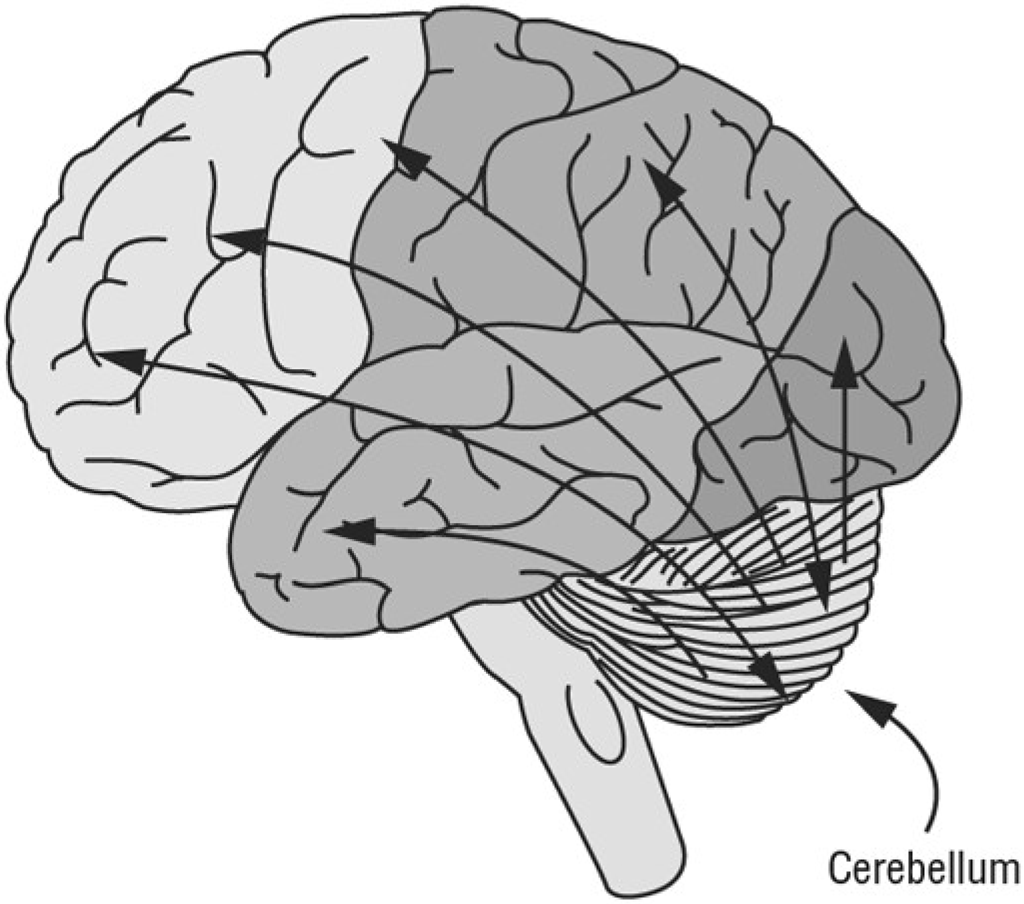
Evidence of Mind-Body Links

The first evidence of a linkage between mind and body was scattered in various proposals over the past century (Schmahmann, 1997). Today, the evidence has become a groundswell, and most neuroscientists agree that movement and cognition are powerfully connected.

Anatomical Evidence

The area of the brain most associated with motor control is the cerebellum. It's located in the back of the brain, just under the occipital lobe, and is about the size of a small fist. The cerebellum takes up just one-tenth of the brain by volume, but it contains *nearly half* of all its neurons (Ivry & Fiez, 2000). This structure, densely packed with neurons, may be the most complex part of the brain. In fact, it has some 40 million nerve fibers—40 times more than even the highly complex optical tract. Those fibers feed information from the cortex to the cerebellum, and they feed data back to the cortex. In fact, most of the neural circuits from the cerebellum are “outbound,” influencing the rest of the brain (Middleton & Strick, 1994). Peter Strick at the Veteran Affairs Medical Center of Syracuse, New York, has documented another link. His staff has traced a pathway from the cerebellum back to parts of the brain involved in memory, attention, and spatial perception. Amazingly, the part of the brain that processes movement is the same part of the brain that processes learning (see Figure 4.1).

Figure 4.1. Links Between the Cerebellum and Other Parts of the Brain



Information travels to and from the cerebellum, the brain's center of motor control, and other parts of the brain involved in learning, but most of the neural circuits are outbound.

Evidence from Imaging Techniques

New data, primarily from studies using functional magnetic resonance imaging (fMRI), have provided support for parallel roles of cognitive structures and movement structures such as the cerebellum. We learn to predict (think about) our movements before we execute them (move) so that we control them better (Flanagan, Vetter, Johansson, & Wolpert, 2003). This ability suggests that all motor activity is preceded by quick thought processes that set goals, analyze variables, predict outcomes, and execute movements. Pulling this off requires widespread connections to all sensory areas.

Various studies support the relationship between movement and the visual system (Shulman et al., 1997), movement and the language systems (Kim, Ugirbil, & Strick, 1994), movement and memory (Desmond, Gabrielli, Wagner, Ginier, & Glover, 1997), and movement and attention (Courchesne & Allen, 1997). These studies do not suggest that there is movement in those functions. But they suggest a relationship with the cerebellum in such mental processes as predicting, sequencing, ordering, timing, and practicing or rehearsing a task before carrying it out. The cerebellum can make predictive and corrective actions regardless of whether it's dealing with a gross-motor task sequence or a mentally rehearsed task sequence. In fact, the harder the task you ask of students, the greater the cerebellar activity (Ivry, 1997). Taken as a whole, a solid body of evidence shows a strong relationship between motor and cognitive processes.

Cognitive Evidence

Just how important is movement to learning? The vestibular (inner ear) and cerebellar (motor activity) system is the first sensory system to mature. In this system, the inner ear's semicircular canals and the vestibular nuclei are an information-gathering and feedback source for movements. Impulses travel through nerve tracts back and forth from the cerebellum to the rest of the brain, including the visual system and the sensory cortex. The vestibular nuclei are closely modulated by the cerebellum and also activate the reticular activating system, near the top of the brain stem. This area is critical to our attentional system, because it regulates incoming sensory data. This interaction helps us keep our balance, turn thoughts into actions, and coordinate movements. That's why there's value in playground activities that stimulate inner-ear motion, like swinging, rolling, and jumping. A complete routine might include spinning, crawling, rolling, rocking, tumbling, and pointing. As noted in Chapter 2, Lyelle Palmer of Winona State University has documented significant gains in attention and reading from these stimulating activities (Palmer, 2003).