SIGNALING EFFECTS: INCREASED CONTENT RETENTION AND NEW ANSWERS–PART II

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ABSTRACT

This study investigated the role of signaling in helping good readers comprehend expository text. As the existing literature on signaling, reviewed in the last issue of this Journal, pointed to deficiencies in previous studies' methodologies, one goal of this study was to refine prose research methods. Two passages were designed in one of eight signaled versions each. The design was constructed to assess the individual and combined effects of headings, previews, and logical connectives. The study also assessed the effect of passage length, familiarity, and difficulty. The results showed that signals do improve a reader's comprehension, particularly comprehension two weeks after the reading of a passage and comprehension of superordinate and superordinate inferential information. This study supports the hypothesis that signals can influence retention of text-based information, particularly with long, unfamiliar, or difficult passages.

In the last issue of this Journal, I reviewed a number of current signaling studies, studies where contradictory results may well have been the product of methodological problems. I concluded by suggesting that by examining longer passages, by using delay as well as immediate comprehension tests, and by assessing and controlling for content familiarity and difficulty, investigators might increase the likelihood of demonstrating strong and consistent results for signaling. The purpose of the study presented here is to apply these methodological suggestions so as to isolate the effects of individual and combined signals on reading comprehension. The specific objectives of this research are

- To investigate the effects of previews, logical connectives, and headings on technical readers' reading comprehension;

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To identify what level of technical text would best benefit from the inclusion of signals; and
To refine prose research methodology.

After presenting the procedures used in this study, this article restates the research hypotheses, reveals and interprets the results, and offers conclusions about the effects of signals on comprehension and the validity of the methodology.

PROCEDURES

The review of previous research on signaling studies suggests that further studies of signals must control for previously uncontrolled for variables such as rhetorical structure, length, difficulty, reader familiarity with the topic, and comprehension test timing. These specific issues were considered in the development of procedures for the study presented here. The experimental design addresses the issues of subject identification and selection, material design, and statistical analysis.

Subject Selection

Identifying the subject population and sample involved selecting a group of lower division students at the University of Washington, ascertaining their verbal aptitudes, and identifying topics they would have little prior knowledge of. Subjects for the research study were native, English-speaking, pre-engineering majors. The average verbal composite score on the Washington Pre-College test for pre-engineering majors at the University of Washington is consistently higher than the average score for the general University population. Subjects with this level of verbal aptitude were considered desirable since one goal of this study was to assess good readers’ comprehension of difficult text, with and without signals. Additional participants were drawn from Introductory Technical Writing classes to assess topic familiarity and to check for passage dependency of test items.

Seeking to use subjects who possessed little prior knowledge of the topic they would be reading, this study controlled for and affected prior knowledge in three ways. First, because pre-engineering majors have had a limited number of technical courses here at the University, their prior knowledge of specific technical topics was easier to work around than that of upper division engineering students. Second, subjects’ familiarity with potential passage topics was determined by having pre-engineering majors in a technical writing class rank-order their familiarity with ten technical topics (from potential passages for the study). Two topics that they identified as least familiar were selected for the passages used in this study. Third, to obtain convergent validity of familiarity determination, all subjects in the test conditions answered a prior knowledge
Material Design

Designing the materials for this study involved selecting, analyzing, and designing the experimental passages; and constructing two comprehension tests.

Passage selection — Initially, ten potential passages, with excerptable portions, were selected from U.S. Government reports. They were selected only if they represented a typical expository structure (e.g., problem/solution, process analysis, cause/effect, comparison, etc.). The goal was to obtain 1,000–1,200 word passages; the purpose was to exceed the length of passages typically used in previous signal studies since the inconsistent results of those studies may have been caused partially by the shortness of the test passages. From the results of the familiarity ratings (discussed earlier), two passages were selected from the five least familiar topics (M ≤ 5.10). The two passages, “Sludge Disposal” (Sludge) [1] and “Soil Stabilization in Road Base Construction” (Soil) [2], were selected so that one represented syntactically and perhaps semantically simpler discourse than the other (method discussed below). The goal here was to use one long, more difficult passage (Sludge) and one long, easier passage (Soil), both on relatively unfamiliar topics. Both of these passages have an overall problem/solution structure with an underlying process analysis structure.

Passage analysis — Passage analysis tasks included the assessment of grade level difficulty and the number of idea units per passage and their importance. Two methods were used to determine the passages’ difficulty:

1. Using the Berta-max Readability Estimator [3], which combines many readability formulae and assigns a grade level to a passage; and
2. Identifying the number of idea units and their relative importance.

Of the seven 100-word excerpts that were analyzed, the mean grade levels proved to be 14.95 (S.D. = 0.526) for the Sludge passage and 12.58 (S.D. = 0.131) for the Soil passage. Interestingly, six of the seven Sludge excerpts exceeded the 17+ grade level top limit of the Dale-Chall and Fog formulae, perhaps implying that the Sludge passage was perhaps even more difficult than this computer package could measure, in that ceiling effects for some specific formulae were obtained.

The number of idea units and their importance were determined by adapting Johnson’s [4] and Water’s [5] text analysis procedures. The analysis was conducted to assess the passages’ relative difficulty per the number of idea units and also to aid in the design of the signalled passages and the tests. After receiving relevant instructions, ten students, enrolled in a Research in Technical Writing class, parsed and rated idea units in the two passages. The rating results
were used to identify three levels of content: most important, least important, and a middle range. The resulting idea unit hierarchy guided the placement of signal additions and the design of the follow-up test.

**Passage design** — The nonsignaled control passages were designed from the naturally occurring passages on Sludge and on Soil; all existing signals fitting the categories of headings, previews, or logical connectives were deleted from the passages. Then, signals (headings, previews, or logical connectives) were added to the nonsignaled passages, either singly or in combination. Syntactic similarity was maintained between nonsignaled and signaled passages. Three headings and six preview sentences were added to each passage to emphasize and clarify organizational hierarchy of idea units in the most important category, as identified from the passage analysis results. Twenty-two logical connectives (conjunctions, conjunctive adverbs, and conjunctive phrases), chosen from Halliday and Hasan's list of coherence devices [6], were added to each text. Words such as "however," "generally," "in fact," "also," "next," etc., were placed among idea units at all levels. The eight texts, resulting from the factorial design, had either

1. No signals;
2. Headings;
3. Logical connectives;
4. Previews;
5. Headings and logical connectives;
6. Headings and previews;
7. Previews and logical connectives; or
8. Headings, logical connectives, and previews.

The length of the eight versions of both texts ranged between 1,029 to 1,172 words.

**Test design** — One twenty-three-question test was designed for each topic, with three questions per test collecting subject information regarding native language (non-native speaker tests were deleted), and subjects' interest and familiarity with the topic. The twenty questions that followed resulted from twenty-four passage related questions that were pretested with students in an Introductory Technical Writing class and then revised according to an item analysis used to identify poor or ambiguous distracter responses or questions. In the final version of the test, twenty forced-choice, comprehension questions assessed four types of information:

1. Superordinate content specifically stated in the passage;
2. Subordinate content specifically stated in the passage;
3. Inferences that readers could make from superordinate content in the text; and
4. Inferences that readers could make from subordinate content in the text.
Each of the information types was measured with five questions: superordinate content questions were drawn from idea units in the most important content category, while subordinate content questions were drawn from idea units in the least important content category. Questions requiring inferences were designed from the superordinate or subordinate content levels; however, they asked about implicit content relationships, tapping the reader’s ability to infer ideas from the texts [7]. These tests were used both immediately after passages were read and after a two-week delay.

**Overall Procedure**

Voluntary subjects (pre-engineering majors in three Fortran classes) were given a stapled set of materials, which included one passage and the related test. They were told to read at their own rate and to answer the test questions on the attached form when done, without referring back to the passage they had read. Fourteen days later, the subjects took the delay test. After deletion of tests of all non-native speakers and random deletion of some tests to obtain equal cell sizes, the tests were scored and analyzed.

**Statistical Analysis**

For both the Sludge and Soil texts, four 2 (headings) x 2 (logical connectives) x 2 (previews) ANOVAs were run on the immediate test data in SPSS: one for each dependent measure (superordinate, subordinate, inferential, superordinate, and inferential subordinate scores). For each passage, eighty-eight subjects’ scores (eleven per cell) were submitted for analysis. Also for both texts, four 2 x 2 x 2 ANOVAs with repeated measures were run on the same dependent measures to assess the immediate and delay conditions for the forty-eight subjects who participated in both sessions. The SPSS ANVAR (Analysis of Variance Repeated) program was used to conduct the analysis: the between subjects’ factors were headings, logical connectives, and previews, each having two levels (presence or absence); and the within subjects factor was comprehension represented by two levels (immediate or delay). Finally, Pearson Correlations were run in SPSS on the familiarity scores with the total test score, and on the interest score with the total test score.

**RESEARCH HYPOTHESES**

It was hypothesized that, while signals would aid readers in comprehending both the easy and difficult text, they would be more helpful to readers of the difficult text. Minimally, headings and previews were expected to increase significantly the comprehension of readers of the difficult text taking the immediate test; it was presumed that these two signals would help the reader form a sufficiently good hierarchical framework in memory so that more
superordinate information would be retained and inferences would be made more accurately. Since logical connectives were situated at the superordinate and subordinate level of the text, they were also expected to help readers integrate subordinate content into this framework. Furthermore, it was hypothesized that although it would be logical to expect headings to show significant effects in the immediate test, they would be even more likely to be of significant aid in the delayed test.

RESULTS AND DISCUSSION

The results and discussion are presented in the following order:

1. Passage dependency test results;
2. Familiarity ratings; and
3. Comprehension levels.

Only results significant at a probability level of < .05 are discussed.

Passage Dependency Results

Students from Introductory Technical Writing classes participated in the passage dependency tests. With about twenty subjects per test, the passage dependency results for the twenty comprehension questions had a mean of 5.33 (S.D. = 1.74) for the Sludge test, and a mean of 5.42 (S.D. = 1.70) for the Soil test. A mean of 5.0 would have represented a chance score for both tests, since each test’s twenty comprehension questions had four possible answers per question. Because the means obtained are quite close to the expected chance mean, the tests were deemed to be passage dependent.

Familiarity Results

Subjects in the final study were asked to rate their familiarity with the topic about which they had read. One question (at the beginning of both immediate tests) assessed subjects’ familiarity with the topic. The question used a Likert scale, with 1 representing the unfamiliar end of the scale and 4 representing the more familiar end of the scale. On this familiarity question, participants who read the Sludge passage had a mean of 1.25 (S.D. = 0.48) and participants who read the Soil Passage had a mean of 1.14 (S.D. = 0.48). The means for both texts reveal that the subjects deemed themselves to be quite unfamiliar with both topics. Pearson Correlations were calculated for the familiarity scores with the total comprehension test scores (the summed scores of the four submeasures): nonsignificant correlations were found (r of 0.01 and 0.12 for Sludge and Soil, respectively). The nonsignificant correlations confirm that unfamiliar texts were chosen.
Such low means were anticipated, since familiarity rankings had been used to identify unfamiliar passages for the study. These low means would suggest that subjects would need to rely more heavily on cues in the text to help them

1. Interpret the content correctly; and
2. Construct a workable hierarchical framework in memory.

Even though the subjects in this study should have possessed schemata for the overall structure of the technical discourse, they would have been able to design only a very general hierarchical framework in memory to accept incoming content. Their lack of familiarity with either Sludge Disposal or Soil Stabilization of Road Bases would have impeded their ability to construct that framework beyond the problem/solution level. The further levels of the hierarchy could not be built from prior schemata, since the subjects were unfamiliar with the passage topics. Thus, these readers would have to rely on the text for help in designing the hierarchical levels of the framework. They would be forced to make text-based inferences instead of schema-based inferences [8].

This finding, on the matter of familiarity, seems to clarify some previously inconsistent results. One must now question whether previous studies that found no significant results with good readers for similar signal types were in fact using somewhat familiar topics for experimental passages [9-11].

Levels of Comprehension

It was hypothesized that headings, logical connectives, and previews would differentially affect comprehension of various levels of information. Specifically, headings, logical connectives, and previews were expected to be of benefit with superordinate content and inferential relationships, while logical connectives were expected to reveal effects at the subordinate level as well. These expectations were confirmed through analyses of four comprehension submeasures:

1. Superordinate content;
2. Inferential superordinate relationships;
3. Subordinate content; and
4. Inferential subordinate relationships.

In general, signals were expected to benefit readers by helping them design hierarchical frameworks in memory; hence, the majority of significant results were expected at the superordinate and inferential superordinate levels. This prediction was confirmed in both the ANOVA and ANVAR analyses.

Using the ANVAR analyses, the researcher also expected that all three signals, particularly headings, would prove to be of more aid over time than immediately after subjects read a passage containing signals. If, in fact, signals do help readers form hierarchical frameworks in memory and link content together, subjects in
all signaled conditions should be able to retain and retrieve content, and make inferences from it; this effect would first surface on the immediate tests.

Superordinate content — Only one significant effect surfaced in the scores for retention of superordinate content. On the ANOVA analysis of the immediate Soil test, a heading and logical connective disordinal interaction occurred, \( F(1, 80) = 3.841, p < .05 \) (see Figure 1). The high mean for headings (\( M = 3.41 \)) occurred in the absence of logical connectives and the high mean for logical connectives (\( M = 2.91 \)) occurred in the absence of headings. Readers appear to have retained more superordinate content when headings appeared without logical connectives. Furthermore, logical connectives were somewhat more helpful in the absence of headings; this issue is discussed in the subsection on Signals in Combination.

Inferential superordinate relationships — Inferential superordinate relationships concern subjects' ability to infer superordinate relationships among superordinate idea units stated in a text [8]. Five significant results were found for this measure. For the Soil passage, both the ANOVA and ANVAR analyses resulted in significant interactions between previews and logical connectives [ANOVA \( F(1, 80) = 3.907, p < .05 \); ANVAR between subjects' analysis, \( F(1, 40) = 15.795, p < .05 \)]. Figure 2 presents the disordinal interaction identified in the ANVAR analysis, an interaction that was virtually identical to

![Graph](image)

Figure 1. Readers retained more superordinate content on the immediate test when headings appeared without logical connectives.
the ANOVA analysis interaction. With the ANVAR data, the mean for previews alone was 2.54, and the mean for logical connectives alone was 2.33; both of these are considerably higher than the mean of 1.79 when both signals were present together. In fact, the mean of the two signals together is not much higher than the mean of 1.54 for the absence of previews and logical connectives. Previews and logical connectives individually provided more help to the subjects for inferring superordinate relationships than did the two signals in combination; this issue is discussed in the subsection on Signals in Combination.

The other three effects for inferential superordinate relationships appeared in headed versions of the Soil passage. A between subjects' main effect occurred, $F(1, 40) = 4.120, p < .05$. The headings present mean was 2.19 versus the headings absent mean of 1.71, indicating that headings helped subjects infer superordinate relationships. When the delay versus immediate test factor was analyzed, two within subjects' interactions were found: one was identified for headings and the test date factor, $F(1, 40) = 5.382, p < .05$. Figure 3 shows that although the presence ($M = 2.08$) or absence ($M = 1.92$) of headings made little difference in the immediate test, there was a large difference with the delay test. When headings were present, the mean for the delay test on the superordinate measure was 2.29, versus 1.50 when they were absent. Not only was the presence of headings of more help when subjects inferred superordinate
relationships, but also the subjects' ability to make inferences actually appeared to increase over time. Overall, headings must have been extremely helpful to have increased the subjects’ scores, two weeks after subjects had read the passage.

Another significant interaction arose for headings, logical connectives, and the test date factor on the inferential superordinate measure, $F(1, 40) = 8.636$, $p < .05$. Figure 4 shows the various aspects of the interaction. On the immediate test, headings and logical connectives together produced a mean of 2.08, but a mean of 2.16 when both were absent. Although there seems to have been a slight improvement when headings and logical connectives were absent, the difference is not significant. Interestingly, logical connectives with headings produced a mean of 2.08, yet, when the headings were removed, the mean fell to 1.67; logical connectives functioned better in the presence of headings. However, the interaction of greater interest here is the one that occurred with the delay test. Headings alone produced a mean of 2.58, but a mean of 1.25 when they were absent, a drop of more than one point. Furthermore, headings functioned better alone ($M = 2.58$) than they did in the presence of logical connectives ($M = 2.00$). Logical connectives alone showed an effect with delay ($M = 1.75$) that was similar to the effect they had in the immediate condition ($M = 1.67$). In this three-way interaction, headings were most beneficial in the delay condition. Incredibly, headings actually increased the subjects' inferential superordinate scores over time and were most helpful in the absence of logical connectives.
These results imply that headings did not greatly improve readers’ ability to infer superordinate relationships in immediate memory, but that headings helped the readers retain and retrieve information over time and aided them in making inferences from it. The aid that headings provided was so strong that readers performed better two weeks after reading a passage than a few minutes after reading it. Logical connectives did not contribute much to the subjects’ ability to make superordinate inferences.

Subordinate information — Two significant findings for subjects’ retention of subordinate information occurred in the ANVAR between subjects’ analysis. In the Sludge passage, previews were found to help readers answer questions about subordinate information, $F(1, 40) = 6.25, p < .05$. The means, 2.42 for previews when present and 1.71 for previews when absent, reveal that subjects retained more subordinate content when they read passages containing previews than when they read passages without previews. This result is explainable only if previews aided the readers in developing a hierarchical framework which could accept the subordinate information. However, no positive effect was noted on either the superordinate or inferential superordinate measures, a result which would have indicated construction of such a framework; hence, it is difficult to explain the significance of previews in aiding the retention of subordinate content. In the Soil passage, a heading/logical connective
disordinal interaction occurred with the subordinate measure, $F(1, 40) = 4.289$, $p < .05$. Figure 5 portrays this disordinal interaction; both headings and logical connectives individually helped the subjects retain more subordinate content than when the two signals were used together. The mean for headings alone was 2.79 and the mean for logical connectives alone was 2.13, while the mean for the two signals in combination was 2.00. Furthermore, when neither signal was present, the mean was 1.83. Both signals were of some aid together, yet they were more helpful individually. This interaction, exhibiting a potential conflict between signal types, is discussed in the subsection on Signals in Combination.

Inferential subordinate relationships — The aspect of comprehension discussed here relates to the subjects’ ability to infer relationships among subordinate information stated in the text. Only one significant effect (a heading/test date factor interaction) for this measure was noted in the ANVAR within subjects’ analysis of the Soil passage, $F(1, 40) = 5.356$, $p < .05$. Figure 6 reveals that, when headings were present, the immediate mean was 2.58 and the delay mean was 2.67; the headings absent mean in the immediate condition was 2.58 versus 1.87 on the delay.

Headings did more to help subjects make inferences about subordinate relationships in the delay test than they did in the immediate test. This result is not surprising; because subjects had used headings to construct a framework in
Figure 6. Readers of headed texts retained subordinate inferential information better than readers of non-headed texts. Note the drop on the delay test for readers of non-headed texts.

memory to accept content (as shown by the inferential superordinate result), sufficient subordinate content resided in that structure to help the reader make inferences.

GENERAL DISCUSSION

The following discussion examines individual and combined effects, immediate and delay effects, and text difficulty effects.

Effects of Signals Alone and In Combination

It was hypothesized that signals would work well alone, but also in combination. Many main effects exist to show that signals work well alone, but the significant interactions of signals in combination are more relevant here, since they can confirm or disprove the theory that signals should work well together.

Individual signals — Three significant main effects were identified for individual signals in the statistical analyses. Previews were found to improve comprehension on the subordinate measure in the ANVAR analysis of the immediate test data from the Sludge passage. As stated earlier, this effect is difficult to explain in the absence of any significant effects on the superordinate
or inferential superordinate measures. Overall, the lack of many significant findings for the Sludge passage could suggest that subjects were quite lost in the passage due to its difficulty. If this were the case, one would expect readers to use a rote or list reading strategy and, hence, recall subordinate content without recalling superordinate content [11, 12].

More interpretable main effects occurred for headings on the inferential superordinate and total measure for the Soil passage’s ANVAR analysis of the immediate test data. Headings appear to have helped the subjects build a strong hierarchical framework in memory from which they could infer superordinate relationships. Headings also consistently aided comprehension on delay measures, as exhibited in the Soil passage’s ANVAR analyses of the test date interactions, a point discussed later.

**Signals in combination** — Numerous signal interactions arose in the analyses; some reflect the positive effects of signals working in combination and some reflect the opposite. In fact, most of the interactions reveal that each signal type individually helped readers more than any two signals in combination. Two heading/logical connective interactions arose for the Soil passage; one for superordinate measure (ANOVA), and one for the subordinate measure (ANVAR analysis of immediate test data). Headings and logical connectives were identified as functioning best alone, although they were of some benefit in combination. Headings alone provided the most aid. A third heading/logical connective interaction with the test date factor occurred in the Soil ANVAR analysis for the inferential superordinate measure. Again, headings were most helpful in the absence of logical connectives; this effect also occurred in the delay condition.

It appears that headings and logical connectives must have delivered considerably different messages to readers. If they were functioning similarly, minimally they would work equally well when present alone, if not additively when present together. Furthermore, more often than not, they seem to have impeded each other’s positive effect when present together. This result can only be explained by examining the two signals’ functions. Headings and logical connectives are both phrasal additions (as opposed to clausal structures) to text. Yet, headings are added at the superordinate level and logical connectives are added at many levels (in the present study, at the superordinate, intermediate, and subordinate level). It may be that readers, when functioning at the superordinate level to build a hierarchical framework in memory, are distracted by logical connectives that emphasize subordinate information and relationships; the opposite may also be true.

Similar patterns occurred for previews and logical connectives in combination. In the Soil passage’s ANOVA analysis of the inferential superordinate measure, a preview and logical connective interaction was noted: previews and logical connectives functioned best alone. In fact, previews were of more aid than logical connectives overall, yet logical connectives were considerably more
helpful in the absence of previews. Interestingly, when present together the two signals were of no more aid than when the two were absent. A virtually identical pattern arose in the ANVAR analysis of the same measure and in the ANVAR analysis of the total test measure.

The interpretation of the combined effects of headings and logical connectives holds for the combined effect of previews and logical connectives. Previews are quite similar to headings: although previews generally occur in clauses, they function at the superordinate level and must be conveying messages that are contradictory to the messages logical connectives are conveying.

It is interesting to note that only headings were of sufficient aid to appear as main effects with any frequency, although previews did surface as a main effect once. It seems that no preview/heading interactions occurred because of the similarity of their functions; however, the results imply that headings were more powerful than previews, since headings occurred more often in main effects than previews did. Furthermore, previews and logical connectives, as well as headings and logical connectives, surfaced in many interactions, but frequently these interactions reveal that the individual signals were strongest by themselves. It is logical to assume that previews and headings were both functioning to reveal superordinate content before readers encountered the actual content; hence, they helped readers to construct hierarchical frameworks in memory. On the other hand, logical connectives were not as helpful at the superordinate levels as were headings or previews, yet they do seem to have contributed somewhat at the superordinate level, as well as at the subordinate level.

The results of the individual and generally nonadditive effects for signals are particularly interesting in light of many previous studies' lack of significant findings for signals. It is almost impossible to believe that signals in combination could impede subjects' comprehension, yet it may be that signaling studies (including this one) have incorporated so many signals in the hopes of registering effects that the potential combined effects are obscured. One saving grace of this study is that the signals were tested in a factorial design that allowed their individual and combined effects to be analyzed. In other words, numerous previous studies of headings, previews, and logical connectives might have found significant effects for signals if only one signal type had been added or if the multi-signal additions had been decreased in number.

**Immediate and Delay Effects**

It was hypothesized that certain signals would show strong effects with the delay test as well as with the immediate test. One would expect that signals should help a reader build a hierarchical framework in memory, and an immediate comprehension test would reflect this. In fact, six positive effects were identified for signals' contribution to immediate comprehension. Moreover, if the subjects who had read signaled passages had actually built hierarchical
frameworks, then their comprehension over time should certainly decrease less than the comprehension of subjects who had read nonsignaled passages. This effect would be greatest for headings and previews, since they signal superordinate content, and one would expect superordinate content to fade less quickly from memory than subordinate content (signaled with logical connectives).

Specifically, it was hypothesized that headings might be helpful with delay, even if they did not prove helpful with immediate comprehension. This expectation was based on much of the literature that has failed to find immediate effects for headings [13, 14]. Although many have theorized that headings are more valuable in search and retrieval tasks than in actual comprehension tasks, the current study worked on the assumption that headings might function much like road signs. People frequently pass a road sign without consciously registering it, yet weeks later they may know where some street is located because of the sign they had seen earlier. In other words, headings were minimally expected to help readers to remember content when called upon after a period of time.

Relevant here are the ANVAR within subjects’ analyses that reveal interactions with the test date factor, reflecting differences between the immediate and delay comprehension tests. Three such interactions arose. The two heading/test date factor interactions (inferential superordinate and inferential subordinate measures) that occurred with the Soil passage indicated that headings helped more on the delay test than on the immediate test—in fact, the subjects’ scores had improved with time. Headings, indeed, showed a strong effect with time. The final interaction over time occurred with headings, logical connectives, and the test date factor on the inferential superordinate measure for the Soil passage. Again, headings were more helpful in the delay condition than in the immediate condition; their strength was even greater in the absence of logical connectives.

**Text Difficulty**

The answer to the question—whether readers benefit most from signals in difficult text situations—is still not finally resolved. Both length and reading level can affect a passage’s difficulty. Longer passages appear to be aided by the inclusion of signals more so than short passages. The numerous results for the passages used here (approximately 1,000 words) suggest that readers of relatively long passages do benefit from signaled text. In Spyridakis and Standa’s earlier studies [15, 16], shorter passages (approximately 400–750 words) were used and fewer significant results were noted. In the current study, headings in particular appear to have been extremely helpful in the longer passages.

Another factor of text difficulty concerns reading level. The two texts that were used in this study were chosen to provide different levels of text difficulty:
the Sludge passage had a reading level of grade 14.95 while the Soil passage had a reading level of grade 12.58. It was assumed that the Soil passage would be relatively easy for university freshmen and sophomores and result in few significant findings, while the Sludge passage’s difficulty would result in many significant findings. The results, in fact, indicated exactly the opposite of this expectation: the Soil passage resulted in more significant effects.

A few possible reasons may explain this result. Although the Soil passage was easier than the Sludge passage, as indicated by the Berta-max Readability Estimator [3], perhaps both passages were quite difficult for these students. In actuality, the Soil passage may have been sufficiently difficult to reveal effects for signals, while the Sludge passage may have been so difficult that even signals could not be of consistent aid. Another possible reason lies in the content of these two passages: the Sludge passage describes in detail a mechanical process while the Soil passage describes a human process. Perhaps the subjects, who were unfamiliar with the topic of sludge disposal specifically, did not possess generalizable schemata for mechanical processes that exceeded the simple schemata for problem/solution organizational patterns, thus increasing the difficulty of the passage. In contrast, the subjects may have possessed schemata for human processes that were generalizable and useful in their comprehension of the Soil passage. Or, perhaps readers of the Soil passage perceived the human process of stabilizing soil as more concrete than the mechanical process presented in the Sludge passage. Hence, readers of the Soil passage may have been more able to conjure up images of the ideas presented in the text than readers of the Sludge passage. Thus, it is possible that, although the reading level analysis indicated that the Sludge passage was more difficult than the Soil passage for syntactic and semantic reasons, the Sludge passage may have been even more difficult because of its content.

There can be no final answer to the question at this point. Previous studies have done little to account for the effect of passage difficulty on signaling, and it appears that the present study’s attempts to account for difficulty through readability formulae may be insufficient. Unfortunately, since the real difficulty of the two passages is in question, the results must be examined most specifically across passages, with less emphasis placed on differences between passages. One should note, though, that passage length does seem to correlate positively with the significant effects of signals.

**CONCLUSIONS**

The purpose of the study presented here was to investigate the role of signaling in helping good readers comprehend expository text and to improve the methodology of such studies. The results of this study have proved to be quite informative. The conclusions reached in this study are listed below and suggestions for further research follow.
Passage Selection and Design

1. It appears that having a sample group of potential subjects rank order the familiarity of possible topics for test passages serves as a good method for selecting topics that would be unfamiliar to another sample group from the same population. Such a technique is important in controlling for the potentially confounding effect of topic familiarity; using passages with which subjects are unfamiliar apparently forces readers to rely heavily on textual cues instead of on their prior knowledge.

2. The assessment of passage difficulty by means of readability formulae failed to fully account for differences in difficulty between the Sludge and Soil passages. Assessing passage difficulty is crucial in tests of prose comprehension, yet readability formulae alone may not be a sufficient measure of difficulty.

3. The design of signals and their location, and the four test measures (superordinate, inferential superordinate, subordinate, and inferential subordinate) were successfully based on partitioning the Sludge and Soil passages into idea units and a subsequent three-way rating of the idea units' importance. In fact, the division of the dependent measure into two literal and two inferential measures helped identify the specific effects of different signal types.

Signals in General

1. Good readers in this study found signals beneficial, when they read unfamiliar expository texts. If a topic is unfamiliar to a reader, he or she will rely heavily on textual cues to form a hierarchical framework that can receive incoming textual information.

2. Specifically, signals appeared to aid readers’ ability to retain, retrieve, and make inferences from superordinate information presented in the texts used in this study. The majority of significant findings in this study were for superordinate and inferential superordinate test measures. Signals help readers form in memory hierarchical frameworks which they can use to encode incoming text and from which they can make inferences.

3. All three signal types appeared to improve readers’ immediate comprehension, but headings were of primary importance with delayed comprehension. It is believed that with moderately difficult text, headings provide a reference point that is highly accessible over time.

4. When the text subjects found the Soil text difficult, they depended on signals to encode the text in memory. However, with the exceedingly difficult Sludge passage, even signals did not significantly help comprehension. If a passage is difficult for readers, they will benefit from the inclusion of signals, yet if a passage is simply too difficult, signals may be incapable of providing sufficient help for readers.
Individual Signal Types

1. In this study, headings, previews, and logical connectives functioned better individually than in combination. Headings and previews proved to be more helpful to readers than logical connectives. Headings were frequently significant for literal as well as for inferential comprehension. It appears that, as a rule, headings signaling superordinate content and, on occasion, previews signaling superordinate content and relationships reveal to readers what information they should place in memory. Logical connectives, which function at all content levels, appear to help readers integrate subordinate information with superordinate information. Their subordinate information function, however, seems to undercut the positive effects of headings and previews.

2. Signals, most specifically headings, appear to have benefited readers of relatively long texts.

Further Research Needed

This study leads to the development of a tentative model for signaling effects; this model suggests that with relatively long, unfamiliar, difficult texts, signals will improve even a good reader’s comprehension. However, more research is needed on several aspects of signaling if we are to develop a final model that would explain effects for good comprehenders with relatively long texts, while simultaneously explaining differences in signal types and signaling interactions, familiarity levels, difficulty levels, and rhetorical structures. Although this study helped improve signal research methodology, more needs to be done. Future studies will need to identify text difficulty factors in order to evaluate when signals will and will not be of value for good readers. Studies will need to use many texts to control for specific content in passages; ultimately, if numerous texts at similar difficulty levels on different topics were used, analyses could be collapsed across topics, in order to erase specific content effects. Furthermore, large sample groups will be needed, because prose research can be full of many naturally occurring variables that will be eliminated only by the use of large samples. Although delay testing is of great value with signal research, subject mortality will only be avoided if subjects are rewarded (perhaps monetarily) for their ongoing participation in immediate and delay conditions. Finally, studies will have to use qualitative, as well as quantitative, tests of comprehension and use factorial designs which will allow assessment of signals individually and in combination.

REFERENCES


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