STEP
11

Create Meaningful Graphics, Icons, and Images

The graphics era in interface and screen design began with the Xerox Star computer in the 1970s and fully blossomed with the advent of Apple's Lisa and Macintosh in the mid-1980s. GUI systems rapidly began to supplement the earlier text-based systems that had been in existence for three decades. When Microsoft finally entered the picture with their Windows system, GUI systems quickly became the dominant user interface. The significant graphical feature of a GUI system is the use of icons (the symbolic representation of objects, such as applications, office tools, and storage locations) and the symbolic representation of actions that could be applied to objects. The faces of many 1990s and beyond GUI screens scarcely resembled their older text-based siblings of the mid- to late-twentieth century.

The graphical evolution in interface design was further expanded in the 1990s with the maturing of the World Wide Web. The Web permitted easy inclusion of other media on a screen, including images, photographs, video, diagrams, drawings, and spoken audio. Because these media, including icons, could be combined in various ways, the term multimedia was coined to describe these combinations. A Web interface, then, has its foundation in GUI systems, but it has added its own unique elements to screen design.

Screen graphics, if used properly, can be a powerful communication and attention-getting technique. They can hold the user's attention, add interest to a screen, support computer interaction, and help overcome language barriers. Research over the years has shown that the use of graphics can facilitate learning and recall. Pictures, for example, are more easily recognized and recalled than words. It has been found, however, that memory for pictures and words together is superior to memory for words alone or pictures alone (Lidwell et al., 2003). A recent study evaluating graphics in Web site

design has found that people prefer and recall better a picture of a product paired with text (Hong et al., 2004). Improperly used graphics, however, can confuse the user, lead to navigation inefficiencies, and be distracting. Screen graphics must always serve a useful purpose.

This step will provide design guidelines for the various graphical techniques available in GUI and Web screen design. It will review

- The kinds of icons available, their characteristics, and their usability influences.
- How icons are chosen and the icon design process.
- Design guidelines for the various other graphical media including images, photographs, pictures, diagrams, drawings, audition, and animation.

Icons

Icons are pictorial images most often used to represent objects and actions with which users can interact with or that they can manipulate. Icons may stand alone on a desktop or in a window, or be grouped together in a toolbar. A secondary use of an icon is to reinforce important information, such as a warning icon in a dialog message box.

Kinds of Icons

The use of icons to reflect objects, ideas, and actions is not new to mankind. We've been there before. Early humans (100,000 years or so ago) used pictographs and then ideographs to communicate. Some of these early communications can still be found today on rock walls and in caves around the world. Until recent times, this was also the only way to communicate in some cultures (Native Americans and Australian aborigines, for example).

Word writing is traced back to Chinese writing from about 6000 B.C. and Egyptian hieroglyphics from about 3000 B.C. This was followed by cuneiform (Babylonia and Assyria) from about 1900 B.C., and the contemporary Chinese vocabulary (numbering about 50,000) around 1500 B.C. In 1000 B.C. the Phoenicians developed a 22-sign alphabet that the Greeks adopted about 800 to 600 B.C. The Greeks passed this alphabet on to the Romans about 400 B.C., who then developed a 23-character alphabet. This alphabet has been modified and embellished but has remained essentially the same for the last 2000 years.

Pictorial representations, then, have played a prominent role in mankind's history. Word writing, however, unleashed much more flexibility and richness in communication. This has caused some skeptics to wonder why, after taking 2500 years to get rid of iconic shapes, we have now revived them on screens.

Whatever the past, today objects or actions *are* depicted on screens by icons. The term *icon*, however, is not very specific and can actually represent very different things. An attempt has been made by some to define the actual types of icons that do exist. Marcus (1984) suggests icons fall into these categories:

- **Icon**. Something that looks like what it means.
- **Index**. A sign that was caused by the thing to which it refers.
- **Symbo**l. A sign that may be completely arbitrary in appearance.

He states that what are commonly referred to as icons may really be indexes or symbols. A true icon is something that looks like what it means. It is representational and easy to understand. A picture of a telephone or a clock on a screen is a true icon. An index is a sign caused by the thing to which it refers. An open door with a broken window indicates the possible presence of a burglar. The meaning of an index may or may not be clear, depending upon one's past experiences. A symbol is a sign that may be completely arbitrary in appearance and whose meaning must be learned. The menu and sizing icons on screens are examples of symbols. From this perspective, strictly speaking, so-called icons on screens are probably a mixture of true icons, signs, and indexes.

Rogers (1989) provided an expanded definition for icon kinds.

- **Resemblance** — An image that looks like what it means.
- **Symbolic** — An abstract image representing something.
- **Exemplar** — An image illustrating an example or characteristic of something.
- **Arbitrary** — An image completely arbitrary in appearance whose meaning must be learned.
- **Analogy** — An image physically or semantically associated with something.

She suggests that an icon is used in a number of different ways: for *objects* such as a document, *object attributes* such as a color or fill pattern, *actions* such as to paste, *system states* such as ready or busy, and *message types* like critical or warning.

The different ways icons are used may then be represented by different design schemes. A *resemblance* icon is an image that looks like what it means — a book, for example, to represent a dictionary. This is equivalent to Marcus's icon. A *symbolic* icon is an abstract image that represents something. A cracked glass, for example, can represent something fragile. Marcus's symbol would be similar. An *exemplar* icon represents an example or characteristic of something. A sign at a freeway exit picturing a knife and fork has come to indicate a restaurant. An *arbitrary* icon is not directly related in any way and must be learned. Marcus's symbol would be an equivalent. Finally, an *analogy* icon is an image physically or semantically associated with something — a wheelbarrow full of bricks for the move command, for example. Marcus's symbol would also be similar.

In a study looking at various kinds of icons, Rogers found that those depicting both an action and an object were quite effective. For example, a drawing of a page and an arrow pointing up means "go to the top of the page." She also found that arbitrary icons were only meaningful in very small sets, and that icons based on analogies were relatively ineffective.

Characteristics of Icons

An icon possesses the technical qualities of syntactics, semantics, and pragmatics (Marcus, 1984). *Syntactics* refers to an icon's physical structure. Is it square, round, red, green, big, small? Are the similarities and differences obvious? Similar shapes and colors can be used to classify a group of related icons, communicating a common relationship. Semantics is the icon's meaning. To what does it refer, a file, a wastebasket, or some other object? Is this clear? *Pragmatics* is how the icons are physically produced and depicted. Is the screen resolution sufficient to illustrate the icon clearly? Syntactics, semantics, and pragmatics determine an icon's effectiveness and usability.

Influences on Icon Usability

Simply providing an icon on a screen does the user no particular favor, unless it is carefully designed to present a natural and meaningful association between the icon itself and what it stands for. Unfortunately, a sampling of many current systems finds icons that do not achieve this objective. Icons are included because "this is the thing to do" in a graphical system today. Little concern is given to effectiveness. The result is too often a cluttered and confusing screen that is visually overwhelming. So, proper icon design is important from an acceptance, learning, and productivity perspective. The following factors influence an icon's usability:

- Provide icons that are
  - Familiar.
  - Clear and Legible.
  - Simple.
  - Consistent.
  - Direct.
  - Efficient.
  - Discriminable.
- Also consider the
  - Context in which the icon is used.
  - Expectancies of users.
  - Complexity of task.

Familiarity. How familiar is the object being depicted? Familiarity will reduce learning time. How familiar are the commonly seen icons in Figure 11.1? Lack of familiarity requires learning the icons' meanings. Very unfamiliar icons require a great deal of learning.

Experience often makes words and numbers more familiar to a person than symbols. Confusion matrices have been developed through extensive research for alphanumeric data (0 versus O, 1 versus I). Graphic symbols may be more visually similar to each other.

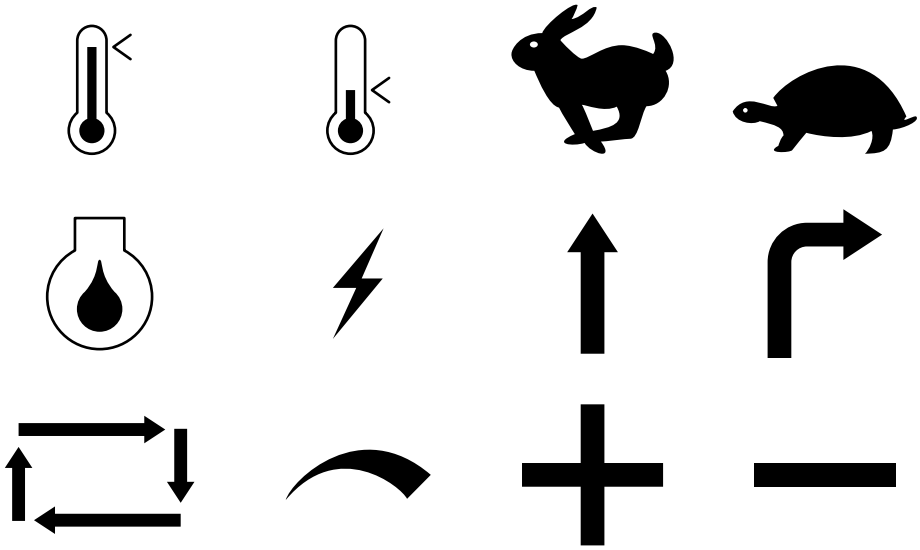

Figure 11.1: Some common icons. What do they stand for? Answers are on the next page.

Clarity. Is the icon legible? Does the shape, structure, and formation technique on the screen permit a clear and unambiguous depiction of what it is? Screen resolution should be sufficiently fine to establish clear differences of form at the normal working distance. The resolution and pixel shapes for screens differ from one another. Icons must appear correctly and consistently no matter what kind of screen is used. If color is used, it should contrast well with the background. Poor clarity will lead to identification errors and slower performance.

Simplicity. Is the icon simple? Is the shape clean and devoid of unnecessary embellishments? Too many parts will only confuse the screen viewer.

Consistency. Are families of icons consistent in structure and shape? Are the same icons displayed on different screens consistent in shape and structure? Are the same icons displayed in different sizes also consistent in structure and shape?

Directness. How "sign-like" is the icon; how well does it convey its intended meaning? For concrete objects and actions, direct links are more easily established. Adjectives, adverbs, conjunctions, and prepositions can cause problems, however. Also, how does one easily convey concepts such as bigger, smaller, wider, or narrower?

Efficiency. In some situations, a graphics screen may be less efficient, consuming more screen display space than a word or requiring more physical actions by the user than text. A telephone directory of 50 names and numbers listed on an alphanumeric screen may consume the same screen space required for, and manipulation of, 15 file cards. Raising an arm or moving a mouse may be slower than simply typing. In other situations, icons can be more effective than words in communicating concepts in a smaller area of space. Icons' strength lies in situations where this occurs.

The icons depicted in Figure 11.1 have the following meanings:

Hot	Cold	Fast	Slow
Engine Oil	**Ammeter/Generator**	**Straight**	**Turn**
Automatic	**Variable Regulation (Increase/Decrease)**	**Plus/Positive**	**Minus/Negative**

From Micro Switch (1984).

Discriminability. The symbols chosen must be visually distinguishable from other symbols. A person's powers of differentiation for shapes and other forms of codes have been experimentally determined over the years. The maximum number of codes that can be effectively differentiated by a human being, including geometric shapes, is summarized in Table 11.1. A person's ability to discriminate alphabetic or alphanumeric information is much more potent.

Context. The context of a symbol may change its meaning. Does the rabbit symbol illustrated in Figure 11.1, if seen on a road sign in a national park, mean "go faster"? From this contextual perspective, icons are similar to words.

Expectancies. The symbol may be comprehended, but a false conclusion may be reached about the desired action because of an incorrect expectancy. A study of international road signs found that 8 percent of all drivers never saw the "do not do" slash through a symbol on a road sign. Their expectancy was that they could do it, not "not do it."

Complexity of task. The more abstract or complex the symbol, the more difficult it is to extract or interpret its intended meaning. It has been found that more concrete graphic messages are easier to comprehend than the more abstract. Icons, therefore, cannot completely replace words in more complex situations.

Table 11.1: Maximum Number of Codes for Effective Human Differentiation

ENCODING METHOD	RECOMMENDED MAXIMUM	COMMENTS
Alphanumerics	Unlimited	Highly versatile. Meaning usually self-evident. Location time may be longer than for graphic coding.
Geometric Shapes	10–20	High mnemonic value. Very effective if shape relates to object or operation being represented.
Size	3–5	Fair. Considerable space required. Location time longer than for colors and shapes

Table 11.1 *(continued)*

ENCODING METHOD	RECOMMENDED MAXIMUM	COMMENTS
Line Length	3–4	Will clutter the display if many are used.
Line Width	2–3	Good.
Line Style	5–9	Good.
Line Angle	8–11	Good in special cases (such as wind direction).
Solid and Broken Lines	3–4	Good.
Number of Dots or Marks	5	Minimize number for quick assimilation.
Brightness	2–3	Creates problems on screens with poor contrast.
Flashing/Blinking	2–3	Confusing for general encoding but the best way to attract attention. Interacts poorly with other codes. Annoying if overused. Limit to small fields.
Underlining	No data	Useful but can reduce text legibility.
Reverse Polarity	No data	Effective for making data stand out. Flicker easily perceived in large areas, however.
Orientation (location on display surface)	4–8	-
Color	6–8	Attractive and efficient. Short location time. Excessive use confusing. Poor for the color blind.
Combinations of Codes	Unlimited	Can reinforce coding but complex combinations can be confusing.

Data derived from Martin (1973); Barmack and Sinaiko (1966); Mallory et al. (1980); Damodaran et al. (1980); and Maguire (1985).

Choosing Icons

Icon design is an important process. Meaningful and recognizable icons will speed learning and recall and yield a much more effective system. Poor design will lead to errors, delays, and confusion. While the art of icon design is still evolving, it is agreed that the usability of a system is aided by adhering to the following icon design guidelines.

A Successful Icon

- Looks different from all other icons.
- Is obvious what it does or represents.
- Is recognizable when no larger than 16 pixels square.
- Looks as good in black and white as in color.

Fowler and Stanwick (1995) provide these general guidelines. An icon must look different from all other product icons, making it discriminable and differentiable. What it does or represents must also be obvious so it is interpretable. It must be recognizable when no larger than 16 pixels square. Finally, it must look as good in black and white as in color. Color is always an enhancing quality of an icon.

Size

- Supply in all standard sizes.
  - — 16 × 16 pixels
    - 16- and 256-color versions.
  - — 32 × 32 pixels
    - 16- and 256-color versions.
    - Effective: 24 × 24 or 26 × 26 in 32 × 32 icon.
  - — 48 × 48 pixels
    - 16- and 256-color versions.
- Use colors from the system palette.
- Use an odd number of pixels along each side.
  - — Provides center pixel around which to focus design.
- Minimum sizes for easy selection:
  - — With stylus or pen: 15 pixels square.
  - — With mouse: 20 pixels square.
  - — With finger: 40 pixels square.
- Provide as large a hot zone as possible.

Size. Typically, icons come in three standard sizes: 16, 32 and 48 pixels square. For clarity, 16 × 16 should be an icon's minimum size. An effective combination for an image is a 24 × 24 or 26 × 26 in a 32-pixel square icon.

Colors. Microsoft suggests that while 256 colors may be used in sizes smaller than 48 × 48 pixels, to do so increases icon storage requirements, and they may not be displayable on all computer configurations. If 256 colors are used for icons, they suggest that the standard 16-color format should always be provided. Also, use colors from the system palette to ensure that the icons look correct in all color configurations.

Odd number of pixels. Horton (1994) recommends using an odd number of pixels along each side of the matrix. This provides a center pixel around which to focus, thus simplifying the design process.

Icon selection. For easy selection the following are minimum icon sizes: with a stylus or pen, 15 pixels square; with a mouse, 20 pixels square; with one's finger, 40 pixels square.

Hot zone. An icon's hot zone, the area within it that allows it to be selected, should be as large as possible, preferably the entire size of the icon. This allows easier selection.

Choosing Icon Images

- Use existing icons when available.
- Use images for nouns, not verbs.
- Use traditional images.
- Consider user cultural and social norms.

Existing icons. Many standard icons have already been developed for graphical systems. Use these standard icons where they are available. This will promote consistency across systems, yielding all the performance benefits that consistency provides. Where standard icons are not available, determine if any applicable icons have already been developed by industries and trade or standards organizations. The International Standards Organization (ISO), for example, has developed standard shapes for a variety of purposes. Always consult all relevant reference books before inventing new symbols or modifying existing ones.

Nouns. An object, or noun, is much easier to represent pictorially than an action or verb. Choose nouns for icons whenever possible.

Traditional images. Old-fashioned, traditional images often work better than newer ones. They have been around longer, and more people recognize them.

Cultural and social norms. Consider users' cultural and social norms. Improper design of icons can create problems internationally. Social norms vary, so great variations exist in what is recognizable and acceptable throughout the world. What one culture recognizes may have no meaning in another. What is acceptable in one country may not be in another. International considerations are discussed in Step 10.

Creating Icon Images

- Create familiar and concrete shapes.
- Create visually and conceptually distinct shapes.
  — Incorporate unique features of an object.
  — Do not display within a border.

- Clearly reflect objects represented.
- Simply reflect objects represented, avoiding excessive detail.
- Create as a set, communicating relationships to one another through common shapes.
- Provide consistency in icon type.
- Create shapes of the proper emotional tone.

Concrete and familiar shapes. Ideally, an icon's meaning should be self-evident. This is enhanced when concrete shapes are provided, those that look like what they are. A study found concrete icons are easier to recognize for infrequent users but frequent users perform equally well using both concrete and abstract icons. An icon should also be intuitive or obvious, based upon a person's preexisting knowledge. Familiar shapes are those images that are well learned. Figure 11.2 illustrates concrete and familiar icons for a file folder, book, and telephone as well as images for the same objects that are more abstract and unfamiliar. A study found that concrete, familiar icons were preferred to abstract, unfamiliar ones.

Keep in mind, however, that familiarity is in the eye of the viewer. The concrete images pictured may be familiar to us, readers of this book, but not to a tribal chief living in a remote area of the world where these objects do not exist. Similarly, items familiar to those working on the factory floor may not be at all familiar in the office or in the home, and vice versa. Mayhew (1992) also cautions that some abstract images should not be discounted because they have become familiar, in spite of their being abstract. On a road sign, for example, an angled red bar inscribed over an object means do not do what is pictured beneath (at least to most people, as described earlier). While abstract, it is a very familiar shape today. If an abstract image must be used, it should be capable of being learned quickly and easily recalled. Familiarity can only be determined through knowing one's user.

Visually and conceptually distinct shapes. It must be easy to tell icons apart so the chances of confusing them are minimized. Differentiation is aided when icons are visually different from one another. It is also aided when icons are conceptually different, that is, when they portray specific features of an object that are relatively unique within the entire set of objects to be displayed. Figure 11.3, based upon Mayhew (1992), illustrates how distinctiveness may be achieved for two similar items: a dictionary and a telephone book. Visual distinctiveness is achieved by incorporating unique features of each: for the dictionary, it is its content of letters and words; for the telephone book, numbers and the telephone bell. Visual distinctiveness is degraded when borders are placed around icons, as illustrated in Figure 11.4. Borders tend to obscure the shape of the object being displayed.

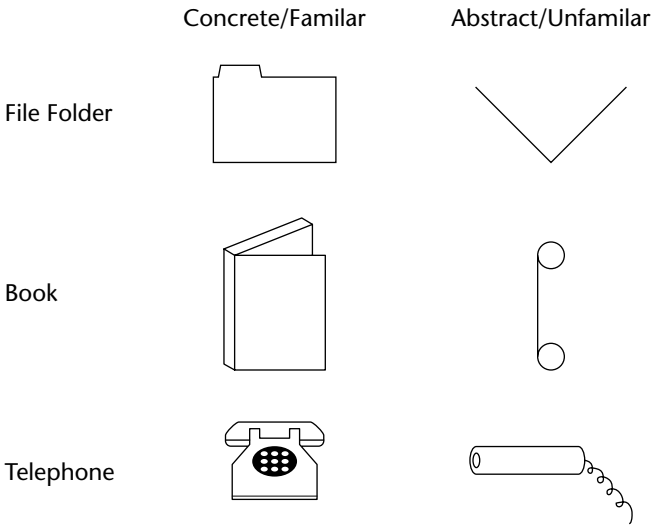

Figure 11.2: Concrete and familiar shapes.

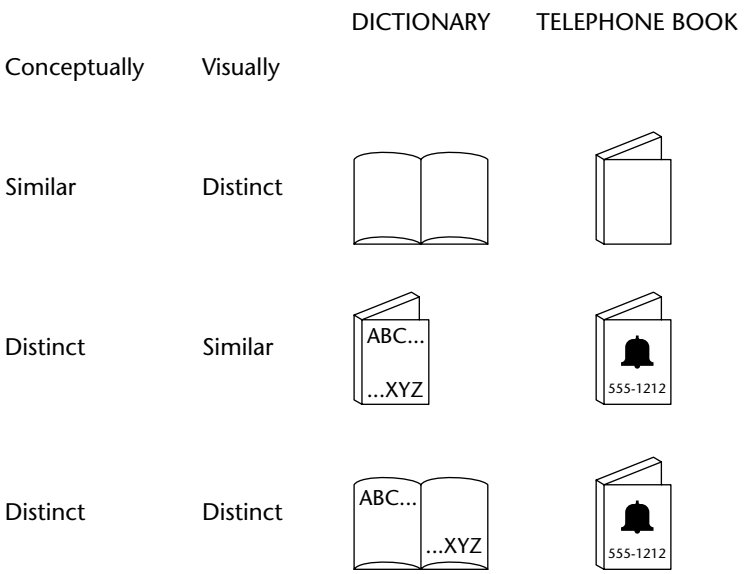

Figure 11.3: Visually and conceptually distinct shapes.

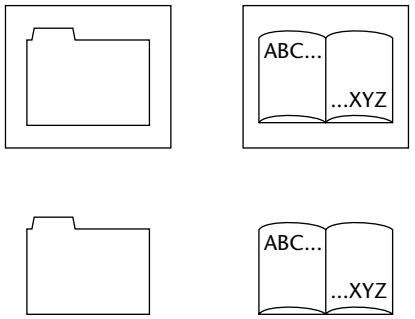

Figure 11.4: Borders degrading icon distinctiveness.

Clearly reflect objects. The characteristics of the display itself should permit drawings of adequate quality. Poorly formed or fuzzy shapes will inhibit recognition.

Simply reflect objects. Construct icons with as few graphical components as necessary, using no more than two or three, if possible. Also, use simple, clean lines, avoiding ornamentation. Byrne (1993) found that simple icons, icons containing fewer graphical elements, were located faster in a visual search task than complex icons, icons with more components. He concluded that complex icons seemed to clutter a screen with information that people were unable to employ to their advantage. Too much detail inhibits rather than facilitates perception, as illustrated in Figure 11.5. For real-world objects, use only enough detail to permit recognition and recall.

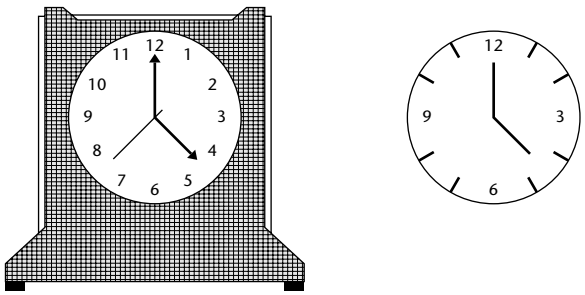

Figure 11.5: Avoid excessive detail in icon design.

Design as a set. Do not design icons in isolation, but as a family considering their relationships to each other and the user's tasks. Provide a common style. When icons are part of an overall related set, create shapes that visually communicate these relationships. Objects within a class, for example, may possess the same overall shape but vary in their other design details, as illustrated in Figure 11.6. Color may also be used to achieve this design goal. In creating sets, always avoid repeating unrelated elements.

Consistency in icon type. As previously noted, there are many different kinds of design schemes for icons (resemblance, symbolic, arbitrary, and so on). All these schemes might be used to create a meaningful family of icons for an application. Learning the meaning of icons and searching for the right icon, however, will be aided if the same design scheme is used for all icons within a family. In presenting a series of icons for actions such as paint, cut, and so on, one could, for example, (1) depict a before-after representation of the action, (2) depict the action itself being performed, or (3) picture the tool to perform the action. While a series of meaningful icons could be developed using each scheme, the best approach would be to use only one of these schemes to develop the entire family of icons.

Proper emotional tone. The icon should appropriately reflect the environment in which it is used. A sewage disposal system would be an inappropriate metaphor for an electronic mail system wastebasket.

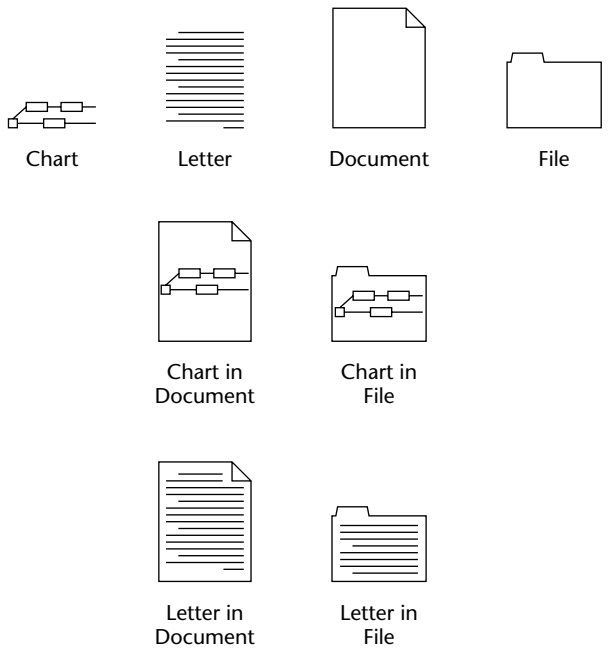

Figure 11.6: Communication relationships in icons.

Drawing Icon Images

- Provide consistency in shape over varying sizes.
- Do not use triangular arrows in design to avoid confusion with other system symbols.
- When icons are used to reflect varying attributes, express these attributes as meaningfully as possible.
- Provide proper scale and orientation.
- Use perspective and dimension whenever possible.
- Accompany icon with a label to assure intended meaning.

Consistency. When drawing images, create consistency in shapes for identical icons of differing sizing. Preserve the general shape and any distinctive detail. Consistency is achieved through limiting the variations of angles, line thicknesses, shapes, and amount of empty space.

Triangular arrows. Avoid using a triangular graphic similar to that used as a cascade symbol for menus, a drop-down button for controls, and scroll arrows. The similarity may cause confusion.

Meaningful attributes. When an icon is also used to express an attribute of an object, do this as meaningfully as possible. The status of a document, for example, might be represented by displaying it in a different shade, but would be more effectively illustrated by filling it in, as illustrated in Figure 11.7. Shading requires remembering what each specific type of shading stands for; the filled-in proportion is more intuitively obvious.

Scale and orientation. Ensure that the size and orientation are consistent with other related objects. Also ensure that they fit well on the screen.

Perspective and dimension. Use lighting and shadow to more accurately reflect the real-world experiences of people. When a light source is used, it must be located upper left, as is done with other screen elements.

Caption or label. Because icons may not be used often, the ability to comprehend, learn, and recall an icon's meaning can be greatly improved by attaching textual captions or labels to them. This is especially important for new or infrequent users. Wiedenbeck (1999), comparing textual and iconic links, found inexperienced people performed best with text-only links. Frequent users used either equally effectively but icons were not faster, relative to text links alone. The preferred label location is directly beneath the icon, not within it, because of the international considerations discussed in Step 10. Labels beneath the icon also provide a larger target, speeding selection. Labels should always be related to icons in a consistent positional way. "Mystery icons," icons with no caption or label to explain them, lead to a user guessing game and many errors. While ToolTips can be used to present labels, they are time-consuming to present, taking about two-thirds of a second to appear and be comprehended. Scanning an entire row of 15 icons with ToolTips, therefore, will consume about 10 extra seconds.

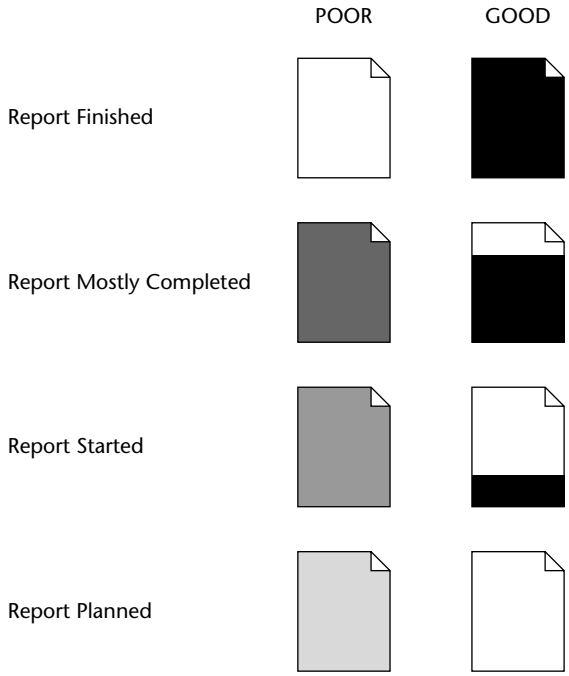

Figure 11.7: Expressing attributes in icon design.

MAXIM **If people must remember hieroglyphics, they won't stick around long.**

Icon Animation and Audition

- Animation:
  - — Use:
    - To provide feedback.
    - For visual interest.
  - — Make it interruptible or independent of user's primary interaction.
  - — Do not use it for decoration.
  - — Permit it to be turned off by the user.
  - — For fluid animation, present images at 16 or more frames per second.
- Audition:
  - — Consider auditory icons.

Animation. Recent research has explored the use of bringing to life on screens the icons representing objects and actions. An animated icon appears to move instead of maintaining a static position on the screen. Animation can take two forms, best described as static and dynamic. A *static* icon's appearance is unchanged over a period of time and changes only at the moment that a system

event occurs. An example would be the open door of a mailbox shutting when an electronic message is received. A *dynamic* icon's movement is independent of a system event, changing appearance to represent functions, processes, states, and state transitions. An example is an icon that begins movement to illustrate an action when a pointer is moved close to it.

Animation can be used to provide feedback and to create visual interest. Researchers caution, however, that there are many outstanding issues. Among them are that few animation creation rules exist, prototyping is difficult, a scheme for how they fit into a larger system is lacking, and whether they can be made useful for more complex and abstract concepts is not known. Morimoto et al. (1993) found that dynamic animation of the type in the preceding example did not increase the comprehensibility of icons. Its only advantage was its entertainment value. Faraday and Sutcliffe (1997) did find animation was useful in calling attention to an item to which users should first attend.

Some general guidelines, however, seem appropriate. First, do not prevent the user from interacting with the system while the animation is performed. Unless the animation is part of a process, it should be independent of what the user is doing. It should also be interruptible. Be conservative in its use; do not use animation simply for decoration. It can be very distracting or annoying. Finally, provide the user with the option of turning it on or off, as desired. Microsoft recommends that to achieve fluidity in movement, images should be presented at a speed of at least 16 frames per second. The reader interested in more information on animation is referred to Baecker and Small (1990).

Audition. Objects make sounds as they are touched, dragged, bumped against one another, opened, activated, and thrown away. Auditory icons are computer sounds replicating everyday sound-producing events. When a printer near one's desk begins printing, the sound of the printing mechanism is heard. This provides auditory feedback that a print operation one has just asked for has successfully started. An auditory icon would be the same sound, generated by the computer. Another example would be to convey information about an object's dimensions. If a file is large, it can sound large. If an object is dragged over a new surface, the new surface is heard. If an ongoing process starts running more quickly, it sounds quicker. Sounds can convey information about many events in computer systems, permitting people to listen to computers as we do in the everyday world. It may be well suited to providing information

- About previous and possible interactions.
- Indicating ongoing processes and modes.
- Useful for navigation.
- To support collaboration.

Auditory icons are distinct from earcons, abstract synthetic tones used in structured combinations to create sound messages. Auditory icons may also be susceptible to the distracting influences that sounds can cause to listeners, especially others. The use of sound is discussed in more detail in Step 9. The reader in need of more information on auditory icons is referred to Garver (1993).

The Icon Design Process

- Define the icon's purpose and use.
- Collect, evaluate, and sketch ideas.
- Draw in black and white.
- Draw using an icon-editing utility or drawing package.
- Test for user
  — Expectations.
  — Recognition.
  — Learning.
- Test for legibility.
- Register new icons in the system's registry.

Define purpose. To begin the design process, first define the icon's purpose and use. Have the design team brainstorm about possible ideas, considering real-world metaphors. Simple metaphors, analogies, or models with a minimal set of concepts are the best places to start in developing icons.

Collect, evaluate, and sketch ideas. Start by designing on paper, not on the computer (Fowler and Stanwick, 1995). Ask everyone to sketch his or her ideas. Do not worry about too much detail; exact pixel requirements are not necessary at this time.

Draw in black and white. Many icons will be displayed in monochrome. Color is an enhancing property; consider it as such.

Test for expectation, recognition, and learning. Choosing the objects and actions, and the icons to represent them, is not a precise process, and will not be easy. So, as in any screen design activity, adequate testing and possible refinement of developed images must be built into the design process. Icon recognition and learning should both be measured as part of the normal testing process.

Test for legibility. Verify the legibility and clarity of the icons in general. Also, verify the legibility of the icons on the screen backgrounds chosen. White or gray backgrounds may create difficulties. An icon mapped in color, then displayed on a monochrome screen, may not present itself satisfactorily. Be prepared to redraw it in black and white, if necessary.

Register new icons in the system's registry. Create and maintain a registry of all system icons. Provide a detailed and distinctive description of all new icons.

Screen Presentation

- Follow all relevant general guidelines for screen design.
- Limit the number of symbols to 12, if possible, and at most 20.

- Arrange icons
  — In a meaningful way, reflecting the organization of the real world.
  — To facilitate visual scanning.
  — Consistently.
- Place object and action icons in different groups.
- Present an interactive icon as a raised screen element.
- Ensure that a selected icon is differentiable from unselected icons.
- Permit arrangement of icons by the user.
- Permit the user to choose between iconic and text display of objects and actions.

In designing, or establishing, screen layout rules, adhere to the following presentation rules.

General guidelines. Follow all relevant general guidelines for screen design. Icons are but one part of a larger picture.

Number of icons. A person's ability to identify shapes is limited (see Figure 11.1). A literature review suggests using no more than eight to twelve or so functions that require icons at one time. At most, present no more than 20. If labels are attached to icons, however, the meaning of the icon is greatly clarified. Too many icons on a screen, though, will greatly increase screen clutter and create confusion. In general, fewer are better.

Arranging icons. Organize icons in a way that reflects the *real-world* organization of the user. Place object icons and action icons within different groupings. *Visual scanning* studies, in a non-iconic world, universally find that a top-to-bottom scan of columnar-oriented information is fastest. Generalization of these findings to an icon screen may not necessarily be warranted if icons have attached labels. Columnar orientation icons (with labels below the icons) will separate the labels from one another by the icons themselves. The labels will be farther apart and fewer icons will fit in a column than in a horizontal or row orientation. A row orientation would seem to be more efficient in many cases, as adjacent icons will be in closer physical proximity. Until research evidence is established to the contrary, organizing icons either in a column or a row seems appropriate. In either case, a *consistent* straight eye movement must be maintained through the icons.

Object and action icons. Conceptually similar items should always be arrayed together. Locating them will be easier.

Interactive icons. To provide a visual indication that an icon is interactive or clickable, present it in a three-dimensional state raised from the screen background.

Selected icon. Ensure a selected icon is visually differentiable from unselected icons. One common method to achieve this is to present the selected icon in a three-dimensional pressed state.

User arrangement. Allow the user to arrange the icons in a manner that is meaningful for the task. A default arrangement should be provided, however.

Iconic or text display. In some situations, and for some users, pure text labels may be more meaningful than icons. The option to display text only should always be provided.

Multimedia

The graphical flexibility of the Web permits inclusion of other media on a screen, including images, photographs, video, diagrams, drawings, and spoken audio. The availability of these additional interface elements has, however, been a double-edged sword. On the one hand, the various media can be powerful communication and attention-getting techniques. Multimedia can hold the user's attention, add interest to a screen, entertain, and quickly convey information that is more difficult to present textually. It can also make the Web much more accessible to people with disabilities. On the other hand, effective use of multimedia in design has been hindered by a lack of knowledge concerning how the various media may best be used, and a scarcity of applied design guidelines. (GUI guidelines relevant to Web page design have been available for years, but their existence was either unknown or ignored.) Effective multimedia use has also been hindered by the "let's use it because we have it" attitude exhibited by many designers. (To be fair, early GUI design has suffered from the same problem.) The resulting usability problems, user confusion and frustration, poor screen legibility, and slow downloads, and so on have created situations where the user was too often denied an efficient and meaningful Web experience.

As a result, recent studies (Spool et al., 1997, for example) have found that the most difficult-to-use Web sites were those that were graphically intense, and the top Web sites were characterized by little, if any, multimedia. Studies have also found that for users, text is currently a much more important Web site component than graphics (at least at this stage in Web evolution). Today, consequently, good interface design employs multimedia in a conservative and appropriate manner. The objective is good interaction design, not "sparkle." In the future, experts say, multimedia elements will be much better integrated with browsers, alleviating many of today's usability problems.

Graphics

- Use graphics to
  - — Supplement the textual content, not as a substitute for it.
  - — Convey information that can't be effectively accomplished using text.
  - — Enhance navigation through
    - Presenting a site overview.
    - Identifying site pages.
    - Identifying content areas.
- Limit the use of graphics that take a long time to load.
- Coordinate the graphics with all other page elements.
- Graphics should not look like gratuitous decorations or banner ads.

Graphics contained in Web pages serve several distinct purposes, which can be classified as follows:

- **Navigational.** To identify links that may be followed.
- **Representational.** To illustrate items mentioned in the text.
- **Organizational.** To depict relationships among items mentioned in text.
- **Explanative.** To show how things or processes work.
- **Decorative.** To provide visual appeal and emphasis.

Graphics must always be used for a specific purpose. This purpose must be determined before designing or choosing the graphic itself. Graphics should only be used when they add to a Web site's message. Graphics that do not relate to a Web site's purpose, and do not strengthen the Web site's message, should never be used.

Supplement textual content. Use graphics to supplement text, not as a substitute for it. Graphics are not easily accessible to search facilities and screen reviewers, and are slower to download than text. As studies have shown, people prefer textual page content to graphical content. So, never use graphics when text will do the job. If a graphic will help people understand the text they are reading, then certainly use it.

Convey information not possible using text. Use graphics to convey information that can't be effectively conveyed using text. In some cases the old adage "a picture is worth a thousand words" is indeed true. Photographs, for example, can be used to communicate the exact appearance of objects. Video is useful for showing objects or things that move. Diagrams can be used to present an object's structure. Drawings are useful when selected parts of an object need to be emphasized or represented. If a graphic does a better job of communicating an idea or concept than text, then use it. (Remember, however, text descriptions or transcripts of the graphic will always be necessary for accessibility reasons.)

Enhance navigation. Graphics can be used to enhance navigation. A graphical *overview* of a site's organizational scheme will enable the user to conceptualize and learn the site's structure faster than can be done through textual overviews. *Site pages* can be related through a consistent graphical theme carried from page to page. This will reinforce the browsing user's sense of place. Graphics can also be used to identify and represent major site *content areas*. The experienced user will locate and identify the content areas faster using meaningful graphical identifiers rather than text.

Limit long-loading graphics. Limit the use of graphics that take a long time to load In general, all graphics must be smaller on the Web than on the printed page. Large graphics take longer to download testing the user's patience. If a large graphic is needed, present a small version and link it to a page containing the large version. Richly colored graphics and pages containing numerous graphics are also slower to load.

Coordinate graphics. Graphics are only one component of a Web page. The graphics must fit in with the style of typography used, the colors used, and the page layout itself. Plain and simple fonts are best coordinated with simple graphics.

Realistic graphics work best with elements like three-dimensional effects and more complex typography.

Gratuitous decorations or banner ads. Important and functional graphics should not look like decoration or an ad. A study found that an informational graphic to access live help was not selected because it looked too much like a decoration or advertisement (Koyani et al., 2004).

Images

- Ensure all images convey their intended messages.
- General:
  - — Use standard images.
  - — Emulate real-world objects.
  - — Use images consistently.
  - — Produce legible images.
  - — Provide descriptive text or labels with all images.
  - — Distinguish navigational images from decorative images.
  - — Minimize
    - The number of presented images.
    - The size of presented images.
      - Restrict single images to 5KB.
      - Restrict page images to 20KB.
      - Provide thumbnail size images.
    - Image animation.
  - — Avoid extraneous or gratuitous images.
- Color:
  - — Minimize the number of colors in an image.
- Format:
  - — Produce images in the most appropriate format.
    - GIF.
    - JPEG.
- Internationalization:
  - — Provide for image internationalization.
- Design:
  - — Limit large images above the page fold.
  - — Use simple background images.
  - — Reuse images on multiple pages.

Convey intended messages. Users and designers frequently differ when asked to select the best image to reflect an intended message. Users tend to select the most familiar images while designers favor more artistic images (Koyani et al., 2004).

Standard images. Whenever possible, use standard images that have already been developed and tested. This will promote consistency across systems, yielding all

the performance benefits that consistency provides. These standard images may be found in guideline books, company or organizational documentation, or in industry, trade, or standards organizations' documentation. The International Standards Organization (ISO), for example, has developed standard image shapes for a variety of purposes. Always consult all relevant reference books before inventing new images or modifying existing ones.

Real-world objects. The meaning and use of images that look like real-world objects will be easily understood. Buttons, for example, that look like the buttons commonly found on common electronic devices or machines will be more readily identified as navigation elements.

Consistency. Use an image consistently throughout an application or Web site. Multiple images with the same meaning will be difficult to learn.

Legibility. Create legible images that are easy to identify from a variety of viewing distances and angles. Legibility is affected by many factors, including contrast with the background, image complexity, and image size. Images with a minimum amount of detail are usually easier to comprehend and faster to load. If an image with more detail is needed, provide a link to a page containing the detailed version. An image that is perfectly legible when it is drawn or rendered large may, when shrunk for placing on a page, become incomprehensible.

Descriptive text or labels. Many images are not immediately clear, even if well designed. The ability to comprehend, learn, and recall an image's meaning, especially if it is used for navigation, can be greatly improved by providing images with descriptive text or labels. Also, many people browse the Web with their graphics turned off. Without alternate text, an image's purpose and function will not be known. Alternate text for an image also provides the following benefits:

- It provides vision-impaired users with access to content through a screen-review utility.
- It helps sighted users determine whether they want to wait for the image to fully load.
- It enables users to read a description of a linked image and activate the link before the image fully loads.

Navigational and decorative images. Clearly indicate which graphical images on the screen are used for navigation by providing a visual indication that an image is interactive or clickable. Possibilities include giving the image a raised or three-dimensional appearance (like a navigational icon) or underlining any descriptive text contained within or near it (like a textual link). Also, alternate text should accompany every interactive image. Navigational images that cannot be distinguished from decorative images force users to mouse over each image to determine which are interactive (once they are over their initial state of confusion). This is time-consuming, and important navigation links may be missed.

Also clearly indicate if the entire image is clickable, or that the clickable sections are obvious. Again, mouse-over should not have to be performed to locate clickable areas on an image.

Minimize number of images. The more images presented on a Web page, the slower the download time. Use text whenever possible. Only present images

when they add value and increase the clarity of the Web site's information. To wait several seconds for an image to load, only to find it adds no value to the information presented can be frustrating for users. Some decorative graphics may be used as long as they are not visually distracting, focusing the user's attention away from the site's important information.

Minimize size of images. Oversized images also take a long time to load. Slow-loading graphics rarely add value to text, and people often don't bother to stick around for them. The design goal is to produce images that load quickly. Make the graphic as small as possible while still retaining sufficient image quality. In general, restrict *single images* to 5KB, *page images* to no more than 20KB. A 200KB file can take several minutes to load. Never put borders around an image with a drawing program because this also adds to the file size.

Thumbnail size. A thumbnail is a small version of an image, usually fairly low in quality. This small image will load quickly because of its small file size. Link this thumbnail image to a large high-quality version of the image. Users can then decide whether or not they want to retrieve and view the full-size version. Always let the user know the size of the full-size image. Thumbnails are especially useful when several images, or a collection of images, must be displayed on a Web page.

Minimize animation. Animated images take a long time to load and are distracting to many people. Only use animation when it serves a useful purpose.

Extraneous or gratuitous images. Similarly, do not present extraneous or gratuitous images. Images take longer to load than text, and Web users prefer text. Images must always serve a useful purpose.

Minimize the number of colors. To reduce the size of image files, reduce the size of the color palette and the number of colors in the image. Color-rich images tend to be large. If the image color palette is too small, however, the image will be degraded. The objective is to retain sufficient image quality while making the file as small as possible. To create images of sufficient color quality while at the same time reducing file size, begin with a high-quality image and create versions using successively smaller color palettes. Stop when the image degradation becomes apparent. (Guidelines for the use of color in screen design are discussed in Step 12 .)

Appropriate format. Produce images in the most appropriate format, GIF or JPEG. CompuServe developed the GIF format (Graphics Interchange Format) in 1987. The JPEG (Joint Photographic Experts Group) was developed for the transfer of photographic images over the Internet.

GIF. Most Web color images and backgrounds are GIF files. They are usually smaller and load faster than JPEGs. They are particularly useful for images that contain flat areas of color. Because GIFs are limited to 256 colors, they are ideal for graphics that use only a few colors. GIFs exist in either a *dithered* or *nondithered* format. Dithering is the color-mixing process a computer goes through when it encounters a color not in its palette. In this process, palette colors are mixed to approximate the appearance of the desired color. The resulting color may be grainy or unacceptable. The dithering will be most apparent in gradations, shadows, and feathered edges. A nondithered GIF attempts to match the closest colors

from the palette to the image. This is referred to as *banding*. This banding may also create an unacceptable image.

One way to control the dithering process is to create images that only use non-dithering colors. The 216 colors that are shared by PCs and Macintoshes are called the Web palette or browser-safe colors. These colors display properly across all platforms without dithering.

GIFs may also be *interlaced*. Interlacing is the gradual display of an image in a series of passes on the screen. The first pass displays a low-resolution out-of-focus image and each succeeding pass creates a clearer view until finally a complete image is displayed. With interlacing, users see a complete, although not clear, image much more quickly. An impression that the image is loading much faster is achieved, and users can quickly determine if they are interested in the image. With a *noninterlaced* GIF, the graphic unfolds more slowly one row at a time. Use interlaced GIFs to give users a preview of graphics while they unfold.

Most Web servers call up to four GIFs at a time for display. Limiting GIF images on a page to four will allow pages to load much faster.

JPEG. JPEG formats are superior for images such as photographs that contain numerous changes in color tonality. They look best on monitors capable of displaying 16 million colors. A JEPG's range of colors cannot be produced in monitors displaying 256 or fewer colors. Images that contain flat areas of color may also find that JEPGs introduce unwanted artifacts. JPEGs usually take longer to download than GIFs.

JPEGs may be displayed as progressive or standard. Progressive images gradually fade into view like interlaced GIFs, each pass an increasingly higher quality scan. *Standard* images are drawn from top to bottom like noninterlaced GIFs. Use progressive JPEGs to give users a preview of the graphics while they are unloaded.

Internationalization. When designing for international or multilingual users, using images may eliminate the need for translating words. All images, however, must comply with the internationalization design guidelines covered in Step 10.

Limit above the page fold. Do not fill an entire screen with an image when a page is first presented. A study found that when presented only with a large image, some users did not scroll down to look for more content, or even suspect that more non-visible content existed (Koyani et al., 2004).

Background Images. Use background images sparingly. In addition to slowing down download times, background images can make text much harder to read. If background images are used, provide simple, small, images with tiling, and/or keep the image resolution low.

Reuse images. Repeat the same images on multiple pages. Repeated images will be stored in a *cache*, the browser's temporary storage area. Loading an image from cache significantly reduces an image's downloading time.

Image Maps

- Use:
  — To provide navigation links to other content.
- Advantages:
  — Can be arrayed in a meaningful and obvious structure.
  — Faster to load than separate images.
- Disadvantages:
  — Consume a significant amount of screen space.
  — Hot spots not always obvious.
  — One's location within image map is not always obvious.
- Guidelines:
  — Use with caution.
  — Provide effective visual cues and emphasis to make it easy to identify link boundaries.
  — Ensure image maps are accessible to the vision-impaired.

Use. An *image map* is a complete image containing individual segments with navigation links to other content. Its primary use is to present a meaningfully structured image within which the links are contained.

Advantages/disadvantages. An *advantage* of an image map is its meaningful and obvious structure. It can reflect the user's mental model of an object, minimizing organizational learning requirements. An image map may be a map of a country, for example, with areas reflecting regions that can be selected as links to more detailed content. An image map can also be an image reflecting a site's organization. Image maps, because of their graphical nature, can aid conceptualization of a Web site and how it is organized. Another image map advantage is that they are faster to load than individual images, at least for users accessing the Web through a modem.

There are several *disadvantages* of image maps. First, they are quite wasteful of screen space. Providing large enough hot spots or clickable areas for each element often necessitates creating very large maps. Within the maps, clickable regions are also not always obvious because they cannot be seen. Whether to click on the map, or where to click, is not always known. This can be confusing for the new user. Unclear or poorly designed image maps can cost users a great deal of time when they make erroneous navigation selections. Selected image map links are also not obvious to the user. A link just selected may be again selected, directing the user right back to the page displayed with no indication that anything has changed. User confusion can again exist. Another disadvantage is that search facilities may not be able to index an image map.

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Guidelines. Because of these disadvantages, be cautious in the use of image maps. Some experts recommend not using them at all. If used, provide effective visual cues and emphasis to make it easy to identify individual selectable segments and where link boundaries exist. Consider supplementing the image map graphic with text to inform users what they will see when they select a particular area. Finally, ensure that image maps are accessible to vision-impaired users.

Photographs/Pictures

- Use:
  — When every aspect of the image is relevant.
- Guidelines:
  — Use JPEG format.
  — On the initial page, display a small version.
    - Display a thumbnail size image.
    - Zoom in on most relevant detail.
    - Link to larger photos showing as much detail as needed.
  — Include fewer people and objects in less complicated settings than in photos for print.
  — Emphasize close-up shots with clean backgrounds.

Use. When every aspect of an image or object is relevant, present a picture or photograph of it. A photo or picture will capture all visible aspects, providing information that is difficult to describe with words.

Will photographs of people increase trust in a Web site? The research was reviewed by Bailey (2003b) and Straub (2003d). Studies by Fogg et al. (2001), Steinbruck et al. (2002), and Zheng et al. (2002) reported that exposure to photographs prior to an interaction did seem to increase trusting behavior. Riegelsberger and Sasse (2002), however, found mixed results ranging from enthusiasm to suspicion. Riegelsberger et al. (2003) reported that photographs do not increase the trustworthiness of already credible sites. They do, however, improve the credibility of sites that are not generally perceived as trustworthy. The conclusion — use photographs of people with care and perform all the necessary usability testing to make a final decision.

If photographs are used, Straub suggests the following regarding people photographs:

- Pictures of people make virtual transactions more familiar and, as such, sites seem more trustworthy, but
  — If a Web site is already credible, photographs will not enhance its trustworthiness.
  — Photographs do not enhance the trustworthiness of sites for users who are not confident about the trustworthiness of the Web in general.
- Photographs without functional value can undermine overall perception of sites for very experienced users by interfering with task completion.

Guidelines. The *JPEG* format was developed for presenting photographs that contain numerous changes in color tonality. Pictures or photos look best on monitors capable of displaying 16 million colors.

A large photo will have an excessively long downloading time. To minimize this time, on the initial page display a small version of the photo and provide a link to a larger, high-quality, complete photo on another page. The small version may be a *thumbnail* image, a complete miniature photograph, usually fairly low in quality. Because of the complexity of a photographic image, a thumbnail may not always be legible. When legibility is a problem, instead of resizing the image to a miniature photo, provide a zoom-in on the most relevant photo detail, cropping and resizing as necessary to provide a meaningful and legible image.

For linked, full-size photographs, provide as much detail as the users need and always inform the users of the image's size. Also, if necessary, provide a zoom or rotation capability for the photograph on the linked page.

Photographs often suffer from background clutter. Therefore, include fewer people and objects in less complicated settings than in photos for print, and emphasize close-up shots with clean backgrounds.

Video

- Uses:
  - — To show things that move or change over time.
  - — To show the proper way to perform a task.
- To show events that cannot be seen directly.
- To convey human behavior and emotions.
  - — To provide a personal message.
  - — To grab attention.
- Disadvantages:
  - — Expensive to produce.
  - — Slow to download.
  - — Small and difficult to discern detail.
- Guidelines:
  - — Never automatically download a video into a page.
  - — Create short segments.
  - — Provide controls, including those for playing, pausing, and stopping.
  - — Consider using
    - Existing video.
    - Audio only.
    - A slide show with audio.

Uses. Video is especially suited to showing things that move or change over time. Examples include product demonstrations, how to repair a piece of equipment, how to perform a dance step, or how to perform a task. Other uses include showing events that cannot easily be seen directly, such as something on the other side

of the world or an historical event. Or it can be used to convey human behavior and emotions — an irate customer interacting with a company employee, for example. Videos can also be used to present personal messages, although the speaker's "presence" may not always have the desired emotional effect. Because of their animation, videos can also be used to grab attention.

Video, however, because of its high attention-capturing capability, should only be used to help convey, or be supportive of, a Web site's message or content. It is important to have clear and useful reasons for its use. Otherwise, it will be an unnecessary distraction.

Disadvantages. Videos are expensive to produce and slow to download and play. They are also small and limited in the detail they can present. Always inform the user of a video's size so a choice of whether or not to download it can be made. Depending on a video's purpose, its animation may also be distracting to the user.

Guidelines. Do not *automatically download* a video into a loading Web page. Create *short segments*. There are many distractions people may encounter while using a video (the telephone or interruptions by people, and so on), so long segments should be avoided. A 60- to 90-second video is considered long, so keep a video's length well within these limits. For all playable files provide the following controls: Play, Pause/Resume, Stop, Rewind, Fast Forward, and Volume.

Because of a video's disadvantages, consider using existing videos, audio alone, or a slide show with audio. Reusing an *existing video* will save production time and money. A new voice-over may be all that is necessary. *Audio alone* may be as powerful a tool as a video, because the human voice is an important aspect of all videos. Determine whether audio alone will accomplish the video's objectives. An *audio slide show* may also be a good substitute for a video. The impression of movement is still achieved as the slides change, but they are quicker and easier to create and download.

Diagrams

- Uses:
  - — To show the structure of objects.
  - — To show the relationship of objects.
  - — To show the flow of a process or task.
  - — To reveal a temporal or spatial order.
- Kinds:
  - — Flow charts.
  - — Cause and effect charts.
  - — Gantt charts.
  - — Entity relationship diagrams.
  - — Organization charts.
  - — Network diagrams.

- Parts:
  — Shapes.
  — Lines.
  — Labels.
- Guidelines:
  — Provide simple diagrams.
  — Provide cutaway diagrams or exploded views to illustrate key points.

This discussion is partially based upon Fowler and Stanwick (2004).

Uses. Diagrams are useful for illustrating the structure of an object, its key parts and how they are related to each other. Diagrams are also useful for illustrating the relationships of objects, the structure of an organization, or the structure of a Web site. Other uses are to illustrate the flow of a process or task, a software program, or an airline passenger check-in sequence, for example. (Guidelines for displaying flow charts are discussed in Step 3.) Diagrams can also be used to reveal temporal or spatial order, including activities such as the sequence in which an object's parts should be assembled.

Kinds. Kinds of diagrams include flow charts, cause and effect charts, Gantt charts, entity relationship diagrams, organization charts, network diagrams, and so forth.

Parts. All diagrams have three elements or components: shapes, lines, and labels. *Shapes* are the entities connected by a diagram's lines. Shapes represent two levels of information. The kind and structure of the shape will have meaning to the viewer, and the shape's label will indicate what particular information this component contains.

A diagram's *lines* (also called *edges*) show the relationships between the shapes and may also contain multiple levels of information. (1) A line connecting two shapes indicates that the shapes are related. (2) The weight or style of the line may indicate a particular type of relationship. (3) Arrows or other symbols at the end of a line may indicate directionality. (4) Labels may describe the purpose of a specific line. Lines do not necessarily indicate physical distances in diagrams.

Labels are any text that states or adds to the meaning of a shape or line. Depending on the type of diagram, labels do not always have to be attached to a shape or line. They can be located in a list or tree to the left of the diagram. To reduce a diagram's clutter, labels may be hidden until the user asks for them. They may be presented in ToolTips or turned on and off through a toggle switch. Other types of information may be included in a diagram's border, if needed. Elements of a diagram are illustrated in Figure 11.8.

Guidelines. Provide simple diagrams showing only as much detail as necessary to clearly illustrate the diagram's objective. Simpler diagrams will also load faster on a Web page. To illustrate key points, provide cutaway diagrams or exploded diagram views. An extensive series of design guidelines for diagrams are provided by Fowler and Stanwick. The required diagram features are summarized in Table 11.2. For an additional listing of optional features see Fowler and Stanwick (2004).

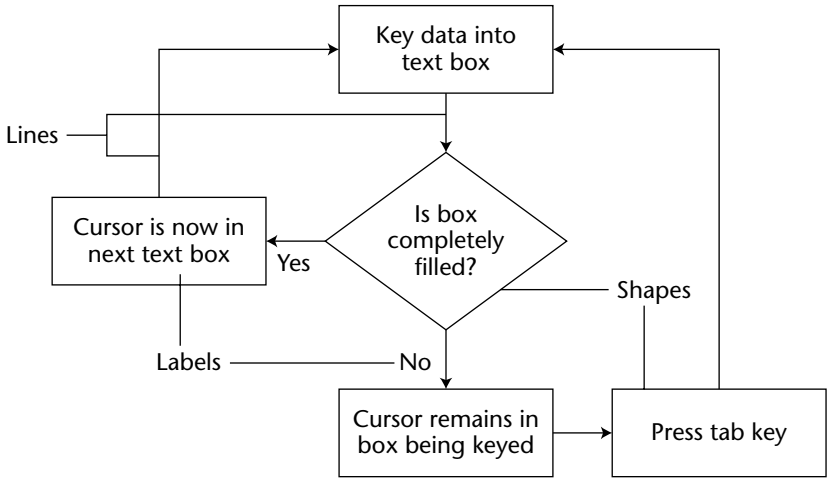

Figure 11.8: Diagram elements.

Table 11.2: Required Features of Diagrams

Diagram Creation	Let users resize shapes and lines. Let users align elements automatically and by hand. Let users arrange elements automatically and by hand. Let users arrange diagrams using an algorithm that minimizes crossing lines and makes the picture more compact. Let users select single or multiple elements using standard selection methods. Provide a grid and a method to turn it on or off. Provide a snap-to-grid option. Provide a method for changing the grids cell size. Make a table or text version of the diagram's data readily available. Make sure the typefaces, sizes, and colors are not hard-coded so accessibility options will work. Provide methods for printing.
Palette	Let users select shapes and lines from a palette. Set the selected shape or line in repeat mode so users don't have to continually reselect it. Provide a method for docking and undocking the palette. Provide a method for keeping the palette on top or visible. Provide palettes of the standard shapes for the domain.
Shapes	Let users move shapes. Let users nudge shapes into position using the arrow keys. Let users add color and texture to shapes. Provide regularly spaced anchor points onto which the lines snap (attach themselves automatically).

Table 11.2 *(continued)*

Lines	Let users add lines to the shapes at anchor points. Let users move lines independent of the shapes (creation only). Let users move the endpoints of lines from one spot on the shape to another. Offer various styles of lines as appropriate (straight, curved, and so forth).
Labels	Provide labels for shapes and lines. Ensure that labels stay visually attached to the elements they describe. If labels can be turned off, show the label automatically when the user holds the pointer over the element (like a ToolTip). Make sure that labels do not overlap.

Adapted from Fowler and Stanwick (2004).

Drawings

- Use:
  — When selective parts need to be emphasized or represented.
- Guidelines:
  — Provide simple drawings showing minimal detail.
  — Provide a link to a complete drawing.

Use. Use a drawing when only certain parts of an image are of relevance, and these parts must be emphasized or clearly represented. If the working of a specific object is to be described, a diagram illustrating its relevant parts should be used.

Guidelines. Provide simple drawings showing minimal detail. They are easier to view and understand and they also load more quickly. Photographs are likely to be less effective because they contain information that is not relevant, they lack clarity, and they take longer to load on a Web page. If the user is also in need of a detailed drawing, provide a link to a page containing a complete drawing.

Animation

- Uses:
  — To explain ideas involving a change in
    - Time.
    - Position.
  — To illustrate the location or state of a process.
  — To provide feedback.
  — To show continuity in transitions.

— To enrich graphical representations.
— To aid visualization of three-dimensional structures.
— To attract attention.

- Disadvantages:
  — Very distracting.
  — Can potentially create problems for people with some disabilities.
  — Slow loading.
- Guidelines:
  — Use only when an integral and meaningful part of the content.
  — Introduce animation.
  — Create short segments.
  — Provide a freeze frame, stop, and replay mode.
  — Avoid distracting animation.

Uses. Use animation only when it serves a useful purpose. Animation has been found to be effective when presenting complex concepts (Weiss et al., 2002). Animations can be used to enhance textual explanations of objects changing over *time*. A map illustrating population growth can be animated to illustrate population densities and patterns over a sequence of years or centuries. Proper sequential body *positions* needed to skillfully perform a sport can also be illustrated as they are textually described. The acceptance and impact of animation is enhanced when (1) animation is introduced, (2) users are warned to expect it, and (3) users are allowed to start it when they want (Weiss et al., 2002).

The current *location* within, or the state of, a process can be highlighted through animating flow arrows or process steps. Dynamic feedback can be provided to confirm something is happening. When copying files in some operating systems, an animation appears showing files flying from one file to another.

Continuity in transitions can also be illustrated. The changing of states of an element with two or more states will be easier to understand if the transitions are animated instead of being instantaneous. In Windows, actually seeing an icon moving as it is dragged from a desktop to the Recycle Bin or the My Documents file strengthens one's understanding of the task and the results. *Graphical representations* can also be enriched. Some kinds of information are easier to visualize with movement rather than with still pictures. *Visualization* of three-dimensional structures can also be aided. While a two-dimensional screen can never provide a full understanding of a three-dimensional element, animating the element by slowly turning it aids in understanding its structure. Animation can also be used to *attract attention*. The user's attention can be directed to an important screen element or alerted to an important condition.

MAXIM **Content is always more important than graphics.**

Disadvantages. Any discussion of screen image animation includes a strong caution concerning animation's side effects. Screen animation is difficult to ignore, often overpowering a person's peripheral vision. As is discussed in Step 1,

peripheral vision competes with foveal vision for a person's attention. That sensed in the periphery is passed on to our information-processing system along with what is actively being viewed foveally. It is, in a sense, visual noise. Mori and Hayashi (1993) experimentally evaluated the effect of windows in both a foveal and peripheral relationship and found that performance on a foveal window deteriorates when there are peripheral windows, and the performance degradation is even *greater* if the information in the peripheral is dynamic or moving. Reeves and Nass (1996) measured brain waves with an EEG and found that attention increased every time motion appeared on a screen. Permanently moving animation on a screen makes it very hard for people to concentrate on reading text, if the brain wants to attend to the motion. Animation can also be very annoying. Banner animation has been found to significantly increase perceived workload and frustration of users (Burke and Hornoff, 2001).

Animation can also potentially create problems for people with some disabilities. Flickering images can trigger some forms of epilepsy, and moving images can be distracting for people with attention deficits. Rapid image changes can make it harder for visually-impaired people with some sight to focus on the images.

Another current negative side effect of Web page animation is its close association with advertising. Animation, including scrolling text, is frequently being used by advertisers to try and gather the users' attention. Studies suggest that people have started equating animation with advertising, so animation as a screen element is being routinely ignored. Important animation may, therefore, be missed. Animated images also take longer to load.

Guidelines. Use animation sparingly. Only use it when it is an *integral part* of the textual content, or reinforces the content. Create short segments. There are many distractions people may encounter while watching animation, so long segments should be avoided. Animation, when used, should be capable of being *stopped* by the user so an image may be studied in detail. It should also be capable of being replayed, and ended entirely so it is eliminated as a visual distraction. In conclusion, always avoid animation or special effects that detract from the screen's message.

Audition

- Uses:
  - — As a supplement to text and graphics.
  - — To establish atmosphere.
  - — To create a sense of place.
  - — To teach.
  - — To sample.
  - — For users
    - With disabilities.
    - In an eyes-busy and hands-busy situation.
    - Who do not have access to keyboard and/or monitor.

- Advantages:
  - — Does not obscure information on the screen.
  - — Shorter downloading time than video.
- Disadvantages:
  - — Is annoying to many people, including users and nonusers in the vicinity.
  - — Can easily be overused, increasing the possibility that it will be ignored.
  - — Is not reliable because
    - Some people are hard of hearing.
    - If it is not heard, it may leave no permanent record of having occurred.
    - The user can turn it off.
    - Audio capability may not exist for the user.
- Guidelines:
  - — When words are spoken
    - The content should be simple.
    - The speed of narration should be about 160 words per minute.
  - — When used to introduce new ideas or concepts, the narration should be slowed.
  - — Off-screen narration should be used rather than on-screen narration.
    - Unless the narrator is a recognized authority on the topic.
  - — Create short segments.
  - — Provide segments of high quality.
  - — Provide audio controls.
  - — Play background audio softly.

This discussion of audition focuses on sound as a communication medium for presenting meaningful information, words, music, and so on. A discussion of sounds used to alert the user is found in Step 9.

Uses. Use audio as a *supplement* to text and graphics and only to reinforce visual content. Audio should never be used alone because of the disadvantages listed previously. Audio can also be used to establish *atmosphere*. A particular type of music reflecting a Web site's content can be played to establish ambience and also to create orientation signposts fostering a *sense of place*. Audio can also be used to teach word pronunciation or to provide *samples* of music.

Nielsen (2003) suggests that pure voice interfaces have the greatest potential in the following situations: (1) For people with various disabilities who cannot use a mouse and/or keyboard or who cannot see elements on the screen. (2) For people whose eyes and hands are busy in tasks such as driving an auto or repairing equipment. (3) For people who do not have access to a keyboard and/or monitor and might have to access a system through a standard telephone.

Advantages. An advantage of audio is its ability to offer commentary or help for a visual display. Audio does not obscure information on the screen, and it downloads faster than most other types of graphics.

Disadvantages. Audio's disadvantages are similar to those of sounds described in Step 9. Audio can be annoying to many people, including users and nonusers in the vicinity. It can be easily overused, increasing the possibility that it will be ignored. Audio is also not reliable because some people are hard of hearing, it

may leave no permanent record of having occurred, it may not be available to the user, or it may be turned off. Loud audio can also be irritating, especially to those with sensitive hearing.

Guidelines. Williams (1998), in a multimedia literature review, extracted most of the following guidelines. When words are spoken, the content should be simple, and the speed of narration should be about 160 words per minute. When the narration is used to introduce new ideas or new concepts the narration should be slowed. Off-screen (invisible) narration should be used rather than on-screen narration. On-screen narration is acceptable, however, if the narrator is a recognized authority on the topic being presented.

Other audition guidelines include these: Create *short segments*. There are many distractions people may encounter while listening to audio, so long segments should be avoided. Always provide audio segments of *high quality*. Research has found (Reeves and Nass, 1996) that while people will accept poor video, they are very affected by poor audio. Let users control the playing of audio. Provide the following *controls*: Play, Pause/Resume, Stop, Rewind, Fast Forward, and Volume. Any *background* audio should be subdued so it does not interfere with main information being presented on the screen.

Interactive Voice Response

- Limit to three or fewer levels.
- Limit to four or fewer choices per level.

Interactive voice response (IVR) systems have now become feasible and are being widely implemented. These systems synthesize both grammatical and statistical models of speech recognition to interpret spoken words reliably and accurately. For applications where the vocabulary of the speaker can be restricted, systems have been implemented with some success. For more complicated dialogues, the requirement for increased number of choices and a wider vocabulary pose more difficulties.

IVR systems have the potential to replace both human agents and the touch-tone (Press 2 for...) menu systems. Suhm et al. (2002) compared an IVR system with a touch-tone system using many factors. They found the following. The accuracy rates at the first decision point were similar. Touch-tone users had a 70 to 75 percent choice accuracy rate, whereas the IVR categorization rate was 78 percent. People, however, were more apt to use the IVR system than the touch-tone system. A larger portion of IVR users, 88.5 percent, when invited to describe their reason for calling, did so. Only 75.1 percent of the touch-tone users entered an initial selection. The remainder pressed "O" to escape the system. The IVR system, because of word recognition problems, re-prompted users more frequently than the touch-tone system. Overall, the researchers conclusion was that the IVR system improved the user experience, and routed callers more accurately and quickly to the right place. Users also preferred the IVR system to the touch-tone system.

Another study by Dulude (2002) compared senior adults with younger adults and found that older people had significantly more problems with the IVR system than did

younger people. While 82 percent of the younger people were able to complete five of the six presented tasks, the success rate of seniors was only 32 percent. Only 50 percent of the seniors could complete one or two of the six tasks. Older users were most challenged by the speed of the presentation, a failure to follow instructions, difficulty in understanding jargon, difficulty with selection entry, and an inability to recover from an error. This led Dulude to conclude that IVRs with three or fewer levels, and four or fewer choices per level, work best.

IVRs also appear to have a significant advantage over touch-tone telephones (like cell phones) that have the keypad on the receiver, not the base. It is more difficult to follow and implement touch-tone instructions when the telephone must be continually removed from one's ear to press the required numbers.

Combining Mediums

- Combinations:
  - — Use sensory combinations that work best together:
    - Auditory text with visual graphics.
    - Screen text with visual graphics.
- Integration:
  - — Closely integrate screen text with graphics.
- Relevance:
  - — Both the visual and auditory information should be totally relevant to the task being performed.
- Presentation:
  - — Visual and auditory textual narrative should be presented simultaneously, or the visuals should precede the narrative by no more than 7 seconds.
  - — To control attention, reveal information systematically.
    - Limit elements revealed to one item at a time and use sequential revelations for related elements.
  - — Animation must show action initiation as well as the action's result.
  - — Avoid animation that distracts from other more important information.
- Downloading times:
  - — Consider downloading times when choosing a media.
- Testing:
  - — Thoroughly test all graphics for
    - Legibility.
    - Comprehensibility.
    - Acceptance.

Interface technology encourages inclusion of the various graphical media (images, photos, video, diagrams, drawings, and audio) along with text on a screen. The design issue is which mediums work best with other mediums, and which mediums should not be employed together. Before reviewing research on this topic, which does find performance advantages for certain combinations of multimedia, theories for why this may happen will be summarized.

The first theory is called the *dual code* theory. It proposes that people store information in two ways in memory: verbally and pictorially. This theory postulates that, because of this dual-storage capability, information communicated to a person in both a verbal and pictorial manner has a greater likelihood of being remembered than information arriving in only one format. Also postulated is that too much information arriving in one format can overtax that particular memory. Combining verbal audio with displayed text is one such overtaxing combination.

The second theory also proposes two independent working memories, but is slightly different in concept. The first type of memory is a visual-spatial sketchpad in which information accumulated visually is stored. This visual information may be graphical or textual in nature. The second type of working memory is a phonological loop for dealing with and storing auditory information. This theory postulates that performance may be improved for certain more complex tasks because working memory is expanded through the application of two senses. The general conclusion is that combining visual and verbal auditory information can lead to enhanced comprehension, when compared to relying on one sense alone.

The two theories diverge on the storage of audio. The former suggests that verbal audio and displayed text is stored together; the latter suggests that they are stored separately.

In learning, *elaborative processing* is another consideration. As summarized by Bailey (2002), to "elaborate" means that people take more time to analyze and store information. This extra cognitive processing aids integration of the material with prior knowledge, which aids learning. Multimedia tends to elicit more elaborative processing of information than text does because graphics contain more features than words. These extra features enhance learning.

Interactivity in user interfaces also appears to enhance learning. Interactive interfaces let people control, manipulate and explore material. Interactivity also allows computers to periodically ask learners to answer questions that help them to integrate the material.

Combinations and integration. Williams (1998) in a literature review found that combining visual and verbal auditory information in multimedia design can lead to enhanced comprehension, when compared to use of these medias alone. Several recent studies have also explored the effects of various media, or combinations of media, on user performance. One such study is that of Lee and Bowers (1997). These researchers evaluated various mediums to see which yielded the best learning. The results, summarized in Table 11.3, compared a control group to groups learning material by the various methods described.

Another series of three studies were those of Tindall-Ford et al. (1997). They compared combinations of the following multimedia conditions for learning and performance:

- A visual diagram or table and separated visual text.
- A visual diagram and integrated visual text.
- A visual diagram or table and spoken instructions.

Table 11.3: Learning Improvements for Various Media

MEDIUM	PERCENT MORE LEARNING
Hearing spoken text and viewing graphics	91%
Viewing graphics alone	63%
Viewing text and viewing graphics	56%
Hearing spoken text, viewing text, and viewing graphics	46%
Hearing spoken text and viewing text	32%
Viewing text alone	12%
Hearing spoken text alone	7%

From Lee and Bowers (1997).

They found that the visual-audio combinations yielded reliably better performance for complex tasks, but no differences were found for easy tasks. They also found that visual text integrated into a diagram yielded better performance than separated visual text. They attributed the better results for the audiovisual combination and the integrated text and diagram alternative to reduced demands on working memory. What can we conclude from these studies?

- The proper multimedia combinations can improve learning and performance. Hearing spoken text combined with a visual graphic is an especially useful combination, especially for complex tasks. All studies found this pairing useful.
- Visual graphics do enhance learning and performance. In the Lee and Bowers study, the various graphical combinations yielded higher learning rates.
- Single-dimensional textual media are not as successful when used alone. In the Lee and Bowers study, viewing text or hearing spoken text alone yielded the lowest learning rates.
- Hearing spoken text and viewing text at the same time may not be great, but it may not be terrible, either. This combination yielded "middle-of-the-road" results in the Lee and Bowers study. The dual code theory would suggest, however, that its use be minimized. Exercise caution in this area.
- Visual text should always be integrated with related visual graphics. Tindall-Ford et al. found much better user performance when visual text was closely integrated with, or adjacent to, related visual graphics. It will be much easier for users to coordinate and integrate the visual materials. Presenting spatially separated text and related graphics places greater demands on working memory.

Relevance. Both the visual and auditory information should be totally relevant to the task being performed. All spoken text should reinforce presented graphics.

Presentation. Faraday and Sutcliffe (1997) also conducted a series of studies addressing multimedia design. Like the aforementioned studies, they found displayed graphics (images and animation) improved user performance, specifically the recall of information. Based upon these studies, they developed the following guidelines. Provide sufficient *time* for reading screen graphic captions. Present simultaneously all visual and auditory *narrative information* to the user, or have the visual information precede the auditory narrative by no more than 7 seconds. To control the users' attention, *reveal* or expose information systematically on the screen, either from left to right or from top to bottom. Limit the information revealed to one item at a time, and sequentially reveal related elements. Finally, any *animation* must show an action being initiated as well as the action's result, and avoid any animation that distracts from other more important screen information.

Downloading times. Consider downloading times in choosing a graphical medium. In general, downloading times range from the fastest, audio, to the slowest, video.

Testing. Thoroughly test all graphics for *legibility*. Make sure visual graphics are easy to see from a variety of viewing distances. Also test them for *comprehensibility*. Are visual graphics and related audio clear and understandable? Are the graphics *acceptable* to the using audience? This is especially critical if the users are multicultural. Always test graphics with all representative user groups. Testing methods are described in more detail in Step 14.

Step 11 Exercise

An exercise for Step 11 can be found on this book's companion Website, www.wiley.com/college/galitz.