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

WE’RE WIRED FOR LANGUAGE, BUT NOT FOR READING

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

In contrast, writing and reading did not exist until a few thousand years BC and did not become common until only four or five centuries ago—long after the human brain had evolved into its modern state. At no time during childhood do our brains show any special innate ability to learn to read. Instead, reading is an artificial skill that we learn by systematic instruction and practice, like playing a violin, juggling, or reading music (Sousa, 2005).
Because people are not innately “wired” to learn to read, children who either lack caregivers who read to them, or who receive inadequate reading instruction in school may never learn to read. There are many such people, especially in the developing world. By comparison, very few people never learn a spoken language.

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

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

- Lines, contours, and shapes are basic visual features that our brain recognizes innately. We don’t have to learn to recognize them.

- Basic features combine to form patterns that we learn to identify as characters—letters, numeric digits, and other standard symbols. In ideographic scripts, such as Chinese, symbols represent entire words or concepts.

- In alphabetic scripts, patterns of characters form morphemes, which we learn to recognize as packets of meaning, e.g., “farm,” “tax,” “-ed,” and “-ing” are morphemes in English.

- Morphemes combine to form patterns that we recognize as words, e.g., “farm,” “tax,” “-ed,” and “-ing” can be combined to form the words “farm,” “farmed,” “farming,” “tax,” “taxed,” and “taxing.” Even ideographic scripts include symbols that serve as morphemes or modifiers of meaning rather than as words or concepts.

- Words combine to form patterns that we learn to recognize as phrases, idiomatic expressions, and sentences.

- Sentences combine to form paragraphs.

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

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

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

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

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

Context-driven or top-down reading operates in parallel with feature-driven reading but it works the opposite way: from whole sentences or the gist of a paragraph down to the words and characters. The visual system starts by recognizing high-level patterns like words, phrases, and sentences, or by knowing the text’s meaning in advance. It then uses that knowledge to figure out—or guess—what the components of the high-level pattern must be (Boulton, 2009). Context-driven reading is less likely to become fully automatic because most phrase-level and sentence-level patterns and contexts don’t occur frequently enough to allow their recognition to become burned into neural firing patterns. But there are exceptions, such as idiomatic expressions.
To experience context-driven reading, glance down quickly at Figure 4.2 (below), then immediately direct your eyes back here and finish reading this paragraph. Try it now. What did the text say?

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

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

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

### FIGURE 4.2
Top-down “recognition” of this expression may inhibit awareness of its actual content.

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

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

### FIGURE 4.3
Top-down reading: Most readers, especially those who know the songs from which these text passages are taken, can read these passages even though the words (A) have all but their first and last letters scrambled and (B) are mostly obscured.
However, empirical studies of readers conducted since then have demonstrated conclusively that the truth is the opposite of what the earlier theory predicted. Reading researcher Keith Stanovich explains:

\[\text{… Context [is] important, but it’s a more important aid for the poorer reader who doesn’t have automatic context-free recognition instantiated.}\]

\[(\text{in Boulton, 2009})\]

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

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

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

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

**SKILLED AND UNSKILLED READING USES DIFFERENT PARTS OF THE BRAIN**

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

\(^{1}\text{Chapter 10 describes the differences between automatic and controlled cognitive processing. For present purposes, we will simply say that controlled processes burden working memory, while automatic processes do not.}\)
people with brain damage near the left temple—an area now called Broca’s area after the doctor who discovered it—can understand speech but have trouble speaking, and that people with brain damage near the left ear—now called Wernicke’s area—cannot understand speech (Sousa, 2005) (see Fig. 4.4).

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

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

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

**FIGURE 4.4**
The human brain, showing Broca’s area and Wernicke’s area.
• **Advanced:** The word analysis area is skipped. Instead the occipito-temporal area (behind the ear, not far from the visual cortex) becomes active. The prevailing view is that this area recognizes words as a whole without sounding them out, and then that activity activates pathways toward the front of the brain that correspond to the word’s meaning and mental image. Broca’s area is only slightly involved.

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

**POOR INFORMATION DESIGN CAN DISRUPT READING**

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

**Uncommon or unfamiliar vocabulary**

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

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

```
Your session has expired. Please reauthenticate.
```

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

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

• **Aforementioned:** mentioned previously

• **Bailiwick:** the region in which a sheriff has legal powers; more generally: domain of control
• **Disclaim:** renounce any claim to or connection with; disown; repudiate
• **Heretofore:** up to the present time; before now
• **Jurisprudence:** the principles and theories on which a legal system is based
• **Obfuscate:** make something difficult to perceive or understand
• **Penultimate:** next to the last, as in “the next to the last chapter of a book”

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

### Difficult scripts and typefaces

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

---

**FIGURE 4.5**

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

Tiny fonts

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

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

FIGURE 4.6
The opening paragraph of the U.S. Constitution, presented in a seven-point font.

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

Text on noisy background

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

There are situations in which designers intend to make text hard to read. For example, a common security measure on the Web is to ask site users to identify distorted words, as proof that they are a live human being and not an Internet “bot.” This relies on the fact that most people can read text that Internet ‘bots cannot
FIGURE 4.8

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

FIGURE 4.9

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

currently read. Text displayed as a challenge to test a registrant’s humanity is called a captcha\(^2\) (see Fig. 4.8).

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

\(^2\)The term originally was coined based on the word “capture,” but it is also said to be an acronym for “Completely Automated Public Turing test to tell Computers and Humans Apart”—Wikipedia entry for “Captcha.”
Poor information design can disrupt reading

Information buried in repetition

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

Another example of repetition that creates noise is the computer store on Apple.com. The pages for ordering a laptop computer list different keyboard options...
for a computer in a very repetitive way, making it hard to see that the essential difference between the keyboards is the language that they support (see Fig. 4.11).

**Centered text**

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

**FIGURE 4.11**

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

**FIGURE 4.12**

FargoHomes.com centers text, thwarting automatic eye movement patterns.
The same site also centers numbered lists, *really* messing up readers’ automatic eye movement (see Fig. 4.13). Try scanning the list quickly.

**FIGURE 4.13**
FargoHomes.com centers numbered items, really thwarting automatic eye movement patterns.
Combining flaws that disrupt reading

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

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

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

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

- Ensure that text in user interfaces allows the feature-based automatic processes to function effectively by avoiding the disruptive flaws described above: difficult or tiny fonts, patterned backgrounds, centering, etc.
• Use restricted, highly consistent vocabularies—sometimes referred to in the industry as *plain language*\(^3\) or *simplified language* (Redish, 2007).

• Format text to create a visual hierarchy (see Chapter 3) to facilitate easy scanning: use headings, bulleted lists, tables, and visually emphasized words (see Fig. 4.15).

**FIGURE 4.15**
Microsoft Word’s Help home page is easy to scan and read.

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

**MUCH OF THE READING REQUIRED BY SOFTWARE IS UNNECESSARY**

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

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

\(^3\)For more information on plain language, see the U.S. government Web site: [www.plainlanguage.gov](http://www.plainlanguage.gov).
2002 and 2007, shortened its instructions for finding a local Jeep dealer (see Fig. 4.17):

- **2002:** The “Find a Dealer” page displayed a large paragraph of prose text, with numbered instructions buried in it, and a form asking for more information than needed to find a dealer near the user.

- **2003:** The instructions on the “Find a Dealer” page had been boiled down to three bullet points, and the form required less information.

- **2007:** “Find a Dealer” had been cut to one field (zip code) and a Go button on the Home page.

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

FIGURE 4.17

Between 2002 and 2007, Jeep.com drastically reduced the reading required by “Find a Dealer.”
cannot or will not read it. Compare Costco.com’s descriptions of laptop computers in 2007 with those in 2009 (see Fig. 4.18).

**FIGURE 4.18**
Between 2007 and 2009, Costco.com drastically reduced the text in product descriptions.

**Design implications: minimize the need for reading**

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

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

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