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ABSTRACT

This report presents a summary of the research designed to develop a psycholinguistics of comprehension and memory for meaningful written prose paragraphs. The approach departs from most previous ones by seeking to formulate an explicit theory, instead of relying on informal qualitative judgments as to paragraph structure, the scoring of data, and the processes of comprehension and memory. The paper discusses overall methodological principles and assumptions designed to yeild as results the specific representations of paragraphs and presents a means for psycholinguistic structural analysis of the paragraph. Experiments intended to aid in perfecting the methodology are described along with results which provide an objective and complete method for scoring recall protocols. A bibliography is included. (Author/VM)

Final Report

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PARAGRAPH STRUCTURE AND PARAGRAPH COMPREHENSION

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Author's Abstract

Comprehension and memory for prose is the topic of the reported research. A psycholinguistic analysis is undertaken consisting of two phases: the development of a linguistic description of paragraph structure and the conducting of experiments to ascertain psychological correlates of the structure. A third phase, formulation of a process model acting on the structure to produce the data, is envisioned in future extensions of the theory.

To date, the major focus has been on constructing the linguistic descriptions. In this respect the approach is unlike most others proposed by psychologists. An explicit model of structure is claimed to be a methodological prerequisite for a psychological investigation, not only for creating process models but also for scoring data and formulating predictive indices. For the present purpose, the aim is to develop the model at a level of generality sufficient for an explicit characterization of individual experimental passages, but admittedly falling short of the generality traditionally sought in linguistic semantic theory. The approach has proceeded inductively from detailed analyses of individual paragraphs, appealing to and attempting to explicate the theorist's semantic intuitions. Results to date are promising, but the evolved principles must be further explicated and generalized. Applications to experiments confirm this advance in methodology for studying prose comprehension and memory.

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Preface

This report is only a summary of the research, because it has been reported in detail in two technical reports previously submitted to the U. S. Office of Education:

Crothers, E. J. The psycholinguistic structure of knowledge. Univer. of Colorado, Department of Psychology. Technical Report. Nov., 1970. 1-93.

Crothers, E. J. Memory structure and the recall of discourse. Technical Report CLIPR-4, April, 1971. 1-74.

An earlier draft of the first paper was presented at COBRE Research Workshop on Cognitive Organization and Psychological Processes, Aug., 1970. A later version of it will appear in the proceedings of that workshop, to be published by the National Academy of Sciences. The second paper was presented at COBRE Research Workshop on Language Comprehension and the Acquisition of Knowledge, April, 1971. It will appear in a volume on the proceedings of the workshop.

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Introduction

The aim of this research is to develop a psycholinguistics of the comprehension and memory for meaningful written prose paragraphs. The approach departs from most previous ones by seeking to formulate an explicit theory instead of relying on informal qualitative judgments as to the paragraph structure, the scoring of data, and the processes of comprehension and memory. Where explicit models have previously been proposed by others, a closer analysis has revealed that such models are not in fact designed to explain comprehension and memory for prose. In particular, the computer simulation of semantic memory (Simmons & Slocum, 1970; Quillian, 1968, 1969) involves mainly the retrieval of highly overlearned facts from long-term memory (LTM). Little is said about how new information gets comprehended and assimilated into the LTM schema. Several formal psychological or linguistic-rhetorical approaches do exist, but they yield superficial descriptions of the structure, both of the stimulus paragraph and of the response protocol paragraph. Either all of the content save for its abstract logical properties is discarded (Dawes, 1966; Frase, 1969; Frederiksen, 1971), or else the passage is reduced to highly abstract outline headings such as " execution of means" (Loriot & Hollenbach, 1970) which at best are a very incomplete description. Another fundamental defect in most of these approaches, and in others as well (Harris, 1963; Katz & Fodor, 1963) is that the essence of paragraph organization, namely that it is built around a theme (topic, gist, abstract) is not represented by the theory. Finally, many of the approaches represent only the underlying semantic content but fail to represent the "surface" properties of the actual text itself, such as its particular pattern of syntactic reduction, implied propositions, etc. which do not change the content, but do selectively affect its salience. The objection to such an incomplete representation is that comprehension and memory clearly will depend not only on the semantic content, but also on the "emphasis", by whatever term it might be called (e.g. "form", "style", "foregrounding").

Thus the first stage of the current program is essentially methodological (or linguistic): to formulate a theory of the underlying and surface structures of prose. This is certainly a formidable problem, since one confronts many of the mysteries of meaning which have confounded semantic theorists and philosophers for centuries. Once progress has occurred on this, at least to a modest degree of generality sufficient to support construction and scoring of experimental paragraphs, the program enters the second stage. Here pertinent experiments are conducted for two purposes: to discover empirical correlates of the structure and thereby to draw inferences pursuant to the third stage, a process model complementing the structure model. As will be summarized here, my efforts and progress have been quite promising on the first stage, satisfactory on the conceptually simpler second stage, and virtually nil on the third stage. The focus of this report will be on methods and results for the first two stages (structure and experiments, respectively), and will be discussed in that order.

Method: psycholinguistic structure

Under this rubric fall the overall methodological principles and assumptions adopted to yield as results the specific representations of paragraphs. They are:

1. The structure model is evolved inductively, by analyzing individual paragraphs in detail and then formulating overall conclusions.

2. A single passage of one or a few paragraphs is a proper unit for analysis.

3. The present application is to primarily descriptive prose. Extensions to narrative and exhortative prose seem feasible, but non-thematic prose is outside the scope of the analyses.

4. The structure model for a particular paragraph is conceptually distinct from the process model, which specifies general operations capable of acting on many particular structures.

5. The structure model represents only the content, whether stated or implied, of the passage itself, plus the surface properties (which do not change the content). Definitions of words in the paragraph are relegated to an LTM component not formulated in the present theory.

6. The structure model must identify the theme (gist, abstract) of a passage. In addition, it must represent the nonthematic content as well.

7. Pursuant to conditions 5 and 6, the semantic analysis must freely resort to semantic intuition, especially to explicate implicit superordinates and other implications. Generally speaking, recourse to superordinates is allowed only when it exhibits the relationship among coordinates in the paragraph or ones in data.

8. The structure model must be the foundation for defining measures, especially indices of difficulty, accuracy of recall, and "centrality" or "theme-ness" of individual statements in the passage.

By and large, the rationale for these principles is that there is simply no other viable way to begin. In particular, the appeal to intuition is not unlike the method in current semantic theories (e.g. Chafe, 1970). Objectivity is sought by successive approximations. Once consensual agreement is won, further analyses are done to explicate the grounds for the consensus. Without exploiting one's unformalized semantic knowledge, all that is possible is a superficial analysis.

Results: psycholinguistic structure

To date, what has been analyzed (underlying structure, mostly) is one passage of from one to four paragraphs on each of the following topics: nebulae, oceanography, steel production, and selenium. Analyses are partially completed for paragraphs on red blood cells, fresco painting, seed testing, the Bari tribe, and the government of the fictitious Circle Island. The later analyses proceed more quickly now that the method is becoming more standarized. However, it certainly cannot be claimed that a set of principles sufficient even for descriptive prose has been formulated yet.

The analysis yields a tree graph representation of a paragraph's underlying structure, save for several notable features. One is that the subtrees for "parenthetic" subtopics are not dominated in the graph by the main root node which corresponds to the theme. The other is that the tree graph is augmented by statements which enumerate the coreferentiality mappings between different subtrees. For example, if objects were classified jointly by size and shape to yield two subtrees, the mapping statements would stipulate which sizes went with which shapes. These two departures from a conventional tree graph are of course departures from an outline equivalent to the graph. Another important difference, of course, is that in the graph the linear ordering of the subtrees is arbitrary, whereas in an outline it generally conforms more or less to the sequencing of sentences in the text. This particular difference between a conventional outline and the present graph disappears later, when that graph is replaced by the superficial (foregrounded) one, but the other two differences remain. In other respects, the representation resembles a tree graph of a very detailed outline, one which does include all the semantic content and not just the abstract headings. Each node corresponds to a sentence, either simple, compound, or complex. All text sentences, even the implied ones, are made explicit in the graph. Often, however, sentences are transformed (by semantic paraphrasing as well as syntactic transforming) in order to normalize them in the graph. Criteria for graphically subordinating one sentence to another, though still subject to revision, are about as follows. If Sentence B differs from Sentence A only by the presence of restrictive modifiers in B (e.g. syntactic modifiers or ones of lexical implication) then B is subordinate to A. Thus B implies A, and the implication ensues by deleting the modifier. When an implication requires more than one premise, they are treated as coordinate to one another and subordinate to the implication.

Here as in a typical outline, the most problematic aspect is the postulating of superordinates not stated explicitly. As originally conceived, the rule for so doing was that a new superordinate is admissible only if it serves to explicate intuitively sensed relationships among stated sentences (and recursively, among any sentences already introduced). Superordinates which express abstractions without uniting two or more subordinates could be added almost without limit, and seemingly without motivation. On later analysis, however, it appears that such

redundant superordinates cannot be avoided entirely, because sometimes they do appear in data. It might be noted briefly that such an analysis sometimes reveals contradictions or ambiguities inherent in the passage. For example, a frequent ambiguity is the failure to state or imply any correspondence between different subtrees.

Major problems which are still only partly resolved include the treatment of pragmatic inferences, the treatment of parallelism, improving the notation (especially for quantifiers, negations, and logical connectives), and developing a general semantic-logical taxonomy of the bases for subordination and coordination (e.g., quantification, lexical implication, etc.)

Given the underlying graph, the final step is to derive what might be called the "superficial structure" or perhaps the "foregrounded structure". Foregrounding refers to selective emphasis, and is undoubtedly a potent determiner of comprehension and memory. Hence it is vital to a theory. Unfortunately, this issue is little understood, and has only recently come under serious scrutiny by linguists. Apparently the foregrounded structure should also be a graph, though this point was not recognized in my earlier papers cited previously. Conceptually, this structure lies intermediate between the actual paragraph and the underlying structure. An important assumption here is that this structure does not obviate the underlying one. Rather, any rigorous derivation of the foregrounded structure seems to require not only the text but also the preforegrounding hierarchies. Foregrounding operations are viewed as analogous to syntactic transformations of raising and lowering, in that both alter the graph structure without changing the semantic content. In both cases, the effect is to create a foreground, topic, or focus of emphasis. The crux of the problem is to identify precisely what the structural cues to foregounding are. Evidently there are a number of cues which probably often covary with one another, such as the sentence sequence, syntactic reduction or zeroing, and frequency of recurrence. A crucial future problem is the investigation of such areas, especially at a level of generality which is moderate but sufficient to support psychological research. Then it will become possible to proceed to a serious study of processes, envisaged as creating the foregrounded mental representation (comprehension) and later degrading it (memory).

Method: experiments

xperiment has been completed, including the data analyses.
s have been run but the analyses are not yet finished. All
mainly to aid in perfecting the methodology, and not to
y major psychological conclusions. The foremost methodo-
was to exploit the theory in order to score the data in a
t, objective manner than has hitherto been possible.

jor objective of the completed experiment was to determine
ot it is indeed true that people tend to remember best the
t of a passage. Each college student subject read four
counterbalanced order, one on each of the topics nebulae,
, oceanography, and steel production. An ancillary
variable was the superfical organization of the nebulae
ther the properties of nebulae foregounded over the kinds
else the reverse foregrounding (this depended chiefly on
sequence.) Also, each subject was tested at the end of the
on the first of his four paragraphs. Then he received
t seven days later on all paragraphs. On a test, he was
write in his own words everything he could remember from
. A pretest was given at the start of the first session,
wledge of each topic prior to reading about it.

thodological innovation was in how the theme was determined.
ow seems unsatisfactory, but at least it and the subsequently
provements have the virture of being explicitly definable
iph. At the time of scoring the data, the solution adopted
ify the gist with the higher, more abstract nodes in the
abstracts are a matter of degree, not either-or.) Unfor-
graph invoked was the underlying (preforegrounding) one,
it was then available and recognized as necessary.

three studies in progress, two resemble the above in that
oted to rather traditional hypotheses, again using normal
of deliberately distorted passages. One of the two was
eplication of well-known studies on the mnemonic value of
izers. There were two groups of subjects, one who read
ohs and the other who also read an abstract prior to each
otal reading time was equated in the two groups. The
were on nebulae, selenium, seed testing, and red blood cells.
evious experiment, subjects were now tested on all para-
the first session; no delayed test was given. The test-
was a random order following the random training sequence.
lly, it might be mentioned that an initial attempt to in-
group who read a full outline rather than the text
cessful. That initial try at outlining yielded headings
nadvertently abstract and confusing to the subjects.

the innovation consisted of invoking the theory to generate
now presenting the theme explicitly instead of only

scoring it in the protocols. Again, the procedure was based on the underlying, preforegrounding graph. However, the former "top-down" procedure for generating the abstract was abandoned, for reasons to be discussed in the summary of the results of the first study. This time, a quasi-information procedure was substituted, as follows. Each node was assigned as number, namely the product over its immediate descendants of their own numbers of descendants. Then the top 10% of the nodes by this measure were selected as comprising the theme. The corresponding sentences were used to compose the abstracts.

The aim of the next experiment was to compare recall after four days as a function of the integrative response executed immediately after reading. There were three groups of subjects. Each began by reading a paragraph, which was then withdrawn from view. Then, depending on the group, the subject either attempted to write his recall of the paragraph, or attempted to recall and organize (as an outline) the passage, or read an outline of the passage. All groups were allowed equal time for the integrative task. One question was whether or not the additional organizing activities of outlining, beyond those induced simply by recalling and writing the recall, would facilitate a second recall. Another question was the pragmatic one of whether or not the advantage of active (subject-produced) outlines over passive ones (experimenter-produced) would offset the presumed greater semantic acceptability of the latter. A further main goal of the experiment, in particular the active outlining condition, was to furnish exploratory data on comprehension, rather than just memory data as in the other comparisons. How closely will a subject's outline reflect the foregrounded graph? One would anticipate an overall concurrence, but the explanation of any discrepancies is an open question. In fact, in some cases a detailed analysis might suggest attributing the disparity to an error in the foregrounded graph, not to a lapse in comprehension.

The other experiment in progress attacked a theoretical issue, namely whether or not memory depends on the location of the item in the graph structure. Unlike either the first experiement or research by others on recall of hierarchically organized words, the point of the design was to control for the lexical content itself. That is, the aim was to assign the words randomly to the nodes, then construct the rest of the sentence frame so as to avoid semantic anomalies. By using a new random order with each subject, one could thereby separate idiosyncratic lexical effects from effects due to the position in the abstract graph. Sentences were contrived so that frequency of overt presentation was constant over (most) nodes. Much trial and error was necessary in order to construct artificial paragraphs suitable for the experiment. To reduce the artificiality, each was then preceded and followed by more natural-sounding sentences on the same topic. Also, successive experimental paragraphs were separated by a buffer paragraph. The order of events was: buffer paragraph, key paragraph, test buffer paragraph, test key paragraph, then recycling with another randomly (without replacement) selected pair until four of each had been administered.

Results: experiments

The main conclusion was that, by and large, the structure model indeed provides a relatively objective and complete method for scoring recall protocols. The first experiment, which is the only one whose data have been analyzed to date, yielded instructive but somewhat unexpected findings. The hypothesis that the theme would be recalled better than the nonthematic content was rejected. Higher-level nodes were not overtly recalled better than lower-level ones, even in those cases where it seemed indisputable that the former were no more abstract lexically than the latter. Nor were elements of the principal subtree remembered more frequently than elements of the "parenthetic" subtrees. What did correlate strikingly with recall was a node's frequency of occurrence within the passage. This outcome can be interpreted as another line of evidence indicating that the basis for predictions should be the foregrounded graph, not the underlying one. A separate result, and a rather puzzling one, was that memories for different subtopics (subtrees) were statistically independent of each other. In interpreting these and other findings from this experiment, it should be noted that total recall was rather poor, averaging only about 20% of the elements identified by the model (not counting elements known on the pretest).

As to the ancillary variables, neither produced statistically significant results. However, their interaction was significant ($p<.01$); in particular, the combination of "properties" organization with immediate plus delayed testing yielded somewhat higher recall than did the other three conditions.

Conclusions

A semantic model of prose, even of single paragraphs, is a formidable task but an essential one if a theory of prose comprehension and memory is ever to be developed. The present approach is unique in the degree to which it emphasizes such a model, and shows promise of achieving a model of at least limited generality. Apparently, the best way to proceed is inductively, beginning with detailed analyses of individual passages. The approach is a methodological advance, and offers a framework within which psychological issues can now be investigated more explicitly. Especially, the semantic structure of prose and the scoring of prosodic data can now be accomplished more adequately. However, a fundamental shortcoming of the approach is the lack of a formal theory of foregrounding. This must be remedied in order to pursue psychological applications. Future theoretical work will concentrate on foregrounding, on generalizing the preforegrounding principles, and on possible psychological processes. For the time being, the main purpose of experiments will be to illuminate these methodological issues.

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Crothers, E. J. Memory structure and the recall of discourse. Univer. of Colorado, Dept. of Psychology. Technical Report. April, 1971. 1-74. (To appear in book on proceedings of a second conference sponsored by COBRE, U. S. Office of Education).

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