cerebral cortex The outer covering of the brain's cerebral hemispheres.

aphasia Any language disruption caused by brain damage.

Broca's aphasia Aphasia characterized by halting speech and tremendous difficulty in choosing words, but fairly good speech comprehension. Also called motor aphasia or expressive aphasia.

Wernicke's aphasia Aphasia associated with fluent speech that is well articulated but often nonsensical, and enormous difficulty in understanding language. Also called sensory or receptive aphasia.

a particular swear word, the syllable *tan* was the only set of speech sounds he'd managed to eke out for 21 years. The patient died a few days after their meeting, and as Broca was aware that scientists were beginning to explore claims about the localization of language, he decided to autopsy Leborgne's brain. He considered language to be a good test case for the more general hypothesis that the various functions of the brain were compartmentalized into different physical regions. He discovered extensive damage to the frontal lobe on the left side of Leborgne's brain, providing some of the earliest hard evidence of localization in the brain (Broca, 1861).

Based on his observations, Broca argued that the faculty of language was further split apart into subfunctions, an idea that was consistent with many earlier reports of language loss due to brain damage. He noticed that Leborgne seemed to understand language much better than you'd expect from his utter lack of ability to speak—for example, when asked how long he'd been hospitalized, he flashed four sets of five fingers and then a single finger, to indicate 21. To Broca, this suggested that he'd lost the ability to produce spoken language (despite maintaining reasonable dexterity of his tongue and mouth) but that other aspects of language functioning were better preserved. Following this famous case, Broca autopsied the brains of a number of patients whose language was impaired after stroke or other brain damage, and he found that a significant portion of them had damage to the same part of the **cerebral cortex** (the brain's outer layer of neurons), specifically on the left side of the frontal lobe.

Shortly after Broca's discovery, neurologist Carl Wernicke studied a patient who had suffered a stroke and, though able to speak fluently, didn't seem to understand anything that was said to him. A later autopsy revealed a lesion, or evidence of brain damage, on the left side of the cerebral cortex—but the lesion was farther back than the region Broca had described, in the temporal lobe rather than the frontal lobe (see **Figure 3.4**).

In 1874, Wernicke published an influential text in which he explored his ideas about **aphasia**, the clinical term for language disruption caused by brain damage. Even though scientists and clinicians had long suspected that language loss came in at least two distinct varieties, the pioneering work of Broca and Wernicke established that the distinct forms of aphasia were related to different areas of the brain. **Broca's aphasia** (also called motor or expressive aphasia) is characterized by halting speech, if any at all, and tremendous difficulty in choosing words, but fairly good comprehension. **Wernicke's aphasia** (also called sensory or receptive aphasia) is associated with fluent speech that is well articulated but often nonsensical, and enormous difficulty in understanding language. (See **Table 3.2** for examples of speech by patients with Broca's and Wernicke's aphasias.)

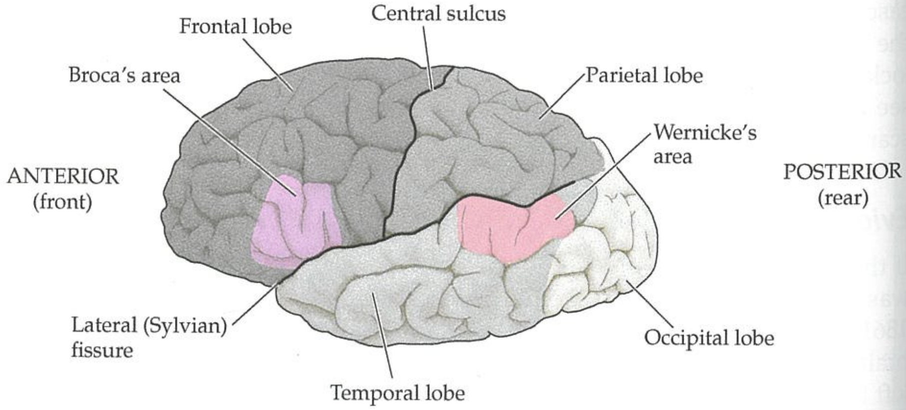


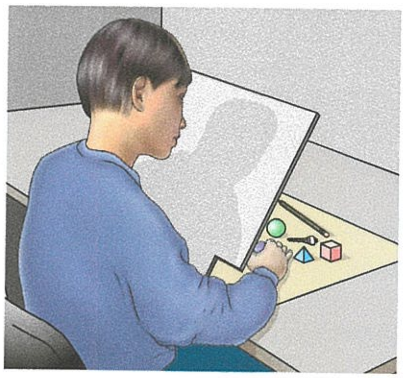
Figure 3.4 A side view of the surface of the brain's left hemisphere. The four lobes of the cerebral cortex are indicated in shades of gray, with Broca's area and Wernicke's area shown in color.

corpus callosum A bundle of neural fibers that connects and transfers information between the two hemispheres of the brain.

er. These patients submitted to a surgery that severed the **corpus callosum**, the bundle of neural fibers that connects the two hemispheres of the cerebral cortex in a high-speed "superhighway." The surgery was approved as a treatment after studies by Roger Sperry showed that the procedure in monkeys resulted in very little change in the monkeys' behavior—and indeed, human split-brain patients were able to function surprisingly well even though their two hemispheres had lost the ability to share information with each other.

But using clever experimental tests, the researchers were able to demonstrate some bizarre consequences of the disconnection. The experiments required finding some way to present information to only one side of the brain. For example, to present information to the left hemisphere, sensory input needs to come from the right side of the body because the brain is wired in such a way that it receives input from, and sends motor commands to, the opposite side of the body. "Split-brain" patients used their right hands to handle objects that were hidden behind a barrier, so that only the left hemisphere had access to information gleaned from touching the objects (see **Figure 3.6**). In other versions of the experiments, patients sat in front of a screen and were told to look

(A)



Left hemisphere functions	Right hemisphere functions
Analysis of right visual field	Analysis of left visual field
Stereognosis (right hand)	Stereognosis (left hand)
Lexical and syntactic language	Emotional coloring of language
Writing	Spatial abilities
Speech	Rudimentary speech

(B)

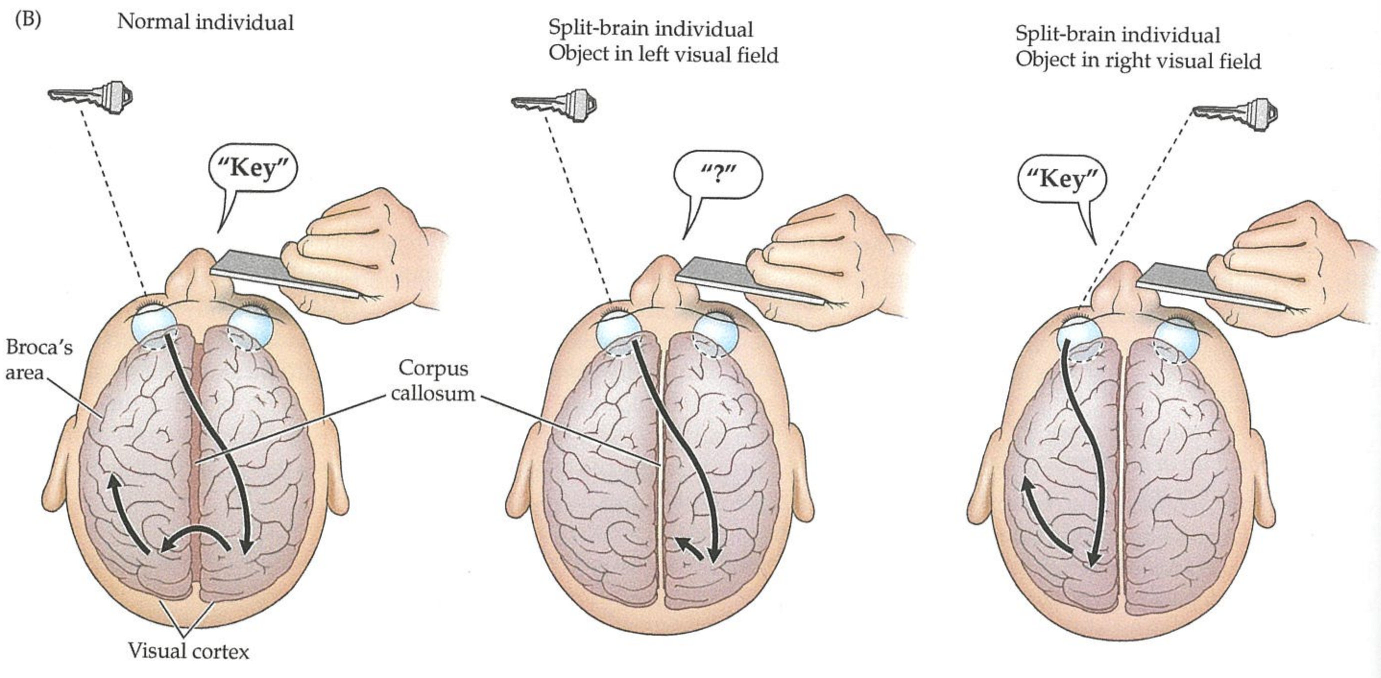


Figure 3.6 (A) A split-brain patient handles an object behind the screen with his right hand. (B) Presenting visual information in just the left or right visual field has different effects on individuals with normal versus split brains. When the corpus callosum is intact, information presented in the left visual field is processed in the right hemisphere but can be relayed to crucial language areas in the left hemisphere. In a split-brain individual, only information presented in the right visual field is able to reach the language areas in the left hemisphere.