Neurophysiology of Human Motor Control

The central nervous system controls the contraction of muscles based on sensory information from vision, the vestibular system and sensors in muscles, tendons, skin, etc. There are several loops of feedback (e.g., through the spinal cord and the brain) that help control the activity of the muscles in a coordinated manner. The main goal of this research in our lab is the study of how the nervous system processes sensory information and how it operates to control muscles and movements. We study, for example, the neural bases of the control of upright posture in humans. We capture and analyze brain and muscle electrical signals (EEG and EMG) as well as biomechanical signals (joint and body segment angles and velocities) to infer how the nervous system must be acting to control the activation of the muscles (based on sensory signals from several sources) in order to accomplish a certain task. We also study ways to improve sensory feedback through the application of electrical or vibratory random stimulation to different parts of the body (fingertips, leg, etc.) so as to improve the quality of postural control and force steadiness. In another research topic, the interest is to better understand the functioning of neural circuits in the spinal cord associated with reflexes, and their bilateral action, i.e., how one side of the cord may influence the other side and how both are influenced by the brain and different sensory pathways. All experiments associated with the studies described above use computers to control the experiments, automating the acquisition of electrical and mechanical signals simultaneously with the application of electrical and mechanical stimuli at the correct times. Due to their complexity, the experiments require sophisticated computational control techniques and several signal processing methods. More recently our experimental results have been analyzed on the basis of computer simulation results of mathematical models, providing a better understanding of associated mechanisms at the neural and muscular levels (see the line of research Computational Neuroscience).