Chp 1-5

Designing with the Mind in Mind

Simple Guide to Understanding User Interface Design Rules

MK
MORGAN KAUFMANN

Jeff Johnson

CHAPTER

We Perceive What We Expect

1

Our perception of the world around us is not a true depiction of what is actually there. We perceive, to a large extent, what we *expect* to perceive. Our expectations—and therefore our perceptions—are biased by three factors:

- ***the past:*** our experience
- ***the present:*** the current context
- ***the future:*** our goals

PERCEPTION BIASED BY EXPERIENCE

Imagine that you own a large insurance company. You are meeting with a real estate manager, discussing plans for a new campus of company buildings. The campus consists of a row of five buildings, the last two with T-shaped courtyards providing light for the cafeteria and fitness center. If the real estate manager showed you the map shown in Figure 1.1, you would see five black shapes representing the buildings.

FIGURE 1.1

Building map or word? What you see depends on what you were told to see.

Designing with the Mind in Mind

Now imagine that instead of a real estate manager, you are meeting with an advertising manager. You are discussing a new billboard ad to be placed in certain markets around the country. The advertising manager shows you the same image, but in this scenario the image is a sketch of the ad, consisting of a single word. In this scenario, you see a word, clearly and unambiguously.

When your perceptual system has been primed to see building shapes, you see building shapes, and the white areas between the buildings barely register in your perception. When your perceptual system has been primed to see text, you see text, and the black areas between the letters barely register.

A relatively famous example of how priming the mind can affect perception is a sketch, supposedly by R. C. James,[1] that initially looks to most people like a random splattering of ink (see Fig. 1.2). Before reading further, look at the sketch.

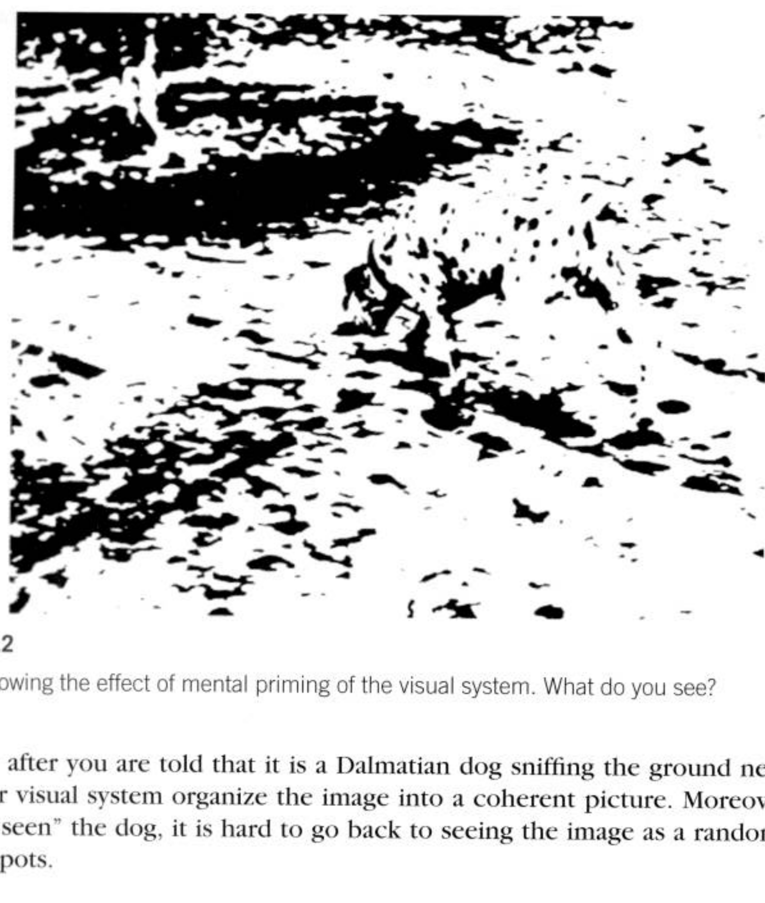


FIGURE 1.2

Image showing the effect of mental priming of the visual system. What do you see?

Only after you are told that it is a Dalmatian dog sniffing the ground near a tree can your visual system organize the image into a coherent picture. Moreover, once you've "seen" the dog, it is hard to go back to seeing the image as a random collection of spots.

[1] Published in Marr D. (1982) *Vision*. W. H. Freeman, New York, NY, p. 101, Figure 3-1.

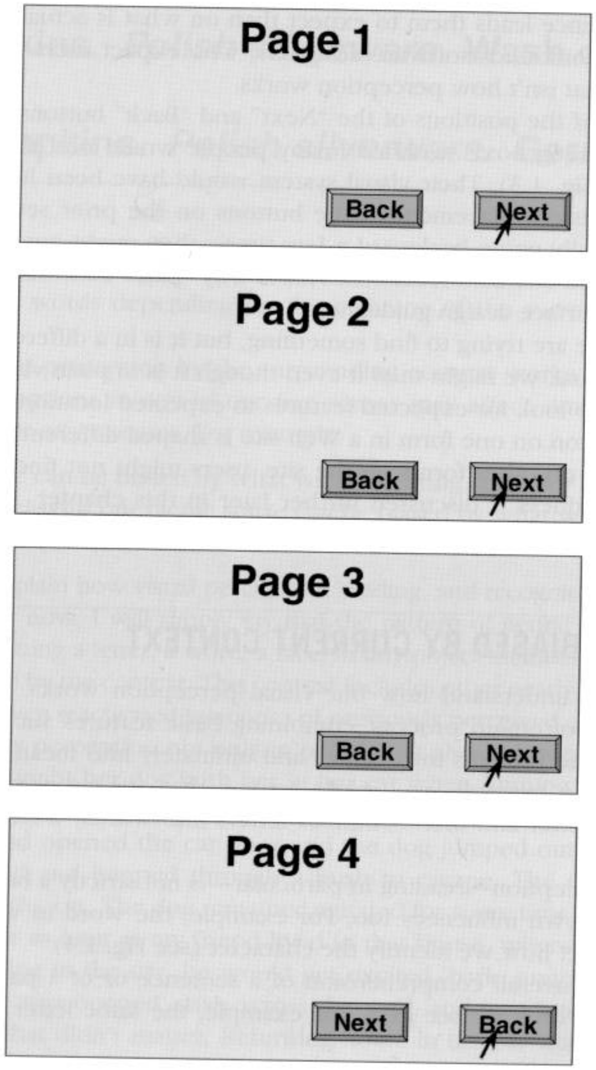


FIGURE 1.3

The "Next" button is perceived to be in a consistent location, even when it isn't.

The examples above are visual. Experience can also bias other types of perception, such as sentence comprehension. For example, the headline "New Vaccine Contains Rabies" would probably be understood differently by people who had recently heard stories about contaminated vaccines than by people who had recently heard stories about successful uses of vaccines to fight diseases.

Users of computer software and Web sites often click buttons or links without looking carefully at them. Their perception of the display is based more on what their past experience leads them to expect than on what is actually on the screen. This sometimes confounds software designers, who expect users to see what is on the screen. But that isn't how perception works.

For example, if the positions of the "Next" and "Back" buttons on the last page of a multipage dialog box[2] switched, many people would not immediately notice the switch (see Fig. 1.3). Their visual system would have been lulled into inattention by the consistent placement of the buttons on the prior several pages. Even after unintentionally going backward a few times, they might continue to perceive the buttons in their standard locations. This is why "place controls consistently" is a common user interface design guideline.

Similarly, if we are trying to find something, but it is in a different place or looks different from usual, we might miss it even though it is in plain view because experience tunes us to look for expected features in expected locations. For example, if the "Submit" button on one form in a Web site is shaped differently or is a different color from those on other forms on the site, users might not find it. This expectation-induced blindness is discussed further later in this chapter, in the section on how our *goals* affect perception.

PERCEPTION BIASED BY CURRENT CONTEXT

When we try to understand how our visual perception works, it is tempting to think of it as a bottom-up process, combining basic features such as edges, lines, angles, curves, and patterns into figures and ultimately into meaningful objects. To take reading as an example, you might assume that our visual system first recognizes shapes as letter and then combines letters into words, words into sentences, and so on.

But visual perception—reading in particular—is not strictly a bottom-up process. It includes top-down influences too. For example, the word in which a character appears may affect how we identify the character (see Fig. 1.4).

Similarly, our overall comprehension of a sentence or of a paragraph can even influence what words we see in it. For example, the same letter sequence can be

FIGURE 1.4

The same character is perceived as H or A depending on the surrounding letters.

[2] Multi step dialog boxes are called "wizards" in user interface jargon.

Fold napkins. *Polish silverware.* Wash dishes.

French napkins. *Polish silverware.* German dishes.

FIGURE 1.5

The same phrase is perceived differently depending on the list it appears in.

read as different words depending on the meaning of the surrounding paragraph (see Fig. 1.5).

This biasing of perception by the surrounding context works *between* different senses too. Perceptions in any of our five senses may affect simultaneous perceptions in any of our other senses. For example:

- What we see can be biased by what we are hearing, and *vice versa*
- What we feel with our tactile sense can be biased by what we are hearing, seeing, or smelling

Later chapters explain how visual perception, reading, and recognition function in the human brain. For now, I will simply say that the pattern of neural activity that corresponds to recognizing a letter, a word, a face, or any object includes input from neural activity stimulated by the context. This context includes other nearby perceived objects and events, and even reactivated memories of previously perceived objects and events.

Context biases perception not only in people but also in lower animals. A friend of mine often brought her dog with her in her car when running errands. One day, as she drove into her driveway, a cat was in the front yard. The dog saw it and began barking. My friend opened the car door and the dog jumped out and ran after the cat, which turned and jumped through a bush to escape. The dog dove into the bush but missed the cat. The dog remained agitated for some time afterward.

Thereafter, for as long as my friend lived in that house, whenever she arrived at home with her dog in the car, he would get excited, bark, jump out of the car as soon as the door was opened, dash across the yard, and leap into the bush. There was no cat, but that didn't matter. Returning home in the car was enough to make the dog see one—perhaps even smell one. However, walking home, as the dog did after being taken for his daily walk, did not evoke the "cat mirage."

PERCEPTION BIASED BY GOALS

In addition to being biased by our *past* experience and the *present* context, our perception is influenced by our goals and plans for the *future*. Specifically, our goals filter our perceptions: things unrelated to our goals tend to be filtered out preconsciously, never registering in our conscious minds.

For example, when people navigate through software or a Web site, seeking information or a specific function, they don't read carefully. They scan screens quickly and superficially for items that seem related to their goal. They don't simply *ignore* items unrelated to their goals; they often don't even *notice* them.

To see this, flip briefly to the next page and look in the toolbox (Fig. 1.6) for *scissors*, and then immediately flip back to this page. Try it now.

Did you spot the scissors? Now, without looking back at the toolbox, can you say whether there is a screwdriver in the toolbox too?

Our goals filter our perceptions in other perceptual senses as well as in vision. A familiar example is the "cocktail party" effect. If you are conversing with someone at a crowded party, you can focus your attention to hear mainly what he or she is saying even though many other people are talking near you. The more interested you are in the conversation, the more strongly your brain filters out surrounding chatter. If you are bored by what your conversational partner is saying, you will probably hear much more of the conversations around you.

The effect was first documented in studies of air-traffic controllers, who were able to carry on a conversation with the pilots of their assigned aircraft even though many different conversations were occurring simultaneously on the same radio frequency, coming out of the same speaker in the control room (Arons, 1992). Research suggests that our ability to focus on one conversation among several simultaneous ones depends not only on our interest level in the conversation but also on objective factors such as the similarity of voices in the cacophony, the amount of general "noise" (e.g., clattering dishes or loud music), and the predictability of what your conversational partner is saying (Arons, 1992).

This filtering of perception by our goals is particularly true for adults, who tend to be more focused on goals than children are. Children are more stimulus driven: their perception is less filtered by their goals. This characterisitic makes them more distractible than adults, but it also makes them less biased as observers.

A parlor game demonstrates this age difference in perceptual filtering. It is similar to the "look in the toolbox" exercise. Most households have a catch-all drawer for kitchen implements or tools. From your living room, send a visitor to the room where the catch-all drawer is, with instructions to fetch you a specific tool, such as measuring spoons or a pipe wrench. When the person returns with the tool, ask whether another specific tool was in the drawer. Most adults will not know what else was in the drawer. Children—if they can complete the task without being distracted by all the cool stuff in the drawer—will often be able to tell you more about what else was there.

Perceptual filtering can also be seen in how people navigate Web sites. Suppose I put you on the home page of New Zealand's University of Canterbury (see Fig. 1.7) and asked you to print out a map of the campus showing the computer science department. You would scan the page and probably quickly click one of the links that share words with the goal that I gave you: *Departments* (top left), *Departments and Colleges* (middle left), or *Campus Maps* (bottom right). If you're a "search" person, you might instead go right to the Search box (middle right), type words related to the goal, and click "Go."

FIGURE 1.6

Toolbox: A

FIGURE 1.7

University of Ca

FIGURE 1.6

Toolbox: Are there scissors here?

FIGURE 1.7

University of Canterbury home page: Navigating Web sites includes perceptual filtering.

Whether you browse or search, it is likely that you would leave the home page without noticing that you were randomly chosen to win $100 (bottom left). Why? Because that was not related to your *goal*.

What is the mechanism by which our current goals bias our perception? There are two:

- ***Influencing where we look.*** Perception is active, not passive. We constantly move our eyes, ears, hands, and so on, so as to sample exactly the things in our environment that are most relevant to what we are doing or about to do (Ware, 2008). If we are looking on a Web site for a campus map, our eyes and pointer-controlling hand are attracted to anything that might lead us to that goal. We more or less ignore anything unrelated to our goal.
- ***Sensitizing our perceptual system to certain features.*** When we are looking for something, our brain can prime our perception to be especially sensitive to features of what we are looking for (Ware, 2008). For example, when we are looking for a red car in a large parking lot, red cars will seem to pop out as we scan the lot, and cars of other colors will barely register in our consciousness, even though we do in some sense "see" them. Similarly, when we are trying to find our spouse in a dark, crowded room, our brain "programs" our auditory system to be especially sensitive to the combination of frequencies that make up his or her voice.

DESIGN IMPLICATIONS

All these sources of perceptual bias of course have implications for user interface design. Here are three.

Avoid ambiguity

Avoid ambiguous information displays, and test your design to verify that all users interpret the display in the same way. Where ambiguity is unavoidable, either rely on standards or conventions to resolve it, or prime users to resolve the ambiguity in the intended way.

For example, computer displays often shade buttons and text fields to make them look raised in relation to the background surface (see Fig. 1.8). This appearance

FIGURE 1.8

Buttons on computer screens are often shaded to make them look three dimensional, but the convention only works if the simulated light source is assumed to be on the upper left.

relies on a convention, familiar to most experienced computer users, that the light source is at the top left of the screen. If an object were depicted as lit by a light source in a different location, users would not see the object as raised.

Be consistent

Place information and controls in consistent locations. Controls and data displays that serve the same function on different pages should be placed in the same position on each page on which they appear. They should also have the same color, text fonts, shading, and so on. This consistency allows users to spot and recognize them quickly.

Understand the goals

Users come to a system with goals they want to achieve. Designers should understand those goals. Realize that users' goals may vary, and that their goals strongly influence what they perceive. Ensure that at every point in an interaction, the information users need is available, prominent, and maps clearly to a possible user goal, so users will notice and use the information.

CHAPTER

Our Vision is Optimized to See Structure

2

Early in the twentieth century, a group of German psychologists sought to explain how human visual perception works. They observed and catalogued many important visual phenomena. One of their basic findings was that human vision is holistic: Our visual system automatically imposes structure on visual input and is wired to perceive whole shapes, figures, and objects rather than disconnected edges, lines, and areas. The German word for "shape" or "figure" is *Gestalt,* so these theories became known as the Gestalt principles of visual perception.

Today's perceptual and cognitive psychologists regard the Gestalt theory of perception as more of a *descriptive* framework than an *explanatory* and *predictive* theory. Today's theories of visual perception tend to be based heavily on the neurophysiology of the eyes, optic nerve, and brain (see Chapters 4–7).

Not surprisingly, the findings of neurophysiological researchers support the observations of the Gestalt psychologists. We really are—along with other animals—"wired" to perceive our surroundings in terms of whole objects (Stafford & Webb, 2005; Ware, 2008). Consequently, the Gestalt principles are still valid—if not as a fundamental explanation of visual perception, at least as a framework for describing it. They also provide a useful basis for guidelines for graphic and user interface design (Soegaard, 2007).

For present purposes, the most important Gestalt principles are: Proximity, Similarity, Continuity, Closure, Symmetry, Figure/Ground, and Common Fate. In the following sections, I describe each principle and provide examples from both static graphic design and user interface design.

GESTALT PRINCIPLE: PROXIMITY

The principle of *Proximity* is that the relative distance between objects in a display affects our perception of whether and how the objects are organized into subgroups. Objects that are near each other (relative to other objects) appear grouped, while those that are farther apart do not.

In Figure 2.1, the stars on the left are closer together horizontally than they are vertically, so we see three rows of stars, while the stars on the right are closer together vertically than they are horizontally, so we see three columns.

The Proximity principle has obvious relevance to the layout of control panels or data-forms in software, Web sites, and electronic appliances. Designers often separate groups of on-screen controls and data-displays by enclosing them in group boxes or by placing separator lines between groups (see Fig. 2.2).

FIGURE 2.1

Proximity: Items that are closer appear grouped. Left: rows, Right: columns.

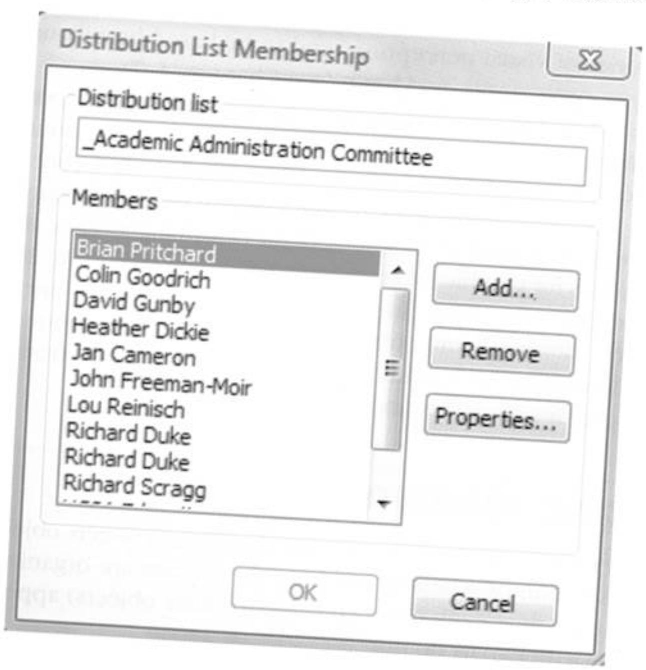


FIGURE 2.2

In Outlook's Distribution List Membership dialog box, list buttons are in a group box, separate from the window-control buttons.

However, according to the Proximity principle, items on a display can be visually grouped simply by spacing them closer together to each other than to other controls, without group boxes or visible borders (see Fig. 2.3). Many graphic design experts recommend this approach in order to reduce visual clutter and code size in a user interface (Mullet & Sano, 1994).

Conversely, if controls are *poorly* spaced, e.g., if connected controls are too far apart, people will have trouble perceiving them as related, making the software harder to learn and remember. For example, the Discreet Software Installer displays six horizontal pairs of radiobuttons, each representing a two-way choice, but their spacing, due to the Proximity principle, makes them appear to be two vertical sets of radiobuttons, each representing a six-way choice, at least until users try them and learn how they operate (see Fig. 2.4).

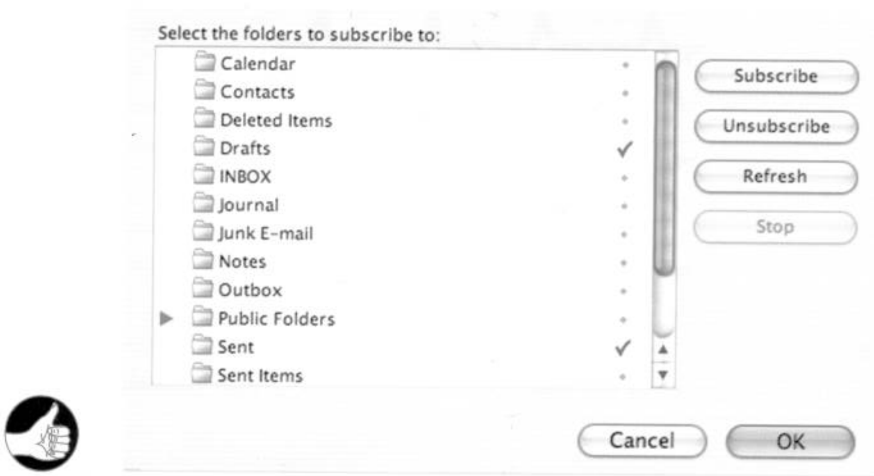


FIGURE 2.3

In Mozilla Thunderbird's Subscribe Folders dialog box, controls are grouped using the Proximity principle.

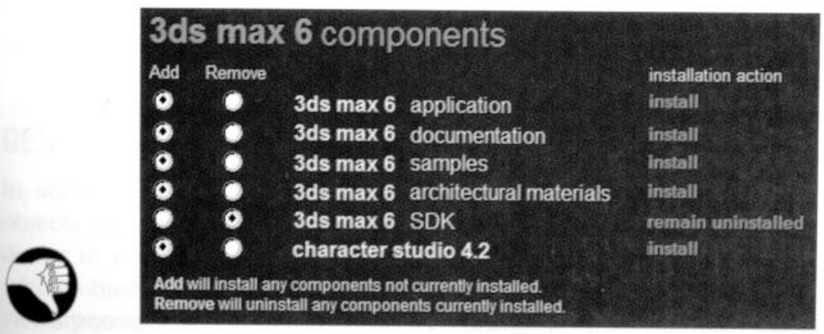


FIGURE 2.4

In Discreet's Software Installer, poorly spaced radiobuttons look grouped in vertical columns.

GESTALT PRINCIPLE: SIMILARITY

Another factor that affects our perception of grouping is expressed in the Gestalt principle of *Similarity:* Objects that look similar appear grouped, all other things being equal. In Figure 2.5, the slightly larger, "hollow" stars are perceived as a group.

The Page Setup dialog box in Mac OS applications uses the Similarity and Proximity principles to convey groupings (see Fig. 2.6). The three very similar and tightly spaced

FIGURE 2.5

Similarity: Items appear grouped if they look more similar to each other than to other objects.

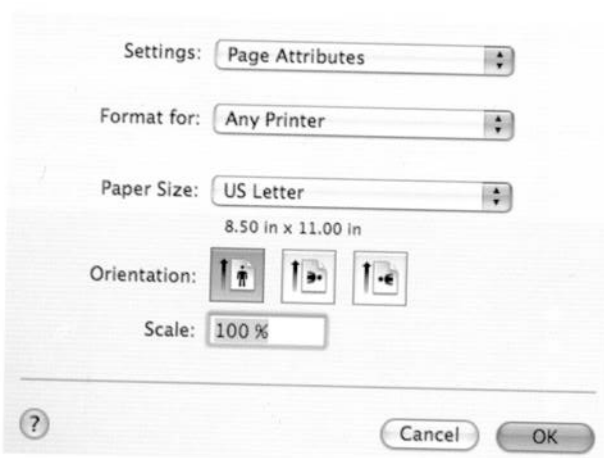
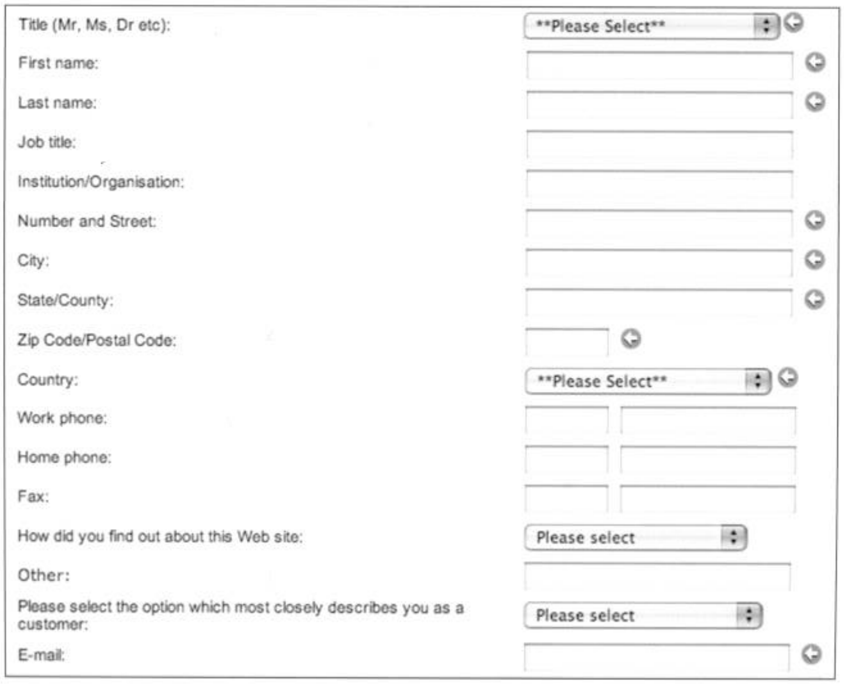


FIGURE 2.6

Mac OS Page Setup dialog box: The Similarity and Proximity principles are used to group the Orientation settings.

Orientation settings are clearly intended to appear grouped. The three menus are not so tightly spaced but look similar enough that they appear related even though that probably wasn't intended.

Similarly, the text fields in a form at the Web site of book publisher Elsevier are organized into an upper group of seven (with three subgroups) for the address, a group of three split fields for phone numbers, and two single text fields. The four menus, in addition to being data fields, help separate the text field groups (see Fig. 2.7). By contrast, the labels are too far from their fields to seem connected to them.



Title (Mr, Ms, Dr etc): **Please Select**
First name:
Last name:
Job title:
Institution/Organisation:
Number and Street:
City:
State/County:
Zip Code/Postal Code:
Country: **Please Select**
Work phone:
Home phone:
Fax:
How did you find out about this Web site: Please select
Other:
Please select the option which most closely describes you as a customer: Please select
E-mail:

FIGURE 2.7

Online form at Elsevier.com: Similarity makes the text fields appear grouped.

GESTALT PRINCIPLE: CONTINUITY

In addition to the two Gestalt principles concerning our tendency to organize objects into groups, several Gestalt principles describe our visual system's tendency to resolve ambiguity or fill in missing data in such a way as to perceive whole objects. The first such principle, the principle of *Continuity,* states that our visual perception is biased to perceive continuous forms rather than disconnected segments.

For example, on the left side of Figure 2.8, we automatically see two crossing lines—one blue and one orange. We don't see two separate orange segments and two separate blue ones, and we don't see a blue-and-orange V on top of an upside-down orange-and-blue V. On the right side of Figure 2.8, we see a sea monster in water, not three pieces of one.

A well-known example of the use of the Continuity principle in graphic design is the IBM® logo. It consists of disconnected blue patches, and yet it is not at all ambiguous; it is easily seen as three bold letters, perhaps viewed through something like venetian blinds (see Fig. 2.9).

Slider controls are a user-interface example of the Continuity principle. We see a slider as depicting a single range controlled by a handle that appears somewhere on the slider, not as two separate ranges separated by the handle (see Fig. 2.10A). Even displaying different colors on each side of a slider's handle doesn't completely "break" our perception of a slider as one continuous object, although ComponentOne's choice of strongly contrasting colors (gray vs. red) certainly strains that perception a bit (see Fig. 2.10B).

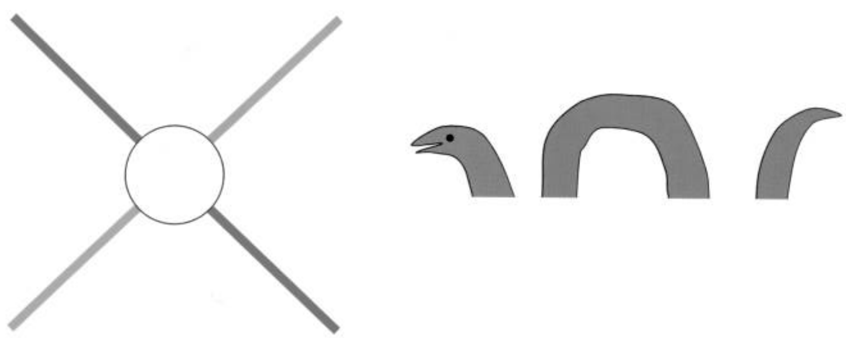


FIGURE 2.8

Continuity: Human vision is biased to see continuous forms, even adding missing data if necessary.

FIGURE 2.9

The IBM company logo uses the Continuity principle to form letters from disconnected patches.

(A)

(B)

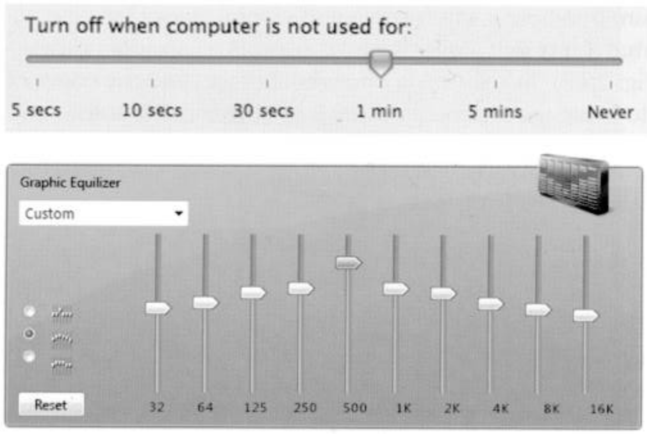


FIGURE 2.10

Continuity: We see a slider as a single slot with a handle somewhere on it, not as two slots separated by a handle. (A) Mac OS, (B) ComponentOne.

GESTALT PRINCIPLE: CLOSURE

Related to Continuity is the Gestalt principle of *Closure*, which states that our visual system automatically tries to close open figures so that they are perceived as whole objects rather than separate pieces. Thus, we perceive the disconnected arcs on the left of Figure 2.11 as a circle.

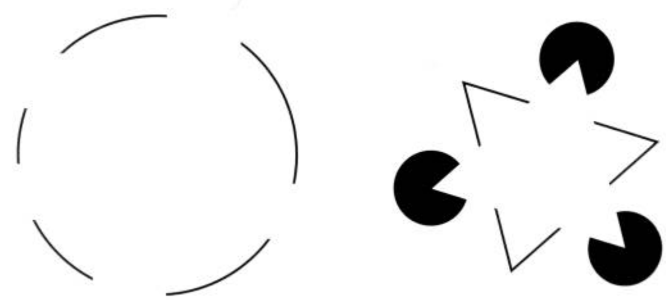


FIGURE 2.11

Closure: Human vision is biased to see whole objects, even when they are incomplete.

Our visual system is so strongly biased to see objects that it can even interpret a totally blank area as an object. We see the combination of shapes on the right of Figure 2.11 as a white triangle overlapping another triangle and three black circles, even though the figure really only contains three V-shapes and three black pac-men.

The Closure principle is often applied in graphical user interfaces (GUIs). For example, GUIs often represent collections of objects—e.g., documents or messages—as *stacks* (see Fig. 2.12). Just showing one whole object and the edges of others "behind" it is enough to make users perceive a stack of objects, all whole.

FIGURE 2.12

Icons depicting stacks of objects exhibit the Closure principle: partially visible objects are perceived as whole.

GESTALT PRINCIPLE: SYMMETRY

A third fact about our tendency to see objects is captured in the Gestalt principle of *Symmetry*. It states that we tend to parse complex scenes in a way that reduces the complexity. The data in our visual field usually has more than one possible interpretation, but our vision automatically organizes and interprets the data so as to simplify it and give it symmetry.

For example, we see the complex shape on the left of Figure 2.13 as two overlapping diamonds, not as two touching corner bricks or a pinch-waist octahedron with a square in its center. A pair of overlapping diamonds is simpler than the other two interpretations shown on the right of Figure 2.13: it has fewer sides and more symmetry than the other two interpretations.

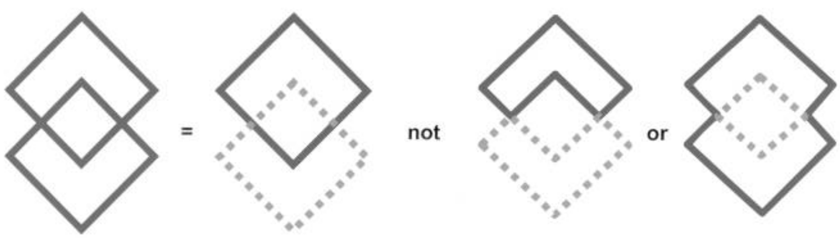


FIGURE 2.13

Symmetry: The human visual system tries to resolve complex scenes into combinations of simple, symmetrical shapes.

In printed graphics and on computer screens, our visual system's reliance on the symmetry principle can be exploited to represent three dimensional objects on a two dimensional display. This can be seen in a cover illustration for Paul Thagard's book *Coherence in Thought and Action* (Thagard, 2002; see Fig. 2.14) and in three-dimensional depiction of a cityscape (see Fig. 2.15).

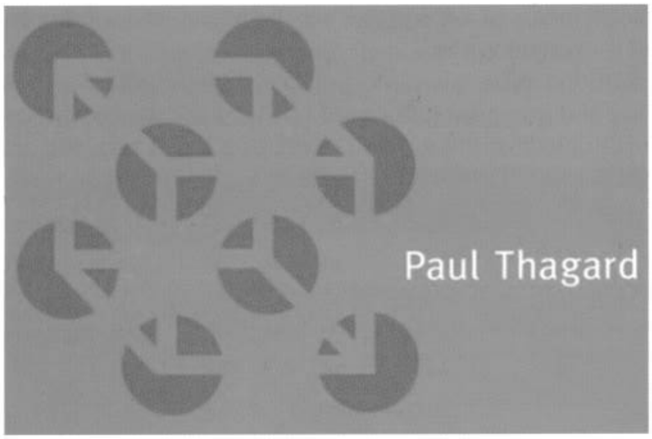


FIGURE 2.14

The cover of the book *Coherence in Thought and Action* (Thagard, 2002) uses the Symmetry, Closure, and Continuity principles to depict a cube.

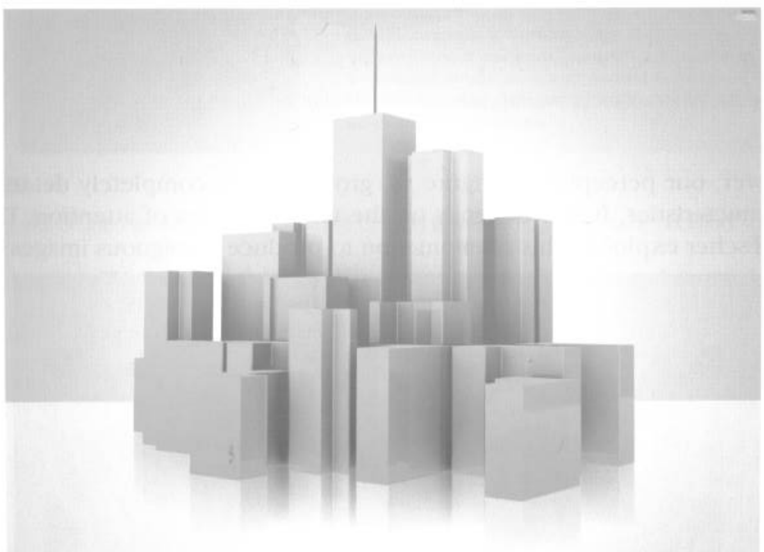


FIGURE 2.15

Symmetry: The human visual system parses very complex two dimensional images into three dimensional scenes.

GESTALT PRINCIPLE: FIGURE/GROUND

The next Gestalt principle that describes how our visual system structures the data it receives is *Figure/Ground*. This principle states that our mind separates the visual field into the figure (the foreground) and ground (the background). The foreground consists of those elements of a scene that are the object of our primary attention, and the background is everything else.

The Figure/Ground principle also specifies that the visual system's parsing of scenes into figure and ground is influenced by characteristics of the scene. For example, when a small object or color patch overlaps a larger one, we tend to perceive the smaller object as the figure and the larger object as the ground (see Fig. 2.16).

FIGURE 2.16

Figure/Ground: When objects overlap, we see the smaller as figure on ground.

However, our perception of figure vs. ground is not completely determined by scene characteristics. It also depends on the viewer's focus of attention. Dutch artist M. C. Escher exploited this phenomenon to produce ambiguous images in which figure and ground switch roles as our attention shifts (see Fig. 2.17).

FIGURE 2.17

M. C. Escher exploited figure/ground ambiguity in his art.

In user interface and Web design, the Figure/Ground principle is often used to place an impression-inducing background "behind" the primary displayed content (see Fig. 2.18). The background can convey information—e.g., the user's current location—or it can suggest a theme, brand, or mood for interpretation of the content.

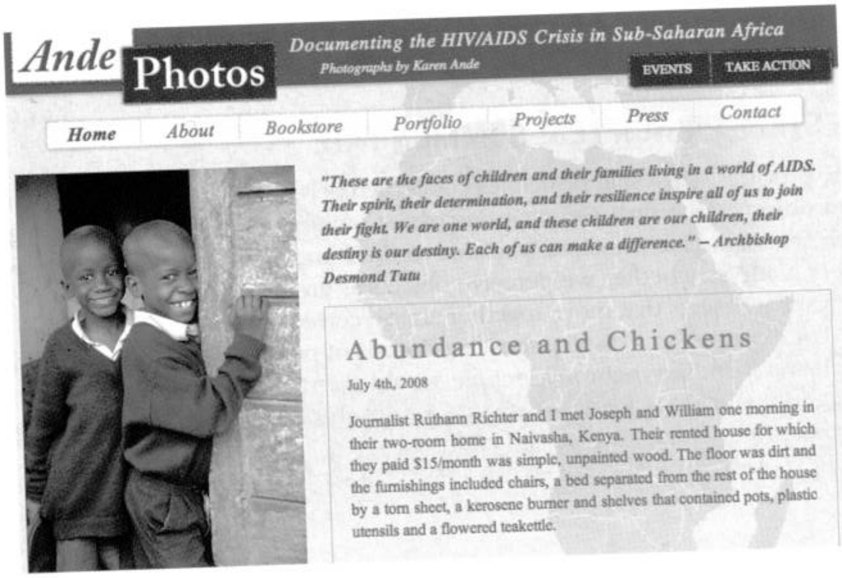


FIGURE 2.18

Figure/Ground is used at AndePhotos.com to display a thematic watermark "behind" content.

FIGURE 2.19

Figure/Ground is used at GRACEUSA.org to pop up a photo "over" the page content.

Figure/Ground is also often used to pop up information over other content. Content that was formerly the figure—the focus of the users' attention—temporarily becomes the *background* for new information, which appears briefly as the new *figure* (see Fig. 2.19). This approach is usually better than temporarily *replacing* the old information with the new information, because it provides context that helps keep people oriented regarding their place in the interaction.

GESTALT PRINCIPLES: COMMON FATE

The previous six Gestalt principles concerned perception of static (un-moving) figures and objects. One final Gestalt principle—Common Fate—concerns moving objects. The Common Fate principle is related to the Proximity and Similarity principles: Like them it affects whether we perceive objects as grouped. The Common Fate principle states that objects that move together are perceived as grouped or related.

For example, in a display showing dozens of pentagons, if seven of them wiggled back and forth in synchrony, people would see them as a related group, even if the wiggling pentagons were separated from each other and looked no different from all the other pentagons (see Fig. 2.20).

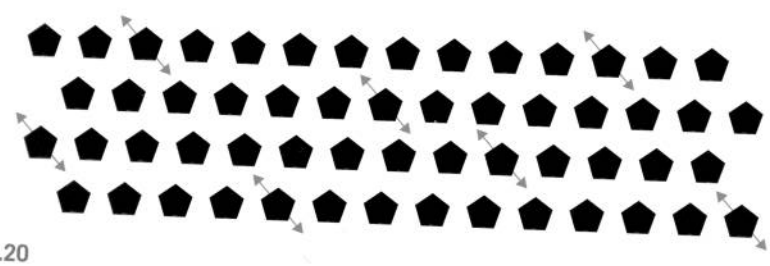


FIGURE 2.20

Common Fate: Items appear grouped or related if they move together.

Common motion—implying common fates—is used in some animations to show relationships between entities. For example, GapMinder graphs animate dots representing nations to show changes over time in various factors of economic development. Countries that move together share development histories (see Fig. 2.21).

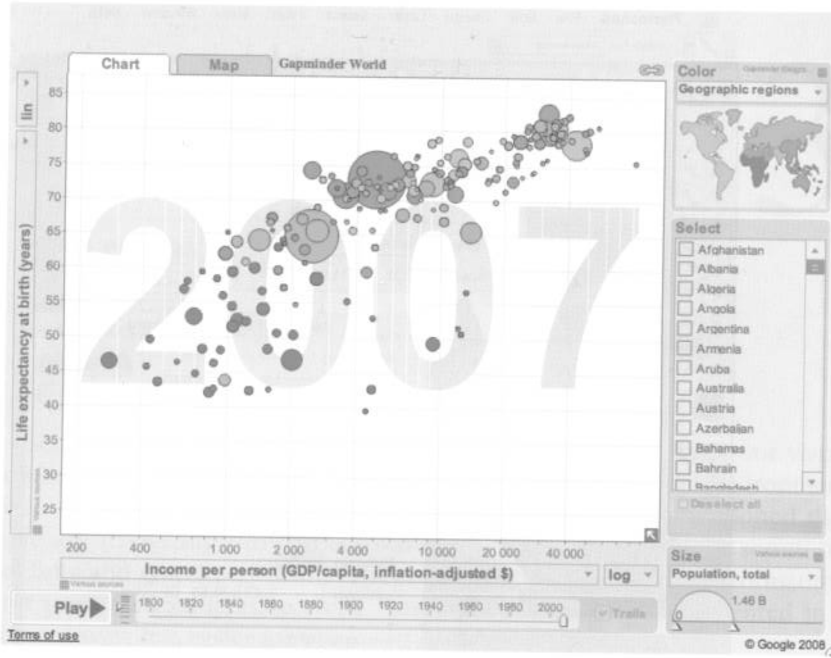


FIGURE 2.21

Common fate: GapMinder animates dots to show which nations have similar development histories.

GESTALT PRINCIPLES: COMBINED

Of course, in real-world visual scenes, the Gestalt principles work in concert, not in isolation. For example, a typical Mac OS desktop usually exemplifies six of the seven principles described above (excluding Common Fate): Proximity, Similarity, Continuity, Closure, Symmetry, and Figure/Ground (see Fig. 2.22). On a typical desktop, Common Fate is used (along with similarity) when a user selects several files or folders and drags them as a group to a new location (see Fig. 2.23).

With all these Gestalt principles operating at once, *unintended* visual relationships can be implied by a design. A recommended practice, after designing a display, is to view it with each of the Gestalt principles in mind—Proximity, Similarity, Continuity, Closure, Symmetry, Figure/Ground, and Common Fate—to see if the design suggests any relationships between elements that you do *not* intend.

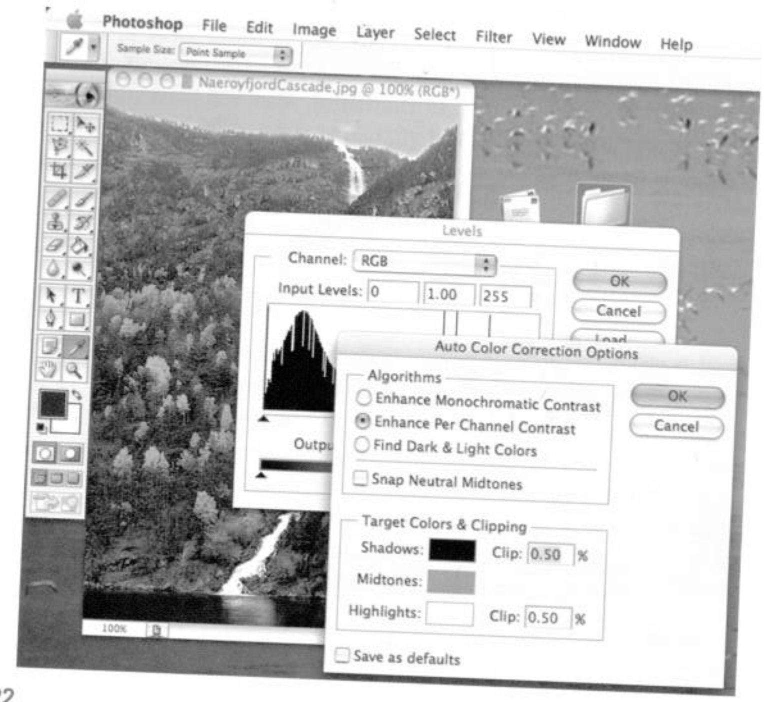


FIGURE 2.22

All of the Gestalt principles except Common Fate play a role in this portion of a Mac OS desktop.

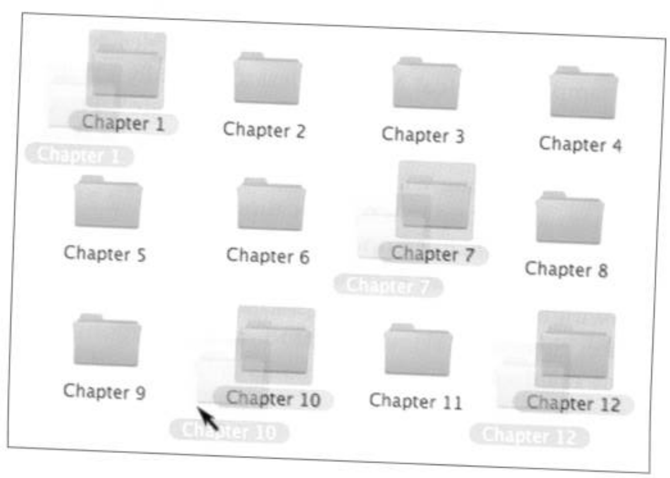


FIGURE 2.23

Similarity and Common Fate: When users drag folders that they have selected, common highlighting and motion make the selected folders appear grouped.

CHAPTER

We Seek and Use Visual Structure

3

Chapter 2 used the Gestalt principles of visual perception to show how our visual system is optimized to perceive structure. Perceiving structure in our environment helps us make sense of objects and events quickly. Chapter 2 also mentioned that when people are navigating through software or Web sites, they don't scrutinize screens carefully and read every word. They scan quickly for relevant information. This chapter presents examples to show that when information is presented in a terse, structured way, it is easier for people to scan and understand.

Consider two presentations of the same information about an airline flight reservation. The first presentation is unstructured prose text; the second is structured text in outline form (see Fig. 3.1). The structured presentation of the reservation can be scanned and understood much more quickly than the prose presentation.

The more structured and terse the presentation of information, the more quickly and easily people can scan and comprehend it. Look at the Contents page from the California Department of Motor Vehicles (see Fig. 3.2). The wordy, repetitive links slow users down and "bury" the important words they need to see.

Unstructured:

You are booked on United flight 237, which departs from Auckland at 14:30 on Tuesday 15 Oct and arrives at San Francisco at 11:40 on Tuesday 15 Oct.

Structured:

Flight: **United 237, Auckland → San Francisco**
Depart: **14:30 Tue 15 Oct**
Arrive: **11:40 Tue 15 Oct**

FIGURE 3.1

Structured presentation of airline reservation information is easier to scan and understand.

Renewals, Duplicates, and Information Changes for Driver Licenses and/or ID Cards

- How to renew your driver license in person
- How to renew your driver license by mail
- How to renew your driver license by Internet
- How to renew your instruction permit
- How to apply for a duplicate driver license or identification (ID) card
- How to change your name on your driver license and/or identification (ID) card
- How to notify DMV of my change of address
- How to register for the organ donor gift of life program

FIGURE 3.2

Contents page at the California Department of Motor Vehicles (DMV) Web site buries the important information in repetitive prose.

Licenses & ID Cards:	Renewals, Duplicates, Changes		
• Renew license:	in person	by mail	by Internet
• Renew:	instruction permit		
• Apply for duplicate:	license	ID card	
• Change of:	name	address	
• Register as:	organ donor		

FIGURE 3.3

The California DMV Web site Contents page with repetition eliminated and better visual structure.

Compare that with a terser, more structured hypothetical design that factors out needless repetition and marks as links only the words that represent options (see Fig. 3.3). All options presented in the actual Contents page are available in the revision, yet it consumes less screen space and is easier to scan.

Displaying search results is another situation in which structuring data and avoiding repetitive "noise" can improve people's ability to scan quickly and find what they seek. In 2006, search results at HP.com included so much repeated navigation data and metadata for each retrieved item that they were useless. By 2009 HP had eliminated the repetition and structured the results, making them easier to scan and more useful (see Fig. 3.4).

Of course, for information displays to be easy to scan, it is not enough merely to make them terse, structured, and nonrepetitious. They must also conform to the rules of graphic design, some of which were presented in Chapter 2.

For example, a prerelease version of a mortgage calculator on a real estate Web site presented its results in a table that violated at least two important rules of graphic design (see Fig. 3.5, left). People usually read (on- or offline) from top to

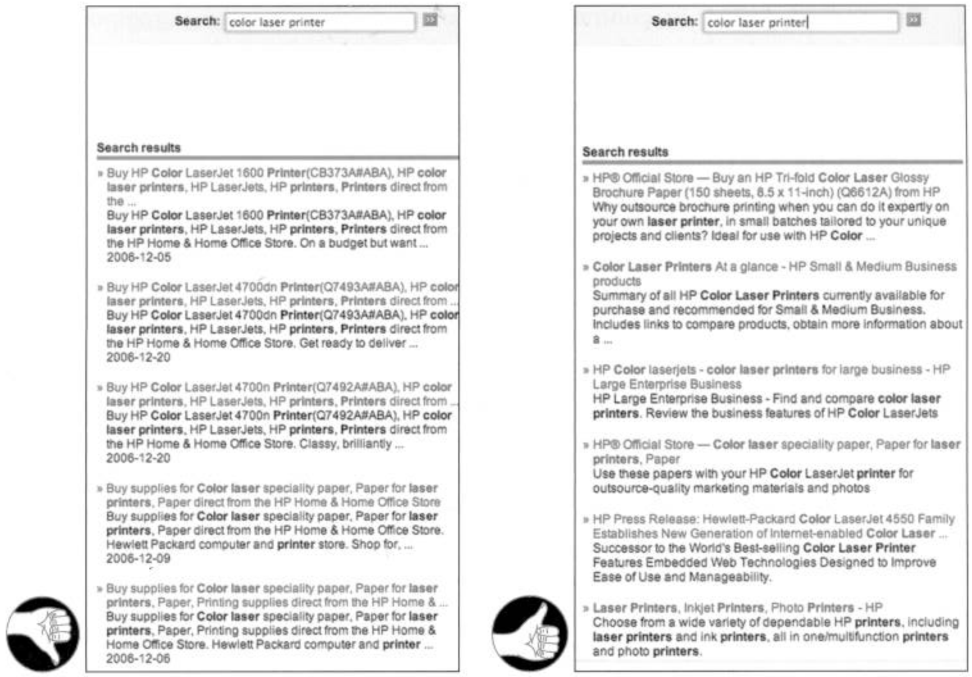


FIGURE 3.4

In 2006, HP.com's site search produced repetitious, noisy results (left) but by 2009 was improved (right).

FIGURE 3.5

Left: Mortgage summary presented by a software mortgage calculator. Right: Improved design.

bottom, but the labels for calculated amounts were *below* their corresponding values. Second, the labels were just as close to the value below as to their own value, so proximity (see Chapter 2) could not be used to perceive that labels were grouped with their values. To understand this mortgage results table, users had to scrutinize it carefully and slowly figure out which labels went with which numbers.

The revised design, in contrast, allows users to perceive the correspondence between labels and values without conscious thought (see Fig. 3.5, right).

STRUCTURE ENHANCES PEOPLE'S ABILITY TO SCAN LONG NUMBERS

Even small amounts of information can be made easier to scan if they are structured. Two examples are telephone numbers and credit card numbers (see Fig. 3.6 and Fig. 3.7). Traditionally, such numbers were broken into parts to make them easier to scan and remember.

A long number can be broken up in two ways: either the user interface breaks it up explicitly by providing a separate field for each part of the number, or the interface provides a single number field, but lets users break the number into parts with spaces or punctuation (see Fig. 3.8a). However, many of today's computer presentations of phone and credit card numbers do not segment the numbers and do not

Easy:	(415) 123-4567
Hard:	4151234567
Easy:	1234 5678 9012 3456
Hard:	1234567890123456

FIGURE 3.6

Telephone and credit card numbers are easier to scan and understand when segmented.

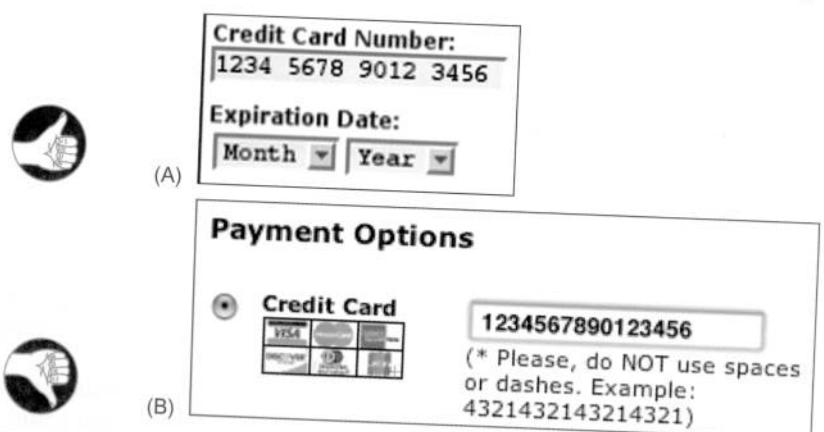


FIGURE 3.7

(A) At Democrats.org, credit card numbers can include spaces. (B) At StuffIt.com. they cannot, making them harder to scan and verify.

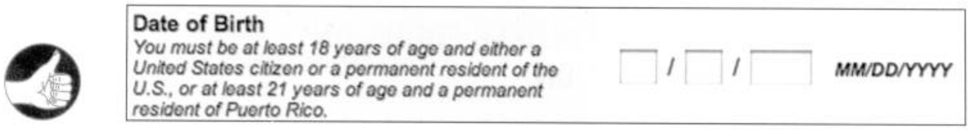


FIGURE 3.8

BankOfAmerica.com: Segmented data fields provide useful structure.

allow users to do it with spaces (see Fig. 3.8b). This limitation makes it harder for people to scan a number or verify that they typed it correctly.

Segmenting data fields can provide useful visual structure even when the data to be entered is not, strictly speaking, a number. Dates are an example of a case in which segmented fields can improve readability and help prevent data entry errors, as shown by a date field at Bank of America's Web site (see Fig. 3.8).

DATA-SPECIFIC CONTROLS PROVIDE EVEN MORE STRUCTURE

A step up in structure from segmented data fields are data-specific controls. Instead of using simple text fields—whether segmented or not—designers can use controls that are designed specifically to display (and accept as input) a value of a specific type. For example, dates can be presented (and accepted) in the form of menus combined with pop-up calendar controls (see Fig. 3.9).

It is also possible to provide visual structure by mixing segmented text fields with data-specific controls, as demonstrated by an email address field at Southwest Airlines' Web site (see Fig. 3.10).

FIGURE 3.9

NWA.com: Dates are displayed and entered using a control that is specifically designed for dates.

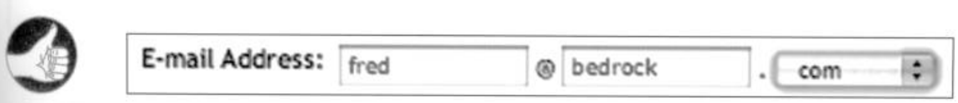


FIGURE 3.10

NWA.com: Dates are displayed and entered using a control that is specifically designed for dates.

VISUAL HIERARCHY LETS PEOPLE FOCUS ON THE RELEVANT INFORMATION

One of the most important goals in structuring information presentations is to provide a visual hierarchy—an arrangement of the information that:

- Breaks the information into distinct sections, and breaks large sections into subsections
- Labels each section and subsection prominently and in such a way as to clearly identify its content
- Presents the sections and subsections as a hierarchy, with higher level sections presented more strongly than lower level ones

A visual hierarchy allows people, when scanning information, to separate what is relevant to their goals from what is irrelevant instantly, and to focus their attention on the relevant information. They find what they are looking for more quickly because they can easily skip everything else.

Try it for yourself. Look at the two information displays in Figure 3.11 and find the information about prominence. How much longer does it take you to find it in the nonhierarchical presentation?

Create a Clear Visual Hierarchy

Organize and prioritize the contents of a page by using size, prominence, and content relationships. Let's look at these relationships more closely. The more important a headline is, the larger its font size should be. Big bold headlines help to grab the user's attention as they scan the Web page. The more important the headline or content, the higher up the page it should be placed. The most important or popular content should always be positioned prominently near the top of the page, so users can view it without having to scroll too far. Group similar content types by displaying the content in a similar visual style, or in a clearly defined area.

Create a Clear Visual Hierarchy

Organize and prioritize the contents of a page by using size, prominence, and content relationships.

Let's look at these relationships more closely:

- **Size.** The more important a headline is, the larger its font size should be. Big bold headlines help to grab the user's attention as they scan the Web page.
- **Prominence.** The more important the headline or content, the higher up the page it should be placed. The most important or popular content should always be positioned prominently near the top of the page, so users can view it without having to scroll too far.
- **Content Relationships.** Group similar content types by displaying the content in a similar visual style, or in a clearly defined area.

FIGURE 3.11

Find the advice about prominence in each of these displays. Prose text format (left) makes people read everything. Visual hierarchy (right) lets people ignore information irrelevant to their goals.

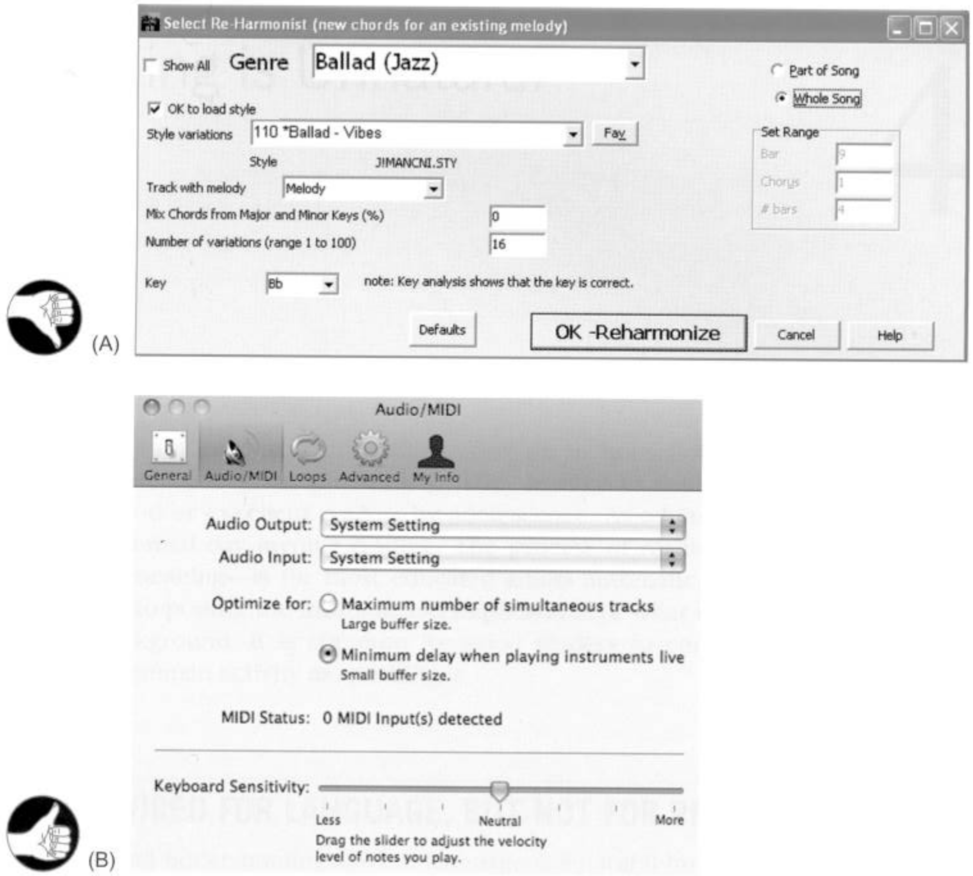


FIGURE 3.12

Visual hierarchy in interactive control panels and forms lets users find settings quickly. (A) Band in a Box (bad), (B) GarageBand (good).

The examples in Figure 3.11 show the value of visual hierarchy in a textual, read-only information display. Visual hierarchy is equally important in interactive control panels and forms—perhaps even more so. Compare dialog boxes from two different music software products (see Fig. 3.12). The Reharmonize dialog box of Band-in-a-Box has poor visual hierarchy, making it hard for users to find things quickly. In contrast, GarageBand's Audio/MIDI control panel has good visual hierarchy, so users can quickly find the settings they are interested in.

CHAPTER

Reading is Unnatural

4

Most people in industrialized nations grew up in households and school districts that promoted education and reading. They learned to read as young children and became good or excellent readers by adolescence. As adults, most of our activities during a normal day involve reading. The process of reading—deciphering words into their meaning—is for most educated adults automatic, leaving our conscious minds free to ponder the meaning and implications of what we are reading. Because of this background, it is common for good readers to consider reading to be as "natural" a human activity as speaking is.

WE'RE WIRED FOR LANGUAGE, BUT NOT FOR READING

Speaking and understanding spoken language *is* a natural human ability, but reading is *not*. Over hundreds of thousands—perhaps millions—of years, the human brain evolved the neural structures necessary to support spoken language. As a result, normal humans are born with an innate ability to learn as toddlers, with no systematic training, whatever language they are exposed to. After early childhood, our innate ability to learn spoken languages decreases significantly. By adolescence, learning a new language is the same as learning any other skill: it requires instruction and practice, and the learning and processing are handled by different brain areas from those that handled it in early childhood (Sousa, 2005).

In contrast, *writing* and *reading* did not exist until a few thousand years BC and did not become *common* until only four or five centuries ago—*long* after the human brain had evolved into its modern state. At no time during childhood do our brains show any special innate ability to learn to read. Instead, reading is an artificial skill that we learn by systematic instruction and practice, like playing a violin, juggling, or reading music (Sousa, 2005).

Designing with the Mind in Mind

Because people are not innately "wired" to learn to read, children who either lack caregivers who read to them, or who receive inadequate reading instruction in school may never learn to read. There are many such people, especially in the developing world. By comparison, very few people never learn a spoken language.

For a variety of reasons, even people who learn to read may never become good at it. Perhaps their parents did not value and promote reading. Perhaps they attended substandard schools or didn't attend school at all. Perhaps they learned a second language but never learned to read well in that language. Finally, people who have cognitive or perceptual impairments such as dyslexia may never become good readers.

Learning to read involves training our brain—including our visual system—to recognize patterns. The patterns that our brain learns to recognize run a gamut from low level to high level:

- Lines, contours, and shapes are basic visual *features* that our brain recognizes innately. We don't have to learn to recognize them.
- Basic features combine to form patterns that we learn to identify as characters—letters, numeric digits, and other standard symbols. In ideographic scripts, such as Chinese, symbols represent entire words or concepts.
- In alphabetic scripts, patterns of characters form *morphemes*, which we learn to recognize as packets of meaning, e.g., "farm," "tax," "-ed," and "-ing" are morphemes in English.
- Morphemes combine to form patterns that we recognize as *words*, e.g., "farm," "tax," "-ed," and "-ing" can be combined to form the words "farm," "farmed," "farming," "tax," "taxed," and "taxing." Even ideographic scripts include symbols that serve as morphemes or modifiers of meaning rather than as words or concepts.
- Words combine to form *patterns* that we learn to recognize as phrases, idiomatic expressions, and sentences.
- Sentences combine to form *paragraphs*.

To see what text looks like to someone who has not yet learned to read, just look at a paragraph printed in a language and script that you do not know (see Fig. 4.1A and B).

Alternatively, you can approximate the feeling of illiteracy by taking a page written in a familiar script and language—such as a page of this book—and turning it upside down. Turn this book upside down and try reading the next few paragraphs. This exercise only approximates the feeling of illiteracy. You will discover that the inverted text appears foreign and illegible at first, but after a minute you will be able to read it, albeit slowly and laboriously.

(A)

አዲስ አበባ ሰኔ 15/93/ኢዜአ/ -- ኢጣሊያ ለኢትዮጵያ የ375 ሚሊዮን ዶላር ዕዳ ስረዛ ለማድረግ መወሰኗን አዲስ አበባ የሚገኘው የአገሪቱ ኤምባሲ

(B)

དགེ་འདུན་དམ་པ་ཆོས་ལྡན་ཐོས་པའི་བཀྲ་ཤིས་ལྷུག །མི་དང་ལྷ་དང་ལྷ་མ་ཡིན་གྱི་མཆོད་པའི་གནས།།
ཚོགས་ཀྱི་མཆོག་རབ་ངོ་ཚ་ཤེས་དང་དཔལ་གྱི་གཞི། །དེ་ནི་འཇིག་རྟེན་དགེ་བའི་བཀྲ་ཤིས་གསུམ་པ་ཡིན།། ||

FIGURE 4.1

To see how it feels to be illiterate, look at text printed in a foreign script. (A) Amharic, (B) Tibetan.

IS READING FEATURE-DRIVEN OR CONTEXT-DRIVEN?

As stated earlier, reading involves recognizing features and patterns. Pattern recognition, and therefore reading, can be either a bottom-up, feature-driven process or a top-down, context-driven process.

In feature-driven reading, the visual system starts by identifying simple features—line segments in a certain orientation or curves of a certain radius—on a page or display and then combines them into more complex features, such as angles, multiple curves, shapes, and patterns. Then the brain recognizes certain shapes as characters or symbols representing letters, numbers, or, for ideographic scripts, words. In alphabetic scripts, groups of letters are perceived as morphemes and words. In all types of scripts, sequences of words are parsed into phrases, sentences, and paragraphs that have meaning.

Feature-driven reading is sometimes referred to as "bottom-up" or "context-free." The brain's ability to recognize basic features: lines, edges, angles, etc.—is built in and therefore automatic from birth. In contrast, recognition of morphemes, words, and phrases has to be learned. It starts out as a non-automatic, conscious process requiring conscious analysis of letters, morphemes, and words, but with enough practice it becomes automatic (Sousa, 2005). Obviously, the more common a morpheme, word, or phrase, the more likely it is that recognition of it will become automatic. With ideographic scripts such as Chinese, which have many times more symbols than alphabetic scripts have, people typically take many years longer to become skilled readers.

Context-driven or top-down reading operates in parallel with feature-driven reading but it works the opposite way: from whole sentences or the gist of a paragraph *down* to the words and characters. The visual system starts by recognizing high-level patterns like words, phrases, and sentences, or by knowing the text's meaning in advance. It then uses that knowledge to figure out—or guess—what the components of the high-level pattern must be (Boulton, 2009). Context-driven reading is less likely to become fully automatic because most phrase-level and sentence-level patterns and contexts don't occur frequently enough to allow their recognition to become burned into neural firing patterns. But there are exceptions, such as idiomatic expressions.

To experience context-driven reading, glance down quickly at Figure 4.2 (below), then immediately direct your eyes back here and finish reading this paragraph. Try it now. What did the text say?

Now look at the same sentence again more carefully. Do you read it the same way now?

It has been known for decades that reading involves both feature-driven (bottom-up) processing and context-driven (top-down) processing. In addition to being able to figure out the meaning of a sentence by analyzing the letters and words in it, people can determine the words of a sentence by knowing the meaning of the sentence, or the letters in a word by knowing what word it is (see Fig. 4.3). The question is: is skilled reading primarily bottom-up or top-down, or is neither mode dominant? Which type of reading is preferred?

Educational researchers in the 1970s applied information theory to reading, and assumed that because of redundancies in written language, top-down, context-driven reading would be faster than bottom-up, feature-driven reading. This assumption led them to hypothesize that reading in highly skilled (fast) readers would be dominated by context-driven (top-down) processing. This theory was probably responsible for many speed-reading methods of the 1970s and 1980s, which supposedly trained people to read fast by taking in whole phrases and sentences at a time.

The rain in Spain falls manly in the the plain

FIGURE 4.2

Top-down "recognition" of this expression may inhibit awareness of its actual content.

(A) Mray had a Itilte lmab, its feclee was withe as sown. And ervey wehre taht Mray wnet, the lmab was srue to go.

(B) Twinkle, twinkle little star, how I wonder what you are

FIGURE 4.3

Top-down reading: Most readers, especially those who know the songs from which these text passages are taken, can read these passages even though the words (A) have all but their first and last letters scrambled and (B) are mostly obscured.

However, empirical studies of readers conducted since then have demonstrated conclusively that the truth is the opposite of what the earlier theory predicted. Reading researcher Keith Stanovich explains:

> **... Context [is] important, but it's a more important aid for the poorer reader who doesn't have automatic context-free recognition instantiated.**
>
> **(in Boulton, 2009)**

In other words, the most efficient way to read is via context-free, bottom-up, feature-driven processes that are well learned to the point of being automatic. Context-driven reading is today considered mainly a backup method that, although it operates in parallel with feature-based reading, is only relevant when feature-driven reading is difficult or is insufficiently automatic.

Skilled readers may resort to context-based reading when feature-based reading is disrupted by poor presentation of information (see examples later in this chapter). Also, in the race between context-based and feature-based reading to decipher the text we see, contextual cues sometimes win out over features. As an example of context-based reading, Americans visiting England sometimes misread "To let" signs as "Toilet" because in the United States they see the word "toilet" often, but they almost never see the phrase "to let"—Americans use "for rent" instead.

In less skilled readers, feature-based reading is not automatic; it is conscious and laborious. Therefore, much more of their reading is context based. Their involuntary use of context-based reading and nonautomatic feature-based reading consumes short-term cognitive capacity, leaving little for comprehension.[1] They have to focus on deciphering the stream of words, leaving no capacity for constructing the meaning of sentences and paragraphs. That is why poor readers can read a passage aloud but afterward have no idea what they just read.

Why is context-free (bottom-up) reading not automatic in some adults? Some people didn't get enough experience reading as young children for the feature-driven recognition processes to become automatic. As they grow up, they find reading mentally laborious and taxing, so they avoid reading, which perpetuates and compounds their deficit (Boulton, 2009).

SKILLED AND UNSKILLED READING USES DIFFERENT PARTS OF THE BRAIN

Before the 1980s, researchers who wanted to understand which parts of the brain are involved in language and reading were limited mainly to studying people who had suffered brain injuries. For example, in the mid-1800s, doctors found that

[1]Chapter 10 describes the differences between automatic and controlled cognitive processing. For present purposes, we will simply say that controlled processes burden working memory, while automatic processes do not.

people with brain damage near the left temple—an area now called *Broca's area* after the doctor who discovered it—can understand speech but have trouble speaking, and that people with brain damage near the left ear—now called *Wernicke's area*—cannot understand speech (Sousa, 2005) (see Fig. 4.4).

In recent decades, several new methods of observing the operation of functioning brains in living people, enhancing noninvasive scanning methods with computer-based analysis techniques, have been developed: electroencephalography (EEG), functional magnetic resonance imaging (fMRI), and functional magnetic resonance spectroscopy (fMRS). These methods allow researchers to watch the response in different areas of a person's brain—including the sequence in which they respond—as the person perceives various stimuli or performs specific tasks.

Using these methods, researchers have discovered that the neural pathways involved in reading differ for novice versus skilled readers. Of course, the first area to respond during reading is the occipital (or visual) cortex at the back of the brain. That is the same regardless of a person's reading skill. After that, the pathways diverge (Sousa, 2005):

- ***Novice:*** First an area of the brain just above and behind Wernicke's area becomes active. Researchers have come to view this as the area where, at least with alphabetic scripts such as English and German, words are "sounded out" and assembled—that is, letters are analyzed and matched with their corresponding sounds. The word-analysis area then communicates with Broca's area and the frontal lobe, where morphemes and words—units of meaning—are recognized and overall meaning is extracted. For ideographic languages, where symbols represent whole words and often have a graphical correspondence to their meaning, sounding out of words is not part of reading.

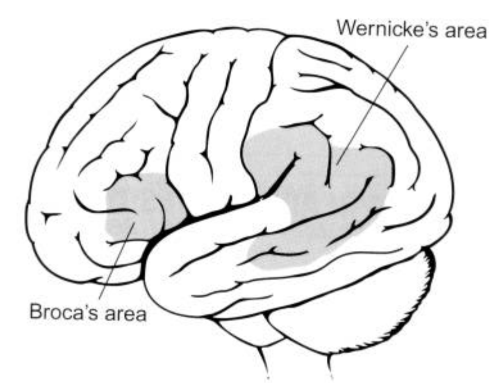


FIGURE 4.4

The human brain, showing Broca's area and Wernicke's area.

- ***Advanced:*** The word analysis area is skipped. Instead the occipito-temporal area (behind the ear, not far from the visual cortex) becomes active. The prevailing view is that this area recognizes words as a whole without sounding them out, and then that activity activates pathways toward the front of the brain that correspond to the word's meaning and mental image. Broca's area is only slightly involved.

Findings from brain scan methods of course don't indicate exactly what processes are being used, but they do support the theory that advanced readers use different processes from those novice readers use.

POOR INFORMATION DESIGN CAN DISRUPT READING

Careless writing or presentation of text can reduce skilled readers' automatic, context-free reading to conscious, context-based reading, burdening working memory, thereby decreasing speed and comprehension. In unskilled readers, poor text presentation can block reading altogether.

Uncommon or unfamiliar vocabulary

One way software often disrupts reading is by using unfamiliar vocabulary—words the intended readers don't know very well or at all.

One type of unfamiliar terminology is computer jargon, sometimes known as "geek speak." For example, an intranet application displayed the following error message if a user tried to use the application after more than 15 minutes of letting it sit idle:

Your session has expired. Please reauthenticate.

The application was for finding resources—rooms, equipment, etc.—within the company. Its users included receptionists, accountants, and managers as well as engineers. Most nontechnical users would not understand the word "reauthenticate," so they would drop out of automatic reading mode into conscious wondering about the message's meaning. To avoid disrupting reading, the application's developers could have used the more familiar instruction "Login again." For a discussion of how "geek speak" in computer-based systems affects learning, see Chapter 11.

Reading can also be disrupted by uncommon terms even if they are not computer technology terms. Here are some rare English words, including many that appear mainly in contracts, privacy statements, or other legal documents:

- *Aforementioned:* mentioned previously
- *Bailiwick:* the region in which a sheriff has legal powers; more generally: domain of control

- *Disclaim:* renounce any claim to or connection with; disown; repudiate
- *Heretofore:* up to the present time; before now
- *Jurisprudence:* the principles and theories on which a legal system is based
- *Obfuscate:* make something difficult to perceive or understand
- *Penultimate:* next to the last, as in "the next to the last chapter of a book"

When readers—even skilled ones—encounter such a word, their automatic reading processes probably won't recognize it. Instead, their brain uses less automatic processes, such as sounding out the word's parts and using them to figure out its meaning, figuring out the meaning from the context in which the word appears, or looking the word up in a dictionary.

Difficult scripts and typefaces

Even when the vocabulary is familiar, reading can be disrupted by hard-to-read scripts and typefaces. Bottom-up, context-free, automatic reading is based on recognition of letters and words from their visual features. Therefore, a typeface with difficult-to-recognize feature and shapes will be hard to read. For example, try to read Abraham Lincoln's Gettysburg Address in an outline typeface in ALL CAPS. (see Fig. 4.5).

ABRAHAM LINCOLN'S GETTYSBURG ADDRESS

FOURSCORE AND SEVEN YEARS AGO, OUR FOREFATHERS BROUGHT FORTH ON THIS CONTINENT A NEW NATION, CONCEIVED IN LIBERTY AND DEDICATED TO THE PROPOSITION THAT ALL MEN ARE CREATED EQUAL.

NOW WE ARE ENGAGED IN A GREAT CIVIL WAR, TESTING WHETHER THAT NATION, OR ANY NATION SO CONCEIVED AND SO DEDICATED, CAN LONG ENDURE. WE ARE MET ON A GREAT BATTLEFIELD OF THAT WAR. WE HAVE COME TO DEDICATE A PORTION OF THAT FIELD, AS A FINAL RESTING PLACE FOR THOSE WHO HERE GAVE THEIR LIVES THAT THAT NATION MIGHT LIVE. IT IS ALTOGETHER FITTING AND PROPER THAT WE SHOULD DO THIS.

BUT, IN A LARGER SENSE, WE CAN NOT DEDICATE – WE CAN NOT CONSECRATE – WE CAN NOT HALLOW – THIS GROUND. THE BRAVE MEN, LIVING AND DEAD, WHO STRUGGLED HERE, HAVE CONSECRATED IT, FAR ABOVE OUR POOR POWER TO ADD OR DETRACT. THE WORLD WILL LITTLE NOTE, NOR LONG REMEMBER WHAT WE SAY HERE, BUT IT CAN NEVER FORGET WHAT THEY DID HERE. IT IS FOR US THE LIVING, RATHER, TO BE DEDICATED HERE TO THE UNFINISHED WORK WHICH THEY WHO FOUGHT HERE HAVE THUS FAR SO NOBLY ADVANCED. IT IS RATHER FOR US TO BE HERE DEDICATED TO THE GREAT TASK REMAINING BEFORE US – THAT FROM THESE HONORED DEAD WE TAKE INCREASED DEVOTION TO THAT CAUSE FOR WHICH THEY GAVE THE LAST FULL MEASURE OF DEVOTION – THAT WE HERE HIGHLY RESOLVE THAT THESE DEAD SHALL NOT HAVE DIED IN VAIN – THAT THIS NATION, UNDER GOD, SHALL HAVE A NEW BIRTH OF FREEDOM – AND THAT GOVERNMENT OF THE PEOPLE, BY THE PEOPLE, FOR THE PEOPLE, SHALL NOT PERISH FROM THE EARTH.

FIGURE 4.5

Text in ALL CAPS is generally hard to read because letters look more similar to each other. Outline typefaces complicate feature recognition. This example demonstrates both.

Tiny fonts

Another way to make text hard to read in software applications, Websites, and electronic appliances is to use fonts that are too small for their intended readers' visual system to resolve. For example, try to read the first paragraph of the U.S. Constitution in a seven-point font (see Fig. 4.6).

> We the people of the United States, in Order to form a more perfect Union, establish Justice, insure domestic Tranquility, provide for the common defense, promote the general Welfare, and secure the Blessings of Liberty to ourselves and our Posterity, do ordain and establish this Constitution for the United States of America.

FIGURE 4.6

The opening paragraph of the U.S. Constitution, presented in a seven-point font.

Developers sometimes use tiny fonts because they have a lot of text to display in a small amount of space. But if the intended users of the system cannot read the text, or can read it only laboriously, the text might as well not be there.

Text on noisy background

Visual noise in and around text can disrupt recognition of features, characters, and words and therefore drop reading out of automatic feature-based mode into a more conscious and context-based mode. In software user interfaces and Web sites, visual noise often results from designers' placing text over a patterned background or displaying text in colors that contrast poorly with the background, as an example from RedTele.com shows (see Fig. 4.7).

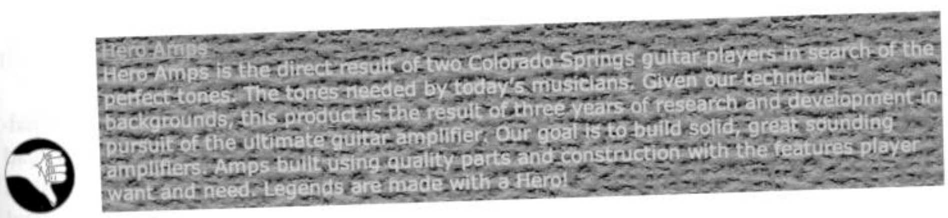


FIGURE 4.7

RedTele.com: Text on noisy background and with poor color contrast compared to the background.

There are situations in which designers *intend* to make text hard to read. For example, a common security measure on the Web is to ask site users to identify distorted words, as proof that they are a live human being and not an Internet "'bot." This relies on the fact that most people can read text that Internet 'bots cannot

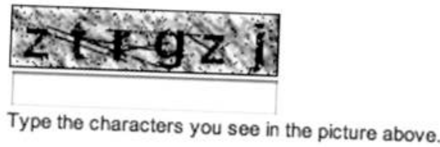


FIGURE 4.8

captchas: Text that is intentionally displayed with noise so that Web-crawling software cannot read it.

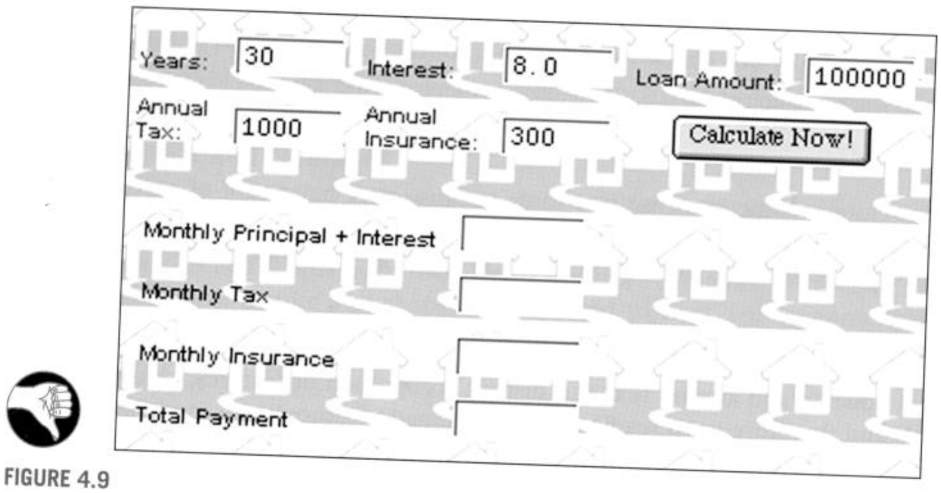


FIGURE 4.9

The Federal Reserve Bank's online mortgage calculator formerly displayed text on a patterned background.

currently read. Text displayed as a challenge to test a registrant's humanity is called a *captcha*[2] (see Fig. 4.8).

Of course, *most* text displayed in a user interface should be *easy* to read. A patterned background need not be especially strong to disrupt people's ability to read text placed over it. For example, the Federal Reserve Bank's collection of Web sites formerly had a mortgage calculator that was decorated with a repeating pastel background with a home and neighborhood theme. Although well-intentioned, the decorated background made the calculator hard to read (see Fig. 4.9). Later, when the Fed redesigned the mortgage calculator to add functionality, it also removed the decorative background (see Fig. 4.10).

[2] The term originally was coined based on the word "capture," but it is also said to be an acronym for "Completely Automated Public Turing test to tell Computers and Humans Apart"—*Wikipedia entry for* "Captcha."

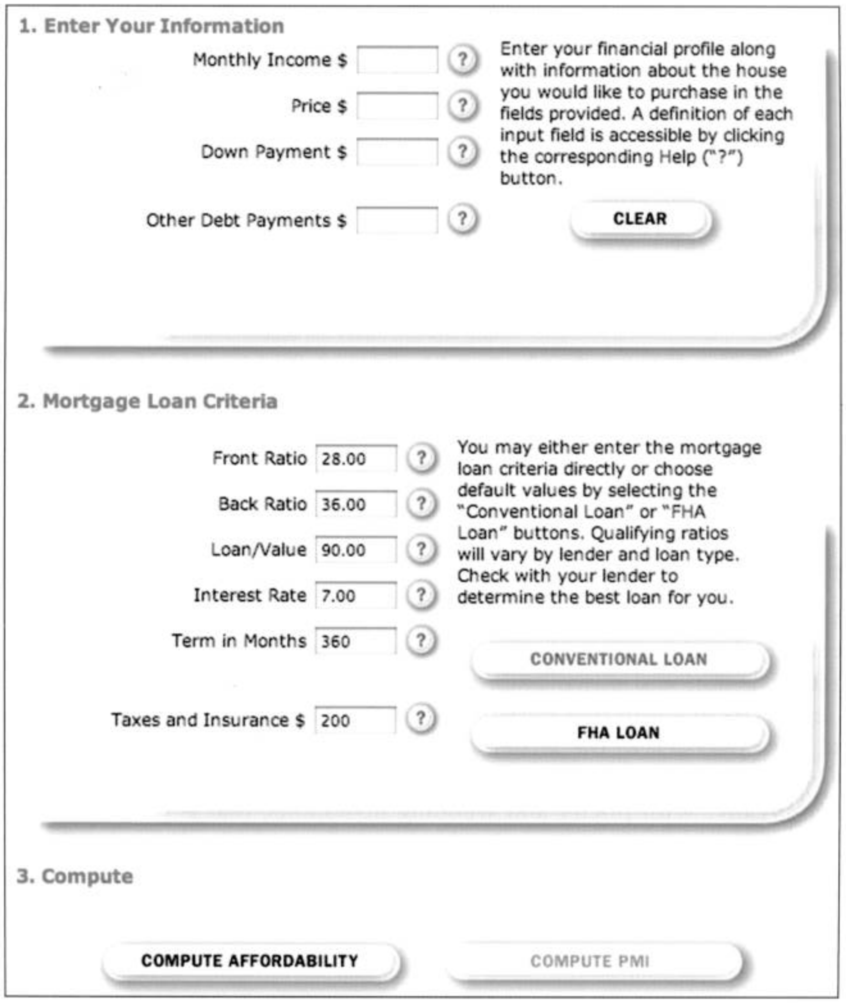


FIGURE 4.10

A more recent mortgage calculator on the FED Web site displays text on a plain white background.

Information buried in repetition

Visual noise can also come from the text itself. If successive lines of text contain a lot of repetition, readers receive poor feedback about what line they are focused on, plus it is hard to pick out the important information. For example, recall the example from the California Department of Motor Vehicles Web site in the previous chapter (see Fig. 3.2, page 26).

Another example of repetition that creates noise is the computer store on Apple.com. The pages for ordering a laptop computer list different keyboard options

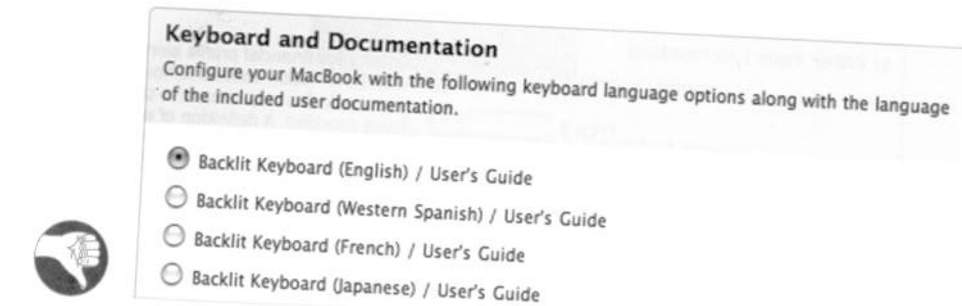


FIGURE 4.11

Apple.com's "Buy Computer" page lists options in which the important information (keyboard language compatibility) is buried in repetition.

for a computer in a very repetitive way, making it hard to see that the essential difference between the keyboards is the language that they support (see Fig. 4.11).

Centered text

One aspect of reading that is highly automatic in most skilled readers is eye movement. In automatic (fast) reading, our eyes are trained to go back to the same horizontal position and down one line. If text is centered or right-aligned, each line of text starts in a different horizontal position. Automatic eye movements therefore take our eyes back to the wrong place, so we must consciously adjust our gaze to the *actual* start of each line. This drops us out of automatic mode and slows us down greatly. With poetry and wedding invitations, that is probably OK, but with any other type of text, it is a disadvantage. An example of centered prose text is provided by the Web site of FargoHomes, a real estate company (see Fig. 4.12). Try reading the text quickly to demonstrate to yourself how your eyes move.

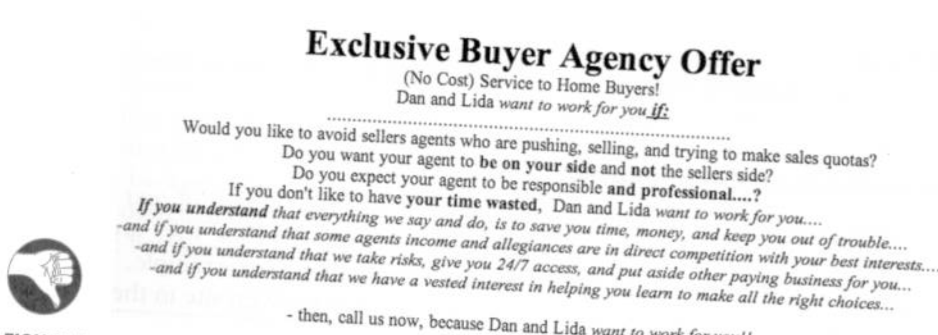
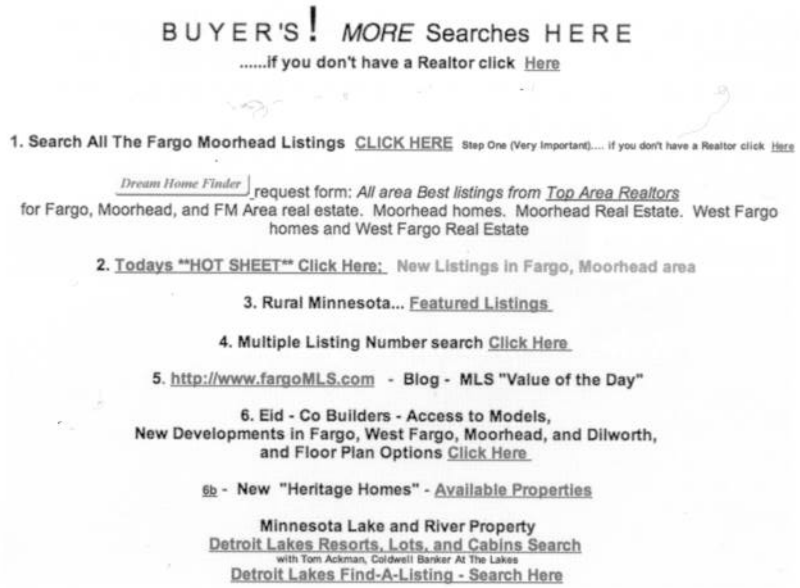


FIGURE 4.12

FargoHomes.com centers text, thwarting automatic eye movement patterns.

The same site also centers numbered lists, *really* messing up readers' automatic eye movement (see Fig. 4.13). Try scanning the list quickly.


BUYER'S! *MORE* Searches HERE
......if you don't have a Realtor click Here

1. Search All The Fargo Moorhead Listings CLICK HERE Step One (Very Important).... if you don't have a Realtor click Here

Dream Home Finder request form: *All area Best listings from* Top Area Realtors
for Fargo, Moorhead, and FM Area real estate. Moorhead homes. Moorhead Real Estate. West Fargo homes and West Fargo Real Estate

2. Todays **HOT SHEET** Click Here; New Listings in Fargo, Moorhead area

3. Rural Minnesota... Featured Listings

4. Multiple Listing Number search Click Here

5. http://www.fargoMLS.com - Blog - MLS "Value of the Day"

6. Eid - Co Builders - Access to Models,
New Developments in Fargo, West Fargo, Moorhead, and Dilworth,
and Floor Plan Options Click Here

6b - New "Heritage Homes" - Available Properties

Minnesota Lake and River Property
Detroit Lakes Resorts, Lots, and Cabins Search
with Tom Ackman, Coldwell Banker At The Lakes
Detroit Lakes Find-A-Listing - Search Here

FIGURE 4.13

FargoHomes.com centers numbered items, really thwarting automatic eye movement patterns.

Combining flaws that disrupt reading

The website of Keller Williams, another real-estate firm, combines many of the above-described ways of disrupting reading. In some places it has insufficient contrast between foreground and background. In other places it has too much contrast, e.g., it places blue against red, causing an annoying shimmering. It also has centered prose text and text on patterned backgrounds. All of the above combine to make this site very hard to read (see Fig. 4.14).

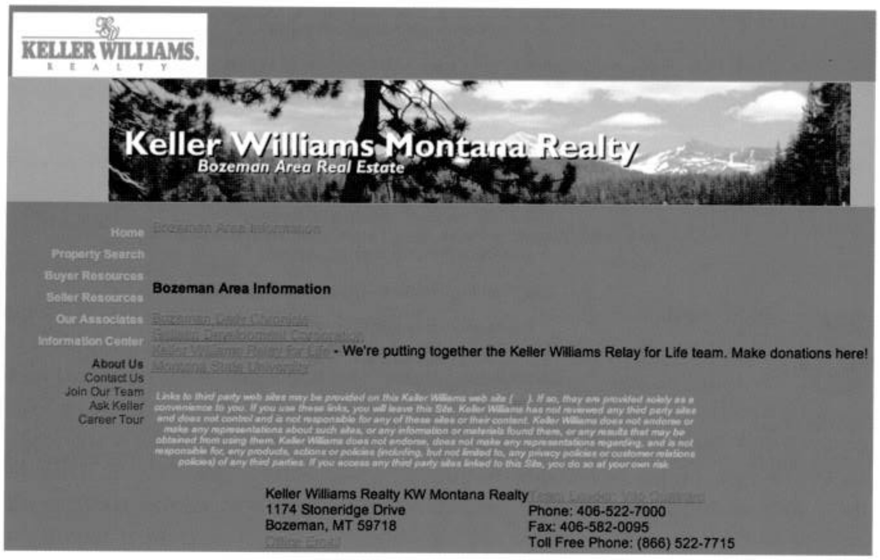


FIGURE 4.14

Keller Williams's Web site makes text hard to read in several different ways.

Design implications: don't disrupt reading; support it!

Obviously, a designer's goal should be to support reading, not disrupt it. Skilled (fast) reading is mostly automatic and mostly based on feature, character, and word recognition. The easier the recognition, the easier and faster the reading. Less skilled reading, by contrast, is greatly assisted by *contextual* cues.

Designers of interactive systems can support both reading methods by following these guidelines:

- Ensure that text in user interfaces allows the feature-based automatic processes to function effectively by avoiding the disruptive flaws described above: difficult or tiny fonts, patterned backgrounds, centering, etc.

- Use restricted, highly consistent vocabularies—sometimes referred to in the industry as *plain language*[3] or *simplified language* (Redish, 2007).
- Format text to create a visual hierarchy (see Chapter 3) to facilitate easy scanning: use headings, bulleted lists, tables, and visually emphasized words (see Fig. 4.15).

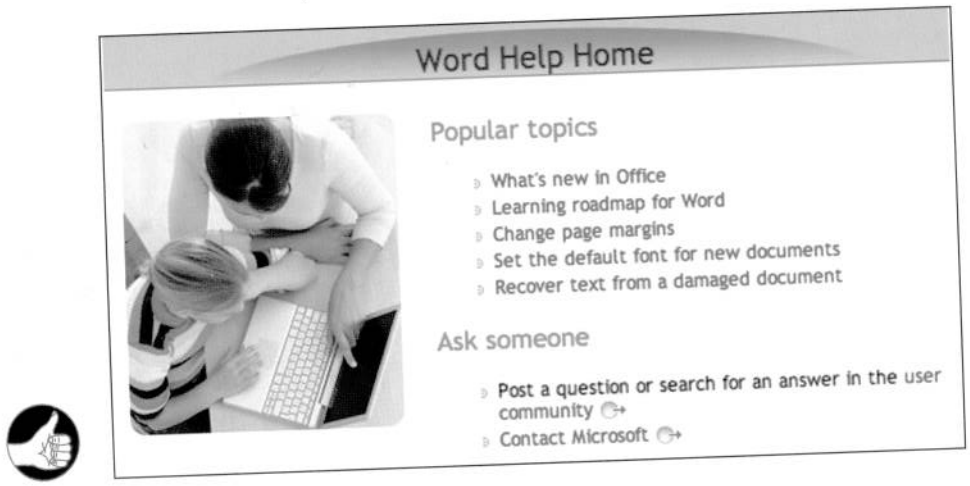


FIGURE 4.15

Microsoft Word's Help home page is easy to scan and read.

Experienced information architects, content editors, and graphic designers can be very useful in ensuring that text is presented so as to support easy scanning and reading.

MUCH OF THE READING REQUIRED BY SOFTWARE IS UNNECESSARY

In addition to committing design mistakes that disrupt reading, many software user interfaces simply present *too much* text, requiring users to read more than is necessary. Consider how much unnecessary text there is in a dialog box for setting text entry properties in the SmartDraw application (see Fig. 4.16).

Software designers often justify lengthy instructions by arguing: "We need all that text to explain clearly to users what to do." However, instructions can often be shortened with no loss of clarity. Let's examine how the Jeep company, between

[3]For more information on plain language, see the U.S. government Web site: www.plainlanguage.gov.

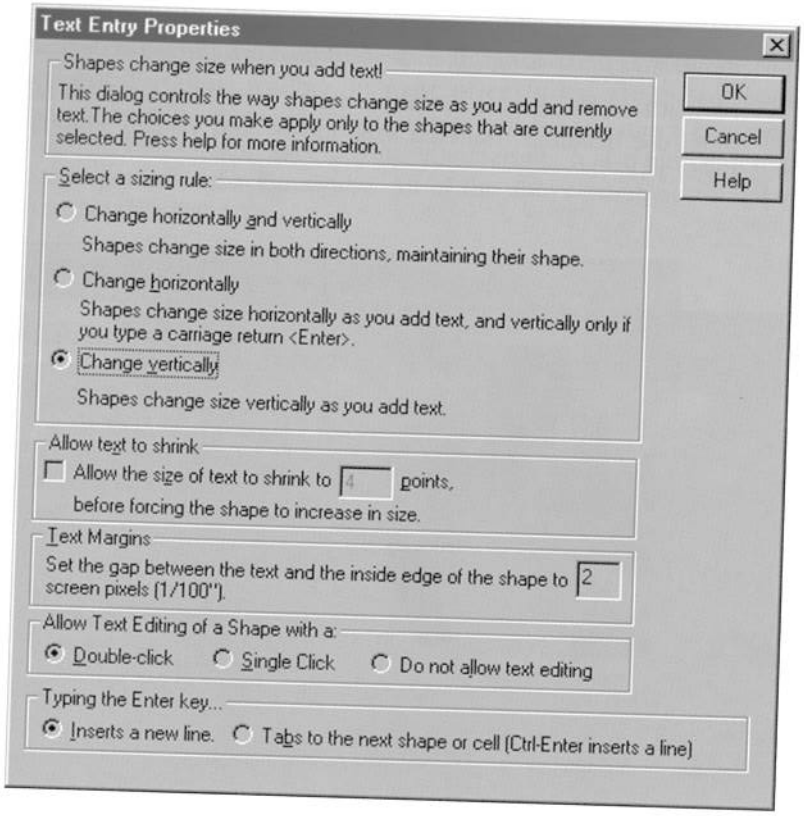


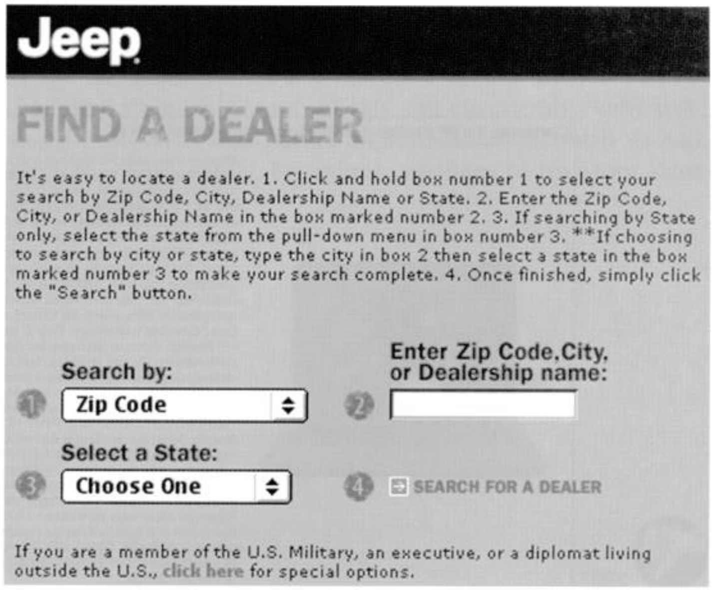
FIGURE 4.16

SmartDraw's Text Entry Properties dialog box displays too much text for its simple functionality.

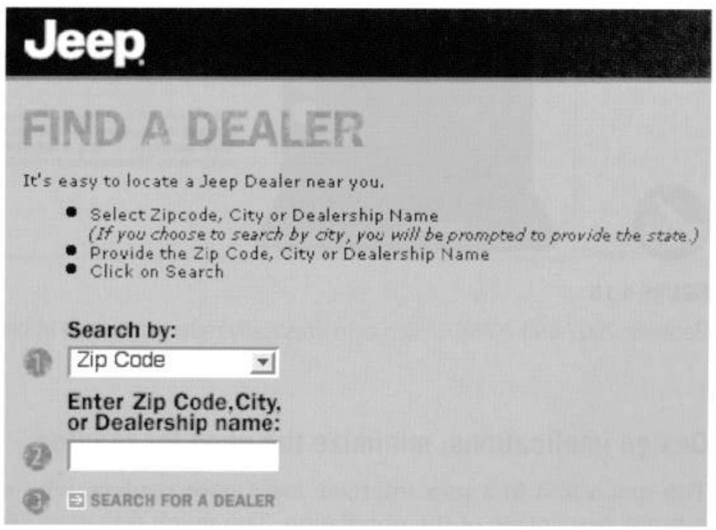
2002 and 2007, shortened its instructions for finding a local Jeep dealer (see Fig. 4.17):

- ***2002:*** The "Find a Dealer" page displayed a large paragraph of prose text, with numbered instructions buried in it, and a form asking for more information than needed to find a dealer near the user.
- ***2003:*** The instructions on the "Find a Dealer" page had been boiled down to three bullet points, and the form required less information.
- ***2007:*** "Find a Dealer" had been cut to one field (zip code) and a Go button on the Home page.

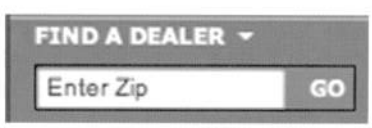
Even when text describes products rather than explaining instructions, it is counterproductive to put all a vendor wants to say about a product into a lengthy prose description that people have to read from start to end. Most potential customers



2002



2003



2007

FIGURE 4.17

Between 2002 and 2007, Jeep.com drastically reduced the reading required by "Find a Dealer."

cannot or will not read it. Compare Costco.com's descriptions of laptop computers in 2007 with those in 2009 (see Fig. 4.18).

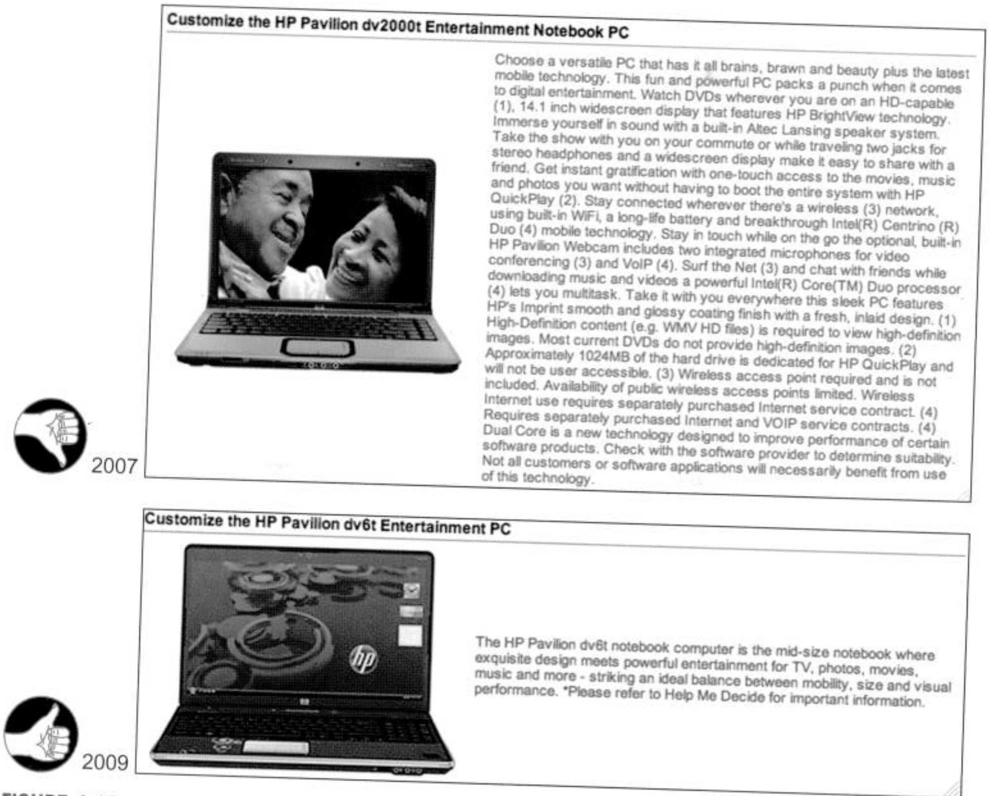


FIGURE 4.18

Between 2007 and 2009, Costco.com drastically reduced the text in product descriptions.

Design implications: minimize the need for reading

Too much text in a user interface loses poor readers, who unfortunately are a significant percentage of the population. Too much text even alienates *good* readers: it turns using an interactive system into an intimidating amount of *work*.

Minimize the amount of prose text in a user interface; don't present users with long blocks of prose text to read. In instructions, use the *least* amount of text that gets most users to their intended goals. In a product description, provide a brief overview of the product and let users request more detail if they want it. Technical writers and content editors can assist greatly in doing this. For additional advice on how to eliminate unnecessary text, see Krug (2005) and Redish (2007).

TEST ON REAL USERS

Finally, designers should test their designs on the intended user population to be confident that the users can read all essential text quickly and effortlessly. Some testing can be done early, using prototypes and partial implementations, but it should also be done just before release. Fortunately, last-minute changes to text font sizes and formats are usually easy to make.

Our Color Vision is Limited

Human color perception has both strengths and limitations. Mar
and limitations are relevant to user interface design:

- Our vision is optimized to detect contrasts (edges), not abs
- Our ability to distinguish colors depends on how colors are
- Some people have color-blindness.
- The user's display and the viewing conditions affect color p

To understand these qualities of human color vision, let's
description of how the human visual system processes color ir
environment.

HOW COLOR VISION WORKS

If you took introductory psychology or neurophysiology in co
learned that the retina at the back of the human eye—the surface
focuses images—has two types of light receptor cells: rods and c
also learned that the rods detect light levels but not colors, wh
colors. Finally, you probably learned that there are three types
to red, green, and blue light, respectively, suggesting that our co
to video cameras and computer displays, which detect or proje
colors through combinations of red, green, and blue pixels.

What you learned in college is only partly right. We do in
three types of cones in our retinas. The rods are sensitive to over
the three types of cones are sensitive to different frequencies
where the truth departs from what most people learned in colleg

First, those of us who live in industrialized societies hardly use our rods at all. They function only at low levels of light. They are for getting around in poorly lighted environments—the environments our ancestors lived in until the nineteenth century. Today, we use our rods only when we are having dinner by candlelight, feeling our way around our dark house at night, camping outside after dark, etc. In bright daylight and modern artificially lighted environments—where we spend most of our time—our rods are completely maxed out, providing no useful information. Most of the time, our vision is based entirely on input from our cones (Ware, 2008).

So how do our cones work? Are the three types of cones sensitive to red, green, and blue light, respectively? In fact, each type of cone is sensitive to a wider range of light frequencies than you might expect, and the sensitivity ranges of the three types overlap considerably. In addition, the overall sensitivity of the three types of cones differs greatly (see Fig. 5.1A):

- ***Low frequency:*** These cones are sensitive to light over almost the entire range of visible light, but are most sensitive to the middle (yellow) and low (red) frequencies.
- ***Medium frequency:*** These cones respond to light ranging from the high-frequency blues through the lower middle-frequency yellows and oranges. Overall, they are less sensitive than the low-frequency cones.
- ***High frequency:*** These cones are most sensitive to light at the upper end of the visible light spectrum—violets and blues—but they also respond weakly to middle frequencies, such as green. These cones are much less sensitive overall than the other two types of cones, and also less numerous. One result is that our eyes are much less sensitive to blues and violets than to other colors.

Compare a graph of the light sensitivity of our retinal cone cells (Fig. 5.1A) to what the graph might look like if electrical engineers had designed our retinas as a mosaic of receptors sensitive to red, green, and blue, like a camera (Fig. 5.1B).

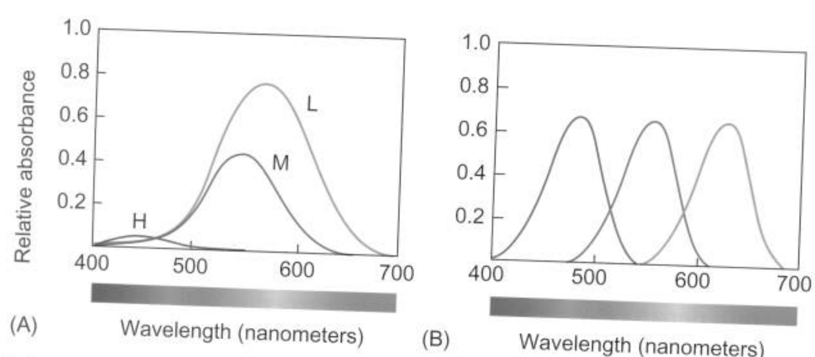


FIGURE 5.1

Sensitivity of the three types of retinal cones (A) versus artificial red, green, blue receptors (B).

Given the odd relationships between the sensitivities of our three types of retinal cones cells, one might wonder how our brain combines the signals from the cones to allow us to see a broad range of colors.

The answer is: by *subtraction*. Neurons in the visual cortex at the back of our brain *subtract* the signals coming over the optic nerves from the medium- and low-frequency cones, producing a "red-green" *difference* signal channel. Other neurons in the visual cortex subtract the signals from the high- and low-frequency cones, yielding a "yellow-blue" *difference* signal channel. A third group of neurons in the visual cortex *adds* the signals coming from the low- and medium-frequency cones to produce an overall *luminance* (or "black-white") signal channel.[1] These three channels are called *color-opponent* channels.

The brain then applies additional subtractive processes to all three color-opponent channels: signals coming from a given area of the retina are effectively subtracted from similar signals coming from nearby areas of the retina.

VISION IS OPTIMIZED FOR EDGE CONTRAST, NOT BRIGHTNESS

All this subtraction makes our visual system much more sensitive to *differences* in color and brightness—i.e., to contrasting edges—than to absolute brightness levels.

To see this, compare the two green circles in Figure 5.2. They are the same exact shade of green—the circle on the right was copied from the one on the left—but the different backgrounds make the one on the left appear darker to our contrast-sensitive visual system.

The sensitivity of our visual system to contrast rather than to absolute brightness is an advantage: it helped our distant ancestors recognize a leopard in the nearby bushes as the same dangerous animal whether they saw it in bright noon sunlight or in the early morning hours of a cloudy day. Similarly, being sensitive to color contrasts rather than to absolute colors allows us to see a rose as the same red whether it is in the sun or the shade.

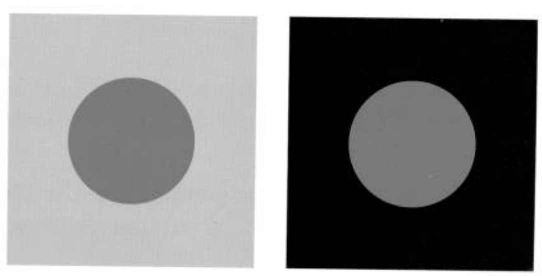


FIGURE 5.2

The circles appear as different shades because their backgrounds are different, but they are the same.

[1] The overall brightness sum omits the signal from the high-frequency (blue-violet) cones. Those cones are so insensitive that their contribution to the total would be negligible, so omitting them makes little difference.

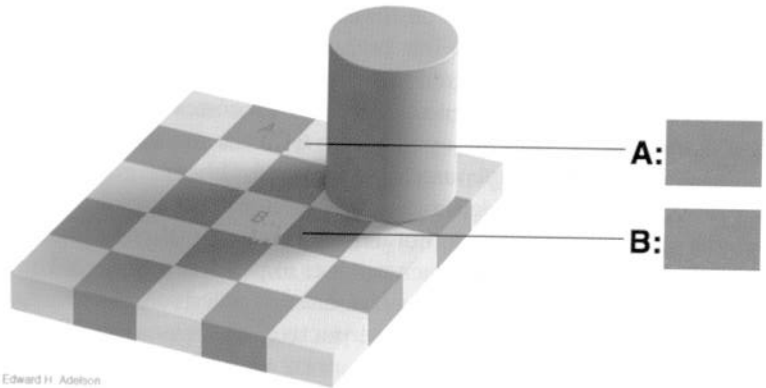


FIGURE 5.3

The squares marked A and B are the same gray. We see B as white because it is "shaded."

Brain researcher Edward H. Adelson at the Massachusetts Institute of Technology developed an outstanding illustration of our visual system's insensitivity to absolute brightness and its sensitivity to contrast (see Fig. 5.3). As difficult as it may be to believe, square A on the checkerboard is exactly the same shade as square B. Square B only appears white because it is depicted as being in the cylinder's shadow.

ABILITY TO DISCRIMINATE COLORS DEPENDS ON HOW COLORS ARE PRESENTED

Even our ability to detect differences between colors is limited. Because of how our visual system works, three presentation factors affect our ability to distinguish colors from each other:

- ***Paleness:*** The paler (less saturated) two colors are, the harder it is to tell them apart (see Fig. 5.4A).
- ***Color patch size:*** The smaller or thinner objects are, the harder it is to distinguish their colors (see Fig. 5.4B). Text is often thin, so the exact color of text is often hard to determine.
- ***Separation:*** The more separated color patches are, the more difficult it is to distinguish their colors, especially if the separation is great enough to require eye motion between patches (see Fig. 5.4C).

Several years ago, the online travel Web site ITN.net used two pale colors—white and pale yellow—to indicate which step of the reservation process the user was on (see Fig. 5.5). Some site visitors couldn't see which step they were on.

Small color patches are often seen in data charts and plots. Many business graphics packages produce legends on charts and plots, but make the color patches in the legend very small (see Fig. 5.6). Color patches in chart legends should be large to help people distinguish the colors (see Fig. 5.7).

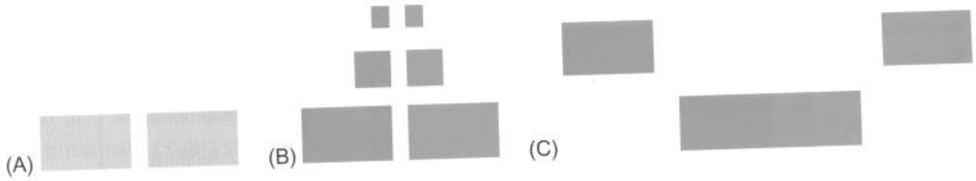


FIGURE 5.4

Factors affecting the ability to distinguish colors: (A) paleness, (B) size, (C) separation.

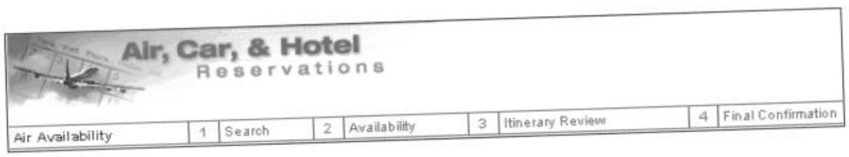


FIGURE 5.5

ITN.net (2003): Pale color marking current step makes it hard for users to see which step in the airline reservation process they are on.

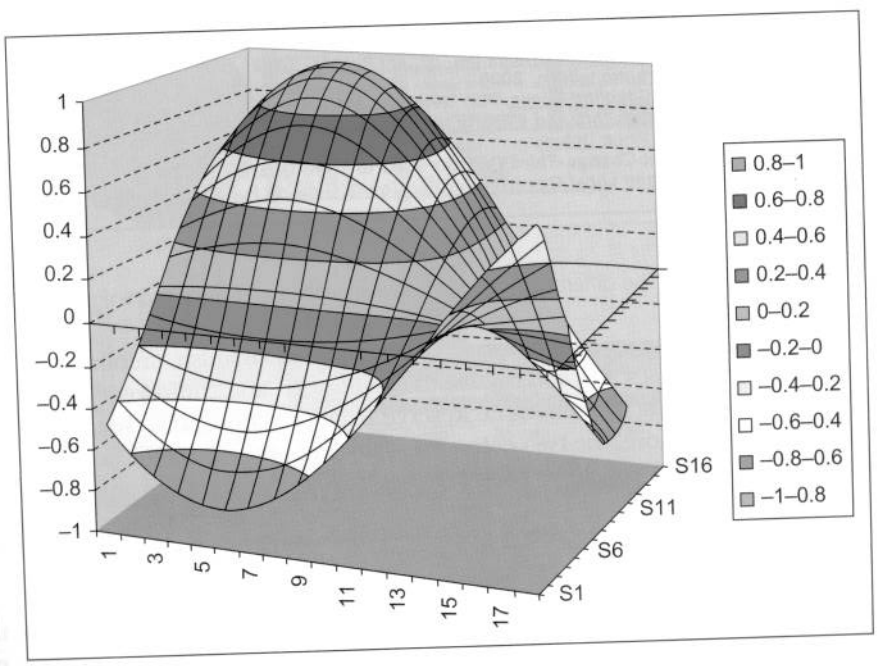


FIGURE 5.6

Tiny color patches in this chart legend are hard to distinguish.

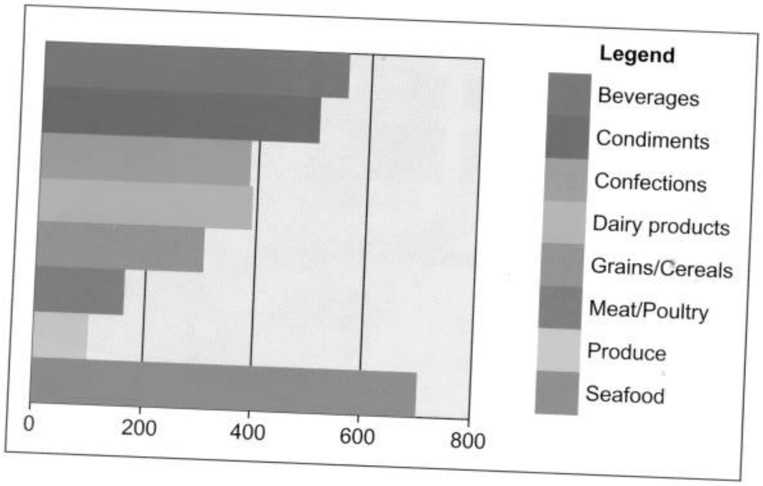


FIGURE 5.7

Large color patches make it easier to distinguish the colors.

- Housing Units Authorized, Percent Change October 2005 Year-to-Date Compared With a Year Earlier
- Electricity Consumption per Capita, 2001
- Drinking and Wastewater Needs per Capita, 2003 Dollars
- Manufactured Homes as a Percent of Total Homes, 2000
- Percent of Occupied Housing Units That Are Owner Occupied
- Percent Change in Private Employment Due to Growth/Decline in Establishments, 2000-2001
- Labor-Force Participation Rate, 2002
- Number of Bank Offices per 10,000 People, 2003
- Total Foreign-Born, 2000
- Retail Gasoline Prices, May 17, 2004
- Total Manufactured Exports per Capita, 2003
- House Price Index, Percent Change-Third Quarter 2002 to Third Quarter 2003
- State and Local Government Per Capita General Fund Expenditure, 1977-2000

FIGURE 5.8

MinneapolisFed.org: The difference in color between visited and unvisited links is too subtle.[2]

On Web sites, a common use of color is to distinguish unfollowed links from already followed ones. On some sites, the "followed" and "unfollowed" colors are too similar. The Web site of the Federal Reserve Bank of Minneapolis (see Fig. 5.8) has this problem. Furthermore, the two colors are shades of blue, the color range in which our eyes are least sensitive. Can you spot the two followed links? (The answer is below.)

COLOR-BLINDNESS

A fourth factor of color presentation that affects design principles for interactive systems is whether the colors can be distinguished by people who have common types of

[2] Already followed links in Figure 5.8: Housing Units Authorized and House Price Index.

color-blindness. Having color-blindness doesn't mean an inability to see colors. It just means that one or more of the color subtraction channels (see above) don't function normally, making it difficult to distinguish certain pairs of colors. Approximately 8% of men and slightly under 0.5% of women have a color perception deficit:[3] difficulty discriminating certain pairs of colors (Wolfmaier, 1999). The most common type of color-blindness is red/green; other types are much rarer. Figure 5.9 shows color pairs that people with red/green color blindness have trouble distinguishing.

The home finance application MoneyDance provides a graphical breakdown of household expenses, using color to indicate the various expense categories (see Fig. 5.10). Unfortunately, many of the colors are hues that color-blind people cannot

(A)
(B)
(C)

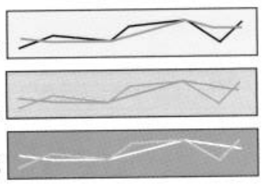


FIGURE 5.9

Red/green color-blind people can't distinguish: (A) dark red from black, (B) blue from purple, (C) light green from white.

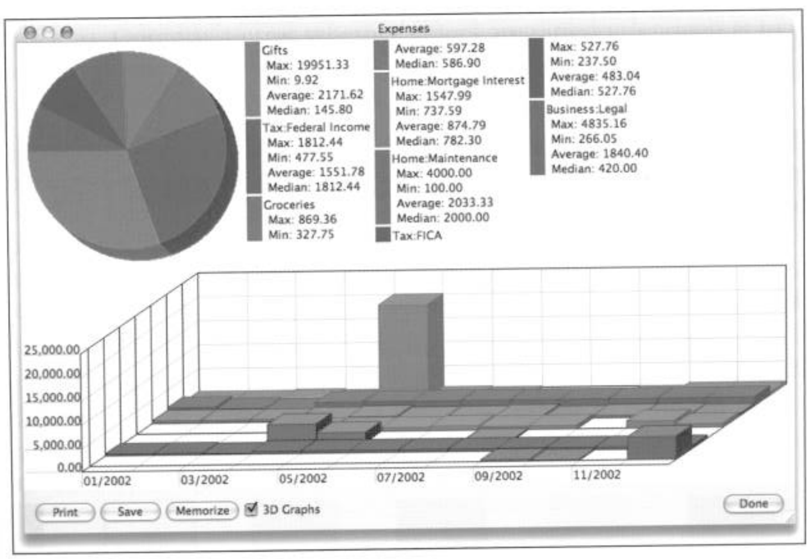


FIGURE 5.10

MoneyDance: Graph uses colors some users can't distinguish.

[3] The common term is color "blindness," but color "vision deficit," "vision deficiency," "vision defect," "confusion," and "weakness" are more accurate. Color "challenged" is also used. A total inability to see color is extremely rare.

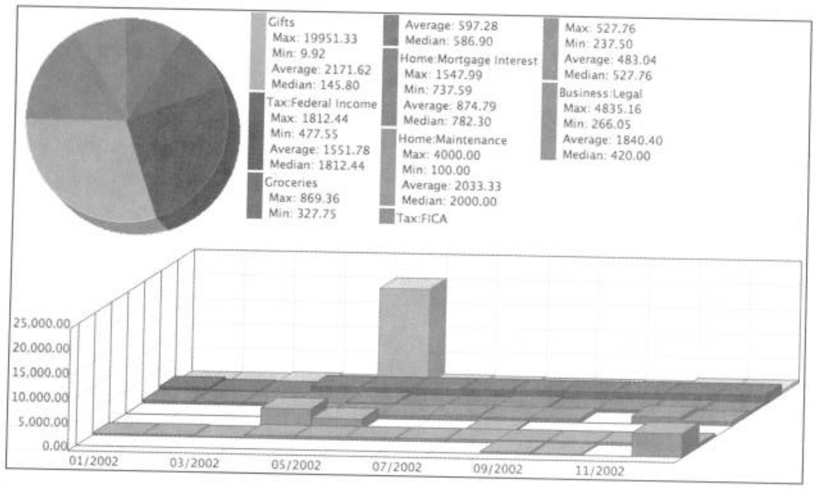


FIGURE 5.11

MoneyDance graph rendered in grayscale.

tell apart. For example, people with red/green color-blindness cannot distinguish the blue from the purple or the green from the khaki. If you are not color-blind, you can get an idea of which colors in an image will be hard to distinguish by converting the image to grayscale (see Fig. 5.11).

EXTERNAL FACTORS THAT INFLUENCE THE ABILITY TO DISTINGUISH COLORS

Factors concerning the external environment also impact people's ability to distinguish colors. For example:

- ***Variation among color displays:*** Computer displays vary in how they display colors, depending on their technologies, driver software, or color settings. Even monitors of the same model with the same settings may display colors slightly differently. Something that looks yellow on one display may look beige on another. Colors that are clearly different on one may look the same on another.
- ***Grayscale displays:*** Although most displays these days are color, there are devices, especially small hand-held ones, with grayscale displays. Figure 5.11 (above) shows that a grayscale display can make areas of different colors look the same.
- ***Display angle:*** Some computer displays, particularly LCD ones, work much better when viewed straight on than when viewed from an angle. When LCD

displays are viewed at an angle, colors—and color differences—often are altered.

- ***Ambient illumination:*** Strong light on a display washes out colors before it washes out light and dark areas, reducing color displays to grayscale ones, as anyone who has tried to use a bank ATM in direct sunlight knows. In offices, glare and venetian blind shadows can mask color differences.

These four external factors are usually out of the software designer's control. Designers should therefore keep in mind that they don't have full control of the color viewing experience of users. Colors that seem highly distinguishable in the development facility on the development team's computer displays and under normal office lighting conditions may not be as distinguishable in some of the environments where the software is used.

GUIDELINES FOR USING COLOR

In interactive software systems that rely on color to convey information, follow these five guidelines to assure that the users of the software receive the information:

1. *Distinguish colors by saturation and brightness as well as hue.* Avoid subtle color differences. Make sure the contrast between colors is high (but see guideline 5). One way to test whether colors are different enough is to view them in grayscale. If you can't distinguish the colors when they are rendered in grays, they aren't different enough.

2. *Use distinctive colors.* Recall that our visual system combines the signals from retinal cone cells to produce three "color opponent" channels: red-green, yellow-blue, and black-white (luminance). The colors that people can distinguish most easily are those that cause a strong signal (positive or negative) on one of the three color-perception channels, and neutral signals on the other two channels. Not surprisingly, those colors are red, green, yellow, blue, black, and white (see Fig. 5.12). All other colors cause signals on more than one color channel, and so our visual system cannot distinguish them from other colors as quickly and easily as it can distinguish those six colors (Ware, 2008).

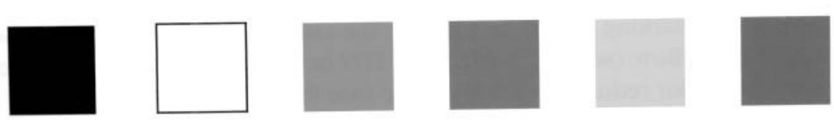


FIGURE 5.12

The most distinctive colors. Each color causes a strong signal on only one color-opponent channel.

FIGURE 5.13

Apple's iPhoto uses uses color plus a symbol to distinguish two ty

FIGURE 5.14

Opponent colors, placed on or directly next to each other, clash.

3. *Avoid color pairs that color-blind people cann* include dark red versus black, dark red versus da ple, light green versus white. Don't use dark red any dark colors. Instead, use dark reds, blues, and v and greens. Use Vischeck.com to check Web pag people with various color vision deficiencies would
4. *Use color redundantly with other cues.* Don't rely color to mark something, mark it another way as both color and a symbol to distinguish "smart" pl albums (see Fig. 5.13).
5. *Separate strong opponent colors.* Placing oppone on top of each other causes a disturbing shimmerin be avoided (see Fig. 5.14).

As mentioned above, ITN.net used only pale yellow to step in making a reservation (see Fig. 5.5, above), which is to strengthen the marking would be to make the current st saturation of the yellow (see Fig. 5.15A). But ITN.net opted which also uses color redundantly with shape (see Fig. 5.15

A graph from the Federal Reserve Bank uses whit (Fig. 5.16). This is a well-designed graph. Any sighted pers a grayscale display.

FIGURE 5.15

ITN.net: The current step is highlighted in two ways: with color and shape.

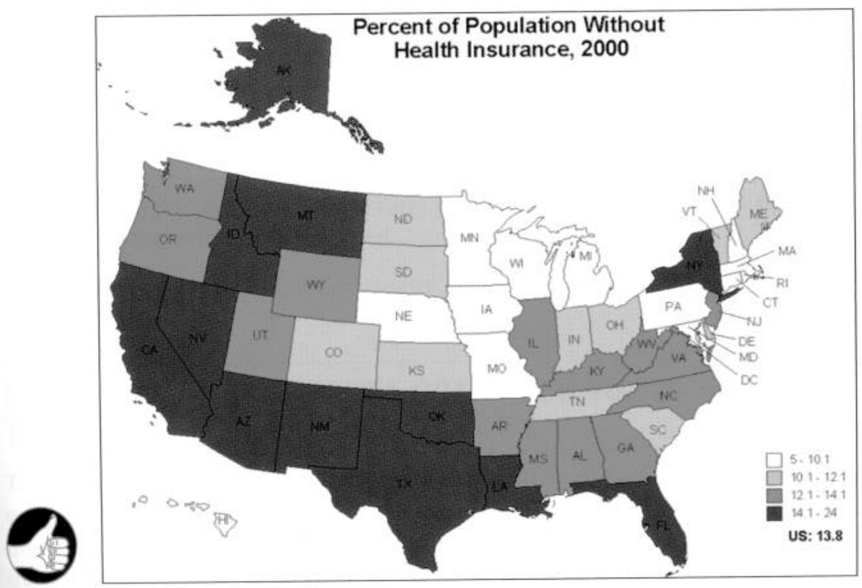


FIGURE 5.16

MinneapolisFed.org: Graph uses color differences visible to all sighted people, on any display.