# The Psychology of Layout:
# Consequences of the Visual Structure of Documents

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## Abstract

Using examples of implemented layout decisions, and from performance-based research on the effects that layout has on readers this paper proposes seven reasons why the layout of documents is important. These reasons range from economic to psychological. The importance of specific layout features will often differ for those generating documents from an information resource and for those seeking to capture existing documents. Many layout problems arise when documents are transferred across media (e.g. print to computer monitor to Personal Digital Assistant). The present discussion emphasises the value of maintaining a functional equivalence of layout features (e.g. visual grouping) rather than preserving formal identity (e.g. spacing). A prerequisite for doing this is an understanding of how layout features influence reading activities. It is suggested that although there are gaps in our knowledge of readers' search and decision-making processes it would nevertheless be possible to devise a simulated reader that responded to layout features , such as the relation between text and graphics, in the way that most readers will. This would be a useful tool for maintaining functional equivalence when documents are moved across media.

## PURPOSE

This paper discusses seven reasons why layout matters: identification, effort, economy, willingness to read, readers' assumptions, reading strategies, cognitive costs. These seven are not intended to be exhaustive but rather to illustrate the range of consequences that decisions about layout can have. During this discussion two other themes will be explored. One concerns the level of abstraction at which it is useful to characterise layout features. For example, the relative size of headings and subheadings may be more critical than their absolute size. Similarly the relation of headings to the logical structure of the document may sometimes be more critical than their physical relation to the page. The other theme concerns the implications of characterising layout in such a way that it enables documents to be transferred across presentation media,

e.g. from print to desktop screen to handheld computer, while preserving document usability. It will be shown that this often involves transforming layout features in principled ways.

## 1. Identification

Conventions have arisen such that documents have customary layouts. These conventions are not necessarily arbitrary. A timetable has a layout that is visually different from that of a letter for several very good reasons relating both to the structure of the information content and the way the document will be used. Replacing every character within an example of a letter and a timetable by the letter x, still allows us to identify which is which (see fig 1).
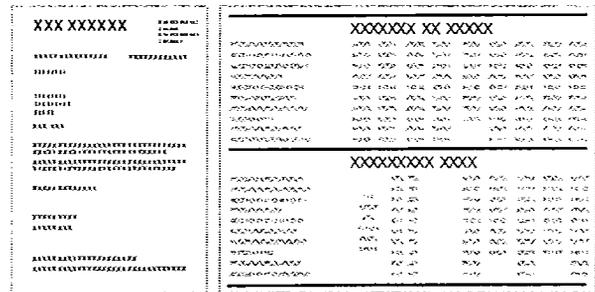


*Figure 1 People can distinguish a timetable from a letter without reading the content.*

Visual identity can be an advantage when searching for documents in printed media but may be less needed for electronic documents because there are other means, such as access devices and retrieval processes, that pre-identify the document. However, some web pages introduce ambiguities when a button labelled 'products' may take readers to a page of technical specifications or to a sales/purchase page. But even here, on arrival the layout can signal what sort of information the page contains before any of the content is read.

Layout not only facilitates document identification but can also influence the identification of constituents within documents. Even when all letters are replaced by

X there would be no ambiguity in distinguishing a page starting a new chapter from an index page. The existence of footnotes and marginalia are evident as soon as the reader accesses a printed page, and their existence says several things about the document - e.g. it is multilayered and non-linear.

Not only within the document but even within a page, the layout provides cues that signal relationships among the elements. Headings that are centred or to one side, have a rhetorical significance. Illustrations and their captions have conventional relationships both in space (proximity) and in font style (distinguished from the body text. From the layout alone readers know a lot about the document before they start to read. Hence phrases such as "the small print" have entered the language and explicitly mark a relation between the visual appearance of a text and its likely content.

While the existence of identifying visual features is an indisputable part of many texts, the question arises as to whether these need to be preserved when a document moves across presentation media. For example, the way footnotes are handled in a printed medium may no longer be appropriate when other options become available in other media − e.g. pop-up windows or hot links to other parts of the text. Clearly the status of the footnote needs to be captured as such, but the specifics of its visual implementation may be highly context dependent. Critical contextual parameters include the display resources (screen size, colour, resolution, etc) and the uses to which the document will be put. Documents used for reference may require that many layout features support access to specific sections within the document; in contrast application forms may need to generate a sequential flow that takes readers through all and only the relevant sections. The same repertoire of layout devices may be used in both documents, but because they are being used for different purposes they will be combined in different ways.

Understanding the purpose of a document and the way people will use it becomes crucial when documents need to be re-displayed on systems having different constraints. Consider the timetable shown in figure 2. If screen resolution does not permit maintaining the typographic distinction between hours and minutes then this will have consequences for the spacing needed between columns. This space will need to become greater to compensate for the lost typographic distinction. If screen size does not permit the whole table to be shown simultaneously then lateral scrolling will not work for readers unless the row headers remain visible. Similarly if the table is deconstructed and the Saturday times presented separately, the row headings will need to be repeated or the information becomes unusable.



| XXXXXXX XX XXXXX | | | | | | | |
|---|---|---|---|---|---|---|---|
| 07 00 | 07 00 | 07 00 | 07 00 | 07 00 | 07 00 | 07 00 |
| 07 30 | 07 30 | 07 30 | 07 30 | 07 30 | 07 30 | 07 30 |
| 08 00 | 08 00 | 08 00 | 08 00 | 08 00 | 08 00 | 08 00 |
| 08 30 | 08 30 | 08 30 | 08 30 | 08 30 | 08 30 | 08 30 |
| 09 00 | 09 00 | 09 00 | 09 00 | 09 00 | 09 00 | 09 00 |
| 09 30 | 09 30 | 09 30 | 09 30 | 09 30 | 09 30 | 09 30 |
| 10 00 | 10 00 | 10 00 | 10 00 | 10 00 | 10 00 | 10 00 |
| 10 30 | 10 30 | 10 30 | 10 30 | 10 30 | 10 30 | 10 30 |
| 11 00 | 11 00 | 11 00 | | 11 00 | 11 00 | 11 00 |
| 11 30 | 11 30 | 11 30 | | 11 30 | 11 30 | 11 30 |

*Figure 2  Display features may be lost moving across media.*

These issues about being able to present the relationships signalled by layout in alternative ways, in response to contextual constraints, applies not only to documents being generated *ab initio* but also those being assembled or transferred from an information resource. Although items within the resource may be tagged to denote their organisational function within the document (e.g. header, footnote, list) the visual implementation can be achieved in many ways in general, although usually only in a subset of ways for a given presentation device.

## 2  Effort

Layout matters because it influences the effort that readers must make to use the information. The alternative layouts adopted for listing television programs will be a familiar example. A run-on, mock paragraph style is sometimes used because it saves space, but this format can make it much harder for readers to answer questions such as, "Is there a nine o'clock news?". Vertical listings of programs, with separate columns for times and program titles, helps people who are searching for information. Similarly a periodic horizontal alignment across channels helps readers answer questions such as, "What's on now?". The interplay between layout and usability is well illustrated by the information boards displayed by large organisations in hallways and at elevators. Often the destinations are grouped by location. Here custom and convention do not help users. Few people consulting the board will ask "What is on level 3?" and so benefit from that grouping. Most will ask "Where is the Z department?" and would have found an alphabetic or thematic organisation much more helpful.

When electronic documents are captured from printed originals, those creating the electronic version may feel it is not their responsibility to improve the document's usability. Nevertheless without an adequate sensitivity to the importance of layout features, they may inadvertently make it more difficult for people to use the document. There is no shortage of evidence that the importance of layout and its impact on usability are often overlooked. I have collected examples of correspondence that includes a return address, which is information provided so that it can be used. Nevertheless some organisations require readers to integrate information from header (company name) and

footer (location) and then make appropriate insertion of the recipient's name and their section within the company. When cross-cultural factors add to the diversity with which this information is be laid out, the overseas reader can be left with a non-trivial puzzle.

Sometimes the effort caused by unhelpful layout is obvious, but this is not always so. Research has shown that even layouts which are formally equivalent (e.g. in having corresponding layers of headings and subheadings) may differ in their psychological consequences. One example of this comes from work on tables. A 4x4 matrix could be laid out so that the four row headings were nested under each of the column headings (see figure 3). When people used these tables to look up information they were more than twice as likely to make a mistake with the matrix compared with the nested tree structure (Wright 1977).
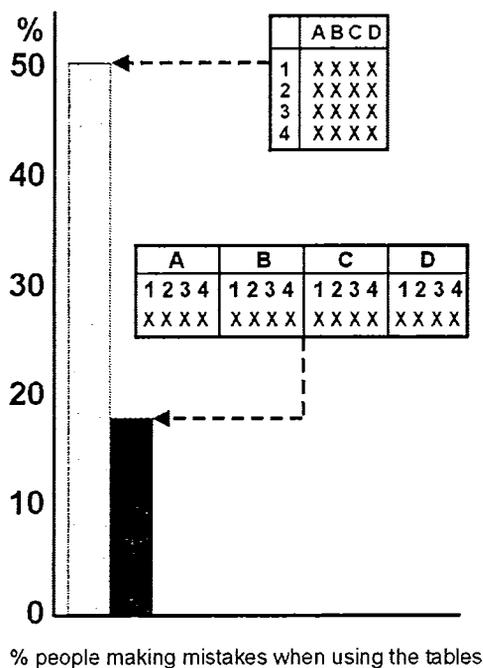


*Figure 3 Table layout influenced the likelihood of mistakes.*

The explanation of this difference appears to lie in what we would today call distributed cognition (Hutchins 1995). The series of nested column headings allows readers to make sequential progress without needing to remember or return to earlier decisions. In contrast, for the matrix readers must remember which column is the relevant one while deciding which is the relevant row, and then these two decisions must be perceptually co-ordinated to locate the cell. The formal, logical equivalence corresponds to the number of decisions that readers must make in each case. The psychological non-equivalence comes from the support that the layout gives in only one case for the detailed cognitive activities inherent in using the table.

## 3 Economy

A very different reason why layout is important is that it often has economic consequences. When considering the two table layouts just discussed it was mentioned that the 4x4 matrix required far less space than the nested headings. Often usability is only one of several factors to be taken into account when making layout decisions. Saving space does not always mean sacrificing usability. Even information such as the names and addresses listed in a telephone book can be effectively re-designed. In the UK British Telecommunications estimated that they made savings of £2 million per year from a sophisticated re-design that capitalised upon the redundancy in repeated surnames to create a listing that was easier to search as well as saving paper.

Costs can unwittingly become a factor when documents move across presentation media. A ten page document on the web, where it is displayed as two columns of text, may become 20 pages when printed if each column gets printed on a different page. When authors assume that readers will see the columns juxtaposed, e.g. so that text can refer to an illustration, this glitch in the transfer across media can impair the document's usability.

Given the evidence that layout has consequences that matter, there is a need to know the layout parameters that should be taken into account in particular circumstances. Although a little later I will show that the level of abstraction at which layout parameters are characterised can be crucial, for the present it will be helpful to start with a simple tripartite division into three categories of layout features: location on the page, space relative to other elements and typography. There are many specific elements within each of these categories (Black 1990, p20 lists 52 document elements) but these three clusters are important because each is known to influence people's willingness to read documents. It obviously becomes a false economy if the layout is changed for cost-cutting reasons but the potential readership vanishes.

## 4 Willingness to read

Many of us will have had the experience of arriving at a web page where the legibility of the text was so poor that we became reluctant readers, and perhaps pursued fewer links than might otherwise have been the case. An example of how typography can change the appearance, tone and invitingness of something as simple as an alphabetic list is shown in figure 4. Although the two listings differ in whether the sequence runs vertically or horizontally, this is not the source of the difference in their impact on readers. They differ aesthetically, and do so in a way that challenges how they should be redesigned to accommodate a smaller screen. The vertical list, with its minimalist typographic cueing, could be scrolled or segmented in various ways with little change to its usability. But if there is space to

display only half the horizontal sequence, should the overall shape of the arranged tiles be preserved? Is this one of the visual features of this display that makes it so attractive?
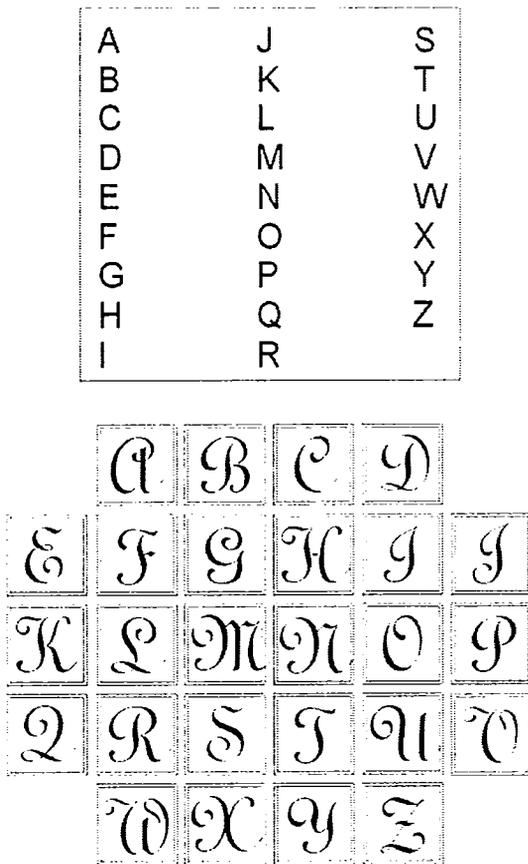
| A | J | S |
|---|---|---|
| B | K | T |
| C | L | U |
| D | M | V |
| E | N | W |
| F | O | X |
| G | P | Y |
| H | Q | Z |
| I | R | |



*Figure 4 Layout decisions have an aesthetic dimension.*

In figure 4 the typography chosen for the fonts is itself a critical factor and there is evidence that changing fonts can influence readers' interpretation of a text. For example, McAteer (1989) gave people sentences such as "It was a hot day", varied the typography of "hot"and asked for estimates of the temperature. People gave higher temperature ratings when hot was written in capital letters. Conventions have evolved within narrative text concerning the use of typographic style (e.g. bold for emphasis, italic for foreign words) but many technical documents require new and richer categories to distinguish what the display is saying from what the user should type, or from the author's comments to readers. Preserving such distinctions can be vital when documents move across presentation media, but this may need to be implemented by different means to overcome display constraints.

When the purpose of a document is to attract readers then the use of space becomes crucial. Figure 5 illustrates two possible layouts for a postcard that was being distributed to college freshmen encouraging them to volunteer as participants in psychology experiments. Both versions have identical content and an identical logical structure as reflected in the relation between headings and body text. But the card on the left shares the layout conventions of many of the official university documents that freshmen will receive whereas the card on the right seeks, through layout, to proclaim that it is different from an official notice. It uses space, borders, typographic variation and a non-linear flow to attract readers.
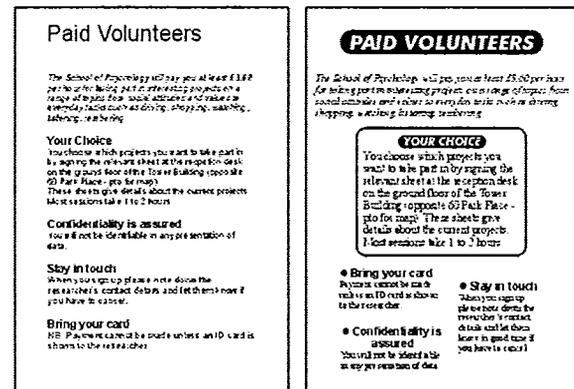


*Figure 5 Layout changes the tone of documents.*

The genre of the card on the right falls between poster and magazine. Its lack of convention and resistance to easy categorisation as a known kind of document was an important factor underlying the design decisions. Knowing how to capture these layout features so that they survive transformations, e.g. to a web page, is an important challenge that cannot be side-stepped once it is realised that documents are not just textual content but that their visual layout has important consequences.

Some of the preceding examples have appealed to reader's intuitions for support but lack empirical evidence that layout has the effects claimed. Not so for the relation between text and graphics. Long ago it was shown that readers would not necessarily look at a diagram in a technical report even though it was on the same page as the author's reference to it, and even though it contained information that was not available elsewhere in the text (Whalley and Flemming, 1975). That this was caused by layout rather than by student aversion to this sort of illustration, a circuit diagram, was shown by redesigning the page so that the diagram occurred immediately after it was referred to in the text (see figure 6). More recently similar findings have been obtained with interactive documents where the way in which illustrations were integrated with and accessed from the text was found to influence whether readers bothered to look at them, and how well they understood the text (Wright, Hull, and Black 1990; Wright, Milroy, and Lickorish 1999).
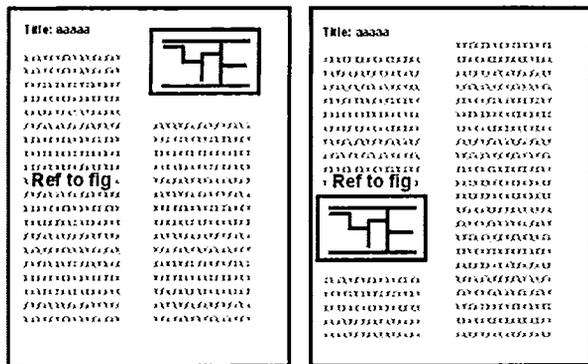
4

*Figure 6 Diagram viewed more often in layout on right.*

Considering the relation between illustrations and text enables us to return to the distinction between formal and functional equivalence. In figure 7, all the alternative page layouts would seem to be formally different. They differ in the number of text columns and in the spatial relation between text and illustration. Nevertheless there may be no functional differences among three of these which for most reading purposes may be equally usable. Only when the illustration occurs mid page across two columns of text does some ambiguity arise as to the flow of the text. So this example again raises the issue of the level of abstraction at which it is useful to represent layout features. It also highlights the need to be able to specify the contexts in which alternative layouts have a functional equivalence. Given the preceding discussion it seems unlikely that a useful model of layout can avoid being context sensitive. Universal truths exist at the level of design goals (e.g. make it legible) not at the level of implementation (e.g. use 12 point Times New Roman).

It is worth noting that the creation of algorithms for capturing layout can be handicapped by the absence of conventions for the way elements within documents are presented. Sequences of graphics are read from left to right in some cultures, but right to left in others. When a graphic sequence is shown as a block, e.g. 2x2 or 3x3, then knowing whether to read vertically down or horizontally along may be an ambiguity resolved only by interpreting the meaning of the graphics. While there may be no easy solution to this when analysing or transforming pre-existing documents, the problem can be resolved for documents being generated *ab initio* by the introduction of other layout elements such as numbers or arrows between the graphics. This suggests that the layout features needed will be a function of the purpose for which the layout is being done. In the one case ambiguity may have to be lived with because there is no automatic resolution. In the other case it can be easily resolved by introducing new layout elements.
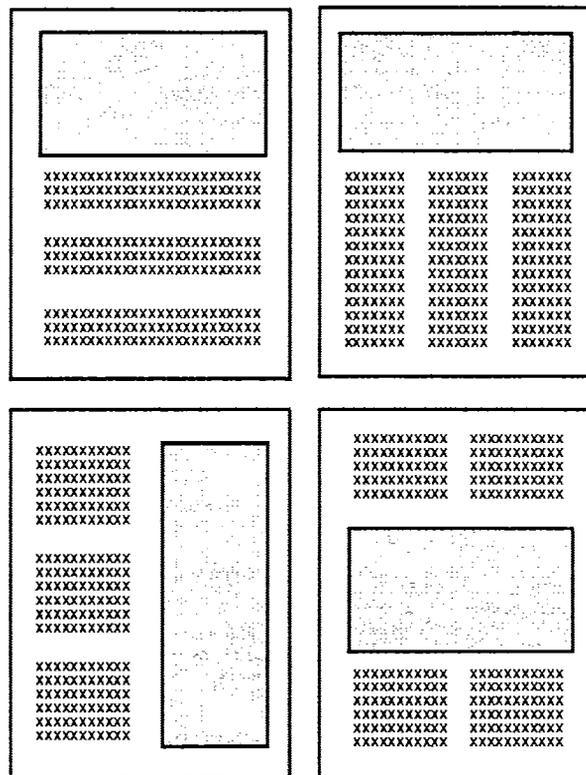


*Figure 7 Alternative layouts may look different but be functionally equivalent.*

To summarise the points made so far, if many aspects of layout involving space, typography or location, influence readers' willingness to engage with the material then document designers need to understand this aspect of readers' behavior. Elsewhere I have suggested that there is a need for "theories of NOT reading" (Wright 1988). If they existed they would undoubtedly have to encompass the role that layout plays in fostering a willingness to read and continue reading.

The other important issue arising from the discussion of willingness to read is that those working with pre-existing documents may face difficult decisions about whether to preserve or replace certain layout features when transferring documents across presentation media. In some instances preserving features of the original may render it unusable in another display medium. For example, a printed book can have text rotated through 90 degrees to accommodate a large table or graphic. While not ideal, it is not a great problem for readers to rotate the book to be able to read this material. But on a CRT screen this rotation option no longer exists for readers and the usability of the rotated information is seriously impaired.

Perhaps a compromise could be envisaged whereby the problem of transformation is shared with the reader through the provision of tools that enable zooming in on

small text, rotating, enlarging, perhaps even extracting textual adjuncts such as tables and illustrations for display in separate windows so that they remain easily available while reading. However this only appears so simplify the task of marking up the critical layout features because they still need to be identified and tagged if readers are to be able to manipulate them. Whether readers have the skills to exploit the potential for customising the layout of elements within a document is a totally separate question.

## 5 Readers' Assumptions
The fifth reason why layout matters is because readers make assumptions about it. These assumptions can lead to not reading material because it is assumed that it belongs to a particular category, such as a header or a figure caption, and so may seem irrelevant to the reader's present information needs. The currency conversion table shown in figure 8 illustrates how layout features can be both helpful and unhelpful within the same document. The large, bold column headings were helpful in speeding search within the table, but when the answer to a question was in a heading some people could not find it. They treated the headings as landmarks for navigation. Answers were sought only within the body of the table (Wright 1969).



*Figure 8 Headings aid search, but readers may assume that answers are in the body text.*

It is tempting to think that when a document introduces a novel format, then as long as this is explained to readers all will be well. Alas such optimism may not always be well founded. If the visual layout invites the assumption that certain items are related, for example by putting them on the same row of a table, then if the reader's attention lapses momentarily errors will result from their prior assumptions (Wright and Threlfall 1980).

If readers' assumptions can be anticipated then a potentially valuable tool for debugging document

transformation could be created through "simulated readers", an AI system that responded to critical layout features in the ways that readers are known to. We may not yet know enough about readers for such a model to be complete, but we certainly know enough for a start to be made. This may be the only viable way of achieving functional equivalence when the need for moving documents across media forces changes to document layout.

## 6 Reading Strategies
Layout decisions influence reading strategies in numerous ways. Hartley (1994, p64-65) has shown that for a printed page the linking of text and graphics by number, together with the spatial location of these text and graphics blocks, resulted in information in the top right hand corner of the page being unread. The layout required modification in order to achieve the writer's objective of people reading all the text.

It is not just writers' goals that can be thwarted by layout. Sometimes readers' goals are also derailed. In a project where we have been studying multidimensional decision-making we provided readers with tools that let them mark items as either worth thinking about further or of no relevance. When they were using the first interface we created, most people adopted a strategy of discarding the irrelevant items. From other work we had done we knew this was an unusual strategy, so we looked for an explanation in the features of the interface. The "reject" marker placed a large cross over the item, and the marker for "further consideration" placed a blue vertical bar alongside the item. It seemed plausible that a difference in the visual salience of these two markers influenced the strategy people adopted. So the study was repeated changing only the visual consequences of the markers: rejecting items caused them to appear foggy, analogous to the dimming of non-available menu items; accepting items put a sandy coloured background behind them. These tools produced a change in the dominant strategy, and most people now focused on potentially relevant items.

What brought about this change in reading strategy? Readers probably had the goal of creating a subset of items that could be given more detailed consideration. The uncrossed items met this criterion in the first interface. So did items with a sandy background in the second interface. Although at some levels of abstraction these two interfaces could be considered formally equivalent, i.e. in terms of the availability of marking tools and the mode of interaction with them, the interfaces were not psychologically equivalent because the visual consequences of the tools differed. So achieving functional equivalence when documents are moved across display devices will require an understanding of readers' goals and the ways in which these could be achieved through alternative display features.

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One implication of findings such as these is that issues of layout may have long been ignored because they are inherently hard. Difficulties arise from ambiguity about what level of abstraction to represent the layout features of existing documents and the need to relate these features to their functional equivalence for readers, in order that this equivalence can be maintained when documents are transformed across display media. At present there is still much we need to know about the functional significance of layout features for readers, but some principles have been established for decades. A set of principles of visual grouping known as Gestalt principles, afford ways of achieving functional equivalence (Wertheimer 1912). Figure 9 offers an illustration of how the groupings of columns within a table, groupings that were originally indicated by space between the columns, can be maintained when display space decreases. This can be done by introducing ruled lines or by having typographic (or color) variation. The existence of these well-established design principles suggests that they could be instantiated in algorithms to aid document transformation. This would in turn offer a test-bed for evaluating a simulated reader, if one were constructed.



*Figure 9 Visual grouping can be achieved in many ways.*

The layout variations in figure 9 all look very similar because vertical and horizontal alignment are maintained. But such alignment is not necessary for preserving functional equivalence. In figure 10 the horizontal grouping on the top table is replaced by a combination of vertical and typographic grouping in the bottom table. Like the Gestalt principles this might seem an algorithmic procedure, mapping cells that are adjacent on a row into a vertical pattern, but how will

that algorithm know that the three rows in column 1 of the top table are a single entity and cannot be split up in this way? Earlier it was pointed out that layout had significance apart from content, but sometimes understanding the content is a prerequisite for interpreting the layout.

| Fault | Possible Cause | Action required |
|---|---|---|
| Machine not working | • Door not closed | Close door |
| | • Start-button not pressed | Press start button |
| | • Machine unplugged | Plug in, switch on |
| | • Fuse blown | Check fuse & replace |
| | • Mains failure | See if other machine is working |
| No water in machine | • Water not turned on | Turn on tap |



*Figure 10 Automating layout variation for tables is a challenge.*

## 7 Cognitive costs

From my own perspective as a cognitive psychologist, one of the most important reasons why layout matters is that it incurs cognitive costs. This was very evident in a study we undertook of people's navigation strategies in an on-line price catalogue (Wright, Lickorish, and Milroy 2000). It is known that menus are easier if they are broad and shallow (e.g. a list of eight options) rather than narrow and deep (e.g. three binary choices) (Fisher, Yungkurth and Moss 1990; Norman 1990). However, broad shallow options take up more space, and in a study where the shallow navigation options were made available in a separate window they were often ignored. We explored why this happened. One possibility was that the visual salience of the easier route was reduced by the overlapping window. Another possibility was that the need to

activate the navigation window was found off-putting by readers. To distinguish between these explanations we created another two interfaces both having the shallow navigation option displayed in the lower part of the screen below the catalogue's price lists, with the deeper option available to the right of the price lists. In order to equate for the activation click needed with an overlapping window, the shallow menu was visible under a transparent blue filter that had to be removed before the contents could be used. The two new interfaces differed in the way this removal was achieved. One interface had a separate button that needed to be clicked to remove the filter, users of the other interface were told they could click anywhere in the blue region and it would turn white enabling the contents to be used.

These three interfaces had strongly differentiated effects on readers' willingness to use the shallow navigation option. When windows overlapped it was only used on 41% trials. When visible below the prices and requiring a separate button, it was the navigation procedure chosen on 58% trials. When visible below the prices but readers could click anywhere most people chose to *double click* on their menu choice, and use of the shallow option rose to 88% trials. So although at certain levels of abstraction these interfaces were equivalent in the choices they offered readers, variation in details of the layout influenced people's willingness to access certain options (see section 4 Willingness). Since readers arrived at their destination no matter which route they took, did it really matter which navigation choices were made? It would matter if their choices had differential cognitive costs.

One of the tools provided by this interface was an online notebook into which prices could be copied by clicking on them. Everyone did this on trials where several items had to be compared. Nobody did it on very simple queries about the price of a single item. It was found that notebook use varied inversely with choice of the shallow navigation option. People thought they were more likely to forget the prices of items if they used the deeper, hierarchic navigation system. So the layout of the interface was miscuing readers into having a more difficult interaction with the document than was intended.

This study shows that relatively small differences in layout can have huge effects on readers' behavior. It also shows how layout can miscue readers into making documents harder to use than they need be. Most importantly it illustrates why any powerful approach to layout cannot be confined to an analysis of the text but must be integrated with an understanding of how people interact with documents, i.e. a broad characterisation of reading and the many different activities subsumed under that label (see figure 11).
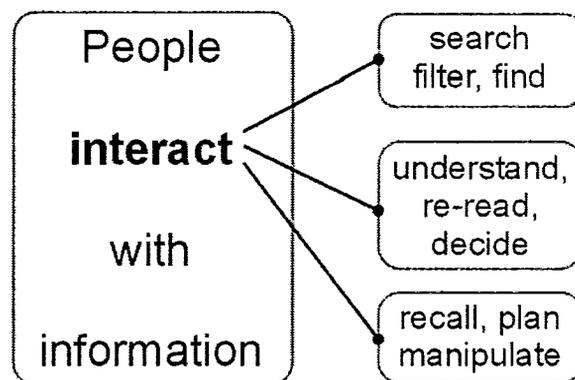


*Figure 11 Layout influences most of the constituent activities of reading.*

One constraint on achieving this integration is that there remains much we need to know about many of these reading activities. Nevertheless we know enough for a start to be possible. Whether the concern is to generate documents *ab initio* from an information resource, or to transfer existing documents across display media, it will be necessary to understand the psychological functions achieved by layout elements in order that contextually appropriate design decisions can be made.

In summary, there exist a diversity of reasons why layout is a critical element of texts. These reasons range from the economic to the psychological. The specifics of which layout elements need to be captured may vary with the purpose of the capture, but rarely will it be adequate to tag only the physical parameters (e.g. 12 point Times bold) without relating these to their function in the document (e.g. subheading, emphasis, etc). It is also necessary to know how these functions might be impaired by variation in other layout features on the page (e.g. if the body text turns bold). The critical features of layout lie in the relationships (spatial and typographic) among elements. The crucial part of this relationship is the way they can change a variety of reading activities. Sometimes even having consequences for meaning (figure 12).
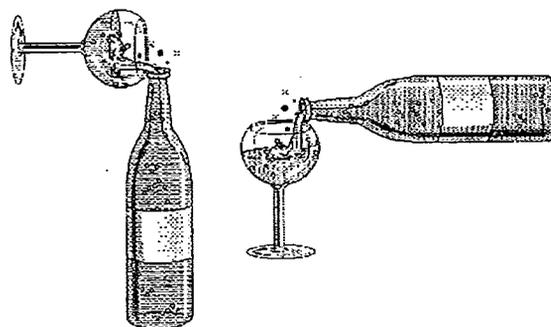


*Figure 12 A 90° rotation can significantly change meaning.*

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