Principles of Effective Visual Communication for Graphical User Interface Design

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Abstract

Researchers and developers should develop a high-quality, integrated approach to the graphical presentation of all elements of human-computer (user) interface *(HCI)* design. Principles from *information-oriented, systematic design can assist in providing guidance for simple, clear, consistent solutions to the design* of menus, windows, icons, dialogue boxes, *and control panels* that are not explicitly specified by current graphical user interface (GUI) paradigms.

Introduction

Some researchers and developers think their user interface design problems are solved because industry conventions for window managers have emerged. However, programmers have discovered that graphical user interface (GUI) paradigms such as Microsoft Windows™, Motif™, Apple Macintosh™, or NextStep™ do not solve the essential task of visually communicating a product's data and functions.

In this tutorial article, you will learn how information-oriented, systematic graphic design can benefit graphical user interface design in conveying information about data and functions. Some basic principles of visual communication can go a long way towards achieving better graphical user interface design.

In the article, I introduce the terminology of visible language and discuss how to achieve effective visual communication in graphical user interfaces, electronic publishing, and presentations. I emphasized three basic principles: organize, economize, and communicate. I show how to apply those principles to the essential elements of typography, symbolism, and layout inherent in all menus, control panels, icons, and dialogue boxes whose visual attributes are not sufficiently specified by current GUI. In the concluding part of my tutorial, I cover the subject of color. This complex and interesting topic requires some detailed examination.

GUIs and Graphic Design

A GUI design must account for the following:

- A comprehensible mental image (metaphor)
- Appropriate organization of data, functions, tasks, and roles (cognitive model)
- ient navig ε among these data and functions, tasks, and roles
- Quality appearance characteristics (the look)
- Effective interaction sequencing (the feel)

Graphic design can help GUIs achieve their potential to communicate. Information-oriented, systematic graphic design is the use of typography, symbols, color, and other static and dynamic graphics to convey facts, concepts, and emotions. Graphic design is found in almost every facet of life, from the design of books, films, magazines, and videos, to the design of exhibits, highway signage, and maps.

Information-oriented, systematic graphic design helps people understand complex information. So, why shouldn't graphic design help users find their way through data and functions, and make the trip more pleasant as well?

Information-oriented, systematic graphic design can help in almost every phase of product development providing effective communication for every kind of user, application, platform, and GUI

How is this possible? Because successful visual communication through information-oriented, systematic graphic design relies on some fundamental graphic design principles. Once you are aware of these principles, you will be able to appreciate why some displays are better than others, and, after a little practice, you'll find your own decision making and accomplishments are improving. You can apply these principles to the design of all typical GUI components: screens, windows, menus, dialogue boxes, control panels, icons, and pointers/cursors.

Design Considerations for Successful GUIs

When designing successful GUIs, development, usability, and acceptance factors are of critical importance.

Development factors include the following: platform constraints, tool kits and component libraries, support for rapid prototyping, and customizability. In all of these areas, graphic design can help by improving visual communication.

Usability factors typically include the following: human abilities, product identity, clear conceptual model, and multiple representations. Again, graphic design principles can assist by taking into account human factors and expressing a strong visual identity.

Finally, acceptance factors include these: installed base, corporate politics, international markets, and documentation and training.

All of these factors benefit from improved visual communication in the user interface. A conceptually distinct organization, a visually consistent presentation, and an effective use of visible language contribute to improved visual communication.

Visible Language

The term 'visible language" may not be familiar to you. The concept of visible language refers to all the graphical techniques used to communicate the message or content. The term includes the following:

- Layout: formats, proportions, and grids; two-dimensional and three-dimensional organization.
- Typography: selection of typefaces and typesetting, including variable-width sans-serif and serif fonts as well as fixed-width fonts found on most computer displays.

Color and texture: color, texture and light that convey complex information and pictoral reality.

- Imagery: signs, icons, and symbols, from the photographically real to the abstract.
- Animation: a dynamic or kinetic display that is especially important for video-related imagery.
- Sequencing: the overall approach to visual storytelling.

Sound: abstract, vocal, concrete, or musical cues. These have been called "earcons", a pun on icons.

- Visual identity: the additional. unique rules that lend overall consistency to a user interface.

All information-oriented, systematic graphic design relies on these visual signs to convey meaning to a viewer. Notice that two strange items appear in the list. Obviously, sound is not visual, but acoustic cues increasingly will be part of the repertoire of the information designer of GUIs. The last item, visual identity, refers to overall decisions about how the corporation or the product line expresses itself in visible language.

The basic technique in achieving effective visual communication involves establishing explicit rules. specifications, and guidelines for visible language that affect the user interface.

Principles of User Interface Design

The manipulation of visible language is a basic task of.user interface design. This set of principles can be a useful guide to professional practice, research, and development.

- Organize: Provide the user with a clear and consistent conceptual structure.
- Economize: Maximize the effectiveness of a minimal set of cues.
- Communicate: Match the presentation to the capabilities of the user.

Let's look at each of these principles in detail.

Principle 1: Organize

The first principle is to get organized (see Figure 1). The Bauhaus artist and designer Josef Albers (Despite Straight Lines, Yale University Press) expressed it this way:

To design is to plan and organize,
to order, to relate, and to *control*.

In short, *it* embraces all means
opposing disorder and accident.

Therefore, *it* signifies a human
need and qualifies man's thinking
and doing.

There are several important concepts within the major principle of organization: consistency, screen layout, relationships, and navigability

Consistency

There are four important aspects of consistency: internal [illegible] , e [illegible]te [illegible]al consistency, [illegible]al world c[illegible] [illegible]y. and when *not* to be cons[illegible]tent i.e., when to deviate from the norm.

The principle of internal consistency says: observe the same conventions and rules for all elements of the GUI. Figure 2 provides an example.

Casual differences should be avoided. Without a strong motivating reason, these casual differences cause the viewer to work harder to understand the essential message of the display.

The second point is external consistency: follow existing platform and cultural conventions across user interfaces. Figure 3 provides an example.

The lack of external consistency can cause confusion for users moving across applications. Imagine the chaos on the interstate highway network if the Stop sign changed visually from state to state! What we need for GUIs is the same kind of consistency for conceptual landscapes. Remember: designing a GUI is like designing a city full of exciting and useful people, places, and activities.

The third point is real world consistency: make the conventions consistent with real world experience. Figure 4 provides an example.

The fourth and last point is innovation: deviate from existing conventions only when doing so provides a clear benefit to the user. In other words, have a good reason for being inconsistent! In an article on the topic of consistency, Jonathan Grudin, a GUI researcher (see Bibliography), showed that sometimes it is impossible to avoid some kinds of inconsistency, and that inconsistency even can be beneficial. However, as a general rule, strive for consistency, without being slavish about it.

Screen Layout

The second major way to organize visual displays is to design their spatial layout or composition. There are three primary ways of achieving organization of screen layout: use a grid structure, standardize the screen layout, and group related elements.

Grids of horizontal and vertical lines can help locate items in menus, major window components, and other two-dimensional compositions such as dialogue boxes or control panels. The exact measurements must be worked out very carefully to take into account the content to be displayed, spaces between text groups, the screen resolution, and the viewing conditions. Generally, the maximum number of major divisions in the horizontal or vertical direction follows what human factors specialists call Miller's magic number, namely, 7 ± 2. This recommendation derives from the maximum number of coding items we can easily remember in short-term memory.

The same idea can be applied to a control panel, menu, dialogue box, or even the small area of icons, in which case a small grid helps to locate individual pieces of these pictograms and ideograms. Figure 5 shows some examples

Relationships

Another technique helpful in achieving visual organization is to establish clear relationships by linking related elements and disassociating unrelated elements. This simple precept may be complex to carry out in practice. Figure 6 presents an example.

Navigability

The final means of organizing visual elements is navigability. Important techniques include these: provide an initial focus for the viewer's attention, direct attention to important, secondaty, or peripheral items, and assist in navigation throughout the material. Figure 7 provides an example.

Principle 2: Economize! (or Make Do with What You Have)

In this first part of the tutorial we have introduced the subject of information-oriented, systematic graphic design for GUIs and the idea of visual language. We have looked at one important principal for achieving effective visual communication: organization. In this next section, we shall investigate how to use the best techniques to reach the user with the message of functions or data that the user interface must communicate.

The second major principle is to economize (doing the most with the least). Don Norman, a cognitive scientist, comments on economy, in his book The Psychology of Everyday Things (Basic Books, New York, 1969). Here are some excerpts:

How many controls does a device need?

- The fewer the controls, the easier it looks to use and the easier *it* is to find the relevant controls...
- To make something look easy, minimize the number of controls.

The concept of economy can be broken down into four major subtopics: simplicity, clarity, distinctiveness, and emphasis.

Simplicity suggests that we include only those elements that are essential for communication. In addition, we should be as unobtrusive as possible.

As they say in the business world, use the KISS method: Keep it Supremely Simple. Do not assume that your audience is stupid; we all have natural limits to the rate at which we can take in

informational-rich content. It you exceed natural limits, you will induce indifference, boredom, or anxiety.

No matter to whom you're communicating, simplicity is a virtue, unless your objective is to confuse, entertain, or beautify, in which cases, overindulgence may be justified. In general, the GUI components should be modest and notoverly attract the viewer's attention. Users should be almost unconscious of the GUI working to convey meaning. Figure 8 provides an example.

Keep It Crystal Clear

The second technique for being economical is clarity: design all components so that their meaning is not ambiguous. Figure **9** provides an example.

The third technique for achieving economy is distinctiveness: distinguish important properties of essential elements. Figure 10 illustrates this technique.

The final technique of economizing is emphasis. In general, make the most important elements salient, i.e., easily perceived. De-emphasize non-critical elements and minimize clutter so that critical information is not hidden. Figure 11 makes this point.

Principle 3: Communicate!

The previous comments explored the principles of organization and economy. The third main principle is, communicate! The visual com unication researcher Sol Worth puts it this ay in his t Studying Visual *Communication* (University of Pennsylvania Press, Philadelphia)

> Communication...is...a social process, within a specified context, in which signs are produced and transmitted, perceived, and treated as messages from which meaning can be inferred.

To communicate successfully, a GUI must keep in balance these factors: legibility, readability, typography, symbolism, multiple views, and color/texture.

The first factor is legibility: design individual characters, symbols, and graphic elements to be easily noticeable and distinguishable. Figure 12 shows some examples.

Typefonts, desktop icons, control panel symbols. etc. all need to be designed so that their parts show. up well. You must select visualization techniques that are appropriate to the output display technology (*e.g.*, the spatial resolution, color, and animation characteristics). Keep in mind that many viewers over 40 years of age often need help with glasses or contact lenses just to see the screen well.

Another factor to remember is that dark screen backgrounds in brightly lighted rooms may cause distracting reflections that can diminish screen legibility. In contrast, brightly lighted screens in dark rooms may be too glaring and hard to see.

Closely reiated to legibility is readability. The term readability means that the display is comprehensible, i.e., easy to identify and interpret, as well as inviting and attractive. Figure 13 presents an example.

One of the key contributors to legibility and readability is the use of typography in the user interface. We still rely on text, tables, lists, and annotation, even if we are showing charts, diagrams, or other graphical displays. Typography includes the characteristics of individual elements (typefaces and typestyles) and their groupings (typesettingtechniques).

Use a small number of typefaces of suitable legibility, clarity, and distinctiveness to distinguish between different classes of information. Within each typeface, select a set of enhanced letterforms, punctuation marks, and symbols. Figure 14 provides some examples. Usually, one to three typefaces are sufficient for most situations, even the very complex code displays that Ron Baecke and I ecommend for e visualization in our book *Human Factors and Typography* For More Readable *Programs* (see Bibliography).

The third and final typographic recommendation concerns typesetting: Within menus, dialogue boxes, control panels, forms, and other window components, adjust the point size, word spacing, paragraph indentation, and line spacing to enhance the readability and to emphasize critical information.

The following are some basic recommendations:

- Generally, you should use a maximum of three typefaces in a maximum of three sizes, no matter what the application.
- Lines of text should have from 40 to 60 characters maximum, and words should be spaced correctly. usually the width of a lower case "r" or "i" for a variable-width text.

Text should be set in appropriate formats, that is, Set text flush left, set numbers flush right, avoid centered text in lists, and avoid short justified lines

of text.

- For fixed-width fonts, justified lines of text can slow reading speed by 12 percent.

Use upper and lower case characters whenever possible, i.e., avoid all capital lines of text, which can also slow reading speed by 12 percent.

Of course, one can always find exceptions to these guidelines, but the basic recommendations should sewe for most typographic settings.

Making Sense of Symbolism

Typographic characters are not the only visible language elements that must be designed so that they communicate their content efficiently. Icons, symbols, charts, maps, diagrams, and photographic imagery used in the displays also must be carefully selected and refined to communicate the desired contents.

The specific principles for designing charts, maps. diagrams, pictograms and ideograms are more numerous than space permits at this time. The Bibliography provides references to some outstanding sources of guidelines and case studies, such as the work of Tufte, Bertin, and Ota.

Multiple Views

One important technique for improving communication in the user interface is to provide multiple perspectives on the display of complex structures and processes. An important principle of good design, then, is making use of these multiple views:

Multiple forms of representation
- Multiple levels of abstraction
- Simultaneous alternative views
- Links and cross references
- Metadata. metatext, metagraphics

Figure 15 shows two examples.

Color/Texture

Our final topic, color, is a very complex subject and will be treated specially to conclude this tutorial. Color can be a powerful tool for communication if used correctly. The basic recommendation is this: use appropriate highlighting and deemphasis techniques to convey meaningful semantic distinctions.

A human factors researcher, Dr. Gerald Murch, comments on color in his paper "The Effective Use of Color in Visual Displays: Text and Graphics Applications" this way: 'Color can be a powerful tool to improve the usefulness of an information display in a wide variety of areas if color is used properly. Conversely, the inappropriate use of color canseriously reduce the functionality of a display system."

Color Terms and Concepts

Color discussions can be confusing because scientists, artists, designers, programmers, and marketing professionals describe color phenomena in different ways. Let's first discuss the color terms using one useful set of dimensions: hue, value, and chroma. These color terms are derived f the Munsell system of color used by artists, designers, and manufacturers. The dimensions differ from the red, green, and blue basis of the "RGB" color system familiar to users of CRT display devices. The approach also differs from another color system, the International Commission on Illumination (CIE), which uses specific spectral measurements to unambiguously specify color.

Hue is the spectral wavelength composition of a color that produces perceptions of being blue, orange, green, etc. Value is the relative amount of lightness or darkness of the color in a range of black to white (also called intensity). Chroma is the purity of the color in a scale from gray to the most vivid variant of the perceived color (also called saturation). Figure 16 shows the interrelations of all of these dimensions. Brightness, a fourth key term, refers to the amount of light energy creating the color. Different amounts levels of brightness affect the shape and size of the hue-value-lightness solid.

The circle of hues, the vertical range of values, and the range of chromas going out from the central vertical axis provide a basic specification of the color. Note that one further dimension, brightness, is required, which refers to the amount of energy in the light. In effect, there is a color solid for each brightness level, and the detailed, shape of the color solid change somewhat, based on the human eye's performance characteristics.

One important point to bear in mind is that color combinations can take place in different media in several ways. Figure 17 shows three typical means of combining color. At the left, primary colors of illuminated light like red, blue, and green, additively combine in pairs to produce magenta, cyan, and yellow, and together produce white light.

In the center, primary colors of pigment like red, blue, and yellow subtractively combine to produce a dark brown-black. CRT screens typically combine light additively, while most hardcopy color is obtained through subtractive mixtures of pigments, dyes, or tints.

At the right is an example of optical mixture in which small lines blend into a single color. Typical four-color process printing of images on paper uses closely spaced small dots of cyan, yellow, and magenta, plus black (the graphic arts industry's CYMK specification of color) to achieve an optical mixing of colors due to the eye's inability to resolve the individual color elements in "full-color" graphic arts printing.

A typical need for screen design is to combine colors so they make visual sense. Artists and designers have proposed several basic approaches to harmonious combinations, which are illustrated in Figure 18.

Beyond the basic technology of color for screen display, it is important to understand how color can help communication. Here are some basic advantages:

- Emphasize important information
- Identii subsystems or structures
- Portray natural objects realistically
- Portray time and progress
- Reduce errors of interpretation
- Add coding dimensions
- Increase comprehensibility
- Increase believability and appeal

With respect to learning and comprehension, color is superior to black-and-white in terms of the viewer's processing time and emotional reactions, and there is a difference in a viewer's ability to interpret information. People often can learn more from a color display if color is used correctly. Another crucial factor is that color is more enjoyable. With respect to memory performance, memory for color information appears to be superior to black-and-white.

These benefits indicate that color can work for you in communicating facts, concepts, and emotions; but Color is definitely a complex tool. At the same time, color has these potential drawbacks:

- Color requires more expensive and complicated display equipment.

- Color displays may not accommodate color deficient vision, which occurs in about 8 percent of Caucasian males.

- Some colors may cause visual discomfort and afterimages.

- Color may contribute to visual confusion or may catalyze negative associations through cross-disciplinary and cross-cultural connotations.

Because color can be misused easily, there is a clear need for guidelines. Establishing complete rules or specifications for color use is difficult. The International Standards Organization (ISO) has begun by publishing draft standards for some aspects of basic color legibility. Their report and some general guidelines on color are referred to in the Bibliography.

Color Design Principles

To keep recommendations simple, we can refer to the original three basic principles, but this time apply them to color. We'll examine selected guidelines under each principle: color organization, color economy, and color communication.

Color Organization

The first set of recommendations about color concerns consistency of organization. Use color to group related items, and use a consistent color code for screen displays, documentation, and training materials. Figure 19 presents an example.

In general, similar colors should imply a relation among objects. A viewer can sense the relatedness by color over space and over time in sequences of images. Be complete and consistent in your color groupings. For example, command and control colors in menus should be avoided for information coding ith a work a, unless a s ific n is intended. Another recommendation is to use similar background colors for related areas. This color coding can subtly orient the viewer to the conceptual link among these areas.

Once color coding is established, the same colors should be used throughout the GUI and all related publications. This color continuity may require designing colors to appear in different media. Remember: CRT screens use additive color mixtures, while most hardcopy devices use subtractive color mixtures. The color gamuts (that is, available color ranges) of these two media usually are not identical.

Color Economy

The next recommendations concern economical use of color:

The principle of color simplicity suggests using a maximum of 5±2 colors where the meaning must be remembered. Note that this maximum is even less than the so called Miller's magic number from human factors, 7±2. If appropriate, use redundant coding based on shape as well as color.

The basic idea is to use color to enhance black-and-white information, that is, design the display to work well first in black-and-white.

For documentation tasks, for example, using color to portray an object, the maximum number of colors needed is dependent on the application. For aesthetic purposes such as design style, emotional expression, or realism, many more colors may be required. Figure 20 shows some examples of using minimal color.

In figure 20 at the left, 5f2 colors may use a set of a few grays and some strongly diierent hues, or the set may use only different values for a given hue.

In the center, the rainbow is a reminder to use spectral order in color coding. To code a large set of colors, use the spectral sequence: red, orange, yellow, green, blue, and violet. Francine Frome, a human factors researcher (see Bibliography), has shown that viewers see a spectral order as a natural one and would select red, green, and blue as intuitive choices for the front, middle, and back layers, respectively, when viewing a multi-layer display.

Note, however, that brightness can change a viewer's perception of depth. If the colors are balanced, then red seems to come forward.

At the right, the images are a reminder to use redundant coding of shape as well as color, which aids those with color deficient vision and makes the display more resilient to color distortions caused by ambient light changes or by medium-to-medium conversion. Ambient light can cause changes in perceived hue, value, and chroma. Conversion from one medium to another can cause unforeseen and sometimes uncontrollable changes. Remember that among Caucasian viewers, 8% of males have some form of color-deficient viewing.

Color Emphasis

Among the remaining principles, color emphasis suggests using strong contrast in value and chroma to focus the user's attention on criiical information.

The use of bright colors for danger signals. attention getters, reminders, and cursors is entirely appropriate. High chroma red-alerts seem to aid faster response than yellow or yellow-orange if brightness is equal, but of course this also depends upon the background colors. When too many figures or background fields compete for the viewer's attention, confusion arises, as can happen in the Las Vegas approach to color design. The hierarchy of highlighted, neutral, and lowlighted states for all areas of the visual display must be carefully designed to maximize simplicity and clarity. Here again we find the basic maxim: simplicity, clarity, and consistency are especially important for color design.

Use saturated or high-chroma colors for older viewers, or for those who have viewed displays for very long periods of time. Bear in mind that frequent, but short term viewing can benefii from low-chroma displays, and that very bright displays of letters, symbols or lines tend to bloom, that is, the light spreads out against the background.

Color Communication

In color communication, recommendations for legibility include the following: use colors appropriately for the central and peripheral areas of the visual field. Use color combinations whose discriminabiliiy is influenced least by the relative area of each color. Do not use colors that are simultaneously high in chroma and spectrally extreme. Figure 21 presents some examples.

The outer edges of the retina are not particularly sensitive to colors in general. Thus, red or green should be used in the center of the visual field, not in the periphery, as in the example at the left. If they are used at the periphery, some signal to the viewer must be given to capture attention, e.g., size change or blinking. Use blue, black, white, and yellow near the periphery of the visual field. The retina remains sensitive to these colors near the periphery.

With regard to the example in the center of Figure 21, use blue for large areas, not for text type, thin lines, or small shapes. Blue-sensitive color receptors are the least numerous in the retina (approximately 5%), and are especially infrequent in the eye's central focusing area, the fovea. Blue is good for screen backgrounds.

If the colors change in size in the imagery, you should bear in mind the following: As color areas decrease in size they appear to change their value and chroma. You also may be able to see this in the center example.

At the right of Figure 21, you see colors that have a strong contrast. Use colors that differ both in chroma and value (lightness). Do not use adjacent colors that diier only in the amount of pure blue, because the edge between the two colors will appear to be fuzzy. To avoid this you might use a dark blue and a light blue.

Regarding use of simultaneously high-chroma, spectrally extreme colors, you can see that strong contrasts of red/green, blue/yellow, green/blue, and red/blue can create vibrations, illusions of shadows, and after-images. Unless you need to create a special visual effect, avoid these combinations.

In general, use light text, thin lines, and small shapes (white, yellow, or red) on medium to dark

backgrounds (blue, green, or dark gray) for dark viewing situations. Typical low ambient-light viewing situations are those for slidepresentations, workstations, and video. Video displays produce colors that are lower chroma.

Use dark (blue or black) text, thin lines, and small shapes on light (light yellow, magenta, blue, or white) backgrounds for light viewing situations. Typical viewing situations are those for overhead transparencies and paper. Reserve the highest contrast in figure-field relationships for text type.

Color Interactions

The interaction of color is a very complex subject that cannot be presented in this limited space. The basic text on the subject is Albers' book, The *Interaction* of Color (see Bibliography). Designers of user interfaces need to become familiar with there phenomena, which students of art and design often study. Figure 22 shows two examples of color interaction phenomena.

Color Symbolism

Finally, we recall the importance of symbolism in communication: use color codes that respect existing cultural and professional usage. Figure 23 shows typical examples.

Use color connotations with great care. Connotations vary strongly among different kinds of viewers, especially from different cultures. The correct use of color requires careful analysis of the experience and expectations of the viewers.

For example, mailboxes are blue in the USA, bright red in England, and bright yellow in Greece. If color is used in an electronic mail icon on the screen, this suggests that color sets might be changed for diierent countries to allow for differences in international markets.

Conclusion

The many recommendations of this tutorial are based on three basic principles: organize! economize! and communicate! These principles may not solve all of the precise GUI design challenges that researchers, developers, and other professionals face when using available GUI paradigms, but these principles can point you in the right direction and get you started.

The next task is to incorporate these principles into your own individual design efforts so that your GUI prototypes and products are better because they communicate their message more effectively. A next stage is to incorporate the principles into your own styleguides, templates, and clip-art so that others may adapt and apply these principles of effective communication.

Developing better visual communication in GUIs will make it possible for everyone to benefit from the capability of high performance computer graphics systems to communicate more efficiently and effectively through high performance graphic design.

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Author's Biography

Aaron Marcus received a BA in physics from Princeton University (1965) and a BFA and MFA in graphic design from Yale University Art School (1968). He is an internationally recognized authority on the design of human-computer interfaces and electronic publishing documents, including chart, form, document, icon, and screen design. He has given tutorials at SIGGRAPH, NCGA, and SIGCHI cc e ces in addition to seminars at businesses and academic institutions in the USA, C... Australia, Israel, Finland, Singapore, and Japan.

As president of Aaron Marcus and Associates, Inc., he and his staff design user interfaces, electronic publishing documents, multimedia, and information displays, such as the visualization of complex structures and processes, executive presentations, and libraries of clip art and templates for computer graphic syste for such clients as Apple, Canon Information S, ;, Digital Equipment, Dupont. Eastman Kodak, Hewlett-Packard, IBM, MCC, McDonnell-Douglas, Motorola, NCR, Prime-Computewision, Reuters, Ricoh, and 3M, among others.

Figures

Figure 1: Chaotic Screen, Ordered Screen. This figure summarizes the ideas of being consistent, using an organized screen layout, making relationships clear, and assisting the user's navigation. This example is notintended to imply that tiled screen layouts are always the correct solution.

Figure 2: Internal Consistency: Dialogue Boxes. In general, you should maximize the similarity of the major components of a user interface, i.e., maximize the regularity of the location and appearance of all items. In the two examples of dialogue boxes, notice that the same kinds of t are sh vn in the : a ɔl: and those with f kir : c ehavic ct have their own special appearance.

Figure 3: External Consistency for Text Tool Icons These text tool icons come from different applications but generally have the same meaning in desktop publishing. The obvious lack of consistency has a negative impact on users using new or similar products.

Figure 4: Real World Consistency: Highway Signage for Screen Display Icons. It is possible to take advantage of objects, processes, or events that are already familiar to the user and build upon this knowledge. This principle is the basis of the success of the desktop metaphor.

Figure 5: Screen, Control Panel and Icon Grids. Screen, control panel and icon grids show how a set of horizontal and vertical lines control size, location, and extent of visual elements.

Figure *6:* Relationships. In the example at the left, shape, location, and color can all create strong visual relationships that may be completely inappropriate. Ask yourself if all the bold items are related. Probably not. In the improved example on the right, the relationships are clear, consistent, appropriate, and strong. These monochrome examples are not intended to suggest that. monochrome displays are superior, only that the out-of control visual relationships in the example at the lefl have been brought into greater control.

Figure 7: Navigation. In this example of poor design and improved design, notice how very simple techniques of spatial layout and color (in this case gray values) can help focus the viewer's attention to the most important tiitlebar areas of the display. Then, the bulleted items guide the viewer through the secondary contents.

Figure **8:** Complicated and Simpler Designs. In the example on the left, the design is overdone, with useless differentiation. At the right, the presentation is simpler, with fewer extraneous changes of direction, typefaces, and capitalization. Once you have reduced tl display to it: utmost simplicity, you can *then* be to add no e as soon as you ban justify the additions.

Figure 9: Ambiguous and Clear Icons. In these examples of icons, notice how the ones on the lefl can be confusing, while the ones on the right are more understandable. Note that the same symbol appears in two situations.

Figure 10: Too Little and Too Much Distinctiveness. The first example shows a typical screen design in which everything is too bland, too much the same. The second example shows a typical Las Vegas approach in which every component is trying to be too distinctive. A happy medium is the correct solution.

Figure 11: Too Much and Improved Emphasis. The busy figure that you have seen before emphasizes too many things at once, making a clutter. The second example establishes a clear hierarchy. Remember that this approach can be used in achromatic (black, gray, white) as well as polychrome displays.

Figure 12: Illegible and Legible Texts. The top left example is a classic case of an illegible font. The example below it shows differences in size that are too minimal.

Figure 13: Unreadable and Readable Texts. The top example shows a more unreadable text in which it is difficult to detect the presence of a subtitle. The second example shows a more readable arrangement of the same contents.

Figure 14: Typefaces and Typestyles. Small caps, and special characters that are routinely available for CRT display, as for laser printers, and other hard copy devices.

Figure 15: Verbal and Visual Multiple Views. With multiple views, you can provide the user with the ability to view simultaneously a major "focus" plus additional information on a single screen. You can also provide links and cross references among these views to facilitate navigation through the contents.

Figure 16: Color Dimensions. The image presents color interrelationships in a simplification of a hue, value, and chroma space based on the TekHVC color model. Detailed descriptions of this color space and others appear in the Appendix on color specification systems.

Figure 17: Color Mixtures Showing Additive, Subtractive, and Optical Mixtures. Typical display media use different means of achieving color mixtures. CRT displays use additive mixtures while hardcopy devices use subtractive. Both can use optical mixtures.

Figure 18: Color Harmonies. The approaches show (beginning at the left) adjacent hues, varying values of a single hue, varying chromas of a single hue, opposing hues (complementary hues), nearly opposing hues (split complements), and equidistant hues (triads).

Figure 19: Color Consistency. On the left, multiple elements unrelatead but with similar colors, can cause confusion about which elements should be understood as a group. On the right, color is used together with location to reinforce grouping. Keep in mind that diierent values of the same color or different shapes of the same hue can be used to group related elements.

Figure 20: Color Simplicity. Limiting the number of colors, in color codes using a spectral order, and/or using redundant coding of shape increase the simplicity of a color display.

Figure 21: Color Legibility. Correct use of colors that account for the retina's physiological characteristics can improve the legibility of color displays.

Figure 22: Color Interactions. Color interactions with the background color fields can create illusions like that shown in the first example: one color appears like two and two different colors appear like one. This illusion often occurs in area maps or complex diagrams. Colors must be chosen to avoid these illusions. The second example shows Mach banding, in which flat areas of color give a fluted effect, like the sides of a column.

Figure 23: Color Symbolism: Commonly used codes are the traffic light at the left (often used in executive displays for exception reporting); the colors of writing: (black on white with red highlighting, used in financial accounting) and the typical colors of water, earth, and vegetation used in maps.

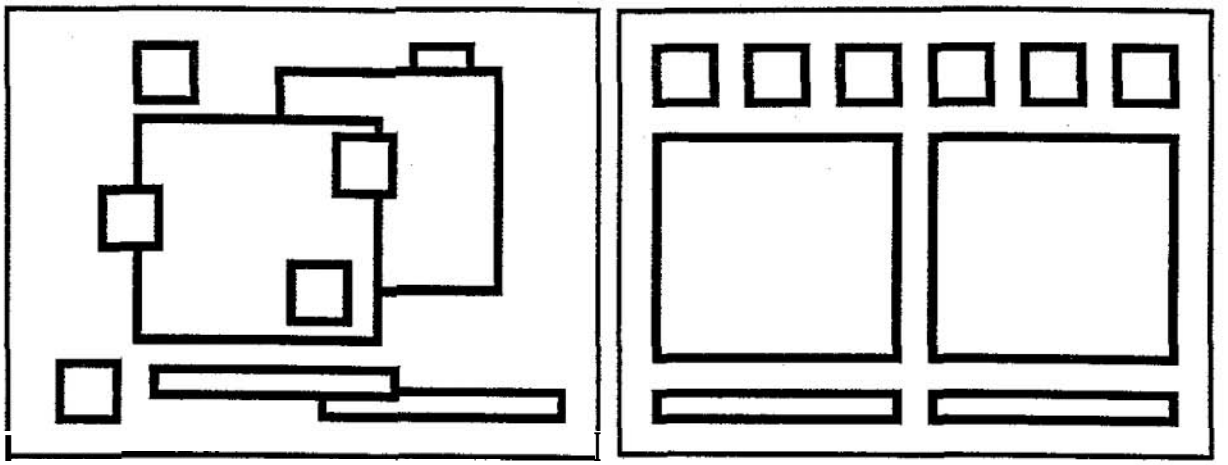


Figure 1: Chaotic Screen, Ordered Screen

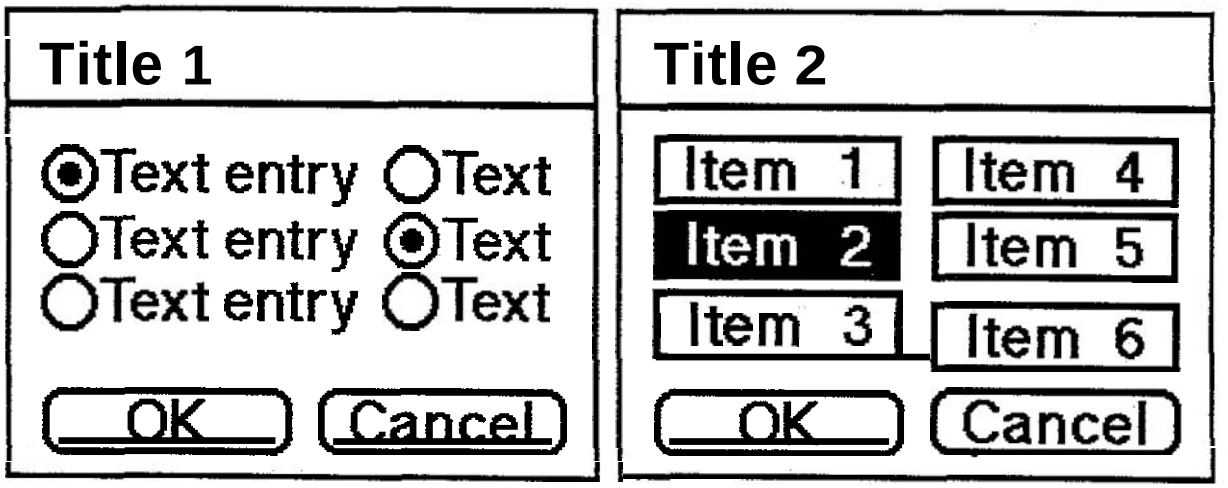


Figure 2: Internal Consistency: Dialogue Boxes

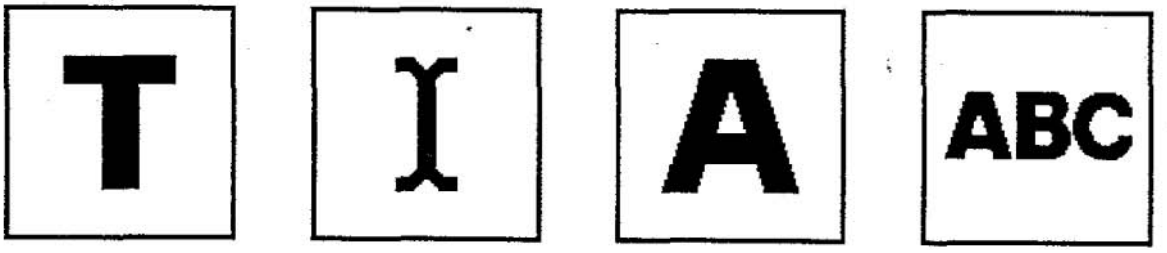


Figure 3: External Consistency for Text Tool Icons

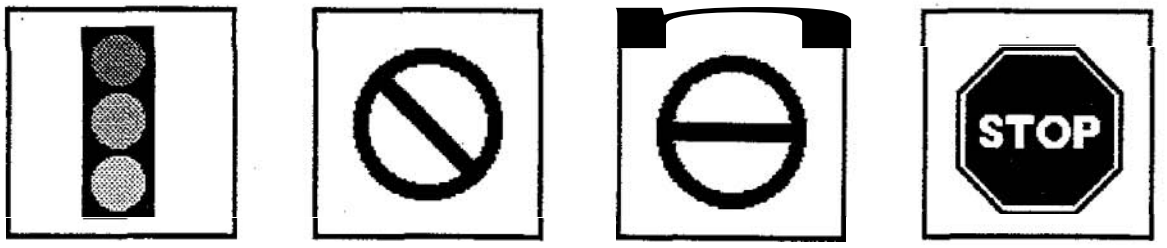


Figure 4: Real World Consistency: Highway Signage for Screen Display Icons

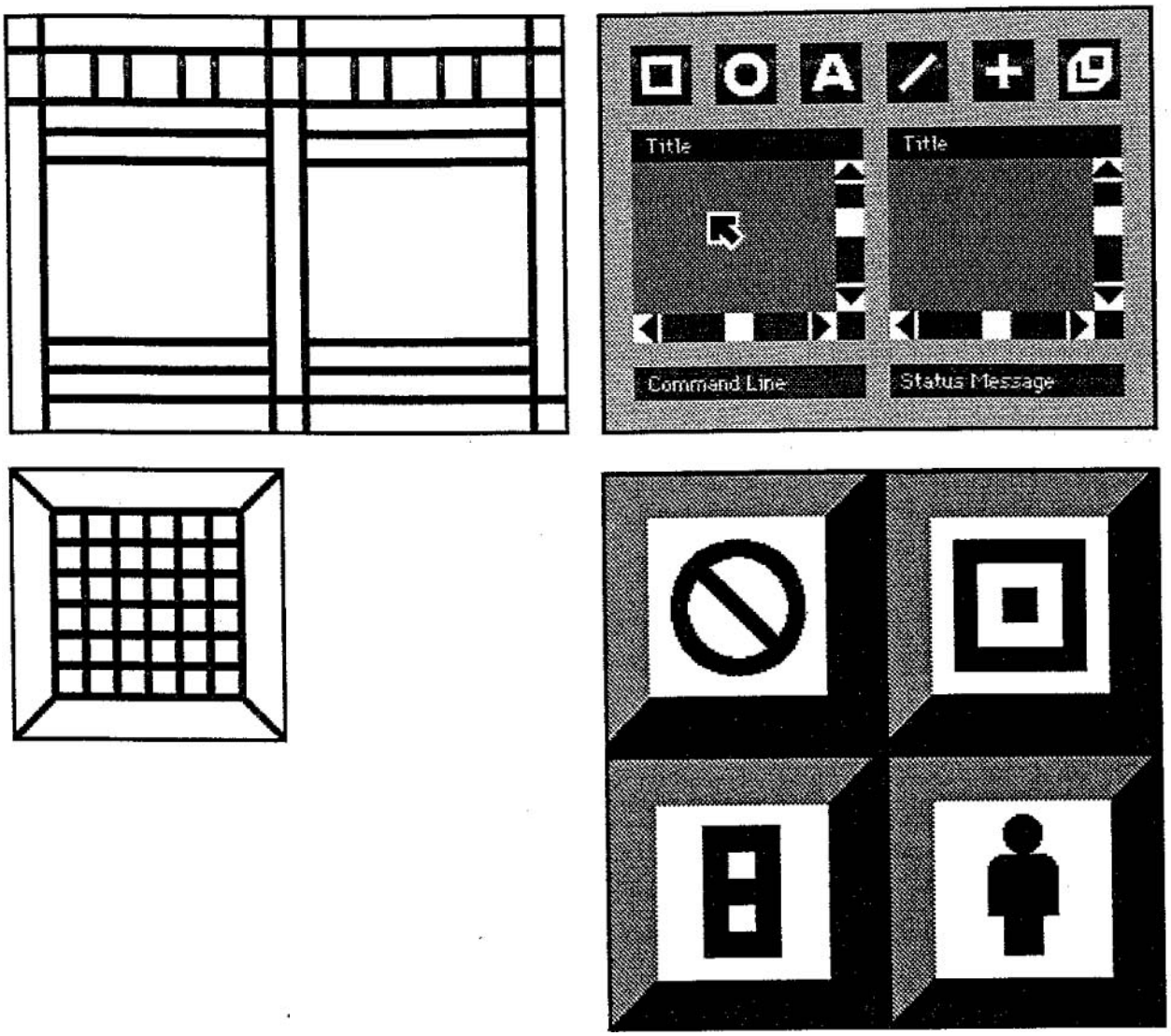


Figure 5: Screen, Control Panel and Icon Grids

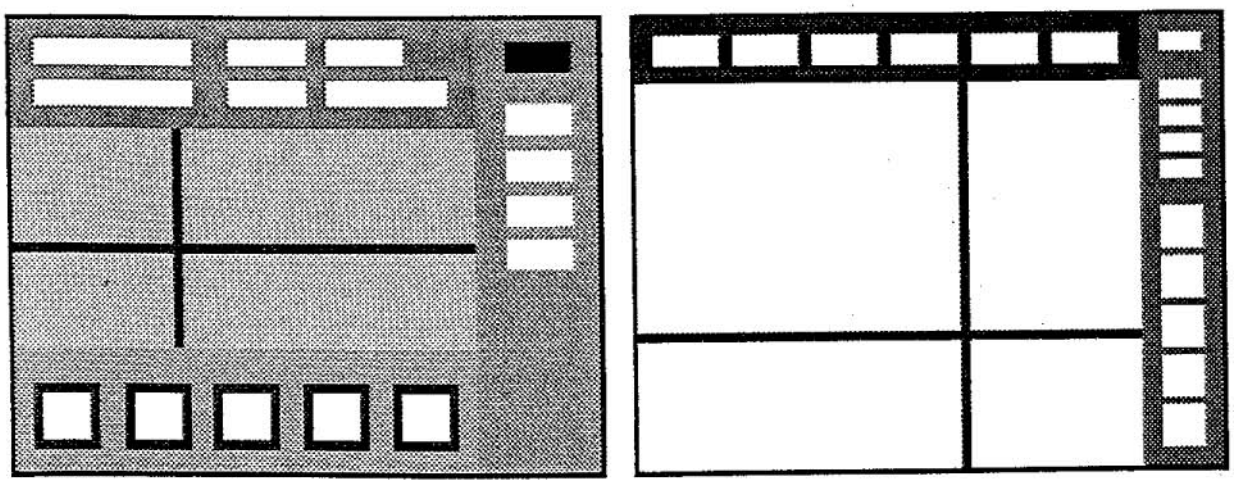


Figure 6: Relationships

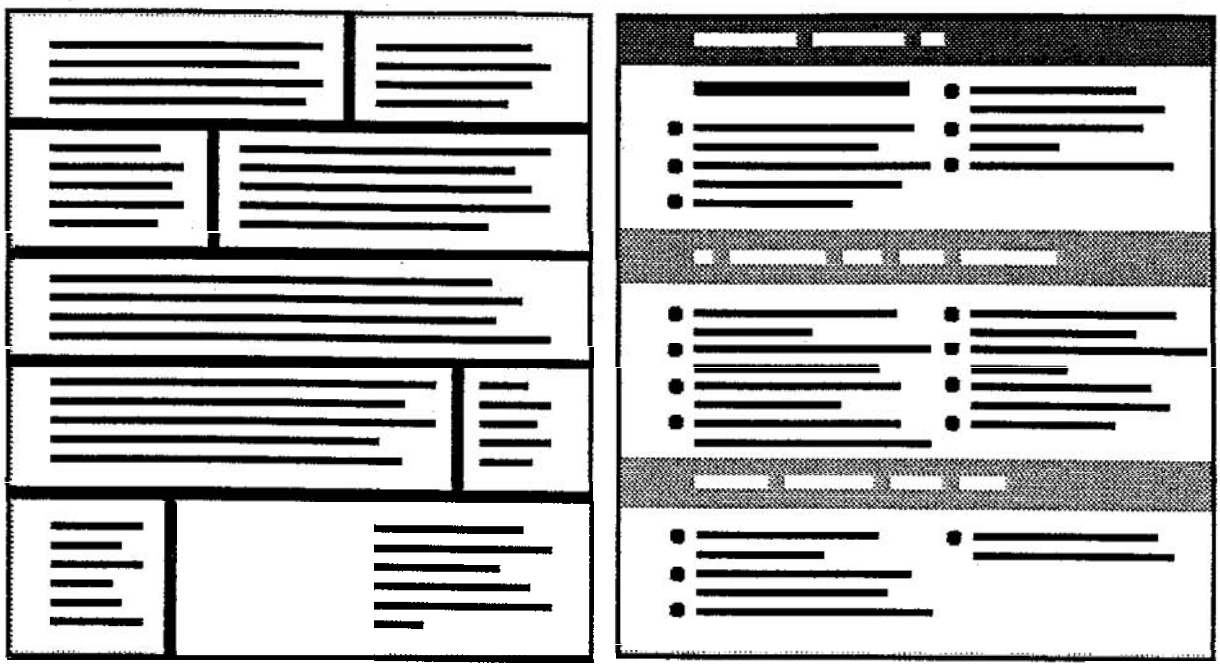


Figure 7: Navigation

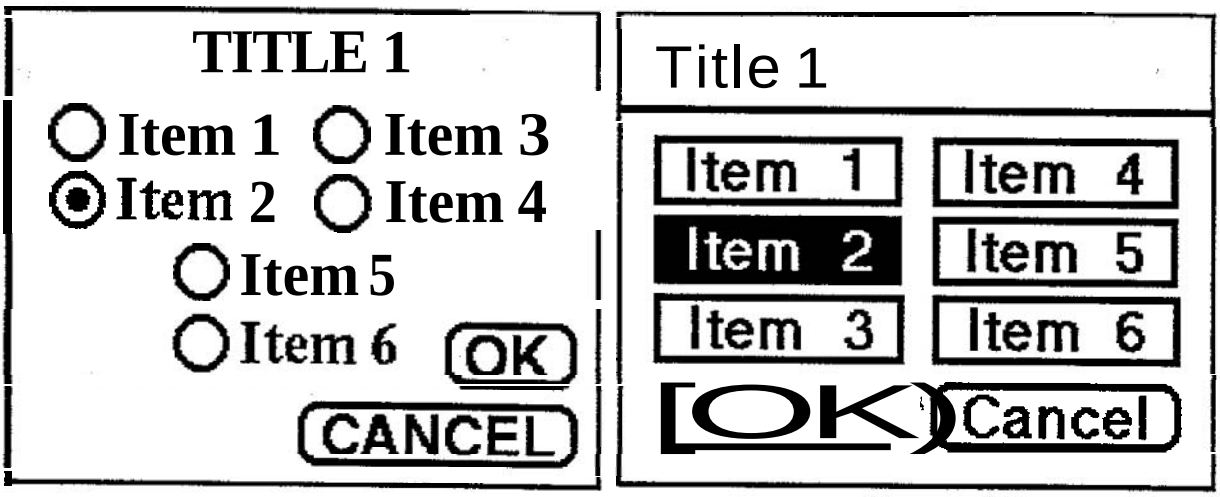


Figure 8: Complicated and Simpler Designs

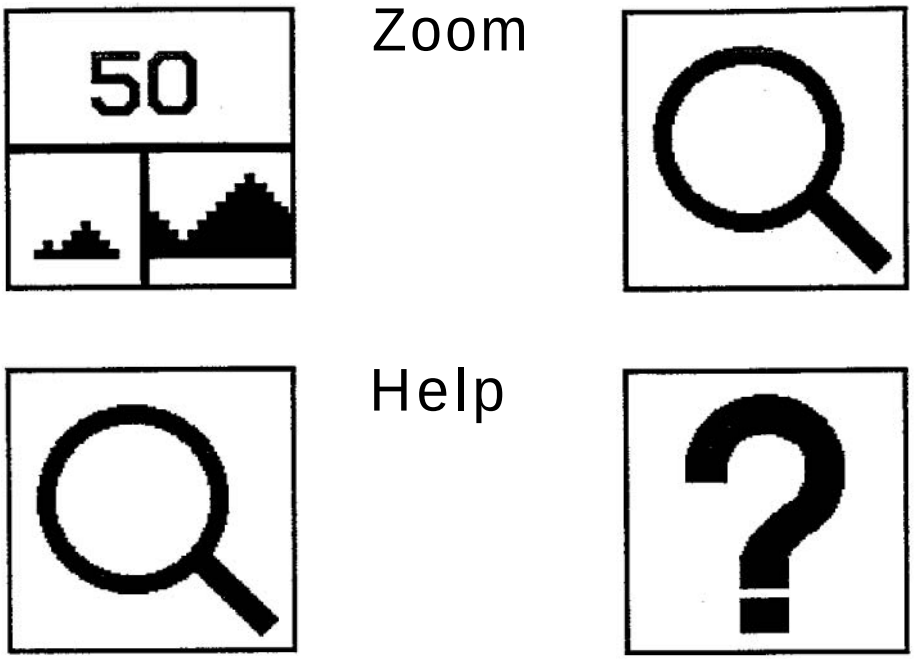


Figure 9: Ambiguous and Clear Icons

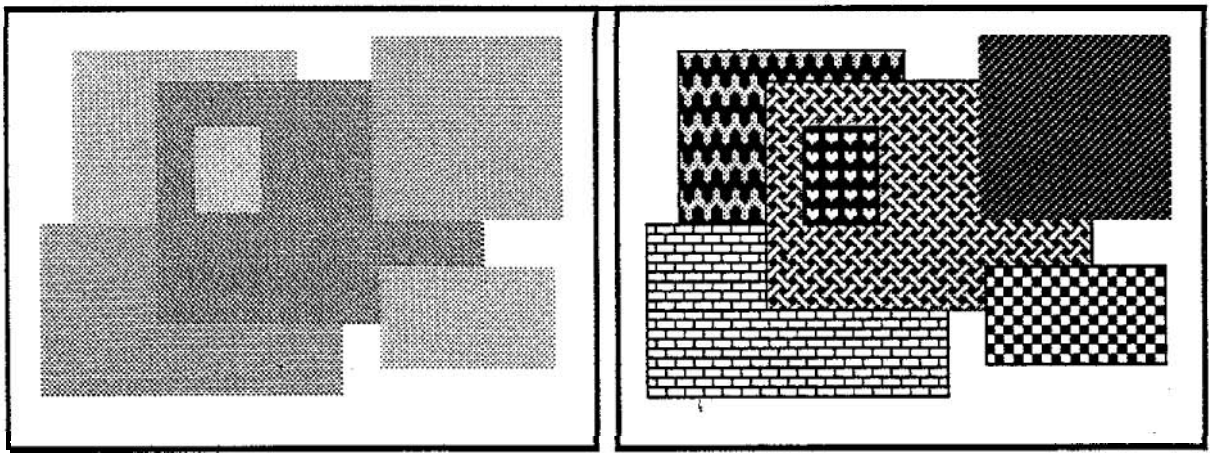


Figure 10: Too Much and Too Little Distinctiveness

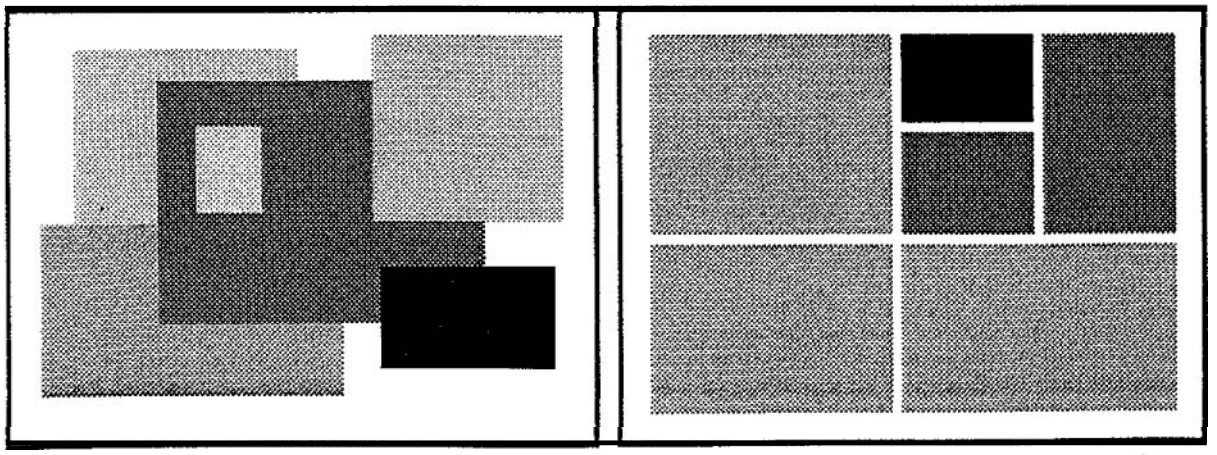


Figure 11: Too Much and Improved Emphasis

illegible	Legible	Illegible	Legible
Text set in Old English	Text set in Univers	Large Medium Small	Large Medium Small

Figure 12: illegible and Legible Texts Based on Fonts and Relative Sizes

Unreadable: Design components to be easy to interpret and understand. Design'components to be inviting and attractive

Readable

Design components to be easy to interpret and understand.

Design components to be inviting and attractive

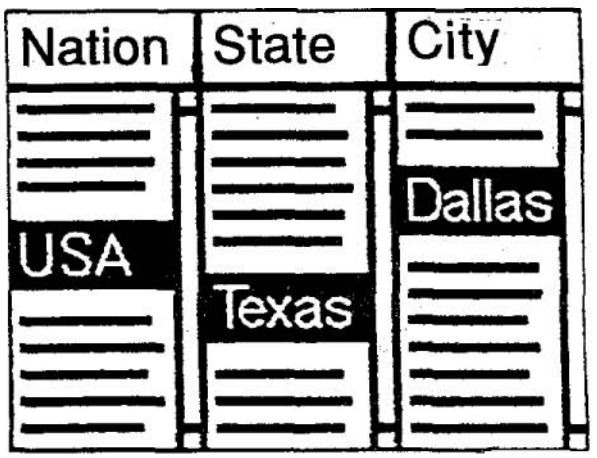
Figure 13: Unreadable and Readable Texts

Univers
Helvetica
Times Roman
Palatino
Courier

ABCDEfghijkl
ABCDEfghijkl
AAaBBbCCcDDd

Uchbφ=>IQm∃

Figure 14: Typefaces and Typestyles



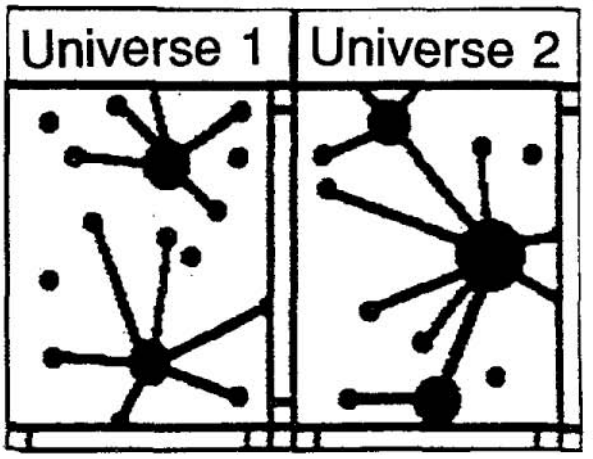


Figure 15: Verbal and Visual Multiple Views

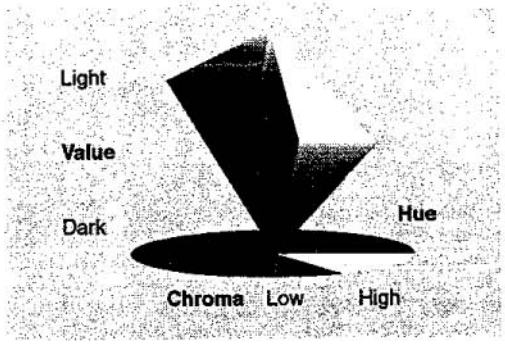


Figure 16: Color Dimensions

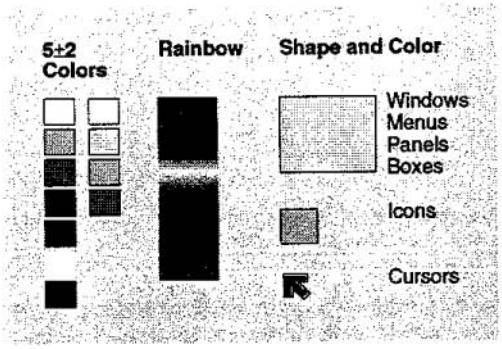


Figure 20: Color Simplicity

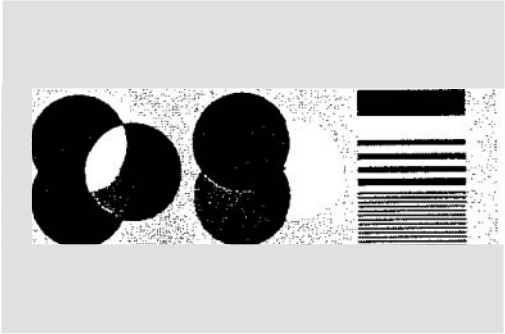


Figure 17: Color Mixtures

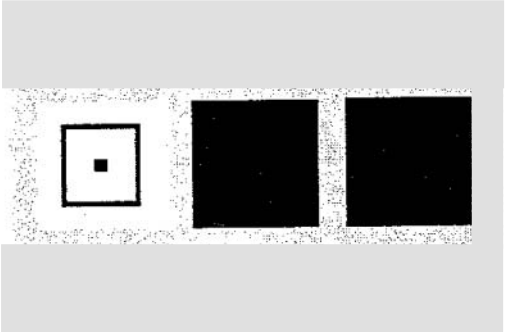


Figure 21: Color Legibility

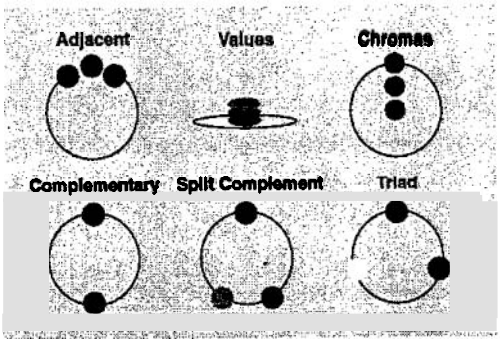


Figure 18: Color Harmonies

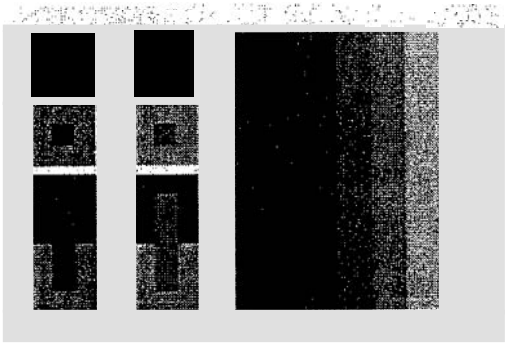


Figure 22: Color Interactions

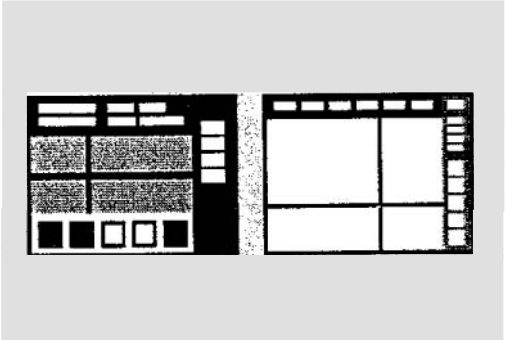


Figure 19: Color Consistency

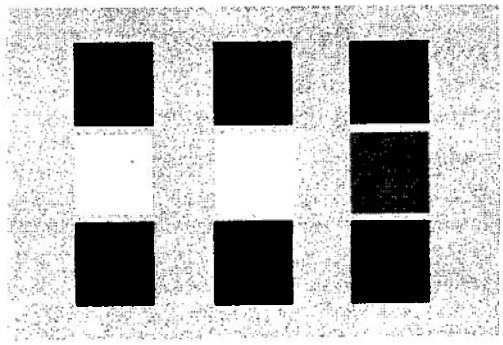


Figure 23: Color Symbolism

Please see the inside front cover for color images C1 through C8 which correspond to Figures 16 through 23.

Color Graphics—Blessing or Ballyhoo

(Excerpt)

G. Murch

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5. Guidelines for Effective Colour Usage

Based on the preceding discussion, some general guidelines for colour usage can be stated. They are listed here according to the area of their derivation – physiological, perceptual, or cognitive.

5.1. Physiological guidelines

Avoid the simultaneous display of highly saturated, spectrally extreme colours. Reds, oranges, yellows, and greens can be viewed together without refocusing, but cyan and blues cannot be easily viewed simultaneously with red. To avoid frequent refocusing and visual fatigue, extreme colour pairs such as red and blue or yellow and purple should he avoided. However, desaturating spectrally extreme colours will reduce the need for refocusing.

Avoid pure blue for text, thin lines, and small shapes. Our visual system is just not set up for detailed, sharp, short-wavelength stimuli. However, blue does make a good background colour and is perceived clearly out into the periphery of our visual field.

Avoid adjacent colours differencing only in the amount of blue. Edges that difler only 'in the amount of blue will appear indistinct.

Older viewers need higher brightness levels to distinguish colours.

Colours change appearance as ambient light level changes. Displays change colour under different kinds of ambient light – fluorescent, incandescent, or daylight. Appearance also changes as the light level is increased or decreased. On the one hand, a change occurs due to increased or decreased contrast, and on the other, due to the shift in the sensitivity of the eye.

The magnitude of a detectable change in colour varies across the spectrum. Small changes in extreme reds and purples are more difficult to detect than small changes in other colours such as yellow and blue-green. Also, our visual system does not readily perceive changes in green.

Difficulty in focusing results from edges created by colour alone. Our visual system depends on a brightness difference at an edge to eflect clear focusing. Multi-coloured images, then, should be differentiated on the basis of brightness as well as of colour.

Avoid red and green in the periphery of large-scale displays. Due to the insensitivity of the retinal periphery to red and green, these colours in saturated form should be avoided, especially for small symbols and shapes. Yellow and blue are good peripheral colours.

Opponent colours go well together. Red and green or yellow and blue are good combinations for simple displays. The opposite combinations - red with yellow or green with blue - produce poorer images.

For colour-deficient observers, avoid single colour distinctions.

6. Perceptual Guidelines

Not all colours are equally dicernible. Perceptually, we need a large change in wavelength to perceive a colour difference in some portions of the spectrum and a small one in other portions.

Luminance does not equal brightness. Two equal-luminance but different hue colours will probably appear to have different brightness. The deviations are most extreme for wlours towards the ends of the spectrum (red, magenta, blue).

Different hues have inherently different saturation levels. Yellow in particular always appears to be less saturated than other hues.

Lightness and brightness are distinguishable on a printed hard copy, but not on a colour display. The nature of a colour display does not allow lightness and brightness to be varied independently.

Not all colours are equally readable or legible. Extreme care should be exercised with text colour relative to background colours. Besides a loss in hue with reduced size, inadequate contrast frequently results when the background and text colours are similar. As a general rule, the darker, spectrally extreme colours such as red, blue, magenta, brown, etc. make good backgrounds while the brighter, spectrum-centered, and desaturated hues produce more legible text.

Hues change with intensity and background colour. When grouping elements on the basis of wlour, be sure that backgrounds or nearby colours do not change the hue of an element in the group. Limiting the number of colours and making sure they are widely separated in the spectrum will reduce wnfusion.

Avoid the need for colour discrimination in small areas. Hue information is lost for small areas. In general, two adjacent lines of a single-pixel width will merge to produce a mixture of the two. Also, the human visual system produces sharper images with achromatic colours. Thus for the line detail, it is best to use black, white, and grey while reserving chromatic colours for larger panels or for attracting attention.

6.1. Cognitive guidelines

Do not overuse colour. Perhaps the best rule is to use colour sparingly. The benefits of colour as an attention getter, information grouper, and value assigner are lost if too many colours are used. Cognitive scientists have shown that the human mind experiences great difficulty in maintaining more than five to seven elements simultaneously; so it is best to limit displays to about six clearly discriminable colours.

Be aware of the nonlinear colour manipulation in video and hard copy. At this point, algorithms do not exist for translating the physical colours of an imaging device into a perceptually structured colour set. Video or hard-copy systems cannot match human perception and expectations on all fronts.

Group related elements by using a common background colour. Cognitive science has advanced the notion of set and preattentive processing. In this context, you can prepare or set the user for related events by using a common colour code. A successive set of images can be shown to be related by using the same background colour.

Similar colours connote similar meanings. Elements related in some way can convey the message through the degree in similarity of hue. The colour range from blue to green is experienced as more similar than the gamut from red to green. Along these lines, saturation level can also be used to connote the strength of relationships.

Brightness and saturation draw attention. The brightest and most highly saturated area of colour display immediately draws the viewer's attention.

Link the degree of colour change to event magnitude. As an alternative to bar charts or tic marks on amplitude scales, displays can portray magnitude changes with progressive steps of changing colour. A desaturated cyan can be increased in saturation as the graphed elements increase in value. Progressively switching from one hue to another can be used to indicate passing critical levels.

Order colours by their spectral position. To increase the number of colours on a display requires imposing a meaningful order on the colours. The most obvious order is that provided by the spectrum with the mnemonic ROY G. BIV (red, orange, yellow, green, blue, indigo, violet).

Warm and cold colours should indicate action levels. Traditionally, the warm (long wavelength) colours are used to signify action or the requirement of a response. Cool colours, on the other hand, indicate status or background information. Most people also experience warm colours advancing toward them — hence forcing attention — and cool colours receding or drawing away.

While these guidelines offer some suggestions, they certainly should not be taken as binding under all circumstances. There are too many variables in colour display, colour copying, human perception, and human interpretation to make any hard and fast rules. So, by all means, experiment.

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