Supplementary Methods

CIRCUIT's online score

After each block of training with the circuit, an online score was displayed to motivate the patients, it that was calculated as follows:

$$\text{Online Score} = \sum_{i=0}^{N} 10 + [10 \times \frac{|Si - I|}{I}]$$

Where:

N is the number of laps completed during the block

I is the length of the ideal trajectory

$\boldsymbol{S_i}$ is the length of the actual path during lap number *i*.

Bimanual REACHING

To evaluate generalization, bimanual reaching was evaluated. Keeping the same physical constraints as for CIRCUIT within session blocks 1-2 and 3-4 (i.e. whether the paretic UL controlled lateral or antero-posterior cursor's displacement), the patients reached as fast and accurately as possible from a home position to five circular targets, each of the five target appeared 8 times in a pseudo-randomized order (Figure 1).

In this REACHING task, the cursor controlled by coordinated bimanual movements was a circle with a 7 mm diameter, the path width was 11 mm. Each time a target and its ideal path appeared, the patient was asked to reach the target as fast and as accurately as possible. The reaching movements were 60 mm long, both targets and home position had a diameter of 15 mm. The targets were allocated at ±45°, ±22.5° and 0° (see Figure 1) and presented in a pseudo-randomised order. Once the cursor was inside the target, it had to stay there for 300 ms before the target turned green. 1000 ms later, the home position re-appeared and the patient had to go back there as fast and accurately as possible.

Once the home position was reached and turned green, then the next target appeared after 1000 ms. The patient had to perform 8 bimanual reaching towards each of the five targets (±45°, ±22.5°, 0°).

Since in REACHING, the ±22.5° targets did not require an equal contribution of both UL (unlike ±45° targets), for analyzing REACHING, the Bi-Co formula was adapted for ±22.5° targets as follows:

$$\mathrm{Bi-Co} = \min\left(|V_x|, |V_y| * 0.41\right) / \|V\|$$

In which:

$$\|V\| = \sqrt{(V_x{}^2 + (0.41 * V_y)^2}$$

Because in the ±22.5° targets (from the Y-axis), the ideal coordination does not happen when $V_x = V_y$ but when V_x is 0.41 x V_y (i.e. tan 22.5° = V_x/ V_y = 0.41).

Finally, as 0° REACHING was actually “unimanual”, Bi-Co was not calculated.

Supplementary Results

Evolution of Bi-SAT and Bi-Co in individual stroke patients:

All patients retained the bimanual motor skill at one week indicated by the improvements in Bi-SAT and Bi-Co under both real and sham conditions except for P6, 14, 16 and 18 who showed a deterioration after one of the sessions. P14 & P16 deteriorated in Bi-SAT in the retention session after sham dual-tDCS (-11% and -7% respectively; R1 compared to baseline). P6 & P18 deteriorated in Bi-Co in the retention session after sham (-20% and -4% respectively). In contrast, three patients (P1, P13 & P20) reached more than 100% of improvements in Bi-SAT from baseline to after60 in real dual-tDCS condition and one patient after sham condition (P21).

Generalization

Generalization was further evaluated with bimanual REACHING. For none of the five targets (±45°, ±22.5°, 0)), the second GLMM detected a significant effect of stimulation (real vs. sham) on the difference between baseline and R1. (Supplementary Table 3, Supplementary Figure 3)

Supplementary Figure legends:

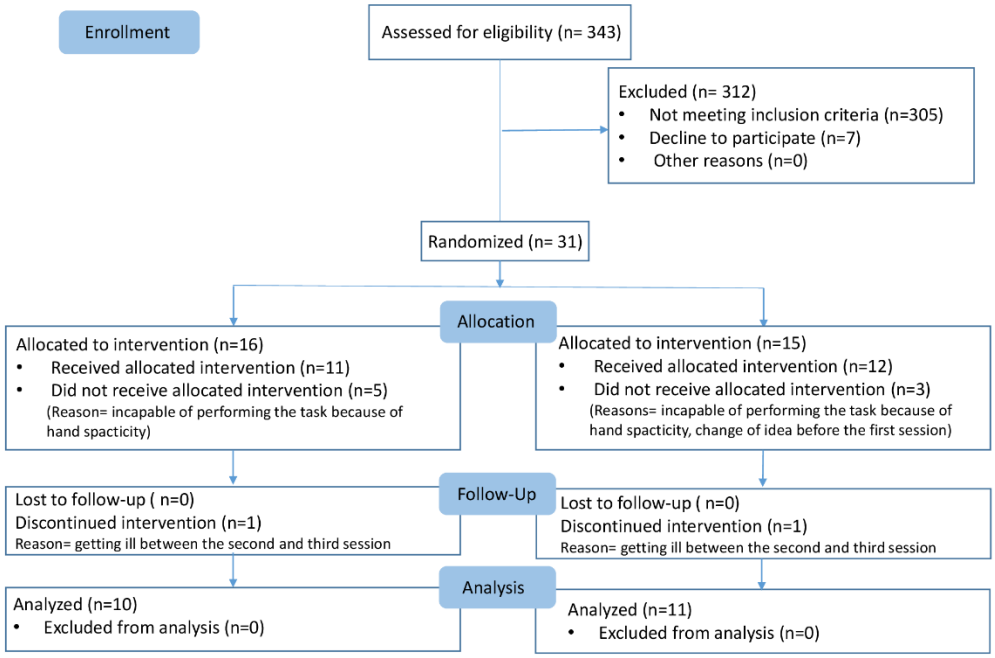
Population

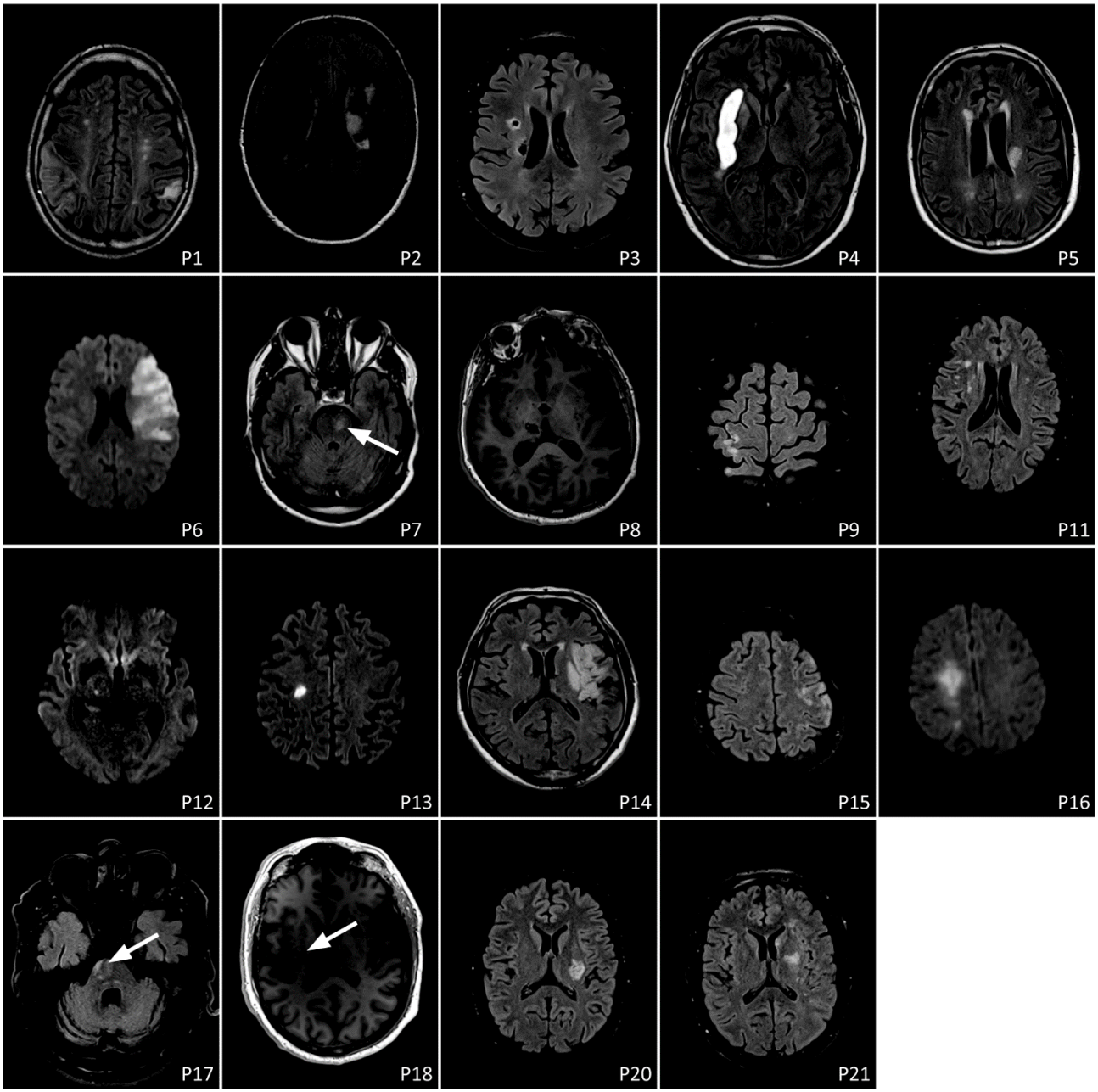
Supplementary Figure 1. CONSORT flowchart. The Stroke database of the CHU UCL Namur (Mont-Godinne) was screened for patients corresponding to the inclusion/exclusion criteria. After providing written informed consent, the selected patients were randomized using the randomisation criteria (see below) by a third person and the Eldith® codes for real/sham stimulation were given to the experimenter. Both the experimenter and patients were blinded about the type of stimulation (real/sham). Some patients had to be excluded because they were not able to perform the bimanual task, their UL being either too paretic (plegic) or too spastic.

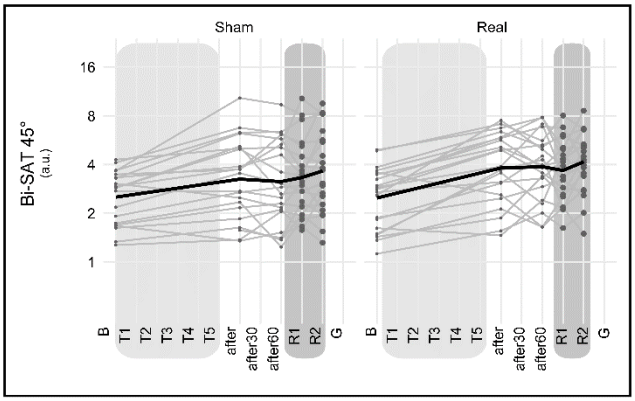
Supplementary Figure 2. MRI scans of the patients. P6, P12 and P13 had Diffusion-Weighted Imaging (DWI). P8 and P18 had T1-weighted MRI. For P10 and P19, only the report of the radiologist was available indicating a small cortico-subcortical stroke of the left precentral-postcental gyri in P10 and a cortico-subcortical infarction of the right fronto-parietal areas (superficial MCA territory) for P19. All other patients had FLAIR T2-weighted MRI.

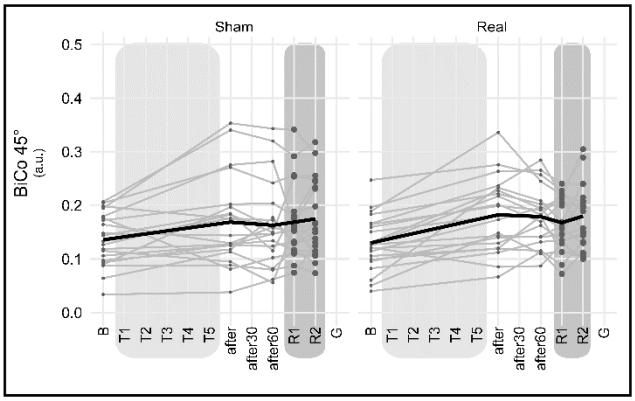
Supplementary Figure 3. Bimanual REACHING. Progression of Bi-SAT & Bi-Co for targets set at ± 22.5° and ± 45°, and that of Bi-SAT for 0° target over five time points: B= baseline; after= after stimulation; after60= 60 minutes after stimulation; R1= before the first retention test; R2= after the second retention test, for real and sham dual-tDCS conditions. Bi-SAT data are presented on a logarithmic scale, and were logarithmically transformed.

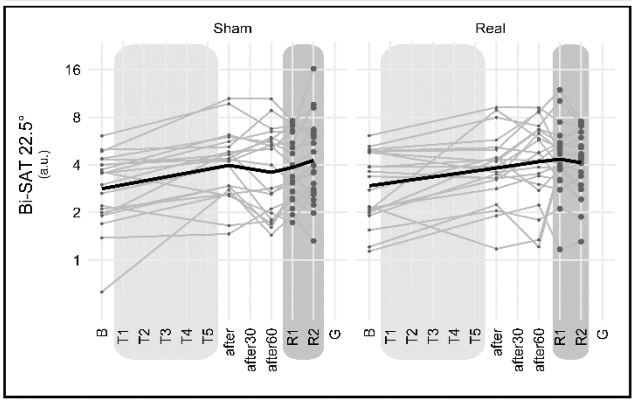
Supplementary Figure 4. Box and Blocks (B&B). Number of blocks transferred by the paretic hand (PH) and non-paretic hand (NPH) for both real and sham dual-tDCS conditions in five time points: B= baseline; after= after stimulation; after60= 60 minutes after stimulation; R1= before the first retention test; R2= after the second retention test.

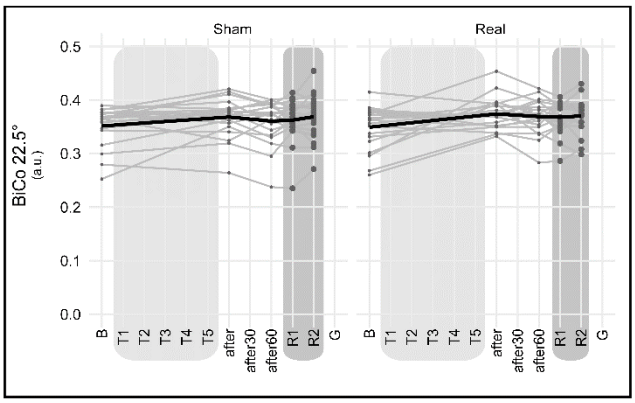

Enrollment
Assessed for eligibility (n= 343)
Excluded (n= 312)
• Not meeting inclusion criteria (n=305)
• Decline to participate (n=7)
• Other reasons (n=0)
Randomized (n= 31)
Allocation
Allocated to intervention (n=16)
• Received allocated intervention (n=11)
• Did not receive allocated intervention (n=5)
(Reason= incapable of performing the task because of hand spacticity)
Allocated to intervention (n=15)
• Received allocated intervention (n=12)
• Did not receive allocated intervention (n=3)
(Reasons= incapable of performing the task because of hand spacticity, change of idea before the first session)
Follow-Up
Lost to follow-up (n=0)
Discontinued intervention (n=1)
Reason= getting ill between the second and third session
Lost to follow-up (n=0)
Discontinued intervention (n=1)
Reason= getting ill between the second and third session
Analysis
Analyzed (n=10)
• Excluded from analysis (n=0)
Analyzed (n=11)
• Excluded from analysis (n=0)

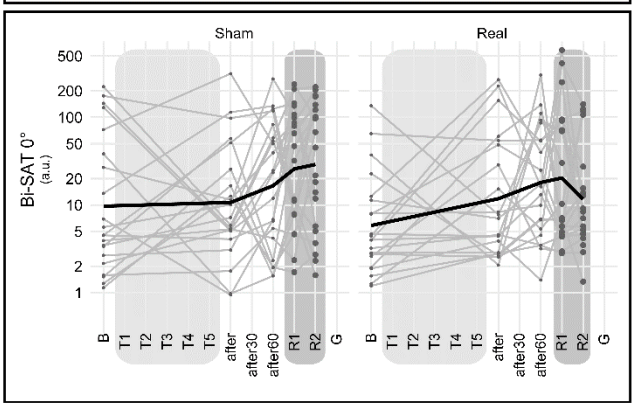

P1
P2
P3
P4
P5
P6
P7
P8
P9
P11
P12
P13
P14
P15
P16
P17
P18
P20
P21

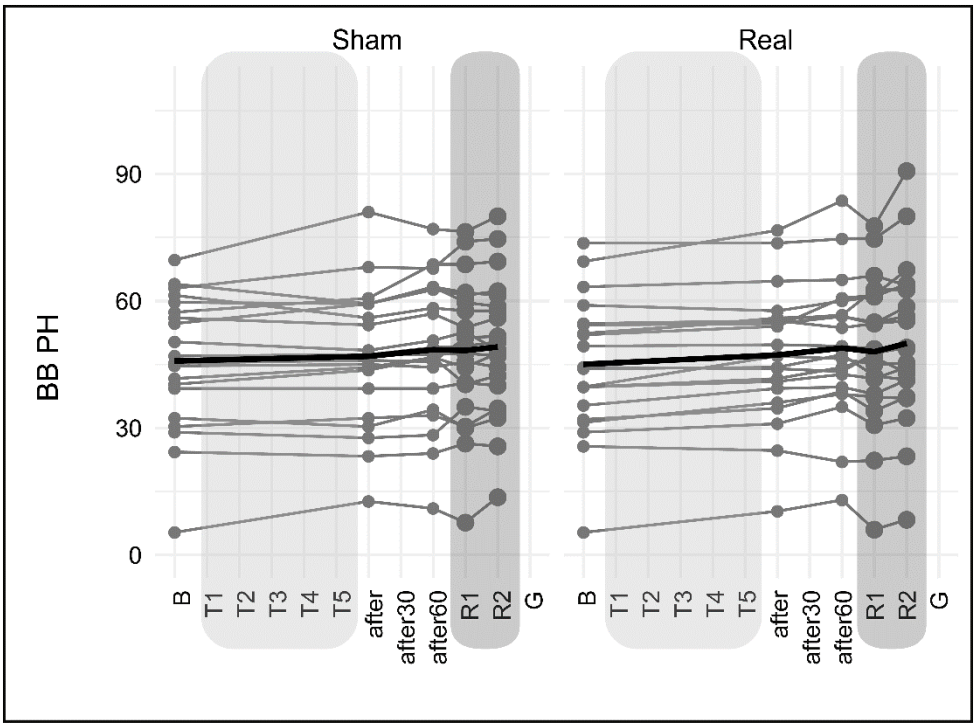

Sham
Real
Bi-SAT 45°
(a.u.)
16
8
4
2
1
B
T1
T2
T3
T4
T5
after
after30
after60
R1
R2
G

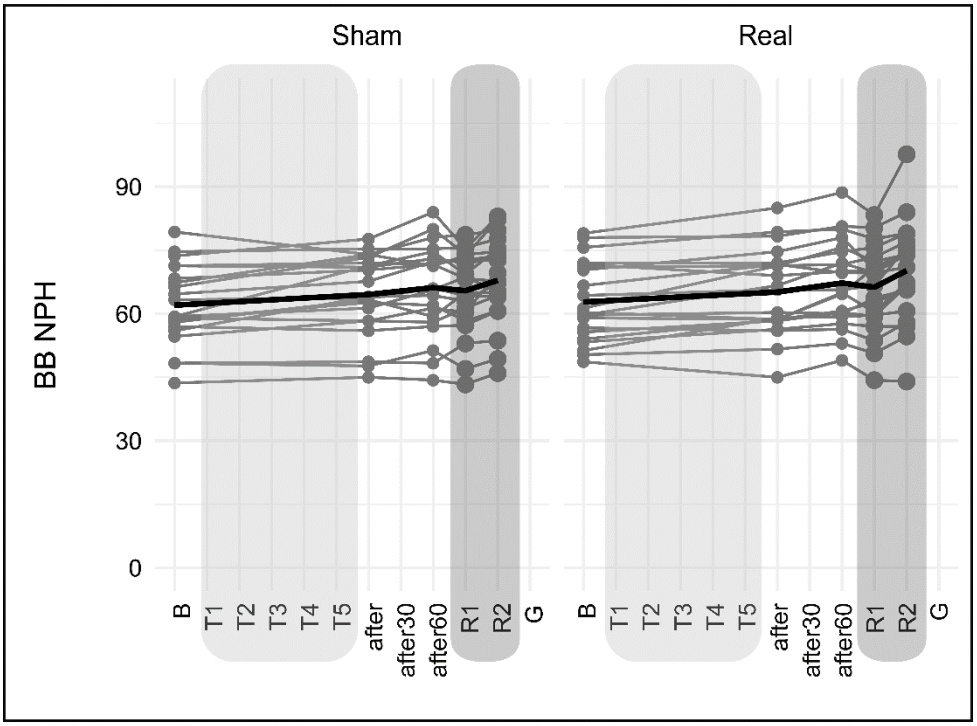

Sham
Real
BiCo 45°
(a.u.)
0.5
0.4
0.3
0.2
0.1
0.0
B
T1
T2
T3
T4
T5
after
after30
after60
R1
R2
G


Sham
Real
Bi-SAT 22.5°
(a.u.)
16
8
4
2
1
B
T1
T2
T3
T4
T5
after
after30
after60
R1
R2
G


Sham
Real
BiCo 22.5°
(a.u.)
0.5
0.4
0.3
0.2
0.1
0.0
B
T1
T2
T3
T4
T5
after
after30
after60
R1
R2
G


Sham
Real
Bi-SAT 0°
(a.u.)
500
200
100
50
20
10
5
2
1
B
T1
T2
T3
T4
T5
after
after30
after60
R1
R2
G


Sham
Real
BB PH
90
60
30
0
B
T1
T2
T3
T4
T5
after
after30
after60
R1
R2
G


Sham
Real
BB NPH
90
60
30
0
B
T1
T2
T3
T4
T5
after
after30
after60
R1
R2
G

Bimanual CIRCUIT

	time	**time × stimulation order**	**time × paretic UL's direction order**	**time × stim. order × paretic UL direction order**
Bi-SAT	(t_{17df}= 0.33; p=0.74)	(t_{17df}= 0.87; p=0.39)	(t_{17df}= 0.71; p=0.49)	(t_{17df}= -1.15; p=0.27)
Bi-Co	(t_{17df}= -0.92; p=0.37)	(t_{17df}= -0.43; p=0.67)	(t_{17df}= -1.17; p=0.26)	(t_{17df}= 0.50; p=0.63)

Supplementary Table 1. No carry-over effect was detected by GLMM for the stimulation type, order of paretic UL's direction or their interaction.

		% of learning (mean ± SD)	% of retention (mean ± SD)	% of generalization (mean ± SD)
Bi-SAT	real	65% ± 26%	56% ± 27%	60% ±30%
	sham	51% ± 23%	49% ± 27%	63 % ±29%
Bi-Co	real	14% ± 9%	14% ±8%	15% ±10%
	sham	6% ±10%	9% ± 6%	9% ±10%

Supplementary Table 2. Percentage of improvement. The degree of improvement (in percentage) in Bi-SAT and Bi-Co one hour after learning (after60), the degree of retention and the degree of generalization after one week under real and sham condition are shown.