LEARNING A COMPLEX BIMANUAL COORDINATION MOTOR SKILL WITH ROBOTICS OVER 3 CONSECUTIVE DAYS IN CHRONIC STROKE PATIENTS

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Background

A loss of bimanual coordination is almost always observed after a unilateral stroke and has functional consequences in the patient daily activities. Bimanual motor skill learning is a key issue in neurorehabililation. Robotic device allows stroke patient to learn complex bimanual skills and to explore how they (re-) learn to coordinate the upper limbs. Our hypothesis was that patients with a chronic stroke are able to learn, retain and generalize a new bimanual task using a robotic device.

Methods

24 chronic stroke patients and 10 HI trained over 3 consecutive days on a complex asymmetrical bimanual coordination task (CIRCUIT) implemented as a serious game in the bimanual version of the REAplan® robot (AXINESIS, Wavre, Belgium). On each day, a complex CIRCUIT was displayed on the screen. With a common cursor controlled by coordinated movements of the ULs interacting with the robotic handles, the subjects were instructed to perform as many laps as possible during the training blocks (speed constraint) while keeping the cursor within the track (accuracy constraint). Through virtual walls imposed by the REAplan®, one hand controlled exclusively lateral displacements of the common cursor, the other hand controlled exclusively sagittal displacements.

The primary outcome used to quantify training-induced improvement was a bimanual speed/accuracy trade-off (biSAT) in arbitrary units (a.u.):

$$\text{biSAT} = \frac{\text{speed}\ (\frac{cm}{s})}{\text{error}\ (cm^2)}.C$$

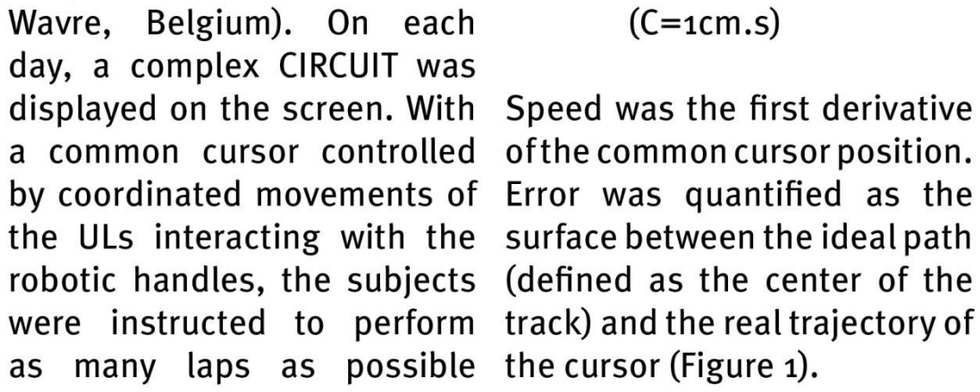
(C=1cm.s)

Speed was the first derivative of the common cursor position. Error was quantified as the surface between the ideal path (defined as the center of the track) and the real trajectory of the cursor (Figure 1).

The secondary outcome was the Bimanual Coordination Factor (biCO), which quantified how well the hands' movements were coordinated. The ideal biCO corresponds to an equal speed of both hands along the X- and Y-axis:

$$\text{biCO} = \frac{\min(|v_x|, v_y|)}{\sqrt{(v_x)^2, (v_y)^2}}$$

Figure 1



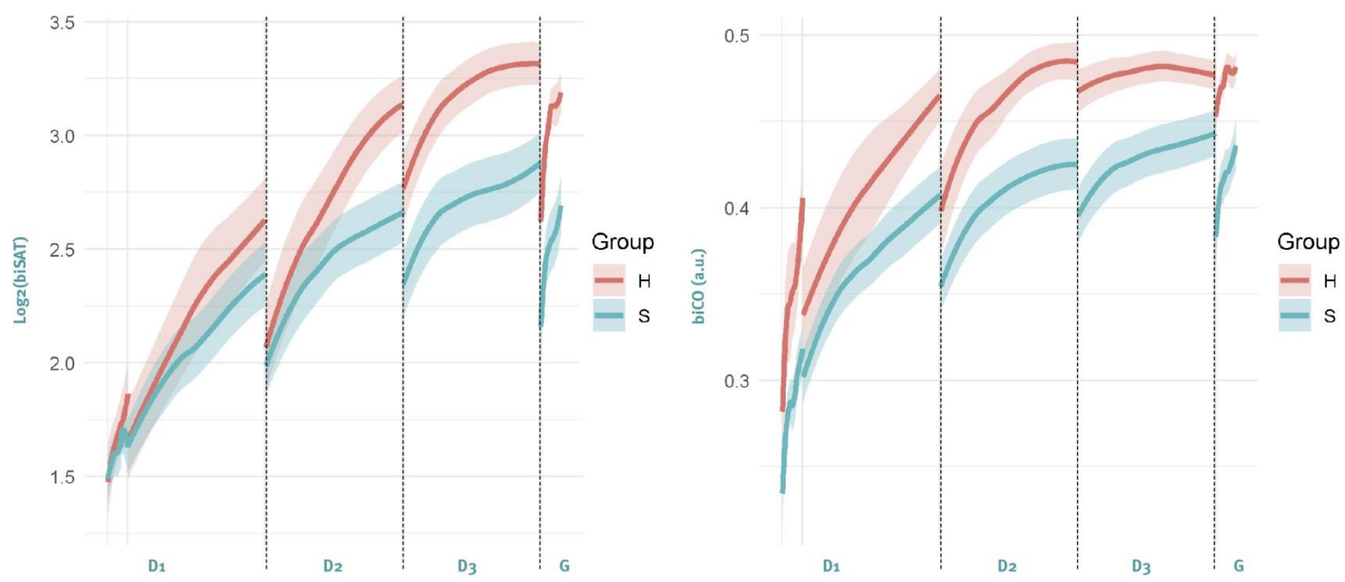
Objectives

- To determine whether and how chronic patients with a supratentorial stroke achieve bimanual motor skill learning (MSkL).
- To compare bimanual MSkL between patients and healthy individuals (HI).

Results

Over the three days, HI achieved typical bim-MSkL: they largely improved biSAT (1.84 ± 0.13, p ‹ .000) and biCO (0.19 ± 0.02, p ‹ .000). There was a significant difference on the principal outcome biSAT's change showing that the HI achieved larger biMSkL than the chronic stroke patients (-0.45 ± 0.16, p ‹ 0.005) with a ratio relative difference of 1.3. There was also a significant difference for the generalisation of the task (-0.45 ± 0.16, p ‹ 0.006), indicating that the HI generalised more than the patient. Compared to HI, improvements on the CIRCUIT task in stroke patients were significant neither for biCO evolution (0.01 ± 0.03 p = 0,585) nor for the generalization (-0.02 ± 0.03 p = 0,416).

Figure 2 : Improvement of the biSAT in arbitrary unit (a.u.) expressed in a logarithmic scale and biCO in raw data (a.u.)
Thick line : group mean; D = Day; G = Généralization (using a new CIRCUIT layout); H : Healthy Individuals; S : Stroke patients.



Conclusion

Every HI and most of the chronic patients with a supratentorial stroke were able to improve and retain the complex bimanual skill (CIRCUIT), and they could generalize their performance to a new bimanual CIRCUIT task. These results demonstrate that bim-MSkL can be achieved in chronic stroke patients by means of a robotic interface, which opens interesting perspectives for neurorehabilitation.

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