The Woolly Jumper: Typographic Problems of Concurrency in Information Display

T. R. G. Green and S. J. Payne

The well-documented use of typographical cues to illuminate instructional text has in the past been limited to illustrating *containment* relations (sections within chapters or subsections within sections) and *succession* relations (after one chapter we come to the next). No other relations have been studied. Powerful though containment and succession are, other relations also exist, and in particular the rise of information technology will make it increasingly necessary to document the relation of concurrency. As it happens, descriptions of simple concurrent processes are already found in knitting patterns, so our suggestions for typographic expression of concurrency are worked out on a fragment of knitting to give a domestic and readily-grasped example.

There is plenty of evidence that well-designed typography improves the quality of instructional texts. Hartley (1978) cites studies showing that both comprehension and recall can be significantly improved by redesigned layouts, utilizing spatial cues and typographical cues to bring out the sense. Figure 1 shows an example of Hartley's suggestions: he argues 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. In highly technical text new sentences start on fresh lines, or are even separated by a line-space (as in Figure 1). In less technical text, paragraphs are separated by one line, sections by two, chapters by four. The endings of lines should coincide as far as possible with syntactic boundaries, rather than coming haphazardly at any point in the syntactic structure and sometimes even breaking up words which then have to be hyphenated. In Hartley's "vertical spacing" scheme, horizontal spacing is not used unless the structure of the document has so many levels that the vertical separations become excessive.

As Hartley himself points out, this is only one scheme among several which have the same aim of displaying structure for the reader's help. Frase and Schwartz (1979) carry the approach much farther, using different levels of "meaningful indentation" to display different levels in the hierarchy of phrase and clause. As Figure 2 shows, the result is very different from Hartley's.

Each system has pros and cons — for instance, "meaningful indentation" works well enough on a single page, but page turns make for

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ASSIGNMENT PROCEDURES

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 ensure 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.

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Figure 1. Top, a passage of technical material in original layout. Bottom, the same passage spaced according to the procedures of Hartley (1978) and Burnhill (1970). The passage comes from Frase & Schwartz (1979).

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```

Figure 2. The same passage as in Figure 1, laid out using the "meaningful indentation" procedure (from Frase & Schwartz 1979).

problems when many indentation levels are used. Is the first line of the new page seven deep or only six?

Despite the difference in approach, both examples start from the same rationale: that learning, comprehending, and recalling prose all involve the segmentation of text into meaningful groups, and that the groupings can be made clearer to the reader by spatial means. Normally printed text, in contrast, does not make these groups readily apparent, and the problem is particularly acute with technical materials. This rationale is very convincing. The purpose of the present paper is not to quibble with it, but to ask whether we can extend it.

Relations and Representations

The schemes illustrated above are different ways to map the relations of *containment* and *succession* into spatial layout. In Hartley's scheme, chapters contain sections, sections contain paragraphs, paragraphs contain sentences. These units are separated by vertical space, indicating the level of containment. Within each level, objects occur in succession — chapter 1 is followed by chapter 2, etc. The Frase and Schwartz scheme maps the same relations, containment and succession, in a different way. In their scheme the objects are much lower-level, phrases and clauses rather than chapters and paragraphs, and the spatial cues are different: containment relations are shown by indenting, and succession is shown by vertical spacing.

Containment and succession are very powerful relations, and many types of structure can be summarized with no additional concepts. A still more general concept can be obtained by adding trivial extensions to indicate elements that can be repeated or can be omitted. This allows us to describe the structure of not just one book, but any book. For instance, *The King's English* (Fowler & Fowler, 1906) is a book consisting of a head and a body, with a preface and a contents list contained in the head. The body contains two parts, with four chapters in the first part, and so on. This gives us the following structure:

The King's English:
  HEAD:
    preface
    contents list
  BODY:
    part 1:
      chapter 1
      chapter 2
      chapter 3
      chapter 4   etc.

But the generalized book can also be defined, and it would look somewhat like this:

BOOK:
  HEAD:
    PREFACE (optional)
    INTRODUCTION (optional)
    CONTENTS LIST (optional)
  BODY:
    PART: (repeatable)
      CHAPTER (repeatable)
  TAIL:
    INDEX (optional)

This is not truly a description of the generalized book, containing no reference to different volumes, possible appendices, new prefaces to later editions, etc.; but it will describe a very large number of textbooks.

This style of presentation can be regarded as a grammar. It states that a book is a head followed by a body followed by a tail. A head may contain any or all of preface, introduction, and contents list. A body contains at least one part, maybe several, each containing at least one chapter. A tail may contain an index. So the sequences:

Preface — Part 1: Chapter 1 to 3: Chapters 4 to 7 — Index
Introduction — Contents List — Part 1: Chapters 1 to 10

would be "legal sentences" of the "language." Our textbook grammar is an example of a *context-free-phrase-structure grammar*, whose mathematical properties are now well understood (Gross and Lentin, 1970). Many other systems can be described in the same way, such as school algebra. For algebra we choose to represent succession and containment using brackets rather than indenting; but we could equally well write:

(x + 1) / ([x + 2] × 3)

as

```
x + 1
             /
x + 2
         ×
3
```

Equally well from a logical point of view, that is. From a psychological viewpoint it is very doubtful that the two versions would be equivalent.

The rationale proposed by Hartley and others can now be rephrased in rather more grandiose terms as follows. Instructional texts can be described as context-free phrase-structure grammars, as can many other structures. Mapping the relationships within the grammar into spatial layout will display the structure more clearly to the reader, and will make the text easier to comprehend, learn, and recall. The choice of a particular mapping (such as Hartley's or Frase and Schwartz's) may prove better or worse for readers but it does not alter the fundamental logic of the system.

Concurrency

Our contention is that although the rationale is excellent as far as it goes, it needs to be extended. Some textual material, as we shall demonstrate, cannot be represented as a phrase-structure, so the argument falls over the first hurdle. The material we have in mind is that which is required to illuminate two or more *concurrent* processes — processes which are executed at the same time.

Sometimes concurrent processes are actually carried out simultaneously, but most of the time this is a clever illusion created by scheduling and interleaving. When a team of chefs prepare a dinner, each one preparing one part of the meal independently, the processing is parallel; but when one cook prepares all the dishes, moving swiftly from pot to pan, the processing is concurrent but not truly parallel.

In many circumstances concurrent processes can be presented with little strain on the notation — users can be left to work out the concur-rency relation for themselves. In a cookery book, for example, each recipe instructs the cook to perform a sequence of steps in the order given. However, the cook prepares a meal by interleaving a number of recipes, arranging matters so that all processes for the main course terminate at approximately the same instant and the potatoes do not have to wait too long for the sausages. In doing so the cook neatly models the scheduler in a computer system, keeping track of the various concurrent processes, turning to one when it needs attention and then to another. At some point all these semi-independent processes meet in a "rendezvous" (a term now taken into the fold of technicality with its use in the programming language Ada; see Pyle, 1981). At the rendezvous point each process waits for the others until all have reached it, and the meal is then ready. During preparation there may be other rendezvous points, for instance the sauce may be ready before the fish, and it is put aside until the fish is ready too.

It is no accident that our introduction to concurrency has borrowed terminology from computer science. We expect that the problems of displaying concurrency in instructional texts will become increasingly common, primarily due to the actions of computers. As the information technology revolution spreads silicon into home and office, the problems of documenting and understanding continually more intelligent devices will tax the resources of technical writers. The complexity of digital watches, for example, is already impressive; and some models with "dual time," "chronograph," and "lap time" features already perform several types of timekeeping simultaneously. A modified finite state diagram of one such device is shown in Figure 3. Clearly the advanced features of the device, including concurrent processing, force complexity into the descriptive notation.

The Woolly Jumper

One type of technical material already contains descriptions of concurrent processes as a matter of routine: the knitting pattern. The authors have collected anecdotal evidence which suggests that knitting patterns are not as clear as they could be. Some knitters, for example, require the pat-

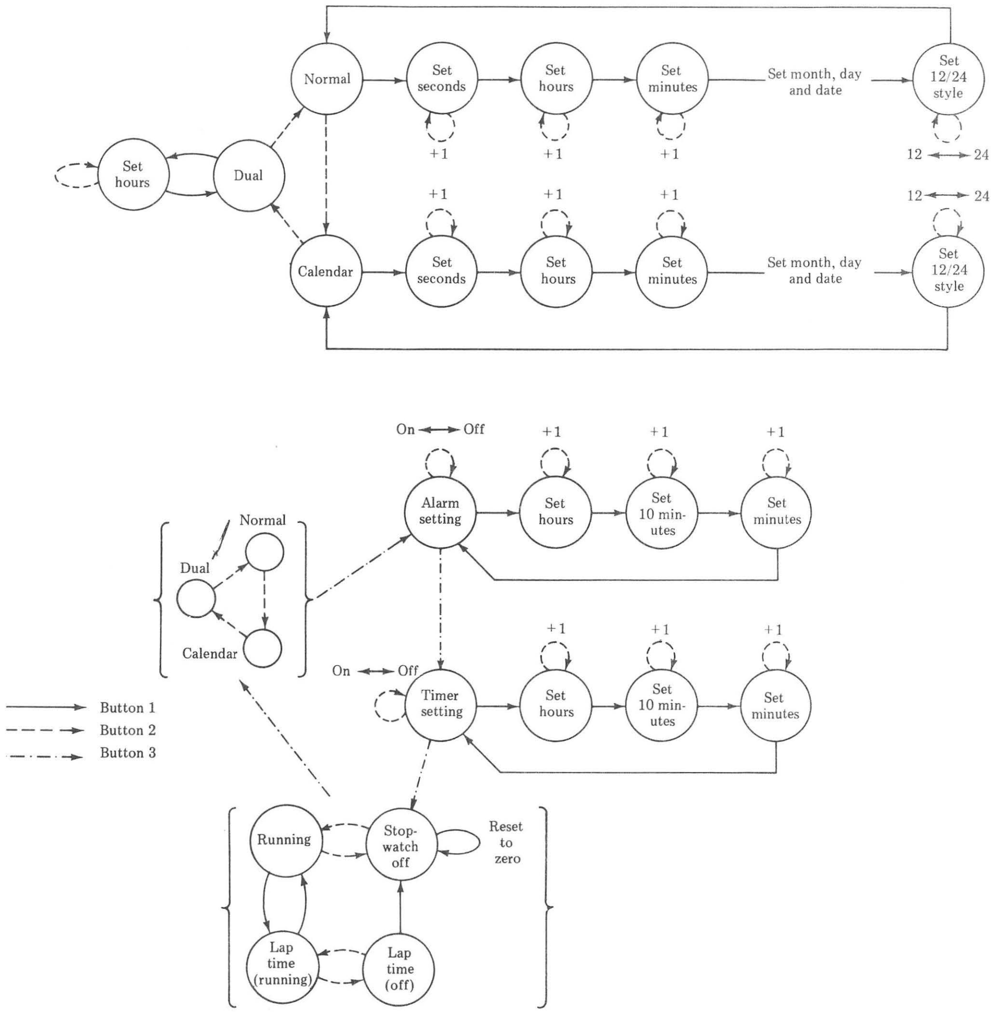


Figure 3. The increasing complexity of digital watches already gives problems. In this diagram the conventional state-transition notation would make it necessary to draw many more states; instead, a new convention has been introduced that braces mean "any of." Thus braces round the (duplicate) trio of dual, normal, and calendar states mean that button 3 will lead from any of those into the alarm-setting state; and button 3 will also lead from any of the four stopwatch states in braces back to whichever of dual, normal, or calendar states was earlier in force (from Green, 1982).

terns to be translated into an audio-notation: one lady described the joys of reading aloud (stitch by stitch) to grandmother; a second championed the use of a tape recorder. None of the experts we talked to boasted an understanding of knitting patterns sufficient to develop some picture of a garment from its pattern; yet an equivalent task is performed regularly by experts in other domains, musicians for example. Finally, none of our knitters could recover from small mistakes by making a corresponding adjustment elsewhere in the garment. Knitters, it seems, habitually unpick to the point where the error was made. As a foretaste of the problems, let us try decomposing a fragment or two, isolating the relations of containment, succession, and concurrency.

At present, knitting patterns are usually printed in a highly abbreviated style. Some publishers make use of typographical and spatial cues, while others restrict themselves to a uniform typeface and a spatially compact layout, giving the reader very little assistance in discerning the segmentation. Figure 4 is a fairly typical example. Here we have a structure which has several levels, not all of which are evident at first glance to untutored eyes. (Indeed, the entire notation of knitting may be obscure at first sight, and the authors thank the native speakers who acted as their informants). In Figure 5 the principles of "meaningful indentation" have been applied to segment the structure into its containment and succession relationships.

BACK. Cast on 65 (69-73-77) sts. and work in rib.
1st row. - right side K.2, * p.1,k.1; rep. from * to last st., k.1.
2nd row. K.1, * p.1,k.1; rep. from * to end. Rep. these 2 rows twice more. Now work in patt. with rib borders as follows:
1st row. K.2, p.1,k.1,p.1, k. to last 5 sts., p.1, k.1, p.1, k.2.
2nd row. [K.1,p.1] twice, k.1, p. to last 5 sts., [k.1,p.1] twice, k.1.
3rd row. Rib 5, * k.2 tog.; rep. from * to last 4 sts., k.1, p.1, k.2.
4th row. [K.1,p.1] twice, k.1, * k.loop, k.1; rep. from * to last 4 sts., rib 4. These 4 rows form one patt. Cont. in patt. without shaping until work measures approx. 63 (63-64-64) cm. from beg., ending with a 4th patt. row.

Figure 4. Fragment of a knitting pattern. Abbreviations: k = knit, p = purl, st. = stitch, sts. = stitches, patt. = pattern, rep. = repeat, tog. = together. The asterisk is used to delimit the scope of a repetition instruction (from pattern 7328, booklet 244, 3 Suisses, 1980).

The sheer size of a knitting pattern presented in the style of Figure 5 should make us pause; but a considerable reduction could be made by putting some instructions on the same line, even though that is against the spirit of the indentation principle. In any case, this is a problem which will be more extreme with knitting, with its very terse commands, than in other technical material. Otherwise, however, this is a very successful exercise, and the structure of the original pattern has very readily allowed itself to be recast in a different form.

Now consider this fragment:

> Now decrease 1 stitch at armhole edge on next 4 rows, then decrease 1 stitch at same edge on the next 5 alternate rows, but at the same time decrease 1 stitch at front edge of next row and every following 4th row until 11 decreases have been completed at front edge, after which decrease 1 stitch at front edge on every 3rd row until 36 stitches remain.

The most obvious point is that two processes are to proceed concurrently, the shaping of the armhole and the shaping of the neck. The scheduler (who is in this case the knitter, of course) must interleave them satisfactorily. As so often happens in plain English, Ambiguity makes an appearance: where does the phrase "at the same time" start operating, at the beginning, "Now decrease . . .," or at the phrase "then decrease . . ."? Probably the latter.

BACK:

```
Cast on (differing numbers
        of stitches for
        different sizes
Edge: (do 3 times)
  1:
    k. 2
    repeat until last st.:
      p. 1
      k. 1
    k. 1
  2:
    k. 1
    repeat to end:
      p. 1
      k. 1

Pattern: (repeat until
         work measures
         enough cms.)
  1:
    k. 2
    p. 1
    k. 1
    p. 1
    repeat to last 5 sts.:
      k.
    p. 1
    k. 1
    p. 1
    k. 2
  2:
    do twice:
      k. 1
      p. 1
    k. 1
    repeat to last 5 sts.:
      p.
    do twice:
      k. 1
      p. 1
    k. 1
  3:
  .............
```

Figure 5. Part of the pattern in Figure 3 presented using "meaningful indentation."

(Main part of pattern)

....

....

FORK

ARMHOLE	NECK
4 times:	4 times:
decrease 1 row	don't decrease
——— *rendezvous* ———	
5 times:	11 times:
decrease 1	decrease 1
don't decrease	3 times:
until rendezvous:	don't decrease
don't decrease	until **36** stitches left:
	decrease 1
	do 2 times:
	don't decrease
——— *rendezvous* ———	

JOIN

....

....

(Rest of pattern)

Figure 6. One approach to the presentation of concurrent processes.

What aids to the reader can we muster?

One possibility that we do *not* want to consider is writing out all the decreasings in full. Not only would that use a lot of paper, but also it would destroy the designer's achievement of separating the two processes, which is part of the segmentation we want to display. The effect would be like this:

> Now decrease 1 stitch at armhole edge on next 4 rows, then decrease on both edges on next row. Don't decrease on either edge on the next row, then decrease on armhole edge alone on the next row. Don't decrease on either edge on next row (and so on).

Although this might look bearable with an effort, even a slight increase in the complexity of the processes to be interleaved would make it totally obscure. It would become virtually impossible to separate one process from the other.

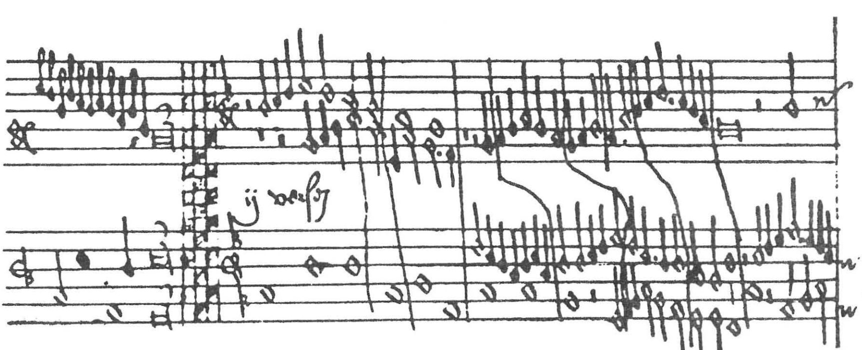
Figure 6 shows another possibility. In this arrangement we have separated the two processes, "armhole" and "neck," showing where they fork and join. Each process has been presented using the conventions of "meaningful indentation," because they feel better here, but any other conventions could equally well be used. It is not possible to maintain a precise horizontal alignment, row for row, of the two processes because they have differing control structures; but we have marked two alignment points with a "rendezvous" cue. This is meant to help the user perceive some of the temporal structure relating the concurrent processes, and to check on their relative progress. Thus our notation not only displays *concurrency* but also displays *synchronicity* where appropriate.

Alignment points can also be used as part of the control structure. The first rendezvous point in Figure 5 is present so that the user can check that both processes have reached the required stage. The second rendezvous point is part of the control structure, being used by the armhole process for the instruction "keep idling until the other process has reached the rendezvous, and then go on with the next instruction."

The evidence cited by Hartley (1980) shows that the various forms of spatial cues to structure have empirically demonstrable results. There are now a large number of studies reported dealing with various possibilities and their effects. But this literature deals exclusively with the relations of containment and succession; there is no corresponding body dealing with the notation of concurrency.

The closet approach is the consideration of conventional musical notation (Sloboda, 1981). In parallel score arrangements two or more concurrent processes are presented (e.g., the left-hand and right-hand parts of piano

Figure 7. From a keyboard manuscript. London, 1540 (from Sloboda, 1981).



music). The music is arranged so that correspondences in time are matched by correspondences in space, and Sloboda describes the layout as "orthochronic." Even experienced performers still benefit from cues to synchronization, such as vertical alignment of bar lines in the separate parts. (cf. Figure 7 showing a splendid manuscript, c.1540, written before standard bar lines were introduced).

It would be particularly useful to collect evidence on the cueing of concurrency. In doing so the usual measures should, of course, be taken in the usual tasks, such as those of comprehension, learning, and recall, mentioned above; but it is clearly desirable to shape some of the experimental tasks explicity towards the problem of concurrent processes. What will the state of process A be when process B does such and such? Can their actions be scheduled successfully, either by executing them "for real" or else in the head? Can it be seen whether one process reaches a particular point before the other process reaches some other point? In the case of knitting, problems also arise about modifying the processes; if one side has gone wrong in a specified way, can the knitter see how to modify the other side? For instance, suppose the back shaping came out a row too short, is it possible to subtract one row from the operation of the front shaping without disaster, or must the back be unpicked?

In our suggestion for the representation of concurrency we have chosen to show only the fork and the rendezvous. Is this sufficient? Maybe empirical tests against genuine tasks will reveal that more must be shown, such as the transmission of information from one process to another when it takes place; or perhaps the particular representation we have chosen will be shown to be inadequate. We would like to see improvements to our suggestion, and we would like to see them empirically tested; and — however important the woolly jumper may be to the British way of life — we would particularly like to see tests against fullsize technical material, rather than isolated fragments of knitting patterns.

References

Burnhill, P. (1970). Typographic education: headings in text. *Journal of Typographic Research* (now *Visible Language), 4*, 353-365.

Fowler, H. W., and Fowler, F. G. (1906). *The King's English*. London: Oxford University Press.

Frase, L., and Schwartz, B. J. (1979). Typographical cues that facilitate comprehension. *Journal of Educational Psychology, 71*, 197-206.

Green, T. R. G. (1982). Pictures of programs and other processes, or how to do things with lines. *Behaviour and Information Technology, 1*, 3-36.

Gross, M., and Lenting, A. (1970). *Introduction to Formal Grammars.* London: George Allen & Unwin Ltd.

Hartley, J. (1978). *Designing Instructional Text.* London: Kegan Paul.

Hartley, J. (1980). Spatial cues in text. *Visible Language, 14*, 62-79.

Pyle, I. C. (1981). *The programming language Ada.* New York: Prentice Hall.

Sloboda, J. (1981). Space in music notation. *Visible Language, 15*, 86-110.

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