**Executive functions training protocol**

Different EF training tasks were administered in blocks. In each block, instructions were presented on screen and were followed by practice trials. Upon successful completion of the practice trials, the participant would proceed to the actual trials.

Table S1. Description of EF training tasks

|  |  |
| --- | --- |
| **Task** | **Description of task** |
| Reaction time task 1 | Smiley faces appeared for a fixed duration at fixed location(s) in each trial. The subject has to press different keys to respond depending on its location.  The subject was administered three blocks of 48 trials each.  Block 1: Smiley faces appeared in the middle  Block 2: Smiley faces appeared at two possible locations (left and right)  Block 3: Smiley faces appeared at four possible locations (left, right, top and bottom) |
| Reaction time task 2 | Light bulb(s) were shown on screen and would flash randomly for a fixed duration at fixed location(s) in each trial. The subject has to press different keys to respond depending on its location.  The subject was administered three blocks of 48 trials each.  Block 1: One light bulb was on screen throughout the block, and lit at fixed intervals  Block 2: Three light bulbs were on screen throughout the block, one of them would light up randomly each time.  Block 3: Six light bulbs were on screen throughout the block, one of them would light up randomly each time. |
| Reaction time task 3 | Buns appeared at random locations for a fixed duration in each trial. The subject has to respond by clicking on it. Upon 10 consecutive correct responses, the interstimulus intervals (starting at 1s) would decrease by 100ms.  The subject was be administered three identical blocks of 48 trials each. |
| Inhibition task 1 | The subject was administered four blocks of 120 trials each.  Block 1: A red or green circle appeared randomly on the left or right side of the screen in each trial. The subject has to press the left or right button, respectively, to respond to a green or red circle, regardless of their locations.  Block 2: A red or green arrow (pointing left or right) appeared randomly on the left or right side of the screen in each trial. The subject has to press the left or right button, respectively, to respond to a green or red arrow, regardless of their locations or the direction these arrows are pointing at.  Block 3: A black circle appeared randomly on the left or right side of the screen in each trial. The subject has to press two assigned buttons in an incongruent manner to respond to the location of the stimuli (i.e., left button to respond to the circle appearing on the right and left button to respond to the circle appearing on the right).  Block 4: same as Block 1. |
| Inhibition task 2 | The subject was administered four blocks of 120 trials each  Block 1: A black arrow (pointing left or right) appeared randomly on the left or right side of the screen in each trial. The subject has to press the left or right button, in a congruent manner, to respond to the location of the arrow, regardless of the direction the arrows are pointing at.  Block 2: same as Block 2 of Inhibition task 1.  Block 3: The subject was instructed to put on headphones for this block. A tone was played to the left or right side in each trial. The subject would respond to the tone in an incongruent manner via two assigned keys (i.e., left key to respond to tone on the right side and right key to respond to tone on the left side).  Block 4: same as Block 1 of Inhibition task 1. |
| Dual-task 1 | The subject was instructed to put on headphones for this task. The subject was administered three identical blocks of 36 trials each.  During each trial, varying number of fruits appeared on screen and a high (880Hz) or low tone (440Hz) was played. The subject has to press one of two buttons depending on whether an odd or even number of fruits had appeared on screen, and also press another one of two buttons depending on whether a high or low tone was heard. |
| Dual-task 2 | The subject was instructed to put on headphones for this task. The subject was administered three identical blocks of 36 trials each.  During each trial, a blue (of different shades) circle appeared on screen, and a high (880Hz) or low tone (440Hz) was played. The subject has to press one of two buttons depending on whether the current circle’s shade was darker or lighter than that of the previous, and also press another one of two buttons depending on whether a high or low tone was heard. |
| Dual-task 3 | The subject was instructed to put on headphones for this task. The subject was administered three identical blocks of 36 trials each.  During each trial, an arithmetic equation (e.g., 42+4) appeared on the screen, and a high (880Hz) or low tone (440Hz) was played. The subject has to press one of two buttons depending on whether the answer to the equation exceeded 45, and also press another one of two buttons depending on whether a high or low tone was heard. |
| Dual-task 4 | The subject was instructed to put on headphones for this task. The subject was administered three identical blocks of 36 trials each.  During each trial, the screen was divided into the left and right halves. In the left half, pegs appeared on the left and right sides within this half of the screen. In the right half of the screen, a random shape would appear. The subject has to press one of two buttons depending on whether there were more pegs on the left or right side within the left half, and also press another one of two buttons depending on whether the shape on the right half was orange or yellow in color. |
| Dual-task 5 | The subject was instructed to put on headphones for this task. The subject was administered three identical blocks of 36 trials each.  During each trial, the screen was divided into the left and right halves. Some coins and leaves would appear on the left and right halves of the screen respectively. The subject has to press one of two buttons depending on whether the total value of the coins exceeded HK$15, and also press another one of two buttons depending on whether there was an odd or even number of leaves |

Table S2. Descriptive statistics of cognitive measures across all time-points

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Time-point** | **Cognitive measure** | **Sham** | | | **tDCS** | | |
| **Valid N** | **Mean** | **SD** | **Valid N** | **Mean** | **SD** |
| Baseline | |  |  |  |  |  |  |
|  | CTT - Part 2 | 33 | 104.580 | 26.985 | 35 | 120.429 | 47.612 |
|  | CTT - Interference | 33 | 1.046 | 0.583 | 35 | 1.058 | 0.449 |
|  | Stroop - Color word | 33 | 34.632 | 8.406 | 35 | 36.531 | 14.689 |
|  | Stroop - Interference | 33 | 19.013 | 8.644 | 35 | 21.232 | 12.894 |
|  | Figural Fluency | 33 | 61.182 | 19.814 | 35 | 58.743 | 26.123 |
|  | Tower of London | 33 | 4.182 | 1.722 | 35 | 3.943 | 1.765 |
|  | HCT errors | 33 | 67.061 | 26.353 | 35 | 90.229 | 28.136 |
| Post-intervention | |  |  |  |  |  |  |
|  | CTT - Part 2 | 33 | 91.980 | 21.719 | 35 | 117.598 | 50.383 |
|  | CTT - Interference | 33 | 1.013 | 0.471 | 35 | 1.216 | 0.732 |
|  | Stroop - Color word | 33 | 31.578 | 9.962 | 35 | 33.453 | 10.468 |
|  | Stroop - Interference | 33 | 16.735 | 8.827 | 35 | 18.477 | 9.379 |
|  | Figural Fluency | 33 | 69.303 | 23.465 | 35 | 60.257 | 25.079 |
|  | Tower of London | 33 | 4.636 | 1.868 | 35 | 4.657 | 2.182 |
|  | HCT errors | 33 | 53.000 | 26.279 | 35 | 83.429 | 31.822 |
| 1-month follow-up | |  |  |  |  |  |  |
|  | CTT - Part 2 | 31 | 91.535 | 27.109 | 33 | 109.014 | 46.358 |
|  | CTT - Interference | 31 | 1.084 | 0.526 | 33 | 1.169 | 0.639 |
|  | Stroop - Color word | 31 | 33.255 | 10.152 | 33 | 31.848 | 14.070 |
|  | Stroop - Interference | 31 | 18.693 | 9.436 | 33 | 16.916 | 10.692 |
|  | Figural Fluency | 31 | 75.516 | 28.969 | 33 | 68.909 | 27.321 |
|  | Tower of London | 31 | 5.000 | 2.000 | 33 | 5.273 | 1.957 |
|  | HCT errors | 31 | 47.065 | 27.889 | 33 | 66.303 | 34.437 |
| Post-intervention – baseline (change score) | | | | | | | |
|  | CTT - Part 2 | 35 | -2.831 | 26.501 | 33 | -12.601 | 18.329 |
|  | CTT - Interference | 35 | 0.158 | 0.717 | 33 | -0.033 | 0.633 |
|  | Stroop - Color word | 35 | -3.078 | 9.438 | 33 | -3.053 | 9.413 |
|  | Stroop - Interference | 35 | -2.755 | 10.191 | 33 | -2.278 | 9.738 |
|  | Figural Fluency | 35 | 1.514 | 16.470 | 33 | 8.121 | 15.089 |
|  | Tower of London | 35 | 0.714 | 2.008 | 33 | 0.455 | 1.660 |
|  | HCT errors | 35 | -6.800 | 20.588 | 33 | -14.061 | 15.019 |
| 1-month follow-up – baseline (change score) | | | | | | | |
|  | CTT - Part 2 | 33 | -10.021 | 28.130 | 31 | -12.119 | 20.537 |
|  | CTT - Interference | 33 | 0.121 | 0.743 | 31 | 0.045 | 0.850 |
|  | Stroop - Color word | 33 | -5.262 | 10.709 | 31 | -1.650 | 7.594 |
|  | Stroop - Interference | 33 | -4.775 | 10.387 | 31 | -0.340 | 8.199 |
|  | Figural Fluency | 33 | 11.636 | 14.616 | 31 | 13.806 | 18.895 |
|  | Tower of London | 33 | 1.333 | 2.026 | 31 | 0.935 | 1.672 |
|  | HCT errors | 33 | -24.636 | 19.371 | 31 | -20.484 | 17.320 |

Note. SD= Standard deviation; HCT=Halstead Category Test; CTT= color trails test.

**Side effects**

The data (only from completers) was fitted to a hierarchical linear model. A random intercept (*β*i0) is included in the model. The stimulation group is modelled as a fixed effect (*β*i1). The model is specified as below:

Level 1:

*y*ij = *β*i0 + *β*i1(stimulation) + *e*ij

Where

*y*ij represents the side-effect score for participanti at sessionj

*β*i0 represents the random intercept for participanti

*β*i1 represents the fixed effect of stimulation (tDCS=1, Sham =0) for participanti

*e*ij represents the residual

Level 2

*β*i0= *γ*00 + ui0

Where

*γ*00 represents the intercept for all participants

*u*i0 represents the residual

As seen from table, the self-reporting ratings of all assessed side-effects were not significantly different between group.

Table S3. Between-group differences in the self-reported ratings of various side-effects

|  |  |  |  |
| --- | --- | --- | --- |
| Side effect | *β* | SE | *p* |
| Itchiness underneath the electrodes | .26 | .20 | .199 |
| Burning sensation underneath the electrodes | -.03 | .17 | .861 |
| Pain underneath the electrodes | -.20 | .15 | .190 |
| Headache | -.14 | .14 | .333 |
| Difficulty in concentration | -.25 | .19 | .180 |
| Anxiety | -.10 | .20 | .601 |

Note. Positive *β* valuesindicate higher ratings in the tDCS group. SE= standard error.

Table S4. Results of all estimated fixed covariates

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Fixed covariate** | **Cognitive measure** | **Standardized Coefficient** | ***Df*** | **SE** | **95% CI** | ***p*** | ***t*** |
| Intercept (*β*0) |  |  |  |  |  |  |  |
|  | CTT - Part 2 | -.156 | 66.920 | .226 | [-.598, .286] | .492 | -.690 |
|  | CTT - Interference | .884 | 62.815 | .373 | [.152, 1.615] | .021 | 2.368 |
|  | Stroop - Color word | -.806 | 69.464 | .267 | [-1.330, -.282] | .004 | -3.013 |
|  | Stroop - Interference | -.852 | 69.703 | .295 | [-1.429, -.275] | .005 | -2.892 |
|  | Figural Fluency | -.869 | 66.638 | .230 | [-1.320, -.418] | <.001 | -3.777 |
|  | Tower of London | -.229 | 67.057 | .336 | [-.888, .430] | .498 | -.682 |
|  | HCT errors | -.634 | 66.452 | .218 | [-1.061, -.207] | .005 | -2.908 |
| Baseline (*β*1) |  |  |  |  |  |  |  |
|  | CTT - Part 2 | .765 | 64.344 | .064 | [.640, .891] | <.001 | 11.977 |
|  | CTT - Interference | .112 | 57.476 | .102 | [-.088, .312] | .277 | 1.098 |
|  | Stroop - Color word | .614 | 63.916 | .074 | [.469, .759] | <.001 | 8.298 |
|  | Stroop - Interference | .517 | 63.503 | .081 | [.358, .676] | <.001 | 6.357 |
|  | Figural Fluency | .691 | 64.026 | .064 | [.566, .817] | <.001 | 1.796 |
|  | Tower of London | .519 | 62.922 | .092 | [.340, .699] | <.001 | 5.658 |
|  | HCT errors | .716 | 63.673 | .069 | [.581, .851] | <.001 | 1.411 |
| Education (*β*2) |  |  |  |  |  |  |  |
|  | CTT - Part 2 | .018 | 63.790 | .016 | [-.014, .049] | .273 | 1.105 |
|  | CTT - Interference | -.056 | 58.380 | .026 | [-.107, -.006] | .032 | -2.197 |
|  | Stroop - Color word | .057 | 64.444 | .019 | [.021, .094] | .003 | 3.078 |
|  | Stroop - Interference | .061 | 64.353 | .020 | [.021, .100] | .004 | 2.971 |
|  | Figural Fluency | .062 | 63.553 | .016 | [.031, .094] | <.001 | 3.866 |
|  | Tower of London | .003 | 63.326 | .023 | [-.043, .048] | .906 | .119 |
|  | HCT errors | .042 | 63.738 | .016 | [.011, .074] | .010 | 2.664 |
| Stimulation (*β*3) | |  |  |  |  |  |  |
|  | CTT - Part 2 | -.190 | 63.553 | .127 | [-.438, .058] | .138 | -1.502 |
|  | CTT - Interference | -.393 | 59.025 | .208 | [-.801, .015] | .064 | -1.888 |
|  | Stroop - Color word | .221 | 65.222 | .147 | [-.066, .509] | .136 | 1.508 |
|  | Stroop - Interference | .260 | 65.108 | .164 | [-.062, .581] | .118 | 1.582 |
|  | Figural Fluency | -.034 | 64.356 | .125 | [-.278, .210] | .785 | -.274 |
|  | Tower of London | .133 | 63.373 | .187 | [-.234, .500] | .481 | .709 |
|  | HCT errors | -.096 | 64.108 | .126 | [-.342, .150] | .447 | -.766 |
| Time (*β*4) |  |  |  |  |  |  |  |
|  | CTT - Part 2 | .106 | 64.531 | .072 | [-.036, .248] | .147 | 1.466 |
|  | CTT - Interference | -.040 | 64.730 | .139 | [-.312, .232] | .773 | -.289 |
|  | Stroop - Color word | .024 | 66.917 | .106 | [-.183, .231] | .819 | .230 |
|  | Stroop - Interference | -.001 | 66.828 | .120 | [-.236, .235] | .994 | -.008 |
|  | Figural Fluency | .308 | 65.444 | .073 | [.166, .451] | <.001 | 4.232 |
|  | Tower of London | .261 | 64.741 | .117 | [.032, .490] | .029 | 2.238 |
|  | HCT errors | .363 | 64.821 | .063 | [.239, .488] | <.001 | 5.725 |

Note. Df= degree of freedom; SE= Standard Error; CI= confidence interval; HCT=Halstead Category Test; CTT= color trails test.