**Experimental protocol and setup for measures at Charing Cross Hospital London with acute post-stroke patients**

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1. **Aims**

* Assessing the presence of residual myoelectric activity in plegic upper limb of heamiplegic acute post-stroke patients, by focusing on extrinsic and intrinsic muscles of the hand
* Analysing motor neurons firing patterns, to localize most activated muscles and extracting temporal features to estimate movement intentions suitable for myoelectric control
* Studying synchronization and synergistic aspects among motor units
* Evaluating and testing a HD-sEMG-based framework for rehabilitation

1. **Team**

~~The investigator team is composed by Simone Tanzarella, Alex Clarke, Megan Hutchings, Deren Y Barsakcioglu. Hsien-Yung Huang provides the technical support for the custom-made force device and he is interested to test and improve it.~~

1. **Subjects**

Subjects were 6 acute hospitalized post-stroke patients. Experiments were carried out after less than four weeks from the stroke event. Patients could not move their hemi-plegic upper limb, if not producing, in some case, spastic weak movements, completely not effective for the task required, when asked to contract at their maximum level of contraction.

1. **Investigated muscles and position of the electrode grids**

EMG signals will be recorded from extrinsic and intrinsic hand muscles with six grids of 64 surface EMG electrodes each (OT Bioelettronica, Torino, Italy). Two 13x5 grids with 8 mm inter-electrode distance (IED) will be placed over the extensor digitorum and flexor digitorum superficialis muscles. Four grids with 13x5 electrodes at 4 mm IED will be placed over the first dorsal interosseous (FDI), the other three dorsal interossei, the thenar and the abductor digiti minimi (ADM) muscles.

1. **Experimental setup**

The electrode grids will be connected to a multi-channel EMG amplifier (Quattrocento, OT Bioelettronica, Torino, Italy) through 64-channel impedance-adapters with a gain of 5V/V. EMG signals will be amplified with a gain of 150, band-pass filtered between 10 and 900 Hz, sampled at 2048 Hz and A/D converted on 16 bits. A reference electrode will be placed on the wrist.

~~Force will be recorded with a custom-made 3D-printed device (fingerForce) with 10 sensors, 5 to record the flexion force of each finger, and 5 to record extension. The device is able to send a trigger with rise to an high-state from a low-state when the force recording starts. The trigger is received by the EMG amplified by a BNC-BNC connection between the force device and one auxiliary channel of the amplifier. This enable to synchronize force and EMG in the offline processing phase of the data.~~

~~A GUI displays the EMG for the investigators with different type of representations, i.e. stacked channels, channels in the grid pin-out configuration, and activation surface/map. Grids can be displayed one at time or in a synoptic view. Another GUI represents the force exerted by the subject measured by the fingerForce device as 10 bars, 5 for flexion and 5 for extension. Protocol can be uploaded in the GUIs through an Excel file, so is possible to represent cues in the succession prescribed by the protocol and stopping and saving automatically the force~~ recording.

1. **Experimental protocol and trials**

The subject lays on a bed or she/he is helped to sit on a chair. After having placed the electrode grids, the subject is asked to assume a comfortable position with the investigated upper limb ~~and to hold the fingerForce device. All the fingers should be embraced by the device so that is possible to measure flexion and extension forces of all the finger for each prescribed trial.~~

~~Before to execute the trials maximum voluntary contraction (MVC) must be recorded for each finger, both for flexion and extension. Every trials implies to follow a cue represented as red bars in correspondence of the activated fingers. The force exerted will be represented with a bar for each finger. The subject will be asked to follow with the latter bars the cue bars, by leaving the others to zero.~~

~~Two cues will be represented. The first cue will be in a rest position for 5 seconds, will be a rising ramp for 5 seconds from 0 to 15 % MVC, then will be a 0.2 Hz sinusoid for 20 s (4 waves) between 10 and 20 % MVC and then will descend as a ramp in 5 seconds, to conclude with 5 seconds of rest. The second cue will have a steady contraction at 20% MVC in the central 20 s, instead of a sinusoid.~~

~~The following trials are asked to be performed by the subject and to be repeated for the two cues :~~

~~- Five-finger grasp (hand closing)~~

~~- Extension of the all the fingers (hand opening)~~

~~- Thumb-index flexion (pinch)~~

~~- Thumb-index-middle flexion (pinch)~~

~~- Thumb-index extension~~

~~- Thumb-index-middle extension~~

~~The experiment will have a duration of 30 minutes for the preparation (by including check of the signal), 5 minutes for the MVC recording, and around 30 minutes for the trials.~~

Subjects were asked to perform three different tasks, each one repeated for three identical trials, each one consisting in a whole-hand grasp in three different conditions.

* Holding a cylindrical object, by modulating their contraction according to a sinusoidal cue as a visual feedback
* Imagining to open and close their hand by following a moving robotic hand in front of them
* Imagining the movement with no visual feedbacks