Any movement of the human body is due to muscle contraction and any muscle contraction is due to contraction of motor units (MUs), i.e. all the muscle fibers innervated by a single spinal motoneuron. A motor unit has an “all or nothing” behavior: either it is contracting or not. Therefore, even the smoothest voluntary movement is due to a sum of discrete events. In contrast, compound muscle action potential (CMAP) recorded after peripheral nerve stimulation or motor evoked potential (MEP) induced by transcranial magnetic stimulation of the human motor cortex are continuous electrophysiological variable. Averaged MEP amplitudes are used as a functional measure of the corticospinal tract, the so called „excitability“. How to correlate a change in “excitability” with a change in the recruitment of MU is unknown.

Our project aims at better understanding the relationship between MU recruitment and MEP amplitudes. Both by using a new stochastic model, the „random sums with independently thinned terms“ and Poisson distributions, we can estimate the number and size of MUPs from a continuous electromyographic variable. Furthermore, by comparing CMAP after peripheral electrical stimulation and MEP amplitudes we can analyze the central organization of the corticospinal tract under several conditions. The main results of our study are: 1) The human primary motor cortex does not select MU individually but in small “clusters” 2) The number and size of these “clusters” strongly depend on the state of the corticospinal tract. 3) In particular, activation of GABA-ergic cortical interneurones using paired-pulse TMS changes the size but not the total number of these clusters. 4) In contrast, the voluntary drive strongly regulates the total number of clusters that have a low threshold for cortical activation. 5) In the last part of our project we are now analyzing the shape of MEP by using “principal component analysis” in order to identify these “clusters”.

Overall, our project introduces a new way of analyzing human corticospinal organization in health and disease.