MRI scanning procedure

The patient went through a training phase before fMRI scanning aimed at familiarizing her with the experimental procedure. She lay supine in the bore of the scanner in a dimly lit environment. Instructions and visual stimuli were presented with a Resonance Technology® goggles-based MRI-compatible visual stimulation system having the following characteristics: visual field 30° horizontal and 22.5° vertical (actual physical distance from display to cornea 40 mm), resolution 800 x 600, 60 Hz monitor frequency, maximum white luminance 70 cd/m². Digital transmission of signal to scanner was via optic fiber. Software E-Prime2 Professional (Psychology Software Tools, Inc., http://www.pstnet.com) was used both for stimulus presentation. Each run lasted about 5 min.

MRI data acquisition

Data were acquired using a 3T GE Discovery MR750 scanner, equipped with an 8-channel receiver head coil. Three gradient-echo echo-planar imaging (GR-EPI) pulse sequence acquisitions were performed as follows: after four dummy scans to obtain the stationary regime for the magnetization signal, 150 volumes were acquired with anterior-posterior phase encoding direction with 36 sequential ascending slices (2.3 mm thickness, inter-slice gap 0.7 mm), TR=2000 ms, TE=30 ms, bandwidth=250 KHz, MATRIX 128 x 128, FOV 240 x 240 mm². A high-resolution T1-weighted sequence was acquired as anatomical reference, and consisted in an inversion-recovery-prepared fast spoiled gradient recalled sequence (IR-prepared FSPGR), 0.9 x 0.9 x 0.9 mm3, TI=650 ms, TE=4 ms, TR=9.7 ms, FA=9°, MATRIX=512 x 512 x 192, BW=98 Hz/pixel.
DTI data acquisition

A DTI spin-echo single shot EPI sequence, with TR/TE 56586/82.4 ms, 2 mm isotropic voxels, 64 encoding directions with an effective b value of 1000 s/mm², 8 images with no diffusion weight in Anterior-Posterior phase encoding direction was added to the MR protocol in order to investigate the white matter connectivity. All DTI data processing was performed offline using the FMRIB Software Library (FSL) tools (version 5.0.9) [S1, S2, S3] with a dedicated workstation. Source images were corrected for head motion and distortions caused by eddy currents with the FSL’s tool Eddy [S1, S4]. Diffusion Tensor reconstruction was performed using FSL’s BEDPOSTX tool, based on a multifiber diffusion model which allows for fiber crossing within each voxel of the brain [S5, S6]. A further probabilistic tractography analysis was performed with FSL’s PROBTRACKX tool (curvature threshold = 0.2, number of sample = 5000) [S5, S6]. The seed points for the reconstruction of inferior longitudinal fasciculus (ILF), superior longitudinal fasciculus (SLF) and corticospinal tract (CS) were drawn as 6 mm cube on the base of ROIs in the Catani and Thiebaut de Schotten tractography atlas [S7] (respective z reference = -37, 15, 33, 33), while the waypoints were selected as points of obligated passage suggested by the same atlas.

fMRI Data preprocessing and statistical analyses

Data analysis was performed with SPM8 (Wellcome Department of Imaging Neuroscience, University College, London, UK; http://www.fil.ion.ucl.ac.uk/spm) running on MATLAB R2016 (The Mathworks, Inc.). Structural images were manually centered and reoriented with functional images to the anterior-posterior commissure axis. The first four EPI volumes of each functional run were discarded to allow the magnetization to reach a steady state. All volumes were slice timing corrected, spatially realigned to the first volume of the first functional run and un-warped to correct for between-scan motion. Motion parameters were used as predictors of no-interest in the
model to account for translation and rotation along the three possible dimensions as determined during the realignment procedure. T1-weighted image was segmented into gray, white and cerebrospinal fluid and spatially normalized to the Montreal Neurological Institute (MNI) space. Spatial transformation derived from this segmentation was then applied to the realigned EPIs for normalization and re-sampled in 2×2×2 mm³ voxels using trilinear interpolation in space. All functional volumes were then spatially smoothed with a 6-mm full-width half maximum isotropic Gaussian kernel.

Single-subject fMRI responses were modelled using a General Linear Model (GLM), for which a design-matrix included the onsets and durations of each block for each condition. Subject contrast images were constructed by comparing the estimated hemodynamic response over all blocks of active tasks to all blocks of rest. In particular, the model included three predictors corresponding to the contrast between each active task and the rest condition (Visual Stimulation vs Rest; Finger Tapping vs Rest; Verbal Production vs Rest) plus six predictors obtained from the motion correction in the realignment process to account for voxel intensity variations caused by head-motion and one constant regressor per run. Statistical significance was thresholded at \( P < 0.05 \), with Family Wise Error correction (FWE) for multiple comparisons applied at voxel level.

References

S1. Smith SM, Jenkinson M, Woolrich MW, et al. Advances in functional and structural MR image analysis and implementation as FSL. Neuroimage. 2004; 23: 208-219.

S2. Woolrich MW, Jbabdi S, Patenaude B, et al. Bayesian analysis of neuroimaging data in FSL. Neuroimage. 2009; 45: 173-186.

S3. Jenkinson M, Beckmann CF, Behrens TE, et al. Fsl. Neuroimage. 2012; 62: 782-790.

S4. Jesper L. R. Andersson and Stamatios N. Sotiropoulos. An integrated approach to correction for off-resonance effects and subject movement in diffusion MR imaging. NeuroImage, 125:1063-1078, 2016
S5. Behrens TEJ, Woolrich MW, Jenkinson M. Characterization and propagation of uncertainty in diffusion-weighted MR imaging. Magn Res Med 2003; 50: 1077-1088.

S6. Behrens TEJ, Johansen-Berg H, Jbabdi S, et al. Probabilistic diffusion tractography with multiple fibre orientations. What can we gain? Neuroimage. 2007; 34: 144-155.

S7. Catani M, Thiebaut de Schotten M. A diffusion tensor imaging tractography atlas for virtual in vivo dissections. Cortex. 2008; 44: 1105–1132.