BRGA-12

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2

Capabilities of Human Beings

2.1 Introduction

Much of what you need to know to create a website will come from the information that you gather about your particular users and the specific tasks they perform. There is no substitute for collecting this information, and Chapter 3 will cover this topic in detail. However, there are some commonalities in how people think and perceive that provide a useful set of considerations for Web design. This information comes from *cognitive psychology*, which studies how people perceive, learn, and remember.

"Cognition" means "the act or process of knowing." For instance, if you are reading a Web-based article with your favorite browser and you come to a phrase written with blue underlined text, you can be reasonably certain that the blue text is a link. Research findings in cognition can help resolve such questions as the following:

"Confronted with a new website, how can a user capitalize on past experience to make sense of it? Can the user depend on the result?"

Anyone who is developing websites needs to know some basics about the limits of human perception, cognition, and memory. We don't have to delve into the latest research, but some basics are essential.

Goals of this Chapter

In this chapter, you will learn about

- human sense, perception, memory, and interruptions
- the concepts of mental models, metaphor, and perceived affordance
- some design guidelines based on these topics.

2.2 Senses

Our senses feed our perceptions. Most of us have at least five senses, primary among which are sight, hearing, touch, taste, and smell. As a whole, we are primarily visual beings. When a number of students were asked which sense they would most hate to lose, 75% replied sight [Synnott 1993]. Visual metaphors permeate our language:

- I see your point.
- Out of sight, out of mind.
- What does she see in him?

16

Designing good Web materials requires knowledge about how people see. The next section shows that seeing involves not only the eyes, but also involves the mind in crucial ways.

2.3 Perception

In a subject as vast and as important as this, it should not be surprising that there are differing schools of thought. Without surveying the others, we will borrow from the school of *constructivism* [Agnew 1987].

Central to constructivism is the idea that our brains do not create a pixel-by-pixel recording of a scene like a digital camera. Instead, our minds create or construct intervening models that abstract and summarize what comes out of the optic nerve, and these models influence what we perceive.

Consider Figure 2–1. This is a picture of a calf. The head takes up the left side of the image. Once you have recognized it, your mind recreates a summary of the picture, and you will see the calf easily when you encounter the image again.

Constructivist theory contends that when we see something, we don't remember all the information in the scene. We retain only the pieces that have meaning for us. Do you remember how many links are in the top menu of amazon.com? What are the colors on the box containing your favorite breakfast cereal? How many lines make up the IBM logo? An honest reaction to any of these questions might well be "Who knows and who cares?" Exactly so. People filter out the irrelevant parts and save the important ones.

Secondly, constructivist theory states that *context* plays a major role in what people see in an image. Figure 2–2 shows what looks like two identical shapes; in context, however, the two shapes are interpreted as two different letters, as seen in Figure 2–3.

The combination of factors revolving around what we know and what we bring to a situation is called *perceptual set* or *mind set*. Mind set can have a profound effect on the usability

Figure 2–1   What do you see?

C **C**

Figure 2–2 Two identical shapes [after Selfridge 1955].

top ace

Figure 2–3 Interpreting a shape on the basis of its context.

of a website. Pearrow [Pearrow 2000] gives a charming example. One of his clients had a website on which patrons could not find important links on the site, even though they were right there in plain sight. The problem came from the fact that the client had used animated graphics for the critical links. Many users have come to assume that any animation is an advertisement, and these users really never saw what the designer intended. Replacing the animations with text-only links completely solved the problem.

A third important aspect of constructivism involves the decomposition or partitioning of images into entities recognized as *figure* (foreground) and *ground* (background). This might at first seem obvious; it gets more interesting when you realize that what constitutes the figure and what the ground can be highly ambiguous. Danish psychologist Edgar Rubin devised images that exhibit a high degree of figure/ground ambiguity [Rubin 1915]. In Figure 2–4, do you see a black vase (or goblet, or bird-bath) on a white background, or silhouetted faces on a black background? Perceptual set operates in such cases too: What we see depends in part on what we are used to seeing. A glassblower might be more likely to see a vase; a person who has a habit of observing people's faces closely might be more likely to see two profiles.

We are now into the branch of psychology known as *Gestalt psychology*, which adheres to the constructivist school of thought [Schultz 1996]. "Gestalt" is the German word for "shape," but it means more than that in this context. A main idea of Gestalt psychology is that we see things not in isolation, but as parts of some larger whole. We organize what we see into meaningful wholes by using five principles—proximity, similarity, symmetry, continuity, and closure.

Proximity. Proximity describes the process of using distance or location to create groups. Consider Figure 2–5. On the left are three groups of vertical lines. On the right are three groups of dots. People tend to perceive any closely clustered objects as a group.
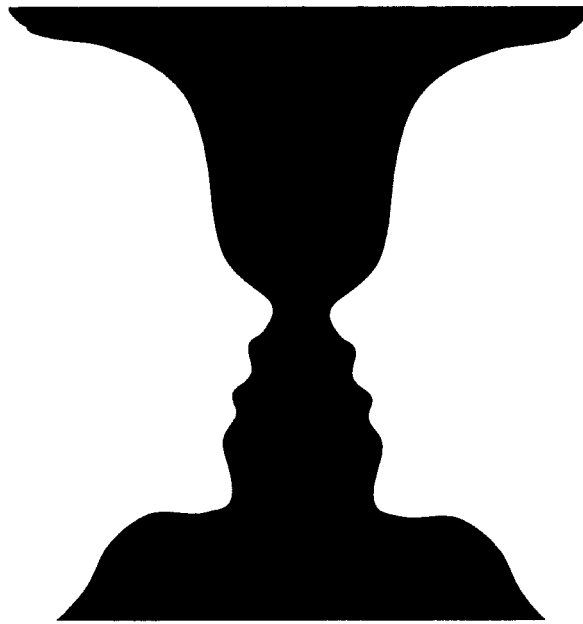
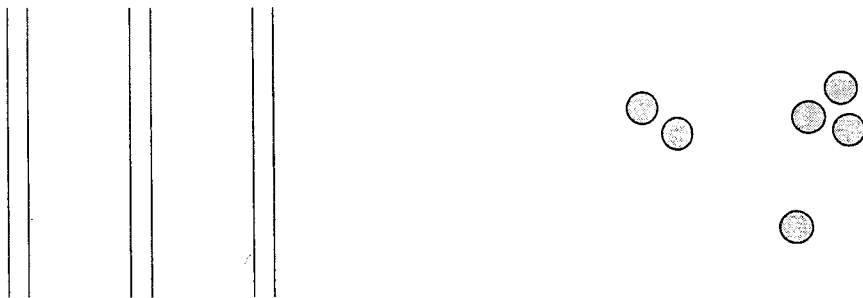**Figure 2–4**   Figure-and-ground ambiguity.

Figure 2–5   Examples of proximity.

Similarity.   Similarity is a grouping by like kind or like type. The collection in Figure 2–6 has an example of grouping by similarity. There are dark dots and light dots – in other words, two groups of dots, determined by shade of gray. It is possible to use similarity in any combination of size, shape, texture, boldness, or orientation to create groups.

Symmetry.   In symmetry, the whole of a figure is perceived rather than the parts that make up the figure. On the left side of Figure 2–7 we see two overlapping triangles, not a little triangle and two complex objects [Mullet 1995]. The example on the right shows three sets of brackets. Notice that your eyes group the left two brackets together, even though the second bracket is physically closer to the third bracket than to the first [Chandler, 2001].

Continuity.   Continuity is the term for groupings created by the flow of lines or by alignment. In Figure 2–8, we see on the left two smooth curves, a–b and c–d, not two broken
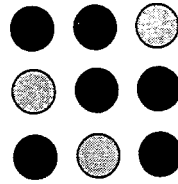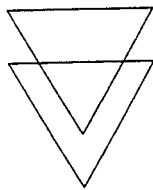
Figure 2–6
Similarity.
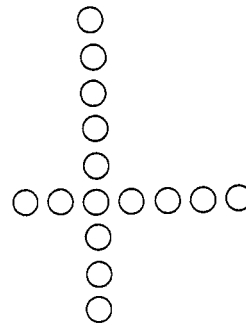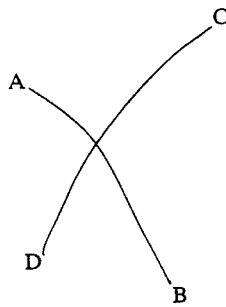

Figure 2–7   Examples of symmetry.

Figure 2–8 Examples of continuity.

curves, a–c and d–b. On the right are two lines created from circles. Although there are no actual lines, our eyes follow the flow formed by the circles. *Alignment* is a type of continuity. An example of alignment is the use of indentation to show hierarchy, as in an outline. In an outline, items of equal importance are aligned.

Closure.   Closure is the process by which we perceive shapes that, in a certain sense, aren't really there. We mentally complete the shape in our heads. It is a way for our minds to impose order and meaning on an incomplete set of data. Figure 2–9 displays three circles. The first has a ring of triangles surrounding it. The second has a chunk missing on the right side. The third has a dashed border. In all three cases, there is no actual circle, but your mind perceives it as such.

Three of the five visual principles of Gestalt are useful in structuring Web pages. When links are grouped together by proximity, people tend to think of those links as being related. Look at the list of links in Figure 2–10a. Considering their names, it appears that there are links to merchandise (camcorders, digital cameras, DVD players, VCRs), links to timely information (breaking news, press releases, reviews), and links to additional services (contacts,
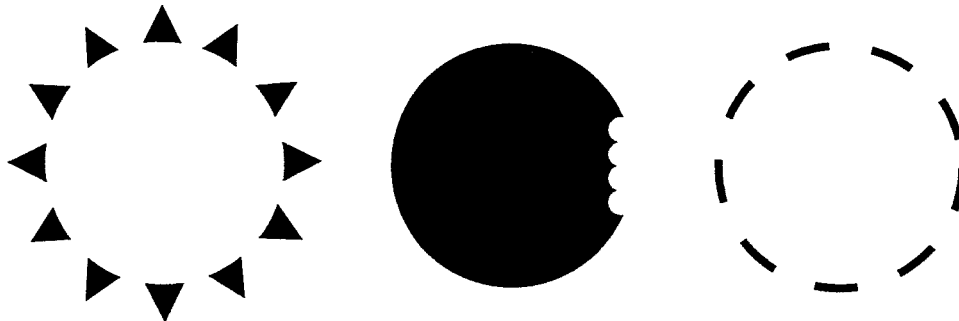
Figure 2–9 Examples of closure.

subscribe, webmaster). So there are three groups of related items: merchandise, time-sensitive information, and services. Instead of throwing them all together, which forces a user to look through the entire list, it's better to present them as three short lists. By adding a little space, the three groups are more visible, as you can see in Figure 2–10b.

The Gestalt principle of similarity says that related objects look alike. Figure 2–11 demonstrates how using this principle can improve a Web page. In all three Web pages, there are four buttons at the top of the page, but, in the first example, the buttons have different sizes and spacing that make
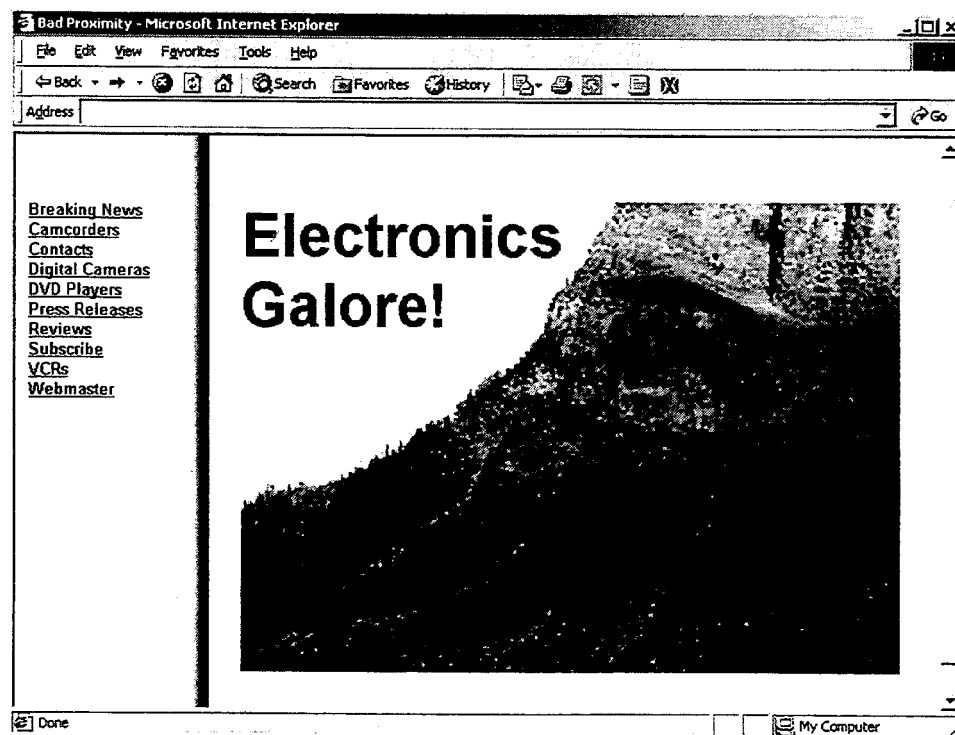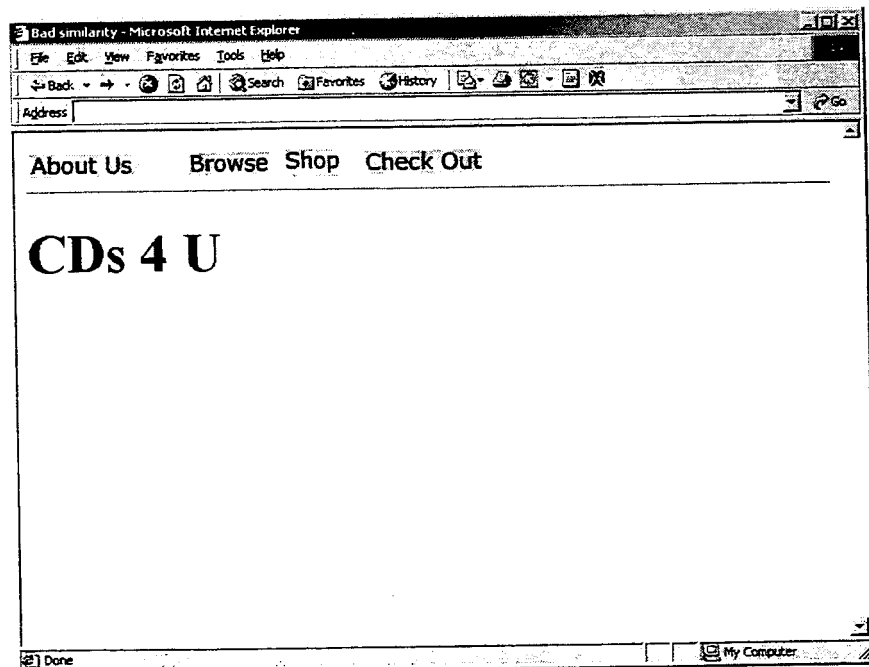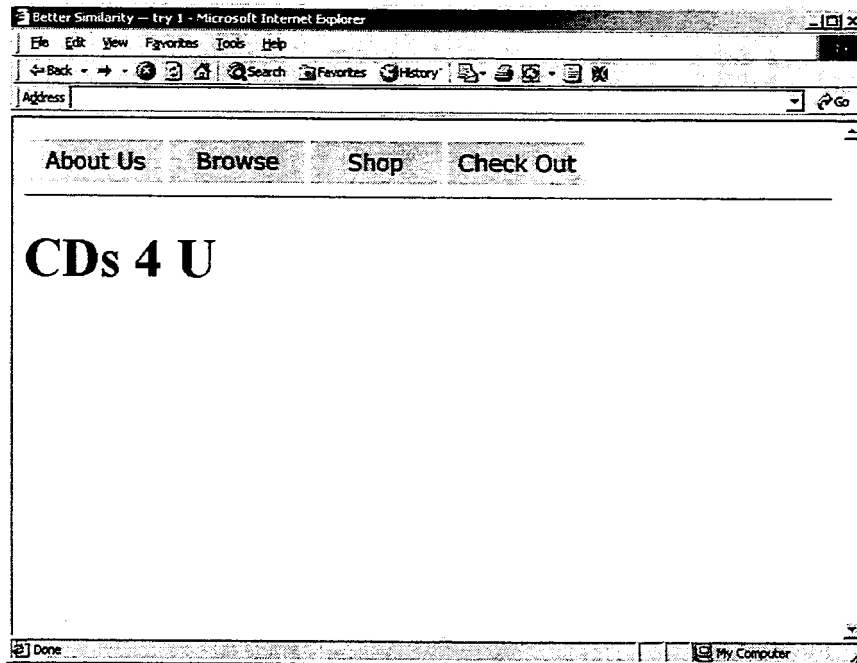

(a)

Figure 2–10 Using Proximity.

190
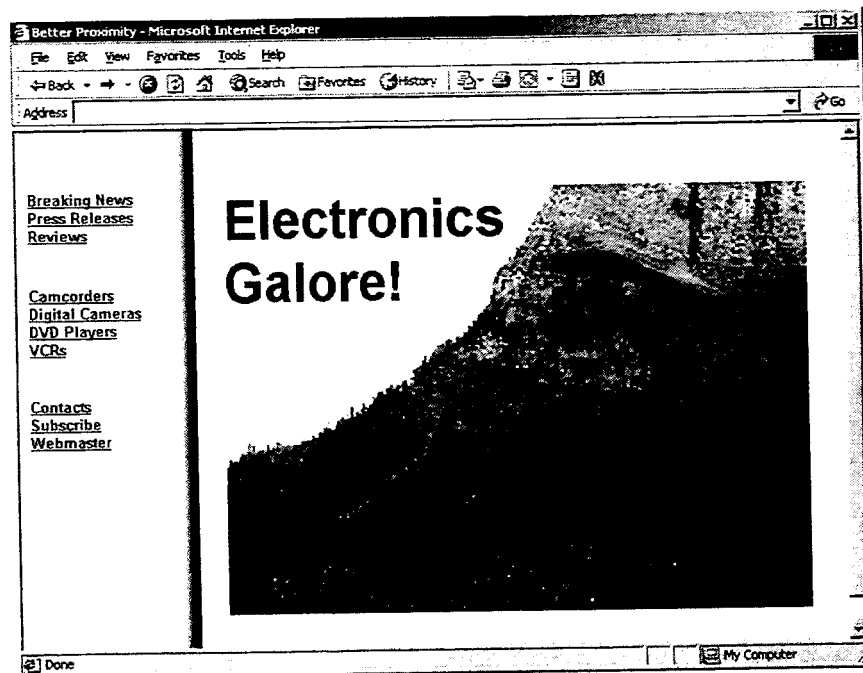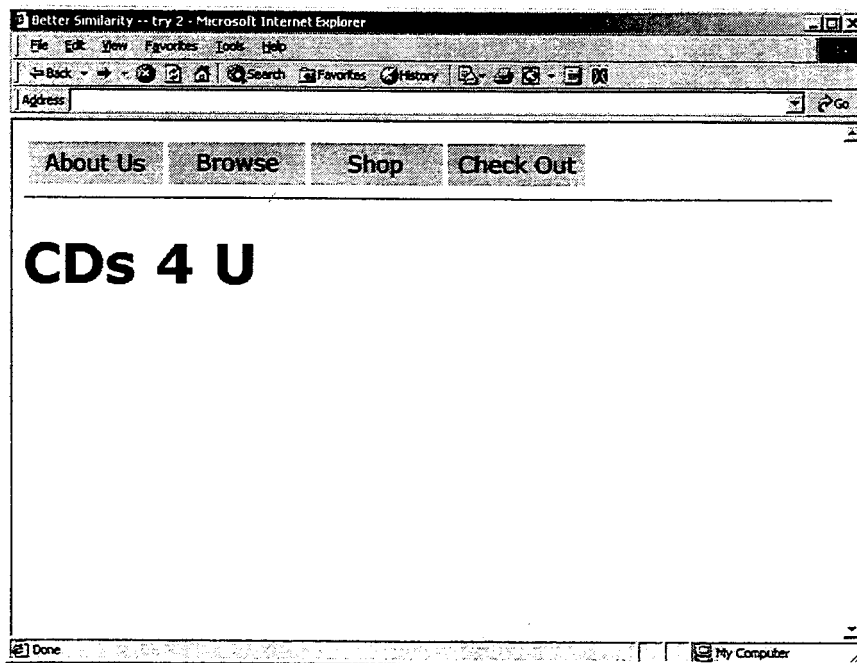
(b)

Figure 2–10   *(Continued)*

(a)

Figure 2–11 Leveraging Similarity.

(b)


(c)

Figure 2–11 *(Continued)*

for a raggedy appearance. In the second example, the buttons are all the same size and have the same spacing. Similarity is at work. There is a third example page in the figure. Compare it to the second page. What additional feature of similarity is present in the third example but absent from the second?

Using alignment, a form of continuity, improves the Web page in Figure 2–12a. Dark lines have been added to this example to show the poor alignment at the top and bottom of the page's content area. The second example has much stronger horizontal alignment across the blocks of text. Compare the second and third pages. What has changed? Is it horizontal or vertical? Compare the first and third pages. Which one appears more professional and inspires more confidence?

These five visual principles of Gestalt psychology make up a fascinating area where psychology and graphic design come together. Chapter 5 discusses how to take advantage of this idea of visual grouping when exploring techniques to promote effective visual communication on websites.

2.4 Memory

Knowing a few facts about the types and limits of human memory will help you design better websites. For example, consider what happens if a website requires a user to type in a 10-digit part number as part of the ordering process. Very often the reaction will be, "Forget it. This isn't worth it."
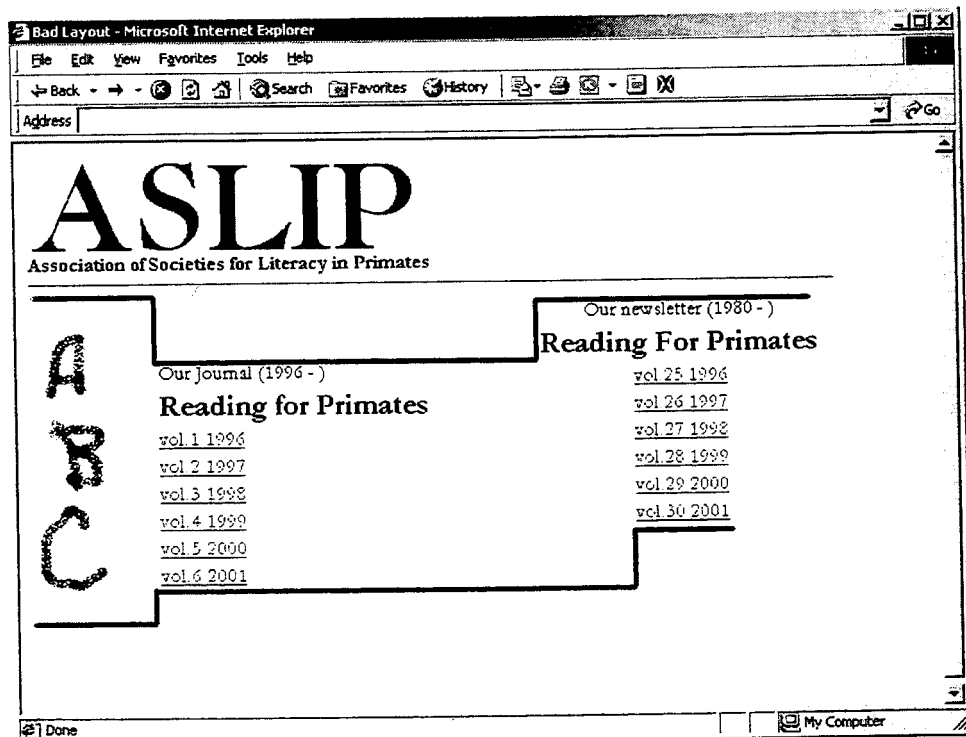
(a)

Figure 2–12 Using alignment, a type of continuity (part 1).
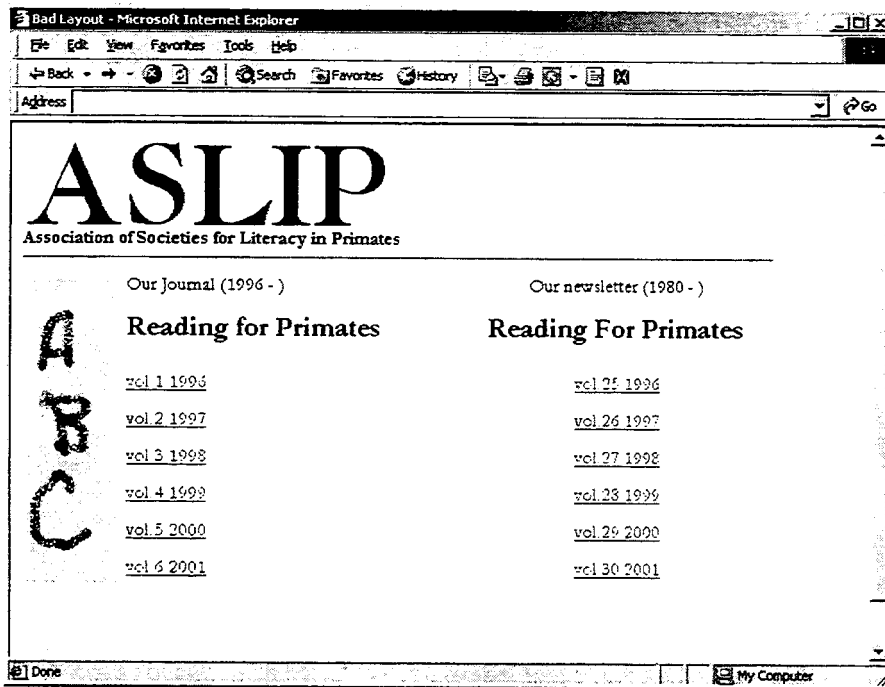
(b)

Figure 2–12 (*Continued*)
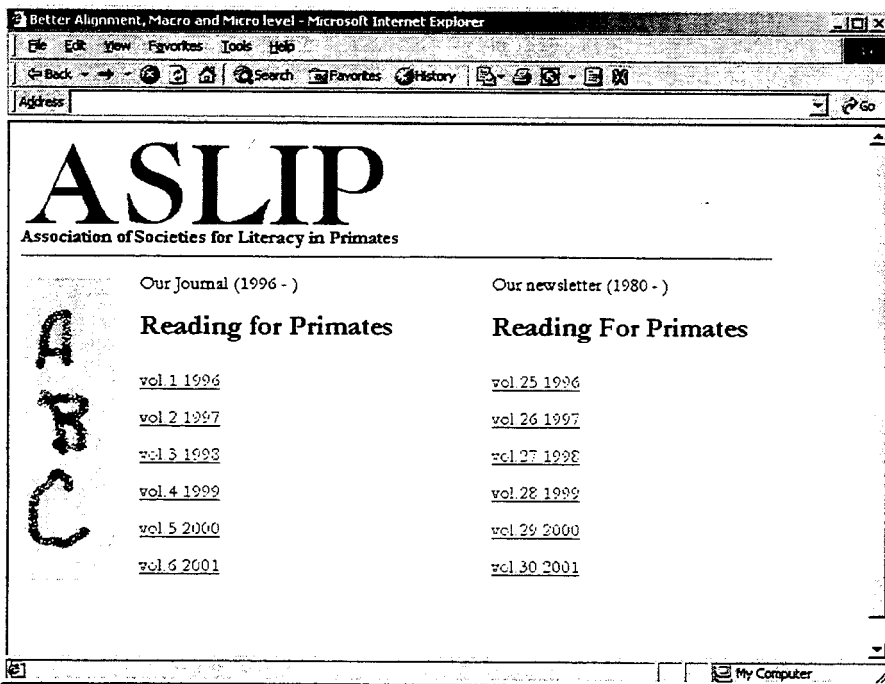
Figure 2–13 Using alignment, a type of continuity (part 2).

Memory is an astonishing capacity and variable in the extreme. One of the authors of this book can lay down his reading glasses and five minutes later have absolutely no idea where they are. In contrast, many people can remember all of the lyrics to a song that was popular in their youth, even if that youth occurred some time ago.

Knowing a few basic facts about memory will help in designing good websites. A few key concepts are the following:

- The hierarchical model of memory: sensory store, short-term memory, and long-term memory.
- The value of "chunking."
- The advantages of relying on recognition instead of on recall.
- Memory aids.

2.4.1 The Hierarchical Model of Memory

The hierarchical model of memory is just that: a model. We don't yet know how memory works at the neuron level, but the model helps explain why people can remember some things while forgetting others [Anderson 2000]. As depicted in Figure 2–14, the model consists of three stages: *sensory memory*, *short-term memory*, and *long-term memory*.

Sensory memory refers to a buffer that stores sensory input. People automatically throw most of it away without being aware of doing so. An example of this is the act of tuning out all of the voices at a cocktail party except for that of the person next to you. Consistent with this concept is the fact that people don't remember most of what they see. As an example, try remembering the commercials that played on last night's newscast.

The second level in the hierarchy is *short-term memory*. Short-term memory holds a limited amount of data for a period of time ranging from 30 seconds to two minutes. As new information arrives in short-term memory, old information is forgotten.

How much data can short-term memory hold? The answer is given in the title of a landmark 1956 paper by the psychologist George Miller: "The Magic Number Seven, Plus or Minus Two" [Miller 1956]. Many people can remember a new seven-digit telephone number long enough to dial it, but most people would not remember the number the next day. It's difficult to remember the page number where you saw an item in a catalog without the additional help of turning down the page corner. One metaphor for short- vs. long-term memory is that short-term memory is like dynamic RAM: Continuously focusing attention
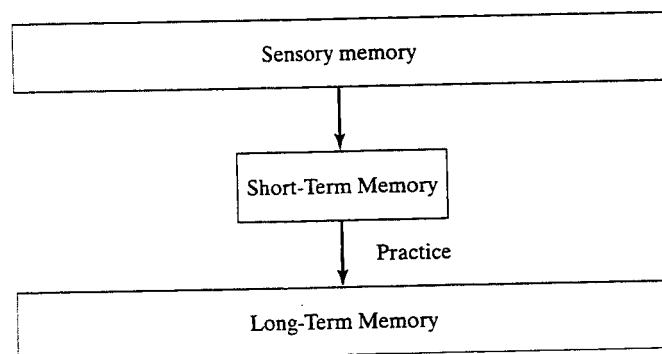

Figure 2–14 Memory Hierarchy (courtesy Maryjo Davidson).

on a set of numbers will constantly refresh the memory. If a person switches attention to something else, the information in the volatile storage medium is lost.

A person needs to expend a great deal of effort to transfer information to *long-term memory*, which is the third and final stage in the memory hierarchy. How it actually works is not known, but it is as if a connection is established between the RAM and a hard disk and the contents of the RAM are stored to disk. If you turn off your computer for a week, anything in RAM is long gone, but contents of the disk are expected to be intact. You already know that it requires a great deal of effort to move information from short-term to long-term memory. You know how much time and concentration it takes to study for an exam.

Long-term memory is quite useful and virtually unlimited, but it isn't infallible. Research has shown that long-term memory is frequently quite unreliable and is easily manipulated simply by how questions are asked. For example, a group of test participants was shown slides of an automobile collision. Later, the subjects were asked either of two questions: "How fast were the cars going when they hit each other?" or "How fast were the cars going when they smashed into each other?" A week later, all participants were asked whether they had seen broken glass in any of the slides they had been shown. Those who had been asked about the cars that "smashed into each other" were much more likely to report having seen glass than subjects who were asked about the cars that "hit each other." In fact, there was no broken glass in the scene [Loftus 1974].

Building long-term memory takes time and effort. When browsing the Web, users are not interested in expending energy to memorize a site or how to use it.

2.4.2 Chunking

In his article, Miller discussed his number seven in terms of *chunks*. A chunk might be a digit, such as the digits in a seven-digit phone number, but what constitutes a chunk will vary with the individual and the context. Consider the URL www.bestbookbuys.com. This URL has 20 characters in it, so at first it might seem that Miller is stating that this URL is too big to fit in short-term memory. In actuality, however, people group the characters into the following chunks:

1. www.
2. best
3. book
4. buys
5. .com

As five chunks, the URL fits nicely into short-term memory.

2.4.3 Recognition vs. Recall

Why is it easier to take a multiple-choice test than an essay test? In a multiple-choice test, it's possible to *recognize* the correct answer among the choices; with an essay exam, one is forced to *recall* the correct answer. When listening to a "golden oldies" radio station, you may *recognize* a tune but fail to *recall* the title. It is easier to read a newspaper in a second language than it is to speak in it, because speaking requires recalling the words you want to say. When using computers, it is far easier to recognize commands in a menu on a graphical user interface than to remember abbreviations in a command-line system.

An effective way of reducing a user's memory burden is to design systems that rely on people's ability to recognize information rather than forcing them to recall it. One way to do

this is through *memory aids*. Memory aids are familiar from everyday life. Many of us do things like sticking Post-It® notes on the fridge to remind ourselves to buy milk. Some people might put their wristwatch on the wrong arm, so that when they get to work and try to look at the time, they will say, "What on earth is my watch doing *there?*" and then they will remember, "Oh, yes. I have to send Joe a fax."

Closer to home, the Microsoft Windows keyboard alternative to clicking on File is alt + F. The fact that F is the first letter of File is a memory aid, and the fact that on the File menu the F is underlined is another. Once the File menu drops down, we are reminded that ctrl + N means New, ctrl + O means Open, ctrl + C means Close, and ctrl + S means Save. These choices seem "natural" to us by now.

Many people use the Favorites list or Bookmarks to store URLs for later use. Hypertext links themselves can be memory aids if they give an indication of the contents of the target page.

2.5 Interruptions

Two phenomena, focusing of attention and handling of interruptions, are closely linked with memory. We have all had the experience of being in a crowded room, at a cocktail party perhaps, where many conversations are going on simultaneously. It is quite easy to focus on just one speaker, blocking out all the competing sounds.

Knowing how and when to focus a user's attention is important in such time-critical applications as the control of nuclear power plant operations, the directing of air traffic, or the monitoring of patients in an intensive-care unit. It is also important for such applications as websites, because people often encounter interruptions.

We are all capable of juggling several things at one time. Many people can cook while carrying on an animated conversation. Sometimes, though, people are interrupted in a way that does not permit doing two things at once. You are typing email when you hear a scream in the hallway; it turns out to be a scream of laughter, but when you get back to the email you have to recover your train of thought. There are definite limitations on the ability to resume an interrupted task because it relies on short-term memory. Have you ever tried to count coins while carrying on a conversation? If the talk gets too interesting, it is easy to lose count.

Consider a situation where you are writing an email message when a visitor knocks on the door. You begin a conversation with the visitor when the phone rings. After finishing the phone call, you need to remember where you were in the conversation with your visitor. If you don't recall, you can ask, "Where were we?" Similarly, when your visitor leaves and you return to your email message, you can read the last sentence or two to recognize your train of thought in the email message. In both cases, you were able to pick up the train of thought, but you relied on external cues, or *knowledge in the world* [Norman 1988] to do it.

For Web designers, it's important to give people cues or memory aids for resuming interrupted tasks. With a fill-out form, users can see where they left off, because some of the text boxes are still blank. Today's browsers return to the exact position within a Web page in response to the "back" button. Followed links have a different color, to tell a user which pages have already been visited. A more sophisticated example is the persistent shopping cart available in e-commerce sites: A user can place items in a cart and return to it even days later. These are all examples of using memory aids to ease the burden on a user's memory while resuming an interrupted task.

Web designers also need to know the answer to the question, "What constitutes an interruption?" Another way to ask this is as follows:

How fast does a system have to respond before the user's attention becomes diverted from the task at hand?

A widely quoted paper by Robert Miller [Miller 1968] gives the answer:

Response time	User reaction
Less than 0.1 second	User perceives this as instantaneous.
Less than 1.0 second	User notices the delay, but has no break in thought stream.
More than 10.0 seconds	User switches to another task.

For a response taking between 1 and 10 seconds, the user will usually wait, but there are some newer studies [Bouch 2000] that indicate that users will wait only 8 seconds for a page to download. For any response taking more than 10 seconds, a user will switch to doing something else, and an interruption has occurred. You will need to think about what type of feedback will help a user remember where the interruption occurred.

When a delay is unavoidable, it is important to give the user some kind of feedback to indicate that the computer isn't brain-dead. Users need an acknowledgment that a mouse click or other input has been received.

2.6 Mental Models

Closely related to how people store knowledge in memory is how people use that knowledge to understand new experiences or to make predictions about new situations. People build *mental models* to make predictions about an external event before actually carrying out actions. Examples are easy to find, both in everyday life and on the Web. A possible mental model of a car might be: If I put gas in here and put the key in there and turn it, the car starts.

Note that this is not the same mental model of a car that a mechanic has, but it doesn't stop the person from making predictions about the car's behavior. A possible prediction might be that if the tank doesn't get filled, eventually the car won't start. Mental models are essential for survival in the world, but, as the previous example suggests, they often do not correctly describe the functionality underlying the interface.

We can't ignore a user's mental models just because they aren't neat and clearly defined. Whether we like it or not, people use mental models to form expectations, and we ignore them at our peril.

2.7 Metaphors

Metaphors can help guide a user to choose the most relevant mental model. The term metaphor has the same meaning here that it does it literature. It's a way to relate a difficult or abstract topic to a more familiar one. For example, everyday language tends to use the metaphor of money to refer to the more abstract concept of time. People talk about "spending time," "saving time," and "wasting time."

When creating interfaces, we can use metaphors to help people become familiar with a new system by comparing it to a more familiar one that they already know. For example, in the 1980s, new computer users found many similarities between typewriters and word processors. When they saw the keyboard on a computer, they assumed that it behaved similarly to a keyboard on a typewriter. Today, many types of user interactions are based on concepts that existed before the computer age. The actions of copying, cutting, and pasting were well known before computers were invented.

The advantage of using a metaphor is that it speeds the learning process. When surveying a new interface, people will draw on their mental models of the presented metaphor to find similarities to things they already know. Using this comparison, they can make predictions about the interface's behavior.

The big disadvantage of metaphors is that they are brittle and do not expand to accommodate new functionality. One of the reasons voice mail was difficult for people to learn was that the telephone metaphor did not accommodate the new functionality of sending or accessing recorded messages. Another example is the trashcan icon on the Mac interface. At one time, the only way to eject a floppy disk was to drag its icon to the trashcan. Many users were paralyzed by this requirement: the trashcan also stood for erasing a file from hard disk, and users wondered whether the floppy would be erased. Apple changed the interface.

2.8 Perceived Affordance

If it is clear to users how to find and pay for items on a website, then it is much more likely that the users will buy. *Perceived affordance* is the quality that makes it easy for a user to spot and identify the services or functionalities of an interface. *Affordance* refers to the functions or services that an interface provides. A door *affords* an exit from a room; a radio button *affords* a one-of-many choice. Perceived affordance is affordance that is visible and comprehensible to the user. If users can spot and predict the functionality of a control, then they will easily understand how the control works. Perceived affordance is a happy result of leveraging memory aids and users' mental models.

An example of perceived affordance is shown in Figure 2–15. Given that these are attached to doors, we know that a handle affords pulling and crash bar affords pushing [Preece 1994]. Figure 2–16 also illustrates perceived affordance: the top switch controls the top lights.
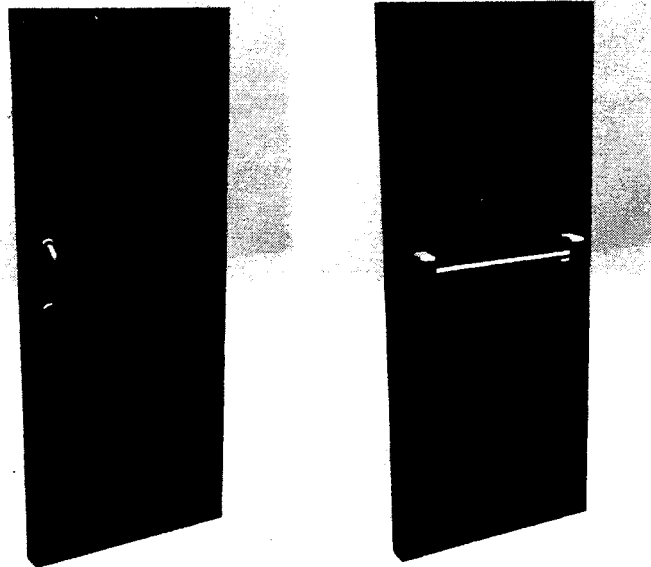

Figure 2–15   Perceived affordance in door handles. Courtesy of Bret Kroll.
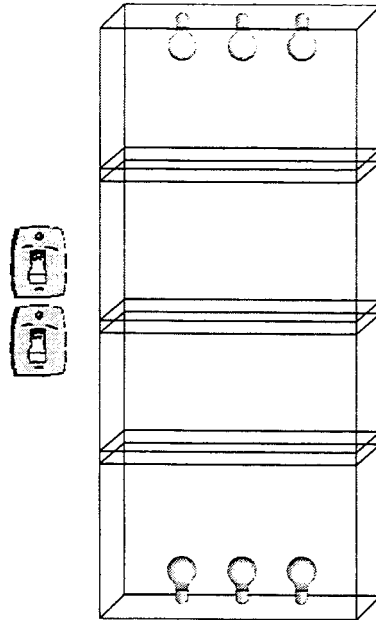
Figure 2–16 Perceived affordance: the top switch controls the top lights.

For more examples of affordance, see Don Norman's insightful and entertaining book, *The Design of Everyday Things* [Norman 1988].

2.9 Some Design Implications

The previous sections examined some key concepts of perception and memory. It covered interruptions and how memory and memory aids are important for successfully resuming an interrupted task. The careful use of metaphors and the development of perceived affordances can help a user comprehend the functionality of an interface more quickly. Here are some design guidelines for the Web that draw on this knowledge:

* Do your best to lessen the burden on a user's memory by
  o relying on recognition instead of recall
  o helping users chunk information
  o requiring as little of short-term memory as possible.
* Consider your user's mental models.
* Provide visual cues or memory aids so a user can easily resume an interrupted task.
* Provide feedback. Let the users know that their input has been received and give them an indication of how long it will take for the system to respond to it.

Review Questions and Exercises

1. According to constructivist theory, how do humans organize the data they receive from their senses?

2. Constructive theory states that context plays a major part in what we perceive. From your experience, give an example of an icon or a word that means different things, depending on the context.

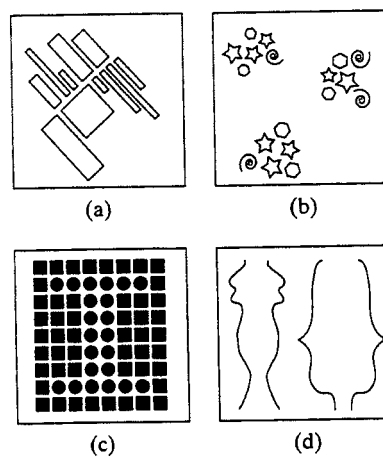3. For each of the four examples shown below, give the Gestalt principle it demonstrates.

(a)   (b)

(c)   (d)

Figure 2-17   For exercise 3.

4. For each of the four examples shown in Figure 2-18, give the Gestalt principle it demonstrates.

5. What Gestalt principles are contributing to the organization of the window depicted in Figure 2-19? Explain.

6. Figure 2-20 shows a proposed home page for a website about pets.

   a. Which of the link names are most closely related? Organize them into two groups according to the meaning of the link names, and list the groups. Explain your rationale for the groups.

   b. What ways do you know to organize information visually? List all five of them. For each one, decide whether it would be useful when reorganizing the link names on the website. Explain your answer.

   c. Make a photocopy of the home page, cut it apart using scissors, and make a new version of the page where the related links appear to be part of a group.

7. What are the three levels in the memory hierarchy? How are they different?

8. For an e-commerce site, why are short domain names more desirable than long ones?
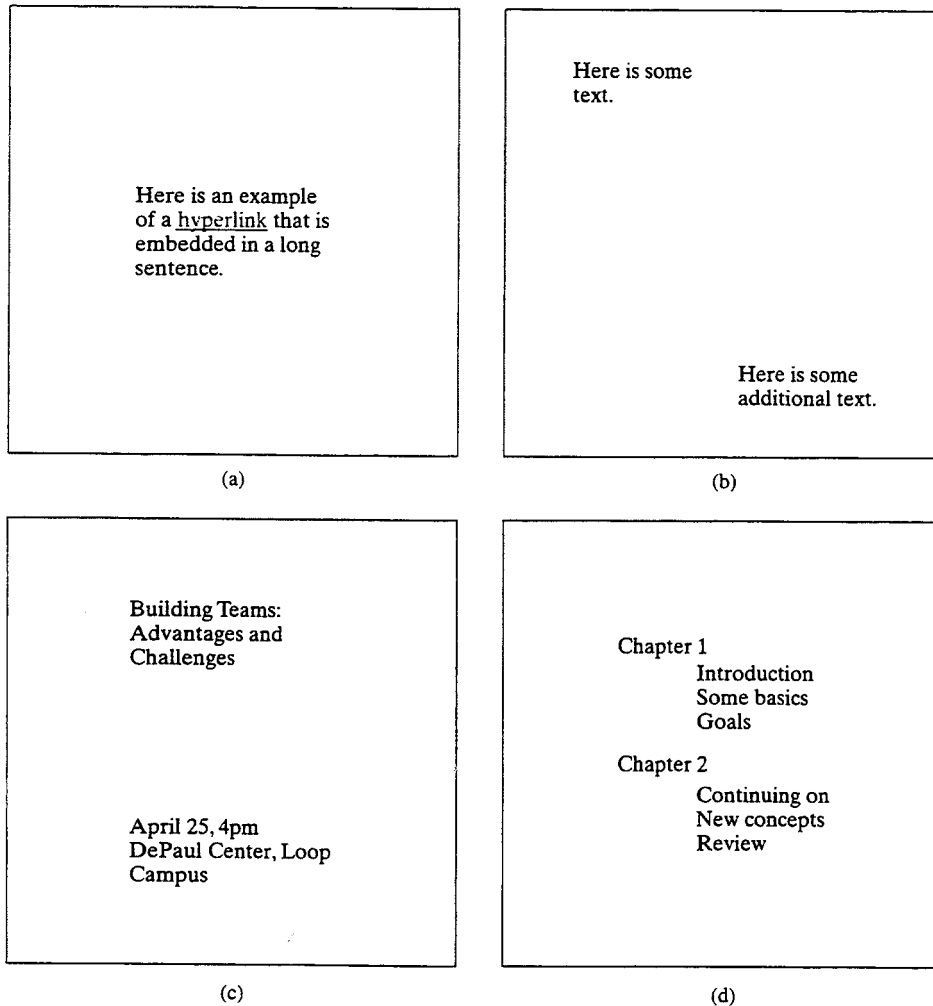
Here is an example
of a <u>hyperlink</u> that is
embedded in a long
sentence.

(a)

Here is some
text.

Here is some
additional text.

(b)

Building Teams:
Advantages and
Challenges

April 25, 4pm
DePaul Center, Loop
Campus

(c)

Chapter 1
        Introduction
        Some basics
        Goals

Chapter 2
        Continuing on
        New concepts
        Review

(d)

Figure 2–18   For exercise 4.

QuickTime Player
Play and edit QuickTime movies

QuickTime™
Version 5.0.2

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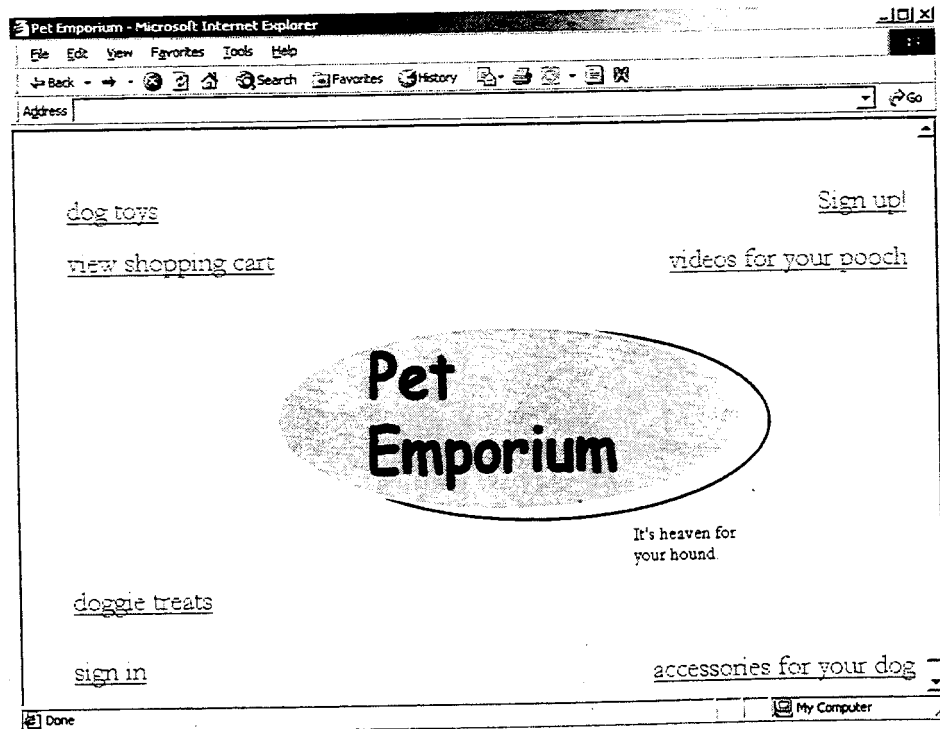**Figure 2–19**   Courtesy of Apple Computer, Inc. Used by permission.

Figure 2–20 For exercise 6.

9. Why do many television ads list a phone number like 1-800 CALL ATT instead of 1-800 225 5288? After all it's easier to use the numbers on the touch pad instead of hunting up the letters. Relate this to short-term memory.

10. Both Netscape and Internet Explorer have a good number of memory aids built into them. Name at least four of them.

11. Why do most people find menu-based systems easier to use than command-line systems?

12. Suppose you are adding a new paragraph to the middle of a term paper when your computer emits a sound letting you know that email has arrived. You switch to your email client to read the new message. After you reply, you switch back to your paper. Why is it easy to know where you left off? How does it focus your attention?

13. You have selected some files that you plan to delete, but you don't get a chance to hit the "delete" key before the phone rings. When you return to your machine, how do you know which files you had chosen for deletion? Relate this to what you know about interruptions.

14. The section about metaphors mentioned that the copy and paste actions existed before the age of computers. What other metaphors do you find in today's Macintosh or Windows interfaces?

15. The following are pictures of two doors. How would you operate door A? How would you operate door B? Compare your responses to these two scenarios. Are they the same or different? How does this relate to concepts discussed in this chapter?
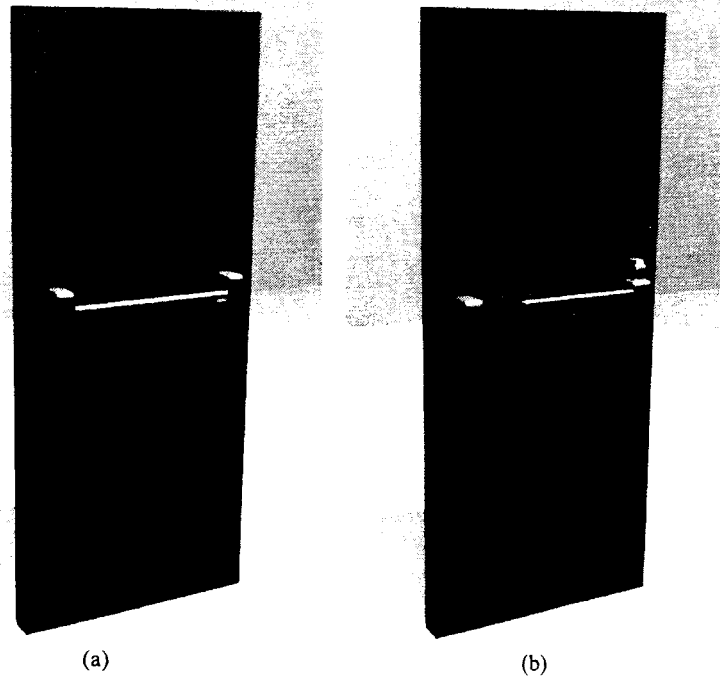

(a) (b)

Figure 2–21 Two doors. For exercise 15. Courtesy of Bret Kroll.

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