

# Do You Need That Second Color?

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**Abstract**—When money is short, two-color printing is often the first thing to go from technical manuals and instructional texts. Does their effectiveness suffer as a result? Conversely, when a second color is used, is it often just a waste of money? This paper sets out, first, the main purpose for which a second color can be used; second, technical and perceptual constraints on the use of color; and, third, research findings on color and learning. The purpose of the paper is to provide practical guidelines for decisions about the use of a second color in texts.

**T**HE addition of a second color can increase the cost of a technical or educational text considerably. In most organizations one has to make a special case for using it. What are the arguments for and against? In this paper we set out the evidence.

First, we consider the communication functions for which you might need a second color. Second, we take the negative side of the argument and list various psychological and technical constraints. Third, relevant to educational and training applications, we review research on the effect of color on learning.

## FUNCTIONS OF SECOND COLOR

### *Second Color in Prose*

The earliest forms of recorded language didn't make many concessions to readers; they had no paragraphs, no typographic distinctions between sentences, and sometimes no symbols for vowels. Those graphic cues were invented as the readers' needs became clear. Modern authors ease reading in several ways: by dividing texts clearly into sentences, paragraphs and sections; by using bold type, italic type, or varying indentation and type size; and by varying the way in which prose is laid out on a page (or arranged on a screen). A good example of the importance of layout is seen in newspapers and magazines, where the placing of text and its relationship to photographs, nearby articles, and other elements are crucial to the way a reader finds and interprets it.

Each reader has his or her own reading purposes and expectations; graphic cues enable one to actively (or even unconsciously) search for relative parts of the text. Color is one of these cues.

Newspapers and magazines are mostly for recreational reading, of course, and color is often used to decorate rather than to convey information. Can color be used to present technical and educational material more effectively?

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For most texts the normal single-color typographic signaling is almost always adequate (bold, italic, size-change, indentation, etc.). It is normally fair to say that if you run out of signaling devices, the text is overly complex and should be simplified. Of course, you may not have the full range of single-color typography available. Word-processor printers and typewriters have only poor boldface fonts, if any, and even the more versatile machines place the designer at a disadvantage. In such cases there may be a strong argument for using color to effectively double the range of available cues.

If you have justified the use of a second color because your illustrations need it, you can also use that color to enhance the prose for little extra cost. Here are some examples of second color used for the display of prose. We found these in our University's textbooks.

- *Highlighting individual words* In some courses the first use of a **technical term** is highlighted in color. A monochrome alternative is to print it in bold type or place it in the margin. In mathematical or technical subjects, though, the use of bold or italic type to highlight elements in an equation or formula might be confused with a special notation—in such cases a second color is a must.

- *Highlighting a block of text* In a similar way, key passages and summaries can be printed in color or, alternatively, a colored tint can be laid over them. This is sometimes done in reverse on forms and questionnaires: White blocks are picked out of a colored background to highlight the parts to be filled in by the respondent. Color is especially useful if continuity must be maintained between the highlighted block and its surrounding text.

- *Presenting parallel discourse* Sometimes two separate but related discourses are interwoven in the same text—the main subject matter and study guidance or critical commentary, perhaps. This can often be achieved in monochrome by using two typefaces—a Roman and a sans serif, perhaps—or a two-column setting, but two-color printing is a particularly effective technique.

Table I summarizes these points. Although a table cannot adequately show how these different text factors are interrelated, we can draw two main conclusions from it.

First, there is no text feature listed here that color cannot signal. Second, there is no text feature listed here that cannot be signaled some other way. Note, however, that if you *take away* certain monochrome cues or *reserve* them for special purposes, color is the only thing left. An example of monochrome cues reserved for special purposes would be using bold or italic type for mathematical symbols. An example of taking cues away is having to economize on typesetting. If you need to change a text or manual frequently, using a word processor will be cheaper

Notes  
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TABLE I  
USE OF GRAPHIC CUES IN TEXT

Cue	Use				
	Highlight Words	Highlight Blocks	Parallel Discourse	Headings	Footnotes, Captions
Type Family (Roman, sans serif)			✓	✓	✓
Typeface (italic, bold)	✓	✓	✓	✓	✓
Type Size			✓	✓	✓
White Space			✓	✓	✓
Rules, Borders			✓	✓	✓
Layout (columns, margins)	✓		✓	✓	✓
Color Tints		✓	✓	✓	✓
Colored Type	✓	✓	✓	✓	✓

than typesetting, and can be as effective if you use a second color.

### Second Color in Graphics

A good illustrator can achieve a great deal using only black and white. Medical illustrators, technical draftsmen, and cartographers often produce precise and effective graphics without color. In fact, for complex realistic illustrations a second color may not actually help—the full four-color process is needed to significantly improve on black and white. Nevertheless, our survey of Open University textbooks revealed a number of good uses of a second color in graphics.

- *Distinguishing between similar features with different functions* Lines are sometimes added to diagrams to link a particular part with a related caption. If the diagram itself consists of similar lines, confusion may result. But if the caption lines are colored, confusion is avoided. This can be done consistently in a series of diagrams. Similar examples we found included

- A colored axis line added to diagrams using a ball-and-stick model of molecular structure.

- A colored grid overprinted on architectural plans to show each design's symmetry.

- Color to distinguish boundary lines and flow lines on a systems chart (Fig. 1).

- Both sides of a circuit board shown in the same chart—the wiring in black and the main components in color.

- *Highlighting noteworthy parts of a single illustration* Color can be used to make special teaching points. Whereas in the above cases we expect illustrations to use color-coding consistently, here the application of color has only local significance. So in one map, for example, the color might be used to highlight roads, and in another, railway tracks. Examples of highlighting we found included

- Tracking a mathematical term during cross-multiplication or other manipulation of an equation.

- Focusing on the process of oxygenation of blood in the heart by changing the color of the flow from black to red (Fig. 2).

- Highlighting development in staged diagrams. These are diagrams built up bit by bit; each time some new element is added it is signaled in color so that readers notice changes more easily.

- *Creating three-dimensional effects* It is possible to create

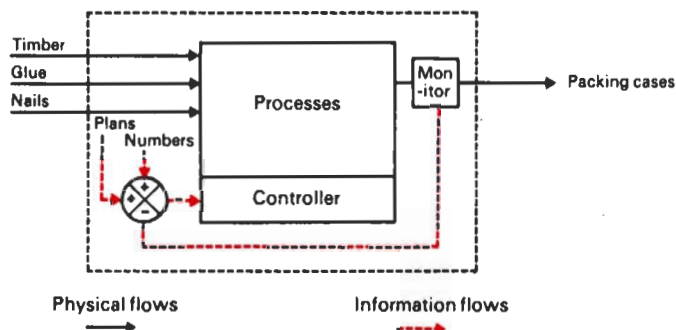


Fig. 1. Color distinguishes two types of flow on a systems chart (from Open University course T242).

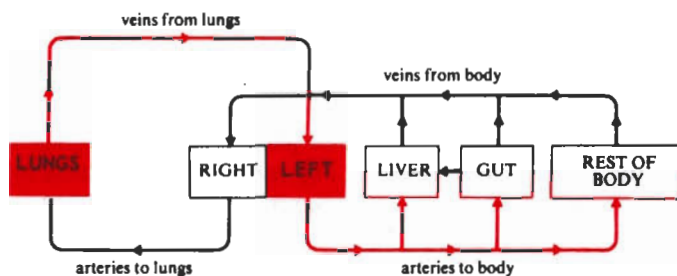


Fig. 2. Schematic diagram of blood flow. Red represents oxygenated blood (from Open University course S101).

three-dimensional effects by printing two images of an object (as seen from slightly distanced viewpoints) in green and red. When looking through a special viewer (with one green and one red filter) the image appears to have depth. Such images are known as anaglyphs or stereograms.

- *Color-coding of quantities* When your bank statement is printed in red you know it shows a negative quantity; your bank manager is using color-coding. Statistical diagrams also use color-coding. Research on maps has shown that different shades of one color should be used to show magnitude (Fig. 3), rather than different colors for different magnitudes [1].

### Does a Second Color Increase Motivation?

A second or third color is usually considered a luxury effect. It is often justified through arguments concerning prestige and motivation rather than through functional analysis of the communication problem. Does a second color have the stylistic effect we expect of it?

Probably the best answer is that a second color can contribute to the prestige of a document but it is only one of a

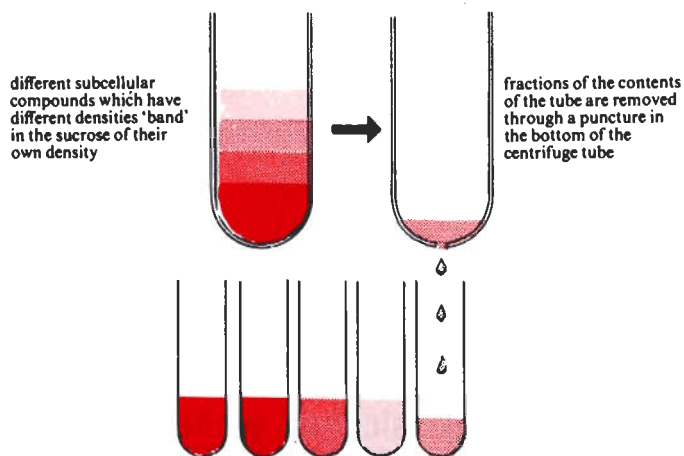


Fig. 3. Shading or screening of a color can be used to represent magnitude—here, differences in sugar concentration (from Open University course S101).

TABLE II  
USE OF COLOR IN THE OPEN UNIVERSITY\*

Where Color Is Used	Color					
	Red	Green	Blue	Brown	Mauve	Orange
Text only	2	2	2	2	3	
Diagrams only	24		1		1	
Text and diagrams	11	4	2	2		1

\* A random sample of 100 course texts, of which 44 used black alone and 56 two colors. Cells total 57 because in one text brown was used for prose with green as second color.

range of options open to the designer. The quality of paper, typesetting, and printing have to be first class before a second color can make a significant contribution. Moreover, a badly printed second color (out of register, perhaps) creates a worse impression than the same document in monochrome.

Choice of color can be important both technically (as we see later) and emotionally. Colors are often said to have emotional effects. Here we can distinguish between culturally determined denotations (e.g., the colors of political parties identify the origin of posters; blue uniforms distinguish airmen from soldiers), their subsequently acquired "cultural" connotations (e.g., black for mourning connotes death; red for socialism connotes revolution), and "natural" connotations (e.g., reds seem more warm and emotional than blues). Beware of confusing these. For example, white is worn for weddings in the West, but for funerals in the East. It has no natural connotation with either.

Connotations, then, can be an unreliable basis for choosing a color. They can also become clichéd and predictable—agricultural products do not have to be advertised in green but they tend to be. Within the bounds of legibility, the choice of color is often largely a matter of personal preference and fashion, as we found in our own institution (Table II).

## CONSTRAINTS ON THE USE OF COLOR

We now turn to the negative side of the case. What are the problems of using a second color? First we look at the constraints imposed on our choice of color by the human

perceptual system. Then we list the technical problems of editing and printing multicolor texts.

### Which Colors Are Most Easily Seen?

Your choice of a second color will affect the legibility of the text. The legibility of color is related both to our perceptual system and to contextual factors such as the level and kind of light (daylight or artificial) in which we view a colored image. Below we list the most important factors affecting the perception of color.

- *The contrast of ink and paper* In our survey of Open University texts, we found a text that used yellow as a second color. It was bright and conspicuous but almost impossible to read because it contrasted insufficiently with the white paper. Tinker [2, p. 150] researched contrast and recommended a minimum of 65 percent contrast between text color and paper color. If you are printing color on color, bear in mind that colors appear different according to their background. For example, orange looks quite different on a blue page than on a pink page.

- *The contrast of first and second colors* We also found a text that used black and brown. Both colors were legible but you could not tell one from the other. It makes sense to ensure differentiation between the two colors chosen.

- *The light level at which color is viewed* The eye contains two kinds of receptors, known as *rods* and *cones*. Cones enable us to perceive color but cease to operate at low light levels, whereas the rod receptors, which do work at those levels, are not color sensitive. In poor light our sensitivity to color is therefore diminished. Various artificial lights distort the "color temperature" of the environment and consequently our color perception. Manuals that may be used in poor light should not rely on color to communicate important information. Labels on equipment should also follow this rule. Color-coding is useless in a photographic darkroom and under sodium street lights.

- *Defective color vision* Very few people are completely color blind (monochromat) but color-defectiveness of some degree is surprisingly common in men although rare in women. Slight defects in color vision and sometimes even serious ones can go unnoticed by the individual concerned. In practical terms, designers should avoid using those combinations of colors that are most often confused—green and red, for instance; and one should avoid using extreme shades of those colors. Very dark or very light reds and greens can look gray to the eight percent of males who have color vision defects.

### Technical Problems of Using Color

The cost of printing extra colors is perhaps the foremost constraint in most circumstances, although longer production runs of larger jobs on two-color presses reduce the cost differential significantly. Other technical constraints to be considered include

- *Proofing problems* Proofs are normally supplied separately for the two colors. With frequent use of a second color this can make proofreading considerably more difficult.

- *Printing problems* Inconsistent inking can wreck a color-coding system; red varied from deep magenta to light pink in

one text we found. Poor registration can also render a text unreadable—particularly when graphs or diagrams are printed in two colors.

- **Photocopying problems** Color copiers are not yet commonplace; the significance of colored images is therefore lost when documents are photocopied. Many copiers still cannot pick up light blues, and red comes out as black. Although some publishers deliberately exploit these effects for copyright protection, if you intend to let users copy your technical documents, choose colors that make it easy for them. Avoid yellow and light blue (which will vanish) and black on red (it will all appear black).

## RESEARCH ON COLOR AND LEARNING

Although many people have written on color in general, few reliable research projects have focused on the effect of color on learning or communication [3–6]. One reason for caution is that most researchers were concerned not with two-color printing but with full-color slides or films. Even when researchers have looked at print [e.g., 2, 5, 7], a close examination of their research framework or design often makes us wary of applying their findings to modern audiences or to specialist needs such as technical communication. Other reviewers of the research literature, and several of the researchers themselves, share our caution. It appears to be extremely difficult to find any effect on learning, although effects on motivation have been detected. Dwyer [8], for example, concluded that the **attention-getting function of color** was stronger even than its effect on the realism of illustrations. Dooley and Harkins [9] concluded that “for these charts, at least, color’s principal effect was motivational, and a black and white code was equally effective as an information transmitter.”

The findings on motivation, though, are by themselves not strong enough arguments for using color. In many cases the problems may outweigh the advantages. Tolliver [4] concluded his review with the comment, “Based on the evidence, it is reasonable to say that people may reveal distinct limitations as they try to utilize color cues from various informational formats.” Otto and Askov [3], too, are somewhat pessimistic about the value of color and of the value of the research itself: “The salient implication of all the existing research on the role of color in learning seems to be that the cue value of color is fragile at best and apt to be superseded by more potent ones.”

Bearing these remarks in mind, we have therefore been selective, looking for research that says something about how an audience makes sense of what it sees on the page.

- **Novelty** If you interpose an occasional two-color figure among monochrome illustrations (Fig. 4), it may attract more attention. [10, p. 22]. The same applies to using an occasional monochrome picture in a mass of colored illustrations (a technique used in some modern films). We warn here that using color just for variety may be counterproductive; every visual distinction should have a clear meaning [11].
- **Selection** Whereas color can be an aid to finding a particular part of a complex picture, it is likely to have little or no effect (other than aesthetic) in relatively simple pictures. The

Take three tablets two times a day

**WARNING** It is dangerous to exceed the recommended dose.

Inform your physician if you suffer nausea during this treatment

Do not drink alcohol while under treatment

Fig. 4. The colored instruction stands out clearly.

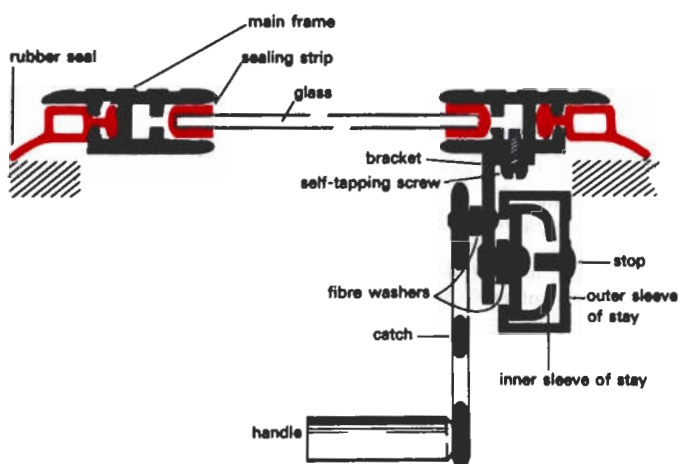


Fig. 5. Color highlights the more important elements in a complex drawing (from Open University course T242).

art is in deciding which features of complex pictures can be eliminated and which are critical. An everyday example is the atlas, in which maps showing one aspect (e.g., physical features) include very little of other aspects (political boundaries, population, etc.). In technical illustration, too, we need to be selective, using the second color consistently to highlight relevant stimuli or important elements (Fig. 5). Used otherwise, it increases the time spent looking at irrelevant parts [9] and improves recall of unimportant aspects [12].

- **Organization** People unconsciously organize the visual field into one or more figures that stand out against a background. This tendency can be reinforced by emphasizing contrast boundaries (rather than line boundaries), smoothly continuous outlines, and symmetry. As with selection, if you use a second color for this, use it sparingly, consistently, and for the important parts only (Fig. 6).

- **Expectations** Expectations and experience radically affect our interpretation of visual scenes. We know of no experiment on this using a second color. It is fair to predict, however, that by setting up a code of color usage as part of the logic of your illustrations, you can introduce a “set” or expectation that will carry through a series of diagrams (Fig. 7).

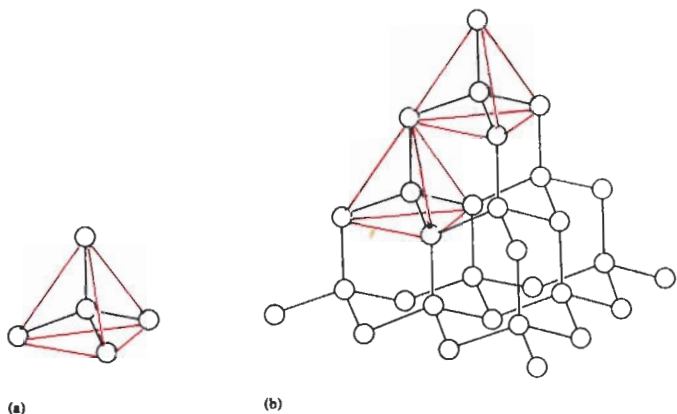
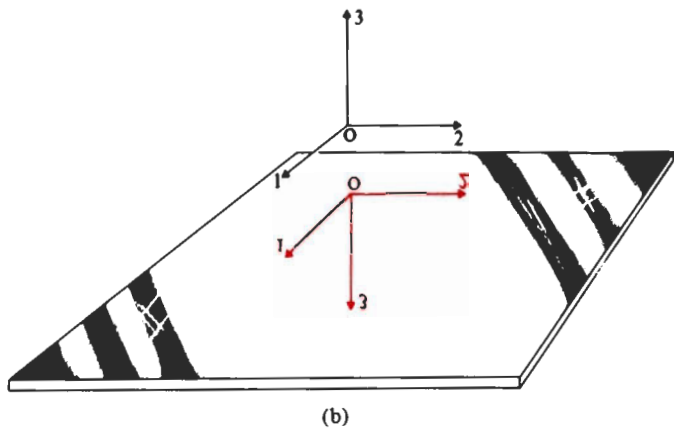
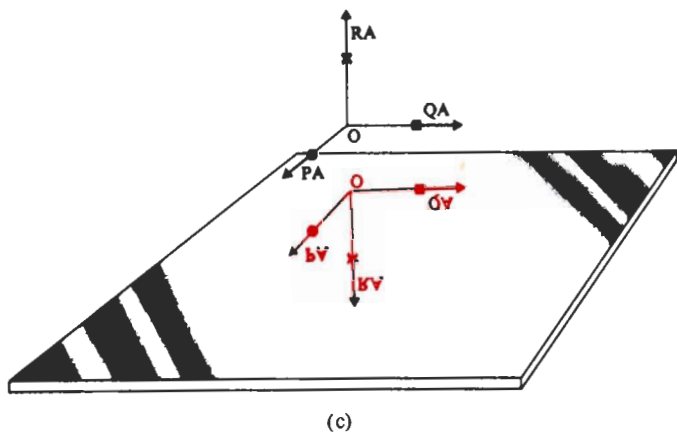


Fig. 6. An example of color aiding the organization of a visual field—here, how carbon atoms link to form diamond (from Open University course T101).

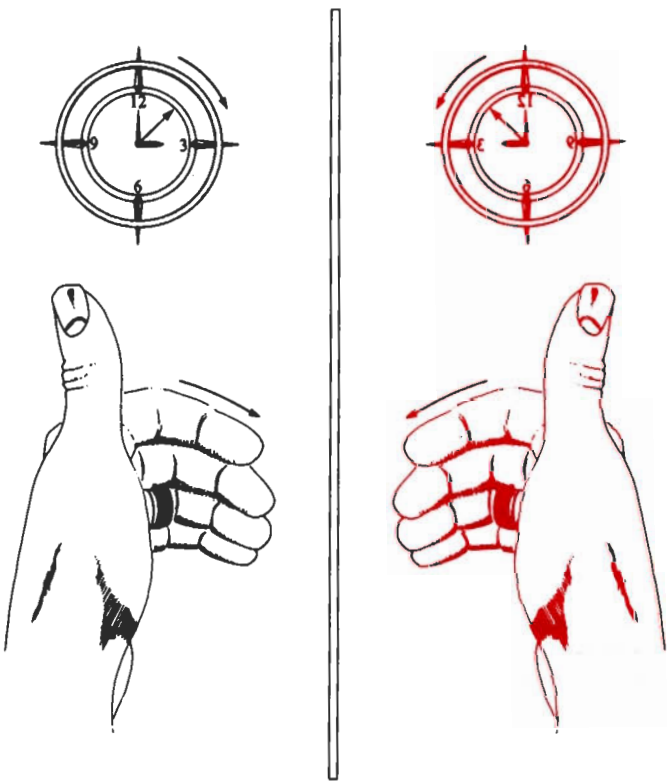


(b)



(c)

Fig. 7. (Continued.)



(a)

*Experiment* Hold a clock or watch with moving hands in front of a mirror and observe the mirror image of the process. (You will have to wait a minute or so if there is no second hand.) In what way does the motion you observe in the mirror differ from what you observe in the real world? Is what you see in the mirror impossible or just unusual?

Fig. 7. Color carries a "mind set" or expectation through a series of diagrams—here, that colored parts are mirror images (from Open University course S354).

The connotations of color we discussed earlier involve expectations in a similar way. One's conscious or unconscious expectations affect the meanings of colors. Although there have been many attempts to establish color preferences and associations scientifically, context and culture overwhelm all other

factors. For example, researchers have shown that people prefer green to yellow in the abstract, but in real life green margarine (its natural color) is spurned in favor of yellow. In practice, too, readers are unpredictable in their response to color-coding, perhaps not seeing it as coding at all but thinking this is literally how it is. As Huckleberry Finn puts it, in his balloon trip in Mark Twain's *Tom Sawyer Abroad*, "Illinois is green, Indiana is pink. You show me any pink down there, if you can. No, Sir: it's green... there ain't no two states the same color" (Dell edition, 1965, p. 31).

### CONCLUSION

Color is one aspect of communication where tentative suggestions are more in order than firm rules or guidelines. However, the economic, technical, and perceptual constraints we have discussed mean that we do need some kind of disciplined analysis of whether a second color is necessary or desirable. Without completely discounting the importance of decorative or aesthetic effects, we conclude that a second color is only one of a range of graphic factors which must be used both (a) with an integrity and consistency of meaning (graphic resources should not be devalued by wasteful or arbitrary use) and (b) with full regard to the users' needs and contexts. Good editing and design are very much a matter of balancing

communication purposes and user constraints. Research findings, too, must be weighed carefully and counterbalanced by instinct born of experience and good sense.

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