

## Spatial cues in text

Some comments on the paper by Frase & Schwartz (1979)

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Abstract

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Frase and Schwartz (1979) found that meaningfully segmented technical prose was searched significantly faster than the same text typed in a standard format. In this paper the rationale and methodology of Frase and Schwartz are criticised and two studies are described which attempted to replicate and extend their findings using a different methodology. Frase and Schwartz's original materials were used and standard layouts were compared with meaningfully indented texts and vertically spaced texts. In both of these studies, however, no significant differences were found between the times taken to retrieve information from the different layouts. Finally these results and their implications are discussed in a more general framework than that provided by Frase and Schwartz.

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Introduction

Frase and Schwartz (1979) argued and demonstrated that technical prose was searched and understood more quickly when it was "meaningfully segmented" and indented. What they meant by this term is best illustrated by an example. Figure 1a shows a standard layout and Figure 1b shows the same text "meaningfully indented."

Frase and Schwartz reported the results from five experiments in which adult participants verified test sentences as true/false whilst reading a page of complex technical information. They found that meaningfully segmented and indented text resulted in 14-18% faster response times than did text typed in a standard format. Their results indicated that it was the meaningful segmentation that was important; experiment five showed that once a text had been meaningfully segmented, then

the addition of indentation cues did not significantly affect response times.

The purpose of this brief paper is to offer some comments on the paper by Frase and Schwartz. In the main these comments focus on the rationale and the methodology of their experiments. Some possible revisions to both of these are suggested and carried out, and the paper concludes with a more general discussion than that provided by Frase and Schwartz.

However, throughout this paper there are certain conflicting issues which I have been unable to resolve. Basically these amount to three beliefs. These are: (i) a belief, shared with Frase and Schwartz, that the spacing of text is an important aid to comprehension; (ii) a belief, nonetheless, that it is possible to criticise their studies and their findings; and (iii) a belief that my own experiments designed to shed light on these problems (and reported on below) in fact really fail to do so! It would seem then that the issues to be discussed in detail below—spacing, timing, and comprehension, and their interrelationships—are more complex than at first appears.

Frase & Schwartz's rationale

The rationale underlying the Frase and Schwartz study was that learning, comprehending, and recalling prose all involve the segmentation of text into meaningful groups, and that segmenting text makes these groupings clearer to the reader. It was argued that normally printed text does not make these groupings readily apparent: with standard justified text (i.e., straight left- and right-hand edges) line endings indiscriminately interrupt sentences, clauses, phrases, and words (which are hyphenated). It is true that the use of punctuation marks and paragraph indentation can provide cues about meaningful components in text, but, it was argued, standard text does not contain enough of these cues to facilitate the reader's task of segmenting it. This problem, it was observed, was particularly acute with technical materials.

Comments on the use of the term typographical cue

Frase and Schwartz referred to all of these cues as *typographical cues*. Personally I prefer the term *spatial cue*, for the phrase "typographical cue" suggests to me a change in the typography or the print—e.g., a change to

italic or bold-face letters. Segment boundaries in text, however, are mainly conveyed by space and by punctuation marks. Sometimes, of course, spatial and typographic cues are combined (e.g., headings in capitals). Text thus provides cues which can be classified as spatial, typographic, or both.

Comments on the review of related studies

Frase and Schwartz reported how their investigations were prompted both by a practical concern and by a theoretical one. The practical concern was with the difficulties that readers faced in processing technical documents; the theoretical concern was with improving readers' comprehension by manipulating the spatial arrangement of the text. Frase and Schwartz reviewed six studies on this latter issue (North and Jenkins, 1951; Coleman and Hahn, 1966; Anglin and Miller, 1968; Carver, 1970; Cromer, 1970; Hartley and Burnhill, 1976). They concluded that five of these studies indicated a superiority for segmented over standard text.

Other studies not included in their review were those of Coleman and Kim, 1961; Epstein, 1967; and Murray, 1976 (with positive results); those of Nahinsky, 1956; Hartley and Burnhill, 1971; and Burnhill et al., 1975 (with non-significant results); and that of Klare et al., 1957 (a negative result). A further study, which refers to the work of Frase and Schwartz, has indicated that segmenting text improves the reading scores of low-ability children (Mason and Kendall, 1978). Thus, although there is evidence that segmenting—of various kinds—can help the understanding of text, the picture is more complex than that presented by Frase and Schwartz.

In addition, one needs to observe that in reaching their conclusions, Frase and Schwartz pooled the results from experiments which had different aims and which used different kinds of segmentation. Cromer (1970), for instance, was interested in grouping text according to phrase boundaries; Hartley and Burnhill (1971) were interested in ending lines at syntactic boundaries; and Burnhill et al. (1975) and Hartley and Burnhill (1976) were interested in totally re-organising documents in order to display more openly their underlying structure.

Comments on the method of segmenting

Frase and Schwartz tested the effectiveness of their ideas by comparing segmented pages with standard ones. The same wording and punctuation occurred in both formats. The segmented format was produced using the authors' joint judgement of where the meaningful boundaries occurred. Frase and Schwartz claimed that Johnson's (1970) study on pausal units supported their assumption that accomplished readers had sufficient language competence to agree between them where the segments should be made in technical prose. Johnson, in fact, was concerned with "pausal units" in a particular folk-tale, and he himself commented "Levitt (1956) has shown there is little agreement among editors as to what are the sub-units in a prose passage" and "Judgements concerning the meaningfulness of the sub-units have been decidedly subjective in nature."

To test the validity of Frase and Schwartz's assumptions in this respect I asked ten students to segment a technical passage following their inspection and study of one of Frase and Schwartz's passages. The results indicated that the students did indeed segment at phrase boundaries, but that there was great discrepancy between them concerning the width of these boundaries; in short there was not the uniformity suggested by Frase and Schwartz.

For example the sentence, "the balance is a sensitive piece of precision laboratory equipment designed to give accurate readings over a long period of time" was segmented by one student thus:

The balance is

a sensitive piece of precision laboratory equipment  
designed to give accurate readings  
over a long period of time.

by another thus:

The balance is

a sensitive piece of  
precision  
laboratory equipment  
designed to give accurate readings  
over a long period of time.

and by a third thus:

The balance is

a sensitive piece of  
precision laboratory equipment  
designed to give  
accurate readings  
over long periods of time.

## ASSIGNMENT PROCEDURES

1a

Conventional assignment procedures are applied when subscriber service is assigned to a spare physical circuit that is providing a working derived circuit. Additional information related to the derived line is entered in the remarks section of the service order (Figure 3.9). Rearrangement of the cable pairs that include pairs used for single channel carrier circuits should be avoided where possible. Such arrangements require coordination among the engineer of outside plant, assignment office, central office, outside work forces, and repair service bureau to insure that transmission requirements are met. Also, bridge tap restrictions for single channel carrier application may not permit cable pairs to be half-tapped in the central office and/or field location, and may prohibit use of carrier once the outside plant facilities are reconfigured.

## ASSIGNMENT PROCEDURES

1b

Conventional assignment procedures are applied when subscriber service is assigned to a spare physical circuit that is providing a working derived circuit.

Additional information related to the derived line is entered in the remarks section of the service order (Figure 3.9).

Rearrangement of the cable pairs that include pairs used for single channel carrier circuits should be avoided where possible.

Such arrangements require coordination among the engineer of outside plant, assignment office, central office, outside work forces, and repair service bureau

to insure that transmission requirements are met.

Also, bridge tap restrictions for single channel carrier application may not permit

cable pairs to be half-tapped in the central office and/or field location,

and may prohibit use of carrier

once the outside plant facilities are reconfigured.

## ASSIGNMENT PROCEDURES

1c

Conventional assignment procedures are applied when subscriber service is assigned to a spare physical circuit that is providing a working derived circuit.

Additional information related to the derived line is entered in the remarks section of the service order (Figure 3.9).

Rearrangement of the cable pairs that include pairs used for single channel carrier circuits should be avoided where possible.

Such arrangements require coordination among the engineer of outside plant, assignment office, central office, outside work forces, and repair service bureau to insure that transmission requirements are met.

Also, bridge tap restrictions for single channel carrier application may not permit cable pairs to be half-tapped in the central office and/or field location, and may prohibit use of carrier once the outside plant facilities are reconfigured.

**Figure 1a.** *One of the passages used in the standard layout. (The original was in pica sized type.)*

**Figure 1b.** *The same passage "meaningfully indented" by Frase & Schwartz. (The original was in pica sized type.)*

**Figure 1c.** *The same passage spaced according to the procedures advocated by Hartley and Burnhill. (The original was in pica sized type.)*

This problem of segmenting text is of particular interest to me. Peter Burnhill and I have proposed a different and (in our view) simpler way of spatially organising text which is structurally complex (see, e.g., Burnhill, 1970; Hartley, 1978, 1980a, b). With this approach one is not so much concerned with the segmentation of the phrases and clauses as with the overall structure of the document.

Peter Burnhill and I have argued that the structure of text can be displayed to a reader by varying in proportion the amount of vertical space between units in the text. Line endings can be determined by syntactic boundaries, but indentation is only used as a device for conveying substructure when the text has several levels in its hierarchical structure (see, e.g., Hartley and Burnhill, 1976). To be brief, the approach that we advocate would produce quite different layouts from the one advocated by Frase and Schwartz (see Figure 1c). The question thus arises of how these methods would compare.

Methodological considerations in designing subsequent studies

In carrying out experiments to make such comparisons experimenters make certain decisions about how best to proceed—about what to include and what to omit. In order to appreciate the decisions made concerning the experiments to be reported below it is first necessary to consider in more detail the methodology and approach of Frase and Schwartz.

The basic procedure used in the five experiments was for the experimenter to hand (through a window) a sentence to a participant, who then indicated to the experimenter when he or she had read and understood it. The participant was then given a copy of a passage (in the segmented or standard format) and he or she had to judge whether the original sentence was true or false. The time taken from the presentation of the passage to the judgement "true/false" was recorded by the experimenter. (Both the sentence to be verified and the passage were available to the participant during this time.)

There were eight sentences (half true and half false) for each passage and half of the judgements were made on segmented passages and half on standard ones. Two short passages (and sixteen questions) were used initially for practice and these were followed by the five experimental passages. Although Frase and Schwartz (1979) do not specifically say so in their paper, the participants were given feedback about the accuracy of their judgements with the practice passages to establish a criterion of over ninety percent correct (Frase, personal communication).

An experimental session thus consisted of forty judgements from each participant, and the orders of questioning, the passages and their layout were all counter-balanced. The participants were volunteer college graduate

A critique of the Frase and Schwartz methodology

technical aides in Experiment 1 (N=8) and paid college summer school students in Experiments 2, 3, 4, and 5 (N=16 in each case).

This experimental design seems to have at least one limitation. Each participant studied each passage in the two formats, and consequently could not fail to have some idea about the purpose of the experiment. Furthermore, of course, the experimenter also knew the aim of the investigations. The data obtained were time measures, and, although the average time to verify each sentence was 25 seconds, the average difference between the experimental and control passages in the five studies was only 3.5 seconds. In short, precise timing was necessary for a large number of judgements in a situation where both the experimenter and the participants would have a clear idea what to expect.

Consequent decisions

In order to get over these difficulties I decided to see if I could reproduce Frase and Schwartz's findings under different conditions. The main changes made in the experiments to be reported were that each participant would see only one layout of the passages (standard or segmented) and that he/she would be timed answering all eight questions together (rather than separately). This procedure, it was felt would (i) give the experiment greater ecological validity, (ii) reduce the possibility of cumulating errors that might arise from fine timing, and (iii) provide a more stringent test of the general hypothesis.

A third condition would also be included. In this condition participants would study the same passages set in the layout advocated by Hartley (1978). In practice this involved typing out the material in the standard way *either*, for lengthy texts, providing a line space (without indentation) between each sentence within a paragraph and two line spaces (without indentation) between paragraphs, *or*, for passages comprised of one sentence paragraphs, providing a line space (without indentation) between the paragraphs (see Figure 1c).

A summary of the differences between the methods

To summarise: Frase and Schwartz recorded how long subjects looked at a text in order to verify a *single* sentence. The subjects had read and understood this sentence *before exposure to the text*. They knew they had to be accurate. In

the experiments described below the experimenter recorded how long subjects looked at a text and verified *all eight* sentences. This time *included* the time needed to read and understand the sentences. Again the subjects knew they had to be accurate. The aim of these experiments was (i) to see if Frase and Schwartz's results could be replicated with this different methodology, and (ii) to see how vertically spaced text would compare with meaningfully indented text in these conditions.

Experiment 1.  
Methodological details

*Materials.* Three of Frase and Schwartz's five passages were selected for use in this experiment. These were entitled Assignment Procedures, Observing Procedures, and Equipment Changes. These passages included the ones that produced the highest and the lowest differences in the original Frase and Schwartz study. Each passage was prepared in three versions: standard, meaningfully segmented, and vertically spaced. Details of these passages are given in Table I.

**Table I.** Characteristics of the experimental passages

	Assignment Procedures	Observing Procedures	Equipment Changes
Number of words	127	279	166
Number of sentences	5	11	7
Average word length (syllables)	1.96	1.55	1.52
Average sentence length	25.40	25.40	23.70
Estimated Grade Level <sup>1</sup>	13.50	10.00	9.60
Number of lines in standard format	15	26	20
Number of lines in segmented format	29	43	42
Number of line feed units in vertically spaced format	26	52	37
Mean time to verify sentences (seconds)			
In standard format <sup>2</sup>	26.43	38.82	24.78
In segmented format <sup>2</sup>	20.86	31.76	23.10
Approximate % reduction	21%	18%	7%

1. Based on Flesch (1949) reading ease score

2. Based on data presented by Frase and Schwartz (Experiments 1 and 2)

For each passage eight sentences were typed out on a single sheet of paper followed by the words true/false. These sentences were the same as the ones used by Frase and Schwartz.

Two practice passages (somewhat shorter than the experimental ones) were prepared in each layout, and each passage was followed by eight sentences for verification. These practice passages and sentences were the same as those used for practice by Frase and Schwartz.

*Participants.* The participants were fifty-four paid American undergraduate college students (nine men and nine women in each condition).

*Procedure.* Each student was tested individually. The nature of the task (read the passages and decide whether each sentence is true or false) was explained and the first two passages were done for practice. An emphasis was made on being accurate; the instructions were, "Take as long as you like: aim to get the questions right," but subjects were not given feedback about their performance. The practice passages were always presented in the same order; the order of the remaining three experimental passages was counterbalanced. All the passages for a particular participant were in the same format.

The results

*Accuracy.* The mean proportion of sentences verified correctly was 0.83 for the standard text, 0.85 for the meaningfully indented, and 0.84 for the vertically spaced passages. These figures are somewhat lower than those obtained by Frase and Schwartz (0.90 and over).

*Response times.* The response times data are shown in Table II. These data were analysed by a three-way analysis of variance: layouts x passages x sex.

The overall mean time to respond to the standard text was 14.7 minutes (s.d. 5.0), to the meaningfully segmented text it was 12.3 minutes (s.d. 3.4), and to the vertically spaced text it was 12.8 minutes (s.d. 3.1). These differences were not statistically significant  $F(2,96) = 1.79, p < 0.18$ . The main effect for the passages was significant,  $F(2,96) = 40.68, p < .001$ . There were no significant sex differences, nor were there any significant interactions between the three main effects.

Experiment 2

Experiment 2 was a replication of Experiment 1, with thirty-six British paid undergraduate students as participants (six men and six women in each condition). In this experiment the students were instructed to read through the passages first before verifying the sentences.

**Table II.** The means and standard deviations of the verification times and the average proportion correct (in italics). U.S. data: 9 men and 9 women in each condition.

		Passages				All Participants
		A	O	E	Total	
Standard text	Men	$\bar{x}$	4.7	5.7	5.2	15.6
		s.d.	2.4	2.2	1.9	6.2
			<i>0.78</i>	<i>0.71</i>	<i>0.92</i>	<i>0.80</i>
	Women	$\bar{x}$	4.1	5.5	4.3	13.9
		s.d.	1.2	1.5	1.1	3.3
			<i>0.88</i>	<i>0.80</i>	<i>0.89</i>	<i>0.85</i>
					14.7	
					5.0	
					<i>0.83</i>	
Meaningfully indented text	Men	$\bar{x}$	3.9	4.6	3.9	12.4
		s.d.	1.3	1.5	1.9	4.3
			<i>0.79</i>	<i>0.83</i>	<i>0.89</i>	<i>0.84</i>
	Women	$\bar{x}$	3.8	4.8	3.5	12.1
		s.d.	0.8	1.2	0.6	2.2
			<i>0.83</i>	<i>0.79</i>	<i>0.92</i>	<i>0.85</i>
					12.3	
					3.4	
					<i>0.85</i>	
Vertically spaced text	Men	$\bar{x}$	3.5	5.3	3.9	12.7
		s.d.	0.8	1.8	1.3	3.6
			<i>0.78</i>	<i>0.72</i>	<i>0.86</i>	<i>0.79</i>
	Women	$\bar{x}$	3.5	5.4	4.0	12.8
		s.d.	0.8	1.1	0.8	2.5
			<i>0.89</i>	<i>0.82</i>	<i>0.92</i>	<i>0.88</i>
					12.8	
					3.1	
					<i>0.84</i>	

The results

*Accuracy.* The mean proportion of sentences verified correctly was 0.89 for the standard text, 0.93 for the meaningfully indented, and 0.88 for the vertically spaced passages. These figures are similar to those reported by Frase and Schwartz (0.90 and over).

**Table III.** The means and standard deviations of the verification times and the average proportion correct (in italics). U.K. data: 6 men and 6 women in each condition.

		Passages				All Participants
		A	O	E	Total	
Standard text	Men	$\bar{x}$	5.0	7.2	6.0	18.2
		s.d.	1.6	0.9	1.5	3.4
			<i>0.85</i>	<i>0.81</i>	<i>0.96</i>	<i>0.88</i>
	Women	$\bar{x}$	4.9	6.7	5.2	16.8
		s.d.	1.5	1.8	1.4	4.7
			<i>0.90</i>	<i>0.81</i>	<i>1.00</i>	<i>0.90</i>
					17.5	
					4.1	
					<i>0.89</i>	
Meaningfully indented text	Men	$\bar{x}$	5.2	7.2	5.1	17.5
		s.d.	1.9	2.9	2.1	6.9
			<i>0.94</i>	<i>0.85</i>	<i>0.96</i>	<i>0.92</i>
	Women	$\bar{x}$	6.0	7.1	5.8	18.9
		s.d.	0.6	1.5	0.9	2.8
			<i>0.96</i>	<i>0.90</i>	<i>0.96</i>	<i>0.94</i>
					18.1	
					5.3	
					<i>0.93</i>	
Vertically spaced text	Men	$\bar{x}$	4.8	6.5	4.1	15.3
		s.d.	1.0	1.6	0.7	2.9
			<i>0.83</i>	<i>0.83</i>	<i>0.91</i>	<i>0.86</i>
	Women	$\bar{x}$	4.5	5.6	4.5	14.6
		s.d.	0.8	0.7	0.4	0.9
			<i>0.83</i>	<i>0.90</i>	<i>0.94</i>	<i>0.89</i>
					15.0	
					2.2	
					<i>0.88</i>	

*Response times.* The response times data are shown in Table III. The mean time to respond to the standard text was 17.5 minutes (s.d. 4.1), to the meaningfully indented text it was 18.2 minutes (s.d. 5.3), and to the vertically spaced text it was 15.0 minutes (s.d. 2.2). These differences were not statistically significant  $F(2,60) = 1.77$   $p < 0.19$ . The main effect for the passages was significant,  $F(2,60) = 51.20$   $p < .001$ . There were no significant sex differences nor any significant interactions between the three main effects.

Comments on the findings

The main results of Experiments 1 and 2 were clearcut:

- (i) The students verified most of the sentences correctly: the average proportion correct was 0.84 in Experiment 1 and 0.90 in Experiment 2.
- (ii) There were no significant differences between the times taken to verify the sentences in the different layouts in either experiment.
- (iii) There were no significant sex differences in the results.
- (iv) The only significant results to be found in these experiments resulted from the use of different passages. In both experiments the sentences from the passage "Equipment Changes" were easiest to verify and the length of the passages affected the total verification times.

Curious readers may ask if other comparisons were carried out. The answer is yes—the data were adjusted for passage length and difficulty (based on the verification scores), the results from the two experiments were standardised and combined, log transformations were made—but none of these measures changed the substance of these conclusions.

Despite this, however, both experiments suggest that spacing of some sort had some effect. In Experiment 1 segmenting the text led to a 15% improvement over the standard text, and spacing to a 14% improvement. In Experiment 2, spacing similarly led to a 14% improvement. And, curiously enough, despite the non-significant  $F$  ratios, a simple  $t$  test between the segmented and the standard text in Experiment 1 was just significant ( $t = 1.66$ , d.f. 34,  $p < .05$ , one-tail), and in Experiment 2 a  $t$  test between the spaced and the standard text was, similarly, just significant ( $t = 1.78$ , d.f. 16.68,  $p <$

$.05$ , one-tail). In short, these data do suggest that the effects of spacing are present but the statistical support for reaching such a conclusion is weak.

To summarise the argument so far: In this paper I have expressed two objections to the Frase and Schwartz paper: I have criticised their method of segmenting text, and their experimental design. In my own experiments I have used their materials but I have changed the design. The between-subjects design used in my experiments may have been a better design than that used by Frase and Schwartz in that the participants were unaware of what the experiment was actually about, but unfortunately, unlike Frase and Schwartz's design, it was not sensitive enough to indicate significant differences between the layouts. The results obtained do little to clarify the debate between different forms of spacing and, of course, must remain specific to the materials and questions used.

It could be that increasing the sample sizes in my studies might have resolved this issue, but there are probably other factors too. Stressing accuracy (as opposed to speed) may have contributed to the fact that the layouts made little difference (although it is important to note that Frase and Schwartz did this also). Furthermore, the procedural differences in the instructions, the task, and the timing may all have made different demands on comprehension in my experiment from those in Frase and Schwartz's. Their experiments simulated a situation in which a person comes to a passage with a question in mind and looks for the answer; my experiments simulated a more typical instructional situation.

Concluding comments: the need for a wider focus

In rounding off this paper, we need to consider wider issues. In particular we need to think more carefully about how different systems of spacing might aid retrieval and comprehension and where they might not.

Frase and Schwartz's rationale was that the way to make technical text easier to comprehend was to segment it, or to space it out in some way. I tacitly shared this rationale in designing the experiments reported in this paper, but it is not one to which I fully subscribe. I have argued elsewhere (Hartley, 1980a) that when a piece of original text is hierarchically spaced and "opened-up," then it is easier to

re-sequence it, to revise it, and to *re-write* it in such a way as to make it easier to understand. In short, one must pay attention to the *content* and the *purpose* of a document—as well as to its layout—in deciding how best it can be presented.

Furthermore, a wider consideration of other methods of spacing (not referred to by Frase and Schwartz) might suggest:

- (i) that their method is suitable for short, complex technical passages which are frequently searched;
  - (ii) that my method is suitable for longer text which has a more complex structure than conventional prose, but which is less technical than the materials used by Frase and Schwartz;
  - (iii) similarly, that Jewett's method (Jewett, 1972a and 1972b) is suitable for longer and typographically less complex passages which have clear levels of material (e.g., main points, expansions and illustrations of these points, and incidental information); and
  - (iv) that Murray's (1976) method could be considered for material which is to be learned by heart.
- (All of these four methods are illustrated in Hartley, 1980b.)

In addition it may be observed that my method is likely to be easier for typists and printers than the others, and also that, unlike the others, my approach takes into account the positioning of sub-elements (such as lists, tables, diagrams, technical drawings, and the like) within the total system (see Hartley, 1978; Burnhill, Hartley and Young, 1976).

Considerations such as these suggest that what is required is a comprehensive study involving different kinds of reading tasks (e.g., verification, search, comprehension, or application) and different layouts for different kinds of text. No doubt such a study would be difficult to do—but it would seem useful to begin to think about moving in that direction.

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