Research Paper: The Manipulation of Electromyography to Derive the Necessary Electric Potentials for Natural Finger Movement

Author: Scott Mandelbaum

Abstract

Introduction: The aim of this research was to quantify and characterize the electromyographic (EMG) potential of several forearm muscles during a controlled motor activity. As this information will be used to develop a control algorithm for a neuroprosthetic hand (prototype shown as *Figure 1*), a further goal was to find electrode placements that provide a consistently low baseline signal and consistently high peak signal, allowing for clear discrimination between intentional and unintentional muscle contractions. Ultimately, upon hitting that threshold, the activation of prosthetic movement will be initiated. These recordings will take advantage of the function of a biological hand, where electrical signals (i.e., "action potentials") are sent from the brain to the muscles through the central, then peripheral, nervous systems. In a healthy hand, a gradient of ions creates a voltage across the axon of a neuron; when enough of a change in this ion gradient occurs to break a threshold, a wave of increased then decreased voltage propagates down the axon. Similarly, the prosthetic will detect this propagation and use it as the input signal for its own specialized motor activity, which will mimic vertical motions used in writing.

Figure 1: Prosthetic hand prototype.

Methods: Surface EMG recordings were made from three muscles, the flexor carpi ulnaris, flexor carpi radialis and brachioradialis, of the right forearm of a single subject. For each trial of the motor task, the subject remained still for 5s to obtain a baseline EMG reading, then flexed a finger over a 1s period to apply a force of 2N against a spring scale. This force was sustained for 5s, after which the subject relaxed the finger over a 1s period, returning to the original position for an additional 5s. This procedure was repeated five times for each digit on the right hand, giving a total of 25 trials per muscle. The average and standard deviation of the EMG signal for each digit/muscle combination was then calculated. The difference of the EMG signal value at each timepoint and the preceding timepoint was also determined. Finally, the signal-to-noise ratio (SNR) was calculated for each digit/muscle combination by taking the average peak difference value and dividing it by the standard deviation of the corresponding baseline difference value.

Results: Of the 75 trials (25 per muscle x 3 muscles), all successfully yielded EMG recordings. For the flexor carpi ulnaris, peaks corresponding to the onset of motor activity were evident for all five digits (*Figure 2*, left). Such peaks were largely absent for the brachioradialis muscle (*Figure 2*, middle) and were of lower magnitude for the flexor carpi radialis muscle (*Figure 2*, right). Motor activation by the thumb yielded the highest SNR value (4.6) for the flexor carpi radialis; the lowest SNR value (2.3) was associated with the little finger.

Conclusions: Results indicated that the flexor carpi ulnaris muscle consistently yielded the clearest EMG signal associated with deliberate onset of muscle activity, and is an excellent candidate for use in neuroprosthetics. Future work will use these data to determine reliable thresholds for a prosthetic control algorithm.

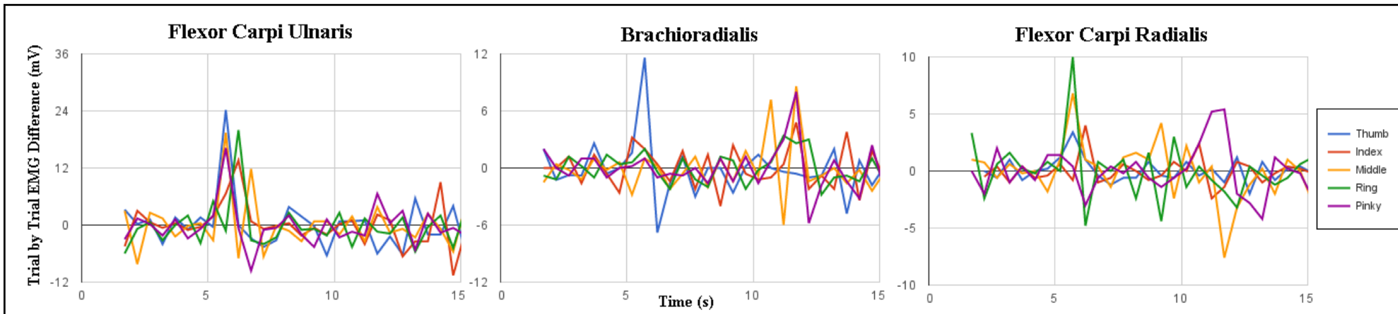

Figure 2: Mean trial by trial difference in EMG signal values for all five digits across muscles. Note the peaks around 5s, which correspond to the onset of motor activity.