APPENDIX S1. Additional information on the experimental settings

Neuromuscular electrical stimulation neuromuscular electrical stimulation (NMES)

A pair of self-adhesive electrodes was placed over the muscle belly of the extensor digitorum communis (EDC) on the paralysed side. NMES (20 Hz, single pulse width 100 μs, 3 s ON, 3 s OFF) was delivered through an electrical stimulator (MEB-2200, Nihon Kohden, Tokyo, Japan). Every day before intervention, the intensity of electrical stimulation was adjusted and fixed at just over motor threshold for evoking visible contraction of EDC muscles (15–20 mA).

Electroencephalography recordings

Electroencephalography (EEG) recordings were made from the scalp near the sensorimotor cortex using 5 silver–silver chloride (Ag-AgCl) surface electrodes with a diameter of 10 mm placed at C3 (left) and C4 (right), defined by the international 10–20 system, and their 20 mm front, back, left lateral, and right lateral positions. The reference electrode was placed at A2 (right earlobe). An additional electrode was placed at A1 (left earlobe) as a ground electrode. EEG was amplified (×50,000) and band-pass filtered (0.5–100 Hz) using a commercially available bioamplifier (g.USBamp, g.tec, Graz, Austria). A Laplacian transformation with 5 electrodes in each hemisphere was used to produce a signal of estimates of current source density for precise cortical activity detection. Signals produced from the left and right hemispheres were digitally sampled at a sample frequency of 1,024 kHz with 12-bit resolution, and were stored on the hard disk of a personal computer.

Calibration of brain computer interface in epoch B

At the beginning of the intervention in epoch B, 40 trials of the cue-based motor task were conducted as a rehearsal, and the parameters of the event-related desynchronization (ERD) detection algorithm in brain computer interface (BCI) were calibrated using the obtained data. During the rehearsal, an arrow pointing to the left ("attempting paretic finger extension") or no arrow (rest) was displayed for 1 s over a cross-shaped icon in the centre of a monitor, and the subject performed the cued task for the next 4 s. Twenty trials per class were given in a randomized order. A 4-dimensional feature vector (the power spectrum densities in alpha (mu) and beta frequency bands in the left and right hemispheric EEGs) was calculated every 30 ms, with a time-sliding window of 1 s during the task. The feature vectors with annotations of either "attempting finger extension" or "during rest" were mapped onto the feature space, and the parameters in the linear discriminant analysis (LDA) algorithm were optimized using g.BSanalyze software (g.tec Guger Technologies, Graz, Austria) to separate the features into appropriate classes. Consequently, the LDA returned either the value "+1" (resting) or "–1" (finger extension) every 30 ms according to the EEGs.

Outcome measures

Functional magnetic resonance imaging analysis. The first 5 images (for 15 s) of each set were discarded, because they showed irregular contrasts acquired before the MRI signal had reached an equilibrium state. Next, motion correction was performed by realigning all the functional volumes to the first volume of the functional series, and by co-registration to the anatomical volume. All co-registered images were normalized to the Montreal Neurological Institute template. After normalization, images were smoothed with a Gaussian kernel (full-width at half-maximum, 8 mm). We estimated the task-specific effects using the general linear model with a delayed boxcar waveform. The boxcar waveform was convolved with the canonical haemodynamic response function. Significance was determined on a voxel-by-voxel basis using a *t*-statistic, which was then transformed to a normal distribution. The resulting sets of spatially distributed *Z*-values constitute statistical parametric maps (SPM{*Z*}), which show regions of significant condition-associated signal changes. These regions were then displayed with a statistical threshold based on the amplitude ($p<0.05$ corrected for multiple comparisons). The voxels with a greater *Z*-value were regions for which blood oxygenation level dependent signal enhancement, caused by changes in blood oxygenation, occurred in accordance with the task. Laterality index (LI) was calculated for the voxels within the whole hemisphere and precentral gyrus.

EEG analysis. The time-frequency map of ERD on the day of admission and the last day of each training period was calculated to examine the change in the value of ERD. ERD was defined as the decrease in the power spectrum relative to the reference period, and the ERD value was defined by the following equation:

$$\mathrm{ERD}(f,t)=\frac{R(f)-A(f,t)}{R(f)}$$

where A(f,t) is the power spectrum of the EEG at frequency f at time t, with reference to the onset of motor intention, and R(f) is the power spectrum of a 1 s epoch of the reference period in each trial. Using this definition, ERD was expressed as a positive number in this study.

As stated above, the computer program returned the result of LDA, either "+1" (resting) or "–1" (finger extension) according to the EEGs. Classification accuracy during training was calculated.

Corticomuscular coherence. EEG and EMG signals during the "finger extension" state were segmented into artefact-free epochs of 1 s duration without overlapping (a total of 100 epochs). To measure the linear correlation between EEG and EMG, coherence was calculated using a fast Fourier transform algorithm with a frequency resolution of 1 Hz, according to the following equation:

$$|R_{xy}(i)|^2=\frac{|f_{xy}(i)|^2}{|f_{xx}(i)\times f_{yy}(i)}$$

In this equation, fxx(i) and fyy(i) are autospectra of the EEG and EMG signals, x and y, for a given frequency (i), and the fxy(i) is the cross-spectrum between them.