times for each sentence were recorded. Both texts discussed several attributes of each of two major topics. For example, one text discussed the geography, climate, exports, imports, people, and politics of each of the two fictional countries of Morinthia and Culatta. Each attribute of each country was discussed in a separate paragraph. For each paragraph, reading times were recorded for two target sentences: the initial topic sentence and a matched nontopic sentence. In one text, the order of the paragraphs was organized by attributes. For example, first the geography of Morinthia was discussed, then the geography of Culatta was presented. Next, the climates of Morinthia and Culatta were discussed, and so on. In the second text, the order of paragraphs was not so systematic; each paragraph transition involved a change of both country and attribute. After reading a text, subjects were given a sentence verification task to test their memory and comprehension of the text. Half of the sentences tested recognition of superordinate facts from the text, while half of the sentences tested recognition of subordinate facts.

The two models make different predictions concerning the joint effects of paragraph organization and shift of topic on reading times for topic sentences. According to the lazy macroprocessor model, there should be no effect of shift of topic on topic sentence processing in either paragraph organization condition. Because it is hypothesized that readers do not process relations among topics on-line, the organization of topics should not influence reading times on topic sentences. According to the on-line macroprocessor model, the ease of processing a topic sentence will depend upon how the sentence can be related to previous topics in the text. For an attribute organized text, a paragraph shift <u>between</u> attributes is less predictable than a paragraph shift <u>within</u> attributes (at least, after the reader has discovered the organization of the text). Therefore, reading times for topic sentences should be slower when a paragraph transition involves a shift of both attributes and countries than when it involves a shift of countries only. In the case of a disorganized text, however, the model predicts no systematic variation in reading times to topic sentences. This is because the topic shift is equally unpredictable at each paragraph boundary.

Method

<u>Subjects</u>

Sixty-one subjects participated in the experiment, but the data of five subjects were lost because of computer malfunctions. All were volunteers from introductory psychology classes at the University of Kentucky and received credit for participation.

<u>Materials and Design</u>

Four different texts were constructed. Two were brief stories adapted from The people's almanac #2 (Wallechinsky & Wallace,1978). One story was about Daguerre's invention of a photographic development process; the other story concerned the Lindbergh kidnapping case. Unlike the experimental texts, these texts had a story structure and were used solely as filler materials.

The two experimental texts had similar structures, but different content. Each text consisted of 13 paragraphs. The introductory paragraph of each was only very generally related to the body of the text. It was intended to give the reader some warm up without divulging any of the content of the body of the text. The remaining 12 paragraphs of each experimental text discussed six attributes of each of two major topics. One text discussed the geography, climate, exports, imports, people, and politics of two fictional countries, Morinthia and Culatta. The other text discussed six attributes of each of two types of apes, chimpanzees and orangutans. The Countries text was 119 sentences long, while the Apes text was 115 sentences long.

For each of the 12 critical paragraphs of each text, two target sentences were constructed. One target sentence was always the initial sentence of the paragraph. It always introduced the next topic in the text and asserted a general property of that topic which was then elaborated in the remainder of the paragraph. These sentences will be referred to as "topic sentences." For each topic sentence, a second "nontopic" sentence was constructed.

The nontopic sentence was approximately equated in length to the topic sentence and the information it conveyed was subordinate to the information contained in the topic sentence. All of the target sentences were written to be less than 64 character spaces long. The 12 target sentences of the Countries text are presented in the appendix.

Four versions were written of each experimental text. Two versions of a given text were organized by attributes. These differed in the sequencing of the two major topics and of the attributes within topics. The major purpose of this manipulation was to counterbalance the assignment of particular target sentences to levels of the "Topic Shift" variable. Corresponding to the two attribute organized versions were two disorganized versions. These two texts began with the same initial paragraph as the corresponding organized versions, but subsequent paragraphs were ordered so that both the major topic and the attribute shifted with every paragraph.

Eight different sets of four texts each were constructed. The initial text in each set was the "Photography" story and the third text was always the "Lindbergh" story. The eight sets represented all possible combinations of three counterbalancing variables: assignment of major topics to levels of the Topic Shift variable (e.g., attributes changed either when Morinthia or when Culatta was the major topic); order of presentation of the organized and disorganized texts; and assignment of texts to the organized and disorganized conditions.

In addition to the texts, 24 sentences were constructed for each experimental text to be used in the sentence verification tasks. Half of the sentences were true and half were false; half tested memory for superordinate information and half tested memory for subordinate details. The true sentences were paraphrases of sentences from the text; the false sentences contradicted statements from the text. All sentences were less than 64 character spaces long and superordinate and subordinate statements were approximately equated in length. The verification sentences were the same for all versions of the texts. Verification sentences were also constructed for the two filler texts. These sentences had the same characteristics as the sentences for the experimental texts. There were 8 sentences for the Photography text and 20 sentences for the Lindbergh text.

Procedure

Subjects participated individually in the experiment. An experimental session lasted approximately 50 minutes. A TRS-80, Model 1 microcomputer controlled the execution of the experiment: It presented instructions, texts, and verification sentences and it recorded all responses by the subject.

When subjects arrived, they were given an overview of the experiment. They were informed that the experiment was investigating reading comprehension and that they would be asked to read four stories and take a short test of their comprehension after each story. They were then instructed that the computer would present each story one sentence at a time and that they would control how long a sentence was on the computer's display screen by pressing the space-bar on the teletype whenever they wanted to continue to the next sentence. They were informed that the computer would be measuring their reading times. It was emphasized to subjects that they should not rush their reading, but read at a comfortable pace without stopping to rest.

Subjects were encouraged to ask questions and to begin when ready. The title of the practice text was presented on the video display screen; it was replaced by the first sentence of the text when the space-bar on the teletype was pressed. Each sentence was presented left-justified, in capital letters, in the same location on the screen. Paragraph boundaries were not physically marked in any way (e.g., no indentation). Reading time was measured from the presentation of a sentence to the next press of the space-bar. Pressing the space-bar caused the current sentence to be erased immediately and the next sentence to appear after a delay of approximately 1 second. Reading times were recorded with a resolution of approximately 9 milliseconds. Text presentation continued in this way until a message was displayed indicating that the story was over.

After each text, instructions were given for the verification task. Subjects were informed that they would be presented sentences one at a time. For each sentence, they were to judge whether it was a true or false statement based on their reading of the text. Subjects responded "true" by pressing the "T" key on the teletype and "false" by pressing the "F" key. The instructions emphasized both speed and accuracy. The order of presentation of the sentences was randomized independently for each subject. Subjects were given feedback for each response. If a subject took more than 7 seconds to respond, the message "Too Slow" was displayed. Feedback messages ("Correct", "Error", "Too Slow") were presented for a duration of approximately 840 milliseconds; the interval between erasure of the feedback and presentation of the next sentence was approximately 2.25 seconds.

After the last sentence of the verification task was presented, subjects were informed that they could take a break if desired. They were then given refresher instructions for the reading task and told to begin when ready. The procedure continued to alternate between the reading and verification tasks until all four texts were read and tested. Subjects were then given an explanation of the experiment and were thanked.

Results

Analyses of Reading Times

In order for a readers to recognize the organization of an attribute organized text, they must read at least the initial two paragraphs of the text (not including the "warm up" paragraph). Thus, the pattern of reading times for the first 2 paragraphs of an attribute organized text was expected to differ from the pattern of reading times over the last 10 paragraphs of the text. Preliminary analyses of the reading time data confirmed this expectation. Consequently, separate analyses were done on the reading times for the first 2, and last 10 paragraphs of the organized and disorganized texts. Two mixed factors ANOVAs were conducted. For both analyses, the within-subjects factors were: type of organization (attribute vs. disorganized); type of sentence (topic vs. nontopic); type of topic shift (minor, within attribute shift vs. major, between attributes shift). The three between-subjects variables were counterbalancing variables: order of texts (organized vs. disorganized first); assignment of texts to organization conditions; assignment of paragraphs to levels of the Topic Shift variable. In both analyses, only the subjects variable was considered to be a random effects variable. In all analyses, all results are significant at the .05 level unless indicated otherwise. Finally, all reported F-tests were based on 1 and 48 degrees of freedom.

The data of primary interest concern the last 10 paragraphs. Mean reading times are presented in Table 1. Several findings are of interest. First, topic sentences were read .349 seconds more slowly than nontopic sentences (F=43.72, MSe=1.565). Second, the magnitude of the topic shift effect depended jointly upon Sentence Type and Organization; F=4.28, MSe=0.800. The nature of this interaction was that when reading the attribute organized text, subjects read topic sentences in major shift paragraphs .336 seconds more slowly than they read the topic sentences in the minor shift paragraphs; for the disorganized text, the topic shift effect for topic sentences was .014 seconds in the opposite direction. There were no reliable effects of topic shift on nontopic sentences in either organizational condition.

Finally, there were three results of interest from the analysis of reading times for the first two paragraphs. These data are presented in Table 2. (Note that the distinction between "major shift" and "minor shift" is a moot one for the first two paragraphs.) First, subjects read an average of .525 seconds more slowly in the first paragraph than in the second paragraph ($\underline{F}$=28.26, MSe=1.092 for the main effect of Topic Shift). Second, topic sentences were read an average of 1.35 seconds more slowly than nontopic sentences ($\underline{F}$=142.52, MSe=1.433). Finally, the topic sentence effect was larger for the attribute organized text (1.63 second effect) than for the disorganized text (1.07 second effect), ($\underline{F}$=8.17, MSe=1.076).

Analyses of Verification Results

Separate analyses were conducted on the reaction times and errors for the verification task. Mixed factors, fixed effects ANOVAs were conducted for both dependent measures. The within-subjects variables in both analyses were: Truth-value of the sentence; Hierarchical level of the sentence; and Organization of the text. The between-subjects variables were the same three counterbalancing variables as in the analyses of the reading times. All errors (13.69%) and times exceeding 7 seconds (0.78%) were excluded from analyses of the reaction times; times exceeding 7 seconds were considered errors for purposes of the analyses of the error data.

The verification results are summarized in Table 3. The reaction time and error results will be considered jointly.

First, subjects made more errors on false statements than on true statements, (F=8.46, MSe=0.857), and they tended to be slower on false statements than on trues (F=3.73, MSe=0.125, p=.059). Second, subjects responded more quickly and more accurately to superordinate statements than to subordinate statements (F=4.37, MSe=0.176 for reaction times; F=15.30, MSe=0.655 for errors). Finally, the effect of hierarchical level on reaction times depended upon text organization. The interaction was only marginally significant (F=3.20, MSe=0.194, p=.080). However, planned comparisons showed a reliable .157 second effect of hierarchical level for the attribute organized text, (F=7.31, MSe=0.189), while the .008 second effect for the disorganized text did not approach significance (F<1).

Discussion

How actively do readers process the topic structure of an expository text? Most theorists hypothesize that macroprocesses are applied on-line in a systematic manner during reading (e.g., Kintsch & van Dijk, 1978; Vipond, 1980). It is possible, however, that readers are lazy processors who apply macro-operations only when required by task demands. We have argued that there is little available evidence to distinguish these positions. In this study, we have distinguished the models by examining the effects of a text's topic structure on on-line measures of reading.

The findings of the experiment clearly support the on-line macroprocessor model. According to this model, whenever a shift of topic is encountered in a text, readers retrieve their representations of the text's topic structure and integrate the new topic into their representations. One finding that is consistent with the model is that reading times were considerably slower to topic sentences than to nontopic sentences in all experimental conditions. This result is similar to Cirilo and Foss's (1980) finding of a "levels effect" on reading times. The topic sentence effect is, however, also consistent with the lazy macroprocessor model. Since topic sentences contain more new information than nontopic sentences, the former require more microprocessing than the latter (Haviland & Clark, 1974).

Although either model can account for the topic sentence effect, only the on-line macroprocessor model predicts that the topic sentence effect will depend upon the paragraph organization of the text. If readers integrate each new topic into their representations on-line, then the time it takes to read a topic sentence should depend on how easily the new topic can be related to previous topics. This prediction was confirmed. When the text was well organized, readers processed a topic sentence faster if the new topic could be related to the immediately preceding topic (i.e., minor shift) than if the new topic could not be related to the immediately preceding topic (major shift). No such topic shift effects were observed for the disorganized text because each new topic was equally difficult to relate to preceding topics. Also, no effects of type of shift were observed for nontopic sentences because they do not require macroprocessing. In sum, the pattern of reading times on topic sentences closely reflected the topic structre of the text. These results are similar to findings that subjects spend more time reading sentences located between rather than within the constituent boundaries of a story (Haberlandt, Berian, & Sandson, 1980; Mandler & Goodman, 1982). Together they demonstrate that experienced readers are active, on-line processors of the macrostructure of a text.

The results for the verification task deserve some brief consideration. Two findings are of interest. First, subjects responded more quickly and accurately to sentences asserting topic information than to sentences asserting detail information. This result replicates previous findings by other investigators (Caccamise & Kintsch, 1978; McKoon, 1977). Second, the effect of hierarchical level on reaction time depended upon text organization. There was a large effect of hierarchical level for the well organized text, but virtually no effect for the disorganized text. Subjects evidently did not possess an integrated hierarchical representation of the disorganized text or they did not use the hierarchical structure as a basis for retrieval during the recognition test. One speculation is that a hierarchically-guided retrieval process requires that readers actively establish a retrieval plan during reading based on the topic structure of the text. Readers did not set up a retrieval scheme when reading the disorganized text because the disorganization discouraged them from on-line macroprocessing of the text's topic structure.

To summarize, the findings of this study clearly demonstrate that readers are on-line macroprocessors. The most important findings were that reading times to topic sentences were generally slow and that they depended upon text organization.

We are proposing that the processing of a text's topic structure is a particularly important component of macroprocessing. There are at least three general ways in which such processing is important to the reading. First, a representation of topic structure can serve as a retrieval plan to aid subsequent retrieval of information acquired from text (Kintsch & van Dijk, 1978). A result consistent with this suggestion is the finding that subjects' recognition test performance showed greater sensitivity to topic structure after reading the well organized text than after reading the disorganized text. (A recently completed recall experiment provides more direct support for this hypothesis; Lorch & Lorch, 1983a).

A second benefit of on-line processing of a text's topic structure is that the availability of the representation should aid other reading processes. For example, when local context is insufficient for interpreting some statement in a text, knowledge of the current major topic will often permit comprehension (Carpenter & Just, 1977; Foss, 1982). If a statement cannot be related to the current major topic, knowledge of the topic structure may help direct the reader to the appropriate context for comprehension.

A final benefit of on-line processing of the topic structure is that it serves as a monitoring process on comprehension. The message of a well-written text will generally be reflected in the organization of topics. If a reader is able to relate each successive topic to the preceding topics, the reader gains some assurance that understanding is being achieved.

One last point should be made. We have discussed the issue of "on-line" versus "lazy" macroprocessing as if one or the other model is necessarily correct. This is surely a simplification. The current study demonstrates only that college students systematically process a text's topic structure under some conditions. It is likely that there are individual differences in how actively topic structure processing is done (Graesser, Hoffman, & Clark, 1980; Lorch & Lorch, 1983b). Also, reading purposes probably influence the kind and extent of macroprocessing in which readers engage (Black, 1981; Cirilo, 1981; Lorch & Lorch, 1983c). Finally, text variables probably affect the kinds of macroprocesses a reader will execute (Cirilo, 1981). The challenge is thus to explain how a given reader's processing of topic structure is affected by that individual's abilities and by the reading conditions.

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Table 1
Mean Reading Times (in seconds) as a
Function of Condition for the Last 10 Paragraphs

	Type of Shift		
	Major	Minor	Mean
Attribute Organized			
Topic Sentence	2.824	2.488	2.656
Nontopic Sentence	2.396	2.293	2.345
Difference	.428	.195	.311
Disorganized			
Topic Sentence	2.725	2.739	2.732
Nontopic Sentence	2.378	2.312	2.345
Difference	.347	.427	.387

Table 2
Mean Reading Times (in seconds) as a
Function of Condition for the First Two Paragraphs

	Type of Shift		
	Major	Minor	Mean
Attribute Organized			
Topic Sentence	4.555	4.079	4.317
Nontopic Sentence	3.067	2.306	2.687
Difference	1.488	1.773	1.630
Disorganized			
Topic Sentence	4.090	3.818	3.954
Nontopic Sentence	3.179	2.588	2.884
Difference	.911	1.230	1.070

Table 3
Mean Reading Times (in seconds) and
Percentage Errors (in parentheses) as a
Function of Condition in the Verification Task

	Hierarchical Level		
	High	Low	Difference
Attribute Organized			
True	2.340	2.556	.216
	(8.93)	(14.58)	(5.65)
False	2.428	2.526	.098
	(11.90)	(17.86)	(5.96)
Mean	2.384	2.541	.157
	(10.42)	(16.22)	(5.80)
Disorganized			
True	2.402	2.442	.040
	(12.50)	(13.39)	(.89)
False	2.533	2.510	-.023
	(14.58)	(22.02)	(7.44)
Mean	2.468	2.476	.008
	(13.54)	(17.71)	(4.17)