Reconstruction of Sentence Clusters at the Paragraph Level from Scrambled Discourse Using Feedback

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Abstract

Subjects reconstructed paragraphs from scrambled passages. There were two passages (240 and 400 words) and three conditions (read-only, reconstruct with no feedback, and reconstruct with feedback). The major dependent measures were recall of idea units, recognition of original sentences, and concordance with the original sentence in paragraph clusters. ANOVA yielded: (1) higher recall for idea units of the shorter passage and reconstruct-no feedback condition, (2) higher recognition of original sentences for the reconstruct-no feedback condition, and (3) greater concordance for the shorter passage. Generally speaking, feedback seemed to intrude into the reconstruction process, and greater concordance did not directly lead to improved comprehension.

This paper is one in a series of experiments concerned with the synthesis of meaning from text in an instructional context. Specifically, scrambled discourse is reconstructed with feedback, and comprehension is assessed through recall of idea units and recognition of original sentences as compared to paraphrases. In addition we have investigated the relationship between the sequential order of the reconstituted text and the original (i.e., concordance) with comprehension. The focus of this research lies in both the importance of passage structure as well as the effectiveness of instructional assistance. Our basic assumption was that the correspondence between structural form and semantic encoding were reasonably high (Langer, Keenan, and Medosch-Schonbeck, 1986). Our work has not dealt with the mechanics of processing discourse, per se, but with the instructional problems associated with feedback and processing text. Traditionally, these areas have not been related in any systematic manner.

The extraction of meaning from language has concerned scholars in various disciplines (Britton & Black, 1985; Just & Carpenter, 1987; van Dijk & Kintsch, 1983). Textual properties that have been investigated include content and structure (Thorndyke, 1977) and referential coherence (Kintsch, 1974). We chose initially to investigate sentence order because text reconstruction from randomly ordered discourse is a process and so amenable to instructional influences. The instructional assistance provided is feedback, which is perceived as an effective instructional adjunct under most circumstances. Feedback is usually defined as any assistance or information presented to the learner subsequent to a response (Langer, 1983). The feedback provided confirmed appropriate sentence placement in paragraphs during reconstruction.

Sequential order of constituents is a fundamental property of any language. Words in sentences must be ordered syntactically to prevent misunderstanding.

Undoubtedly the constraints of sequence are somewhat looser at the level of sentences in paragraphs or paragraphs in passages. The first structural element of discourse we investigated was at the level of sentence sequence. Generally, we found that concordance between the reconstructed sentence order and the original sequence did not consistently predict the level of comprehension (Langer, Keenan, and Culler, 1988).

In this study we investigated this sequencing issue further using a second structural element, i.e., the paragraph. Specifically, we wanted to analyze the effects of feedback on sentence clustering at the paragraph level. Structural features of language that are involved in paragraph sequence include argument overlap for coherence (Kintsch & van Dijk, 1978) and proximity of pronouns to their referents. Prose passages may vary on any of these, and the ordering of components may be much more important in some passages than others.

In addition, some writers have recognized that the problems associated with discourse processing included issues not related to the text itself. Such non-textual variables are the skills and knowledge bases possessed by the reader. Frederiksen (1977) acknowledged a constant interplay between text and reader-processing systems in semantic memory. Similarly Kintsch and Vipond (1979) recognized that readability is both a function of text characteristics as well as the knowledge structure of the reader. Meyer and Freedle (1984) also suggested that the schema available to the reader assists processing discourse. Since reader knowledge bases and skills are generally unknown and idiosyncratic, it is not surprising that this interaction has led researchers to somewhat contrary conclusions. While Reder (1980) argues for a significant relationship between text organization and comprehension, Irwin (1982) pointed out that over-all intersentential coherence does not seem to assist memory significantly.

For purposes of instruction, feedback has been used to guide the learner along conceptual pathways deemed most critical to achievement (Langer, 1983). In one sense the assistance is designed to either support or overcome learner idiosyncrasies insofar as the objectives of instruction are concerned. Within the context of text processing the objective is to encourage the reader to accept the logic of the text as formally predetermined by the writer. This means that the author believes that the sequential properties of the text can and do serve to assist the reader. However, there are several problems associated with any simplistic acceptance of the efficacy of feedback in determining learner outcomes. First, while feedback is almost always associated with improved learning (Berliner & Rosenshine, 1977), research evidence does not support the premise that there is a simple monotonic relationship between levels and types of assistance and achievement (Getsie, Langer, & Glass, 1985). Second, as we have noted, models of discourse processing have remained fairly isolated from instructional concerns, including feedback.

In our reconstruction paradigm we assumed that the assistance provided guided the learner in ordering the text following some developing sets of schemata. Historically retrieval has been proved less effective under conditions of scrambled text without instructional aid (Kulhavy, Schmid, & Walker, 1977; Frase, 1969; Thorndyke, 1977). With the exception of a study by Schultz and DiVesta (1972) in which feedback was inadvertently provided, investigations of reading scrambled prose have employed no specific types of assistance. In addition to the feedback conditions, our studies have used published natural prose rather than the artificial content often provided (e.g. Bransford & Franks, 1971).

Based on previous data from our laboratory it appears that feedback is more likely to assist the recognition of original sentences rather than the recall of idea units, although, under the reconstruction process one might presume that recall would benefit more. That is, we assumed that the reconstruction process would provide ample opportunity for the development of associative linkages, which would support subsequent uncued recall as well as the processing itself. However this has not been generally the case. In some instances, when the passage was short and the content familiar, subjects simply reading the scrambled material did about as well on retrieval as subjects reconstructing the text assisted by feedback (Langer, Keenan, & Medosch-Schonbeck, 1986).

The most common recall effects have involved characteristics of the text itself. If nothing else Clark's (1973) warning about treating content as a fixed variable has been amply demonstrated. For example, some of our later studies have led to the premise that the successful processing of scrambled discourse may be significantly related to passage differences on the episodic-semantic dimension (Tulving, 1983; Langer, Keenan, & Culler, 1987; Langer, Keenan, & Culler, 1988). It appears that within the parameters of our reconstruction-feedback paradigm, retrieval is superior for text assisted by semantically-based schemata as compared to episodic encodings. Tulving's latest model still accords the accessibility of episodic memory as a function of spatial-temporal references, while semantic content is more abstract.

The basic research problem in this study dealt with the effects of feedback on sentence clustering at the paragraph level. We hypothesized that sequential constraints are looser at the paragraph level than at the sentence level, and that feedback might yield enhanced effects for recall and concordance. That is, the cognitive demands for appropriate inclusion of sentences in paragraphs could reasonably be expected to differ from those based on sequencing at the sentence level.

Method

In this study of reconstruction of scrambled discourse at the paragraph level, we utilized two passages which we classified as semantically based in content. The two texts used in this investigation were taken from a study by Young (1984) who adapted several short essays from published periodicals. Each passage contained five paragraphs and both were moderately difficult. The differences in length, topic, and structure were intended to provide generality of results (Clark, 1973). The Computer Crime passage consists of 19 sentences and is 400 words in length, focusing on the invasion of major, supposedly secure databases by a group of youngsters. The Computer Crime text by paragraphs is as follows:

Computer Crime Paragraph Arrangement

1. Seven young computer hackers in Milwaukee got some unwelcome publicity by managing to tap into the computers at Los Alamos National Laboratories in New Mexico, where many of the nation's nuclear bombs are designed. Although the group of kids did not uncover any top secret weapons plans, they caused dismay in government agencies, corporations, hospitals and other institutions across the country by spotlighting the vulnerability of all computerized information.

2. The members of the group, who ranged in age from 15 to 22, proved the contention of artificial intelligence expert Marvin Minsky that "computers are dumb machines, and people can still easily outwit them." The group of kids were not computer wiz kids or mad geniuses bent on cracking almost unbreakable electronic codes. Rather, they were just ordinary home computer hobbyists who used a few standard programming techniques to dial up private files. Among the other computerized data they tinkered with were the records of radiation therapy patients at Manhattan's Sloan-Kettering Cancer Institute.

3. The group began their electronic raids a while back, but stepped up their raids after seeing the movie "War Games," where a clever young kid taps into the nation's defense system computer and begins playing a game of global thermonuclear war. Like the kid in the movie, all the group needed was a personal computer and a modem, a device which links the computer to a telephone. With this equipment they could call up all the computers connected by a giant

network known as telenet. Although each institution subscribing to telenet supposedly has its own security system, sneaking around that security proved to be only too simple.

4. At both Los Alamos and Sloan-Kettering, the tampering was noticed quickly, and the FBI notified. Decoy files were then created in the data banks to try to trap the unauthorized users. Anonymous tips finally led the FBI to the group of kids from Milwaukee. As of recently, no charges have been brought against the group, but in the world of computers, the panic was on.

5. Donn Parker, a computer crime expert at SRI International in Menlo Park, California, views the incident as part of a larger fad. There is an epidemic of malicious computer break-ins. Everybody's privacy is in jeopardy. Just about the only people not upset by the rumpus were the cryptographers who design high security computer codes. It seemed likely that their skills would be in great demand for years to come.

The Chesapeake Bay passage is 13 sentences long and 240 words in length, discussing pollution problems and proposals for their resolution. The paragraph organization is as follows:

Chesapeake Bay Paragraph Arrangement

1. Ten percent of the water in Chesapeake Bay contains virtually none of the dissolved oxygen normally found in clean water. This is because every year the spring runoff flushes large amounts of fertilizer residues and other pollutants into the bay.

2. A research team that studies oxygen depletion reports that the amount of oxygen rich water has steadily decreased since the 1930s, when oxygen depletion occurred only in the months of July and August. Because of oxygen depletion, enough damage has now been done to seriously threaten the Chesapeake Bay commercial fisheries. This led President Reagan to call for a "long, necessary effort to clean up" the Chesapeake last January.

3. The affected area extends from the Susquehanna River to below the mouth of the Potomac. All of the water in between these areas has been highly polluted and suffers from oxygen depletion.

4. The pollution provides nutrients that support large populations of microscopic plants. When the plants die, they sink to the bottom of the bay and begin to decay. From spring until fall, the process of decay consumes the bay's oxygen faster than it is replenished from the atmosphere.

5. The lack of oxygen is the leading suspect in the reduced catch of valuable food fish. All the deep water blue crabs are gone. Additionally, Virginia oystermen have reported hauling in "black bottoms" or foul smelling sediment containing only dead shellfish.

Our assumption was that the topics (computer crime and pollution) were generally familiar to the subjects, but few if any were likely to have read the specific articles. This provided our rationale for categorizing the content as based on semantic rather than episodic memory.

Sixty volunteers from the Introductory Psychology pool were randomly assigned to the experimental conditions. Each text was typed on cards, one sentence per card, and separately randomized decks were prepared for each passage. A slotted board was provided so the reconstruct subjects could place cards in slots as they were read, and reread as new cards were placed. Two randomly ordered versions were prepared for each passage. Tokens were provided the feedback subjects to use for feedback requests.

Three processing conditions were used with each of the two texts creating six experimental cells. The reconstruct-feedback processing required the subject to sort the scrambled sentences into five paragraphs. Subjects had available 25 tokens to request feedback, for a total of 25 individual requests. In the reconstruct-no feedback processing subjects sorted the sentences into five paragraphs but without assistance. For the read-only group the subjects read the sentences aloud from the assigned deck, and then read them aloud again, this time from the alternatively ordered deck. The decks were counterbalanced for each of the other two conditions.

For sorting, the subjects were given a card deck and told that it consisted of the 13 (or 19) sentences which comprised the 5 paragraph passage. The slots in the board were color coded into 5 zones of 7 contiguous slots each. The task was to put the sentences into the zones which would represent the paragraphs in the passage as originally written. For feedback, a subject could ask if a sentence belonged in the same paragraph with some other indicated sentence, and the experimenter would answer 'yes' or 'no,' as was appropriate. A token was given up for each request.

Following completion of a practice task and the appropriate experimental task, the subject was asked to complete a written recall of the experimental passage, and then to complete a forced-choice recognition test consisting of the experimental sentences paired with paraphrases. Finally, the subject was asked for a phrase telling what the passage was about (i.e. gist). This was assessed as a percentage of a five point scale.

In summary, the design was a factorial 2 (Chesapeake Bay - Computer Crime) x 3 (reconstruct feedback, reconstruct-no feedback, and read-only). The principal dependent measures were recall of idea units, recognition of original sentences, and placement agreement with original sentences in paragraphs. The number of ideas produced in written recall was expressed as a proportion of the total. Initially the passages were broken down into idea units following Bovair and Kieras (1981). The Chesapeake Bay passage had 44 idea units, while Computer Crime had 66. The ratio of differences in number of idea units between the two passages (.67) is almost identical to the ratio of differences in number of sentences (.68). Hence the two passages have similar conceptual densities, though they differ in length. The number of original sentences recognized when paired with paraphrases was expressed as a proportion of the total number of sentences in the original passage, 13 for Chesapeake Bay and 19 for Computer Crime.

Placement agreement within paragraphs was a calculated statistic indicating the degree of agreement in placement of sentences with placement of those sentences in the original. In order to make these data comparable to results in prior experiments, the statistic should be considered an approximation of Kendall's tau. To distinguish our statistic from Kendall's tau, we have labelled it cluster tau, (C-tau). Final placements for each subject were recorded, while the subject performed the written recall task. All sentence pairs were scored +1 if in agreement and -1 if in disagreement with the original with respect to placement in the same or different paragraphs. C-tau is therefore the total number of agreements less disagreements as a proportion of total pairs, as in Kendall's tau. An example might help. Let us suppose that the Chesapeake Bay original text contained in the first paragraph, Sentences 1, 2, and 3. However, a subject reconstructing the text actually placed Sentences 1, 2, and 4 in this first paragraph. To score sentence 1 we consider its correct placement with 2 (+), and its incorrect placement with 4 (-). In addition, we count the incorrect exclusion of 3 (-1) and the correct exclusion of the remaining 9 sentences (+9). For Sentence 1 this yields 10 (+) and 2 (-) scores and the process was repeated for all the remaining sentences. Agreements and disagreements were thus calculated for paragraph clusters rather than sequences of sentence pairs as in our previous research.

As noted earlier, we argued that sequential requirements for comprehension at the paragraph level would probably be less constrictive than sentence ordering for the entire passage.. We might assume, therefore, that clustering sentences by feedback would yield results varying in some ways from, but comparable to, those obtained by sequential ordering at the sentence level. Indeed, the data both parallels previous findings, and also shows some differences.

Results

The data analysis for recall and recognition followed our factorial 3 x 2 design. However, for concordance, only the two reconstruction groups were considered, since the read only subjects did not manipulate card order. Analysis of the recall of idea units by passage and processing yielded statistically significant main effects for passage ($F(1,42)=7.45$, $p<.01$) and for process ($F(2,42)=3.26$, $p<.05$). The mean recall for Chesapeake was .310 compared to .213 for Computer Crime. As in previous studies recall was better for the shorter passage. For the processing conditions, the reconstruct-no feedback mean was.325, the read-only mean was .222, and reconstruct-feedback was.238. A Student-Newman-Keuls revealed that the three means did not differ significantly, pairwise.

Sentence-recognition yielded a main effect for process ($F(2,42)=7.25$, $p<.01$). The reconstruct-no feedback condition mean was.873 compared to the read-only mean which was .722 and the reconstruct-feedback mean which was .822. Comparisons of the means showed that the reconstruction means were significantly higher than read-only mean, but not from each other. The feedback provided did not appear to assist comprehension. Again, as in previous research, there were no statistically significant interaction effects for either recall or recognition.

ANOVA for C-tau yielded a statistically significant effect for passage ($F(1,32)=6.40$, $p<.01$). This statistic was calculated for the two reconstruction groups only. C-tau for the Chesapeake passage was .68 compared to .55 for Computer Crime. The relationship between concordance, feedback, and retrieval is not a direct one. While data suggested that feedback did not assist either recall or recognition, the product-moment correlation between feedback and C-tau was positive and significant (.35, $p < .01$). Moreover, while the correlation between C-tau and recall was positive and significant (.53, $p < .01$), the corresponding correlation for recognition was non-significant . Finally, the correlation between C-tau and passage was -.40 ($p < .01$), suggesting that concordance was better for shorter passages. Clearly, there are no simple and overt cause and effect relationships. Feedback did not assist comprehension, although it enhanced concordance.

Finally, there was an effect for gist by passage ($F(1,42)=3.82$, $p < .05$) favoring Chesapeake (67.50 percent) as compared to Computer Crime (51.50 percent). We have accepted the gist data as basically a measure of internal validity. Table 1 lists the means and standard deviations.

Insert Table 1 about here

There were no statistically significant effects for time spent on reconstruction or order within the scrambled decks.

Conclusions

An almost axiomatic belief among instructional developers is that feedback enhances performance (Berliner, & Rosenshine, 1977; Langer, 1983). However, in a recent paper Mannes and Kintsch (1987) suggest that learner assistance does not lead to increased comprehension at all memorial levels. While their study did not deal with feedback, assistance was provided to the learner in the form of outlines either consistent or inconsistent with the experimental text subsequently provided. The consistent-outline students did better on comprehension tasks closely relevant to the materials provided, but the inconsistent-outline students did better on tasks involving deeper processing. The results not only parallel earlier findings (Gallagher, 1981; Battig, 1966), but are also reflected in our data.

In this study as in our previous work feedback assisted concordance, but this was not necessarily reflected in improved comprehension. For shorter passages it is likely that assistance is simply not needed. That is, the subject is likely to have adequate working memory resources to retain a partial surface representation of paragraphs. Basically, the subject is able to encode and retrieve the material involved necessarily extracting meaning (see Kintsch, 1988). That is, matching surface representations at either the paragraph or sentence level does not necessarily lead to improved comprehension. Hence concordance could be described as an outcome of our experimental demands and not necessarily a requisite for discourse comprehension. For the longer passages, the relationship between concordance and recall and recognition have not been consistent (Langer, Keenan, and Culler, 1988). The absence of statistically significant interactions remains a continuing, albeit perplexing, dilemma.

From an instructional point of view our failure to find a consistent relationship between sequential order and comprehension presents the developers of materials with a rather interesting problem. On one hand there is always the assumption that the best internal logic will lead to improved comprehension. Still while one could hardly support an argument for logical chaos, it is clear learners are capable of compensating for differences in instruction (a position any classroom teacher will affirm). The instructional question is probably how much can the student compensate, for what content, and under what conditions. And finally given the idiosyncratic skills and knowledge of an individual learner, just how universal are the assumptions we make about amounts and types of instructional feedback.

At this point it is becoming clearer that there is no general set of relationships between discourse structure, knowledge representations in text and learner, and feedback which can be logically assumed to exist. The commonly and widely held belief that assistance is better than no assistance must be hedged along a number of critical issues. In terms of instructional development it would seem that the more simple causal models utilized by behaviorists may yet have to be supplanted by more complex but as yet unknown cognitive strategies.

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Table 1

Means and standard deviations: Recall recognition, C-tau, and Gist

Source	Proportion Recall		Proportion Recognition		C-Tau		Percent Gist	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Chesapeake Bay	.310	.165	.811	.135	.68	.15	67.50	17.50
Computer Crime	.213	.832	.800	.119	.55	.13	51.50	17.00
Read-only	.223	.830	.723	.126	n/a	n/a	62.50	14.38
Reconstruct-no feedback	.325	.173	.873	.095	.58	.12	58.75	19.96
Reconstruct-feedback	.238	.134	.822	.112	.68	.15	66.25	18.93

Table 1

ANOVA: Proportion of recall scores

Source	SS	Df	MS	F	Sig
Main Effects	2119.56	3	706.52	4.66	.007
Passage (P)	1131.02	1	1131.02	7.45	.009
Condition (C)	988.54	2	494.27	3.26	.05
2-way Interactions	595.29	2	2917.65	1.96	.15
P x C	595.29	2	297.65	1.96	.15
Explained	2714.85	5	5642.97	3.58	.009
Residual	3673.13	42	151.74		
Total	9087.98	47	193.35		

Table 2

ANOVA: Proportion of recognition scores

Source	SS	Df	MS	F	Sig
Main Effects	1896.38	3	632.13	4.88	.005
Passage (P)	16.33	1	16.33	.13	.72
Condition (C)	1880.04	2	940.02	7.25	.002
2-way Interactions	167.54	2	83.77	.65	.53
P x C	167.54	2	83.77	.65	.52
Explained	1063.92	5	412.78	3.19	.02
Residual	5444.00	42	129.62		
Total	7507.92	47	159.74		

Table 3

ANOVA: C-tau

Source	SS	Df	MS	F	Sig
Main Effects	.17	2	.084	5.58	.009
Passage (P)	.097	1	.097	6.40	.02
Condition (C)	.072	1	.072	4.77	.04
2-way Interactions	.007	1	.007	0.48	.50
P x C	.007	1	.007	0.48	.50
Explained	.18	3	.06	3.88	.02
Residual	3.43	28	.02		
Total	.50	31	.02		

Table 4

Means and standard deviations: Proportion recall, proportion recognition, and C-tau

Source	Recall		Recognition		C-Tau	
	Mean	SD	Mean	SD	Mean	SD
Chesapeake Bay	31.00	16.53	81.13	13.53	.68	.15
Computer Crime	21.29	8.32	79.96	11.94	.55	.13
Read-only	22.19	8.30	72.19	12.55	n/a	n/a
Reconstruct-no feedback	32.50	17.32	87.25	9.51	.58	.12
Reconstruct-feedback	23.75	13.39	82.19	11.17	.68	.15