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Supplemental Information

Multisensory Mechanisms in Temporo-Parietal Cortex Support Self-Location and First-Person Perspective

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Inventory of Supplemental Information

Table S1.

Q1	Have you had the impression to look Up/Down at the image of a body Above/Below you?
Q2	How strong was the feeling that you were located at some distance above/below the body that you saw?
Q3	How strong was the feeling that the body you saw was you?
Q4	Have you ever forgotten that you were located in the scanner?
Q5	How strong was the feeling that the touch you felt was located where you saw the stroking?
Q6	I felt my body as usual, nothing changed.

Table S1. Questions administrated to participant during the experimental session, related to Figure 3.

Table S2

Region (*label*)	Hemisphere	$F_{(1,20)}$ score	Cluster Size (voxels)	MNI coordinates		
				x	y	z
Superior Temporal gyrus (*lTPJ*)	Left	14.72	192	-54	-32	20
Superior Temporal gyrus (*rTPJ*)	Right	12.36	197	55	-28	16
Middle-Inferior Temporal gyrus (*lEBA*)	Left	15.33	247	-46	-74	2
Middle-Inferior Temporal gyrus (*rEBA*)	Right	15.02	239	50	-70	0
Postcentral gyrus (*lPtC*)	Left	14.02	68	-22	-30	70
Postcentral gyrus (*rPtC*)	Right	11.76	41	38	-20	44
Occipital lobe (Med*Occ*)	Left+Right	45.40	3440	16	-98	16

Table S2. Active Clusters. Anatomical region and statistical values for all active clusters resulting from the interaction between Object, Synchrony, and Perspective. The abbreviations (in brackets) refer to the different regions as used in the SI, related to Figure 4.

Table S3.

	Patient	Group	Diagnosis	Lesion site (lobe)	Side	Lesion analysis
1	A.B.	OBE	Ischemic lesion	Temporo-parietal	Right	MRI, PET
2	F.M. (Maillard et al., 2004)	OBE	Epilepsy (focal dysplasia)	Parietal	Right	MRI, EEG
3	B. (Brandt et al., 2005)	OBE	Epilepsy (focal dysplasia)	Parietal	Right	MRI
4	A.G.	OBE	Traumatic brain injury	Temporo-parietal	Right	MRI, EEG
5	C.R.(Blanke, 2004)	OBE	Epilepsy (focal dysplasia)	Temporo-parietal	Left	MRI, SEEG
6	D.R. (De Ridder et al., 2007)	OBE	Tinnitus (no structural lesion)	Temporo-parietal	Right	Intracranial stimulation, MRI, PET
7	V.M.	OBE	Subarachnoid bleeding (post operative lesion)	Temporo-parietal	Right	MRI
8	H.B.(Blanke, 2004)	OBE	Epilepsy (dysembryoblastic neuroepithelial tumor)	Parieto-occipital	Right	MRI, EEG, SPECT
9	F.M.(Blanke, 2004)	OBE	Epilepsy (no structural lesion)	Temporo-parietal	Right	Intracranial stimulation, MRI
1	B.F. (Zamboni et al., 2005)	Control	Ischemic lesion (Eclampsia)	Occipital	Right	MRI
2	C.P. (Maillard et al., 2004)	Control	Epilepsy (hematoma)	Parieto-occipital	Right	MRI, EEG*
3	M (Maillard et al., 2004)	Control	Epilepsy (oligodendroglioma)	Occipital	Right	MRI, EEG*
4	A.T.	Control	Epilepsy (parasitosis)	Occipital	Right	MRI, EEG
5	S.M.	Control	Subarachnoid bleeding and ischemic insult	Temporal	Right	MRI*
6	F.M.	Control	Epilepsy (no structural lesion)	Temporo-occipital	Right	Intracranial stimulation, MRI
7	V.K.	Control	Epilepsy (Ischemic lesion)	Parieto-occipital	Right	MRI, EEG, PET, SPECT
8	A.M.	Control	Ischemic lesion	Occipital	Right	MRI, CT

* Enough imaging data were available for accurate tracing onto a normalized standard template brain. No normalization of the original data was possible in these cases.

Table S3. Clinical Characteristics of Patients with OBEs and the Control Group. The lesion analysis was performed using a multimodal imaging approach including data from MRI, PET, SPECT, intracranial stimulation, and subdural EEG (SEEG), related to Figure 5.

Table S4

S.	COND	FREE REPORTS	GROUP
1	Sync	"I had the impression of watching a photo of myself, as if I was higher than before and I was looking at the back of another person in front of me."	Up
	Async	"I had the impression of having two bodies. I arrived to the point of asking myself whether my perceptions were correct."	
3	Sync	"This time the only thing that made me doubt that the filmed body is not me, is that I could not see the hands. Indeed I had the clear impression of floating even if I knew I was not moving."	Up
	Async	"Always well relaxed but the fact that I did not feel the same thing that I was watching determined in me some disturbances."	
5	Sync	"When I was concentrated to estimate the timing, it was as if I did not feel anymore what was happening on my back, as if I was only watching the video in front of me."	Up
	Async	"It was clear that I was watching a movie, unrelated to my experience."	
8	Sync	"I felt as if I were “rising” in a strange way towards the roof."	Up
	Async	"I had the impression of watching a video in the rewind mode."	
12	Sync	"I did not have any particular sensation despite a general, but nevertheless mild, elevation."	Up
	Async	"Not even elevation."	
13	Sync	"The video was so realistic that I thought somebody was above me. My sensations and what I saw were concordant."	Up
	Async	"The delay between the image and the reality increased the impression of watching somebody. For the duration of the stimulation I had the impression that my arms were always in the same place and my trunk moved up and down."	
14	Sync	"I felt the stimuli as if they were linked together. In spite of the absence from my real body, the sensation of being inside my virtual body was even stronger."	Up
	Async	"This time the impression was less strong. I recognized the delay between what I saw and what I felt on my back. The impression of being touched as in the movie decreased."	
18	Sync	"I had the impression of being touched by the stick as if I was between two mirrors and I could see my back."	Up
	Async	"There was simply no connection between the two stimulations."	
21	Sync	"It was kind of weird because I had the impression that I was watching myself in front of me but I knew I could not be here and there at the same time."	Up
	Async	"It is interesting to see yourself from behind, but no sensations of displacement."	
22	Sync	"I had the impression of lying and watching TV instead of perceiving something that directly touched me."	Up
	Async	"I had the impression of being in two different places at the same time as if I had two bodies."	
16	Sync	"I detected the stimulation on my back and it was quite “pleasant”. I felt as if I was not linked anymore with my body."	NotSure/ Up
	Async	"I did not feel as if I was flying. On the contrary the non-correspondence between the video and the touch made me come back to reality."	
4	Sync	"I was looking at my own body from above. The perception of being apart from my body was a bit weak but was still there. I saw the stick moving on my back and I perceived it to be somehow at odds with what I was looking at."	Down
	Async	"This time what I felt on my back did not correspond at all to what I saw. I had the impression of being very far from the real me."	
7	Sync	"With the “stroking” of the stick I lost my landmarks. I had bizarre sensations. The touch of the ball and the button press were completely different. The whole sense of touch was perturbed and the perception of the stick’s movement relied more on the camera below me than on the touch behind my back."	Down
	Async	"Even if I knew that the state was created artificially by the induced sensorial isolation with the goggles and the headphones, I had the impression of flying high and that the stick was touching my belly."	
9	Sync	"I felt myself a bit floating but in a descendent direction. On the contrary of the reality I had the impression that my body was thicker as if front and back were not as close as before the stick touched my back."	Down
	Async	"I felt like I was watching someone else’s body from above, while someone was rubbing my chest with a stick. I also felt as staying above the body I was watching. I felt I was physically located at the point I was looking from."	
15	Sync	"With the virtual reality goggles the vision from above was very bizarre because I was looking downwards at my own body."	Down
	Async	"The delay in time makes it more difficult to believe that what you see is happening where you feel it."	
17	Sync	"At the beginning I was expecting to feel the stick on my front side, but after I realized that it was touching my back. I felt as if I was lying on myself, face to face."	Down
	Async	"I felt as if I was floating, very light, without weight. I had the impression of feeling the impact of a surface on my back as if I was touching the roof."	
19	Sync	"I had the impression of forgetting my body as if my eyes were leaving my body and were going upwards. I was “watching” myself, “my real me”, from above."	Down
	Async	"What I saw did not correspond to what I felt, is was bizarre. As if the body I saw did not belong to me, or as if I had two bodies."	
2	Sync	"I had the impression of being two people at the same time. One myself was flying, and was watching the other (real) myself being touched by the stick."	NotSure/ Down
	Async	"This time what I felt on my back did not correspond at all to what I saw. I had the impression of being further away from the real me."	
6	Sync	"I had the impression of being touched sometimes above and sometimes below the image."	NotSure/ Down
	Async	"What I saw in the goggles did not correspond to the reality that I felt on my back."	
10	Sync	"It was strange to see the stick in a place different to where I felt it. This generated a doubt in me and I was a bit puzzled because I felt closer to the camera."	NotSure/ Down
	Async	"When I imagined releasing the ball, sometimes I had the impression of being lower sometimes the feeling was to be higher, so most of the times the ball was falling in front of me but sometimes it was falling behind my back."	
11	Sync	"I asked myself: if the one that I see in the movie is me, how can they move the mattress up and down?"	NotSure/ Down
	Async	"I felt as if I was floating high and I did not know where I was."	
20	Sync	"I identified a little more with what I saw but I felt quite uncomfortable with this vision."	NotSure/ Down
	Async	"I really did not feel that I was looking at myself since I could not really recognize any part of my body. The touch underneath me and my arms feel different because gravity is pushing on my body in the opposite direction."	

Table S4. Free Reports by participants from both groups (see main text), related to Table 1.

SUPPLEMENTAL EXPERIMENTAL PROCEDURES

Study 1

fMRI

Procedure

Participants. Twenty-two right-handed healthy male volunteers (mean age=25.4 years; SD=5.7 years) took part in the experiment. All participants had normal vision and were naive to the purpose of the experiment. All participants gave their written informed consent before the inclusion in the study. The study was approved by the Ethics Committee of the University of Lausanne (Switzerland) and was conducted in accordance with the ethical standards of the 1964 Declaration of Helsinki.

Stimuli. We showed a visual body that was filmed from an elevated camera perspective, lying on the chest facing a table, and with the shoulders bending somewhat downwards (Figure 1A). We note, that these visual gravitational cues are also in conflict with the cognitive and memory-related cues (participants know and remember that they are in a scanner looking upwards on an HMD) that are compatible with looking at a body that is above. The software E-Prime 2 (Psychology Software Tools Inc., Pittsburgh, PA, USA) was used to present the visual stimuli and to record participants' responses. LabVIEW (Version 8.5, National Instruments Inc., Austin, TX, USA) was used to control the robotic device. Visual stimuli were projected onto MR compatible goggles (VisualSystem, NordicNeurolab. Resolution 800x600, refresh rate 85 Hz, horizontal field of view 30°, vertical field of view 23°). The goggles were placed in front of the participants' eyes and the focus was adjusted to achieve a clear image. The distance from the eyes varied within a range of 3 to 5 cm, according to each participant's face anatomy. The image projected comprised a dual view and covered the whole visual field. During the "body" conditions, a virtual human body wearing a white t-shirt was shown. The back view of the virtual body was previously filmed from an elevated position.

Training session. Prior to the training session participants were asked to wear a white t-shirt and were shown the set up. At the beginning they were explained the self-location task (see below) and that they were going to see a movie through goggles while also receiving tactile stimulation. During the training session they were asked to wear a pneumatic headphone device that occluded the scanner noise and was used to present acoustic cues used to trigger the self-location task (see below). They were then installed comfortably on the robotic device holding the MR-emergency squeeze-ball in one hand and the response box in the other hand (counterbalanced across subjects). All the participants reported that they could feel the movement of the stroking sphere over the midline of their back, between the shoulder-blades. To prevent head movements, participants were installed with a neck cushion providing neck support and two compact square cushions inserted into the space between the headphones and the head coil. The training session consisted in performing exactly the same self-location task that was going to be performed during the fMRI session.

Self-location task (Mental Ball Dropping task). To evaluate our participants' self-location during the training session and the experiment participants were asked to perform the mental ball dropping (MBD) task as described in (Lenggenhager et al., 2009). Participants held a small "ball" (MR-emergency squeeze-ball) in one hand counterbalanced across subjects and, according to the MBD procedure, were asked to imagine dropping the ball and to estimate the time the ball would need to "hit" the ground. The MBD task was cued by an auditory cue delivered through the headphones (white noise was constantly played in the background). Participants were asked to indicate the imagined onset of ball dropping by pressing a button on a response box, to keep it pressed, and to indicate the imagined impact of the ball on the ground by releasing the same button. Response times (RTs) were recorded and the time difference between pressing and releasing the button was calculated in milliseconds. Participants were instructed to press and release the button of the response box with the index finger of either the left or right hand, contralateral to the hand holding the squeeze-ball (counterbalanced across participants). They were also instructed to never physically release the ball (which no participant did).

Questionnaire ratings. At the end of the experiment participants were asked to complete a questionnaire (Botvinick and Cohen, 1998; Lenggenhager et al., 2009; Lenggenhager et al., 2007) (Table S1). Participants completed the questionnaire answering the questions with respect to the two conditions during which they saw the human body (the synchronous and the asynchronous stroking conditions, in counterbalanced order). Still within the MR-scanner, participants were asked to indicate their rating for each question referring to the body conditions only by using the buttons of the response box (see main text). For Q2 to Q6 participants were asked to move the cursor along a horizontal several-points visual analogue scale (VAS). By pressing the index (ring finger) button with the right (left) hand the cursor moved to the right. By pressing the ring finger (index) button with the left (right) hand, the cursor moved to the left. Reference questions and conditions were randomly ordered. After the end of the experimental session, outside the scanner participants were asked to freely report their experience in writing (Table 1)

Analysis of Questionnaires, Self-Location Evaluation, and fMRI Data

Questionnaires. Question 1 was not answered on a continuous scale and therefore was not included in the analysis of variance. Accordingly, we analyzed the questionnaire ratings (VAS data for questions Q2 to Q6) by means of a 3-way analysis of variance (ANOVA) with Perspective (up, down) as in-between factor and Stroking (synchronous, asynchronous) and Question (Q2, Q3, Q4, Q5, Q6) as with-in factors. Post-hoc analyses were carried out using the Newman-Keuls test thresholded at $p<0.05$.

Evaluation of self-location (Mental Ball Dropping).

Trials in which RTs were below 200 ms were excluded from the data analyses (total loss, 3% of trials). RTs for the MBD were then analyzed by means of a 3-way repeated measures analysis of variance (ANOVA), with the in-between factor Perspective (up, down) and the with-in factors Object (body, no-body) and Stroking (synchronous, asynchronous). Post-hoc analyses were carried out using a Fisher Least Significant Difference (LSD) thresholded at $p<0.05$.

fMRI Acquisition and Analysis

T1-weighted anatomical images were collected using Siemens multiplanar rapid acquisition gradient echo sequence (1 mm isotropic voxels, 160 sagittal slices, TR = 9.7 ms, TE = 4 ms). Functional images were collected with a gradient echo EPI sequence. The experiment comprised two runs of 8 blocks. Twenty-seven volumes were recorded during each block, 216 consecutive volumes comprising 28 consecutive 3.5 mm thick slices oriented parallel to the anterior-posterior commissure and covering the whole brain (TR = 3 s, TE = 60 ms, 64 x 64 image matrix, 3.5 x 3.5 mm in-plane resolution) were recorded during each fMRI session. 108 volumes were recorded for each condition, a total of 432 volumes were recorded during the experiment and each run lasted 10 min 54s.

According to a block design, the four conditions (body synchronous/asynchronous, nobody synchronous/asynchronous) were presented in blocks lasting 78s each. Each block consisted of three elements presented in the following order: exposure to visual and tactile stroking (39s); three executions of the MBD task triggered by the auditory cue (15s); observation of a white cross on a black screen without stroking as a “baseline” (24s). The four experimental conditions were presented four times during the experiment in a pseudo-randomized order. The anatomical images (mprage) were collected at the end of the experiment (after the questionnaires were completed).

fMRI data were analyzed using SPM8 (Wellcome Department of Cognitive Neurology, Institute of Neurology, UCL, London, UK). For each subject, functional images were first corrected for head movements using a least-squares approach and six-parameter rigid body spatial transformations (Friston et al., 1995). The high-resolution anatomical image and the functional images were then stereotactically normalized to the Montreal Neurological Institute (MNI) brain template used in SPM8 (Mazziotta et al., 1995). Functional images were re-sampled with a voxel size of 2x2x2 mm and spatially smoothed with a three-dimensional isotropic Gaussian filter of 6 mm full width at half maximum to increase signal-to-noise ratio (Friston et al., 1994). Images were subsequently analyzed at a single subject level using a first-level fixed effects analysis. The effects of the experimental paradigm were estimated on a voxel-by-voxel basis using the principles of the general linear model extended to allow the analysis of fMRI data as time series (Worsley and Friston, 1995). Each experimental block was modeled using a boxcar, convolved with a canonical hemodynamic response function chosen to represent the relationship between neuronal activation and blood flow changes. These single-subject models were used to compute four contrast images per subject, each representing the estimated amplitude of the hemodynamic response in the “synchronous” and “asynchronous” stroking for the “body” and “no-body” conditions, relative to the “baseline” condition. Contrast images representing each of the mentioned conditions for all subject were entered into a second-level random-effect analysis with non-sphericity correction, as implemented in SPM8 (Worsley and Friston, 1995). In order to identify regions where the effect of any of these contrasts was significant in both Up- and Down-group (Perspective in-between factor), i.e. regions discriminating any of the eight conditions (resulting from the 2x2x2 factorial design with Perspective, Object, and Stroking as main factors) from the inter-trial baseline, we used a statistical threshold of $p<0.05$ FDR-corrected for multiple comparisons over the total amount of analyzed brain volume (cluster threshold of 10 voxels). Then, for each identified cluster, the BOLD percent signal change in each condition (relative to baseline) was computed for each subject, by extracting the mean beta value from the contrast across all voxels in the cluster. The estimates of averaged regional responses for each condition were analyzed by means of a 3-way ANOVA with the in-between factor Perspective (up, down), and the two with-in factors Object (body, no-body) and Stroking (synchronous, asynchronous). Post-hoc comparison for significant main effects and interactions were carried out using a Fisher Least Significant Difference (LSD), thresholded at $p<0.05$. To localize and visualize the activated clusters we used the BrainShow software (Galati et al., 2008) implemented in Matlab (The MathWorks Inc., Natick, MA, USA). Brainshow software was also used to project group activations onto the cortical surface of the PALS atlas, to superimpose them to the standard cerebral cortex, and to automatically assign anatomical labels (Tzourio-Mazoyer et al., 2002).

STUDY 2

Lesion analysis

Included Patients

We included 5 patients from the Geneva University Hospital suffering from out-of-body experiences (OBEs) due to circumscribed structural brain lesions and/or transient functional neural dysfunction. The brain pathology was confirmed by magnetic resonance imaging (MRI), computer tomography (CT), ictal and interictal scalp electroencephalography (EEG), intracranial EEG using subdural electrodes, positron emission tomography (PET), ictal and interictal single photon emission computed tomography (SPECT) and intracranial electric stimulation (Table S3). From other clinical research groups, we were able to include 4 additional patients whose data have previously been published and in whom the original neuroradiological data were available for normalization and analysis (Brandt et al., 2005; De Ridder et al., 2007; Maillard et al., 2004). As a control group, 5 patients with complex visual hallucinations of people and/or faces without disturbance of self-location and first person perspective and circumscribed brain lesions affecting the right posterior cortex were recruited were recruited during the same time period at Geneva University Hospital, 2 patients were contributed by Maillard and colleagues (Maillard et al., 2004) and one patient by Zamboni and colleagues (Zamboni et al., 2005) (Table S3).

Lesion Mapping and Analysis

The group of neurological patients with OBEs due to focal brain damage consisted of 9 patients (Table S3). The control group comprised 8 patients (SI).

Normalization of each patient's lesion into the common MNI (Montreal Neurological Institute) reference space permitted voxel-wise algebraic comparisons within and between patient groups. Structural lesions were confirmed by MRI or CT. The functional relevance of these lesions was confirmed by a multimodality imaging approach (Knowlton, 2004; Kurian et al., 2007), which combines structural with co-registered functional imaging. This multimodal approach is classically used to improve the ability to detect and define the extent of temporal and extra-temporal epileptogenic tissue (Blanke et al., 2004; Kurian et al., 2007). MRI brain scans were normalized to the smoothed T1 template using SPM5 (http://www.fil.ion.ucl.ac.uk/spm/software/spm5)

(Ashburner and Friston, 2005). As unified segmentation models give the most precise registration of lesioned structural images (Crinion et al., 2007), no cost-function masking was necessary. Functional imaging (PET, SPECT) was normalized using SPM5 and co-registered to the normalized MRI scans. Intracranial EEG was co-registered to the normalized MRI scans for each patient using the Cartool software developed by Denis Brunet (http://brainmapping.unige.ch/Cartool.htm). Lesions were subsequently traced manually slice by slice either on the individual normalized brain scans or on the T1 weighted images (control group case 2, 3 and 5) using MRIcron (http://www.sph.sc.edu/comd/rorden/mricron) (Rorden et al., 2007). The later manual tracing on the template brain was only done when confidence could be achieved for matching corresponding slices between the lesioned brain and the template brain. If functional imaging highlighted brain areas adjacent to the structural lesions, these were included into the lesion analysis as well.

As to intracranial stimulation and intracranial recording of the seizure onset (OBE group case 3 and 9, control group case 6), the site of the electrode located on the standard T1 template and tissue with a radius of 10 mm around the electrode was declared dysfunctional). No patients with unclear lesion boundaries or metallic artifacts were included into the analysis. Lesion volumes (volume of interest, VOI) were determined as the sum of all voxels compromising the traced lesion in all slices and were spatially smoothed using a 5mm full width at half maximum (FWHM) Gaussian Kernel and a threshold of 0.5.

Statistical lesion overlap comparison was carried out contrasting the lesions of the OBEs-patients with those from the control group using voxel-based lesion symptom mapping (VLSM; Bates et al., 2003). For VLSM we only included patients suffering from lesions on the right hemisphere (predominantly affected, as confirmed by the binomial test we applied). For lesion overlap and statistical analysis we used MRIcron and Non Parametric Mapping (NPM), which is part of the MRIcron software package (Rorden et al., 2007). In a first step simple voxel-based lesion overlap analysis establishing the anatomical sub regions of maximal lesion overlap for OBE was performed (see Figure 4A). In a second step nonparametric voxel based lesion symptom mapping (VLSM) analysis (Bates et al., 2003), contrasting OBE against the control group was computed on the hemisphere, which was significantly more often affected (as confirmed by the binomial test, see below). This resulted in 8 patients with OBEs suffering from a lesion in the right hemisphere (the remaining patient suffered from left temporo-parietal damage). The right hemispheric predominance was significant as confirmed by the binomial test with an expected frequency of 0.5 ($p=0.039$). Eight patients suffering from complex visual hallucinations due to a right posterior lesion were chosen as the control group (Table S3). We used the Liebermeister test and corrected the results for multiple comparisons using a 5% false discovery rate (FDR). The Liebermeister is a nonparametric implementation of a two-group comparison on a binary variable. It is more appropriate than the chi square test (Rorden et al., 2007). We only included voxels affected in at least 30% of all subsequent analyses. Right vs. left hemispheric involvement was tested with a binomial distribution with an expected frequency of 0.5.

RESULTS

Questionnaires. Statistical analysis of the questionnaire data showed the main effect of Stroking [$F(1,20)=33,2$; $p<0.01$] and Question [$F(4,80)=30,7$; $p<0.01$] as well as the interaction between Stroking and Question [$F(4,80)=13,5$; $p<0.01$]. The main effect of Stroking was accounted for by the higher responses during the synchronous (3.2) compared to the asynchronous stroking (1.7; $p<0.01$). The main effect of Question was accounted for by the lowest responses given to questions Q2 (-2.2) and Q6 (1.3) as compared to questions Q3 (3.2), Q4 (4.3), Q5 (5.4) (all $p<0.01$). The significant interaction between Stroking and Question showed that the difference between the responses given with respect to the synchronous and asynchronous stroking was significant for questions Q3 ($p<0.006$) and Q5 ($p<0.0001$) but not for questions Q2, Q4 and Q6 (all $p>0.2$). Post-hoc analysis showed that responses to questions Q3 and Q5 were higher during the synchronous (4.1 and 8.1, respectively) than the asynchronous stroking (2.3 and 2.8, respectively).

Self-location. In addition to the significant 3-way interaction (see main text), RT analysis also showed a significant 2-way interaction between Perspective and Stroking [$F(1,20)=6.2$; $p<0.02$]. Post-hoc comparisons of the 3-way interaction showed (in addition to the comparisons reported in the main text) that in the Up-group RTs for the body/synchronous condition (1071ms) were longer (higher self-location) with respect to the no-body/asynchronous (974ms; $p<0.02$). Post-hoc comparisons of the 2-way interaction showed higher RTs ($p<0.04$) in the Up-group during the synchronous (1042ms) as compared to the asynchronous stroking (968ms). This difference was not significant in the Down-group ($p=0.2$).

fMRI results

The cluster at the left temporo-parietal junction (left TPJ) was centered on the posterior superior temporal gyrus (57% of voxels), including also supramarginal gyrus (36%), and anterior STG (2%). The ANOVA performed on the BOLD signal change in the *left TPJ* showed a significant 3-way interaction between Perspective, Object and Stroking [$F(1,20)=6.08$; $p<0.02$] (see main text) and a significant 2-way interaction between Perspective and Stroking [$F(1, 20)=8.17$; $p<0.01$]. The 2-way interaction was accounted for by the lowest BOLD response in the Up-group during the synchronous stroking conditions (body and no-body together; 0.14%) with respect to the asynchronous stroking in the Up-group (0.82%) and both synchronous (0.88%) and asynchronous stroking (0.73%) in the Down-group (all p<0.01). The main effect of perspective was not significant, suggesting that activity of the left TPJ is not influenced by the experienced direction of the first person perspective per se No other main effect or interaction was significant in this region (all p>0.06).

The cluster at the right temporo-parietal junction (right TPJ) was also centered on the posterior superior temporal gyrus (63% of voxels), including also supramarginal gyrus (26%), and anterior STG (6%). The ANOVA performed on the BOLD signal change in *right TPJ* showed a significant 3-way interaction between Perspective, Object and Stroking [F(1,20)=7.01; p<0.01] (see main text). No other main effect or interaction was significant in this region (all p>0.32).

The cluster at the *right extrastriate body area (rEBA)* was centred on the posterior part of the right middle-temporal gyrus (72% of the voxels within the middle-temporal gyrus and 21% within the inferior-temporal gyrus). The ANOVA performed on the BOLD signal change in rEBA showed a 3-way interaction between Perspective, Object and Stroking [F(1,20)=20.54; p<0.001]. In the Up-group the percentage of BOLD signal change in the body conditions was lower during the synchronous (0.09%) compared to the asynchronous stroking (1.68%; p<0.001). In contrast to the BOLD response in right and left TPJ, the difference between synchronous and asynchronous stroking was also significant in the control conditions (in the Up-group) with higher BOLD response (1.2%) in the no-body/synchronous condition with respect to the no-body/asynchronous condition (0.4%; p<0.03). The significant 2-way interaction between Object and Stroking was accounted for by the higher BOLD response in the body/asynchronous condition (1.2%) with respect to the body/synchronous (0.47%) *and* the no-body/asynchronous conditions (0.72%; all p<0.05). No other main effect or interactions were significant (all p>0.11). To summarize, the signal in rEBA did not reflect self-location as the differences in BOLD response between synchronous and asynchronous stroking were not selective for the body condition. For a discussion of a potential role of right EBA in self-identification see main text.

The cluster at the *left extrastriate body area (lEBA)* was centred on the left middle-occipital gyrus, (70% of the voxels within the middle-occipital gyrus, 16% within the inferior-occipital gyrus, and 12% within the middle-temporal gyrus). The ANOVA performed on the BOLD signal change in lEBA showed a 3-way interaction between Perspective, Object and Stroking [F(1,20)=10.05; p<0.005]. Yet, in contrast to TPJ activity (and changes in self-location), in both the Up- and the Down-group, changes in BOLD response were not selective for the body conditions *and* stroking. Thus, in the Up-group the BOLD response in the body/asynchronous condition was higher (1.3%)

with respect to the body/synchronous (0.39%; $p<0.02$), but also with respect to the control/asynchronous (0.49%; $p<0.03$) condition. Similarly, in the Down-group, the BOLD response in the body/asynchronous condition was lower (0.23%) with respect to the body/synchronous (1.05%; $p<0.04$), but also with respect to the control/asynchronous (1.1%; $p<0.03$) condition. No other main effect or interactions were significant (all $p>0.11$). To summarize, the BOLD response in lEBA did not show the body-selective modulation due to synchrony as found in right and left TPJ and RTs in the mental ball dropping task (although it shared several aspects with TPJ activity).

The cluster at the right postcentral gyrus *(rPtC)* was centered on the postcentral gyrus, with 59% of the voxels within the superior postcentral gyrus, 32% within the inferior precentral gyrus, and 12% within the superior precentral gyrus. The ANOVA performed on the BOLD response showed a significant main effect of Stroking [$F(1,20)=24.02$; $p<0.001$] and a significant 2-way interaction between Perspective and Stroking [$F(1,20)=16.65$; $p<0.001$]. The main effect of Stroking was accounted for by the smaller BOLD decrease for the asynchronous (-0.13%) with respect to the synchronous stroking (-0.51%). The interaction between Perspective and Stroking was accounted for by the greatest BOLD decrease for the synchronous stroking in the Up-group (-0.71%; all $p<0.02$).

The cluster at the left postcentral gyrus (lPtC) was centered on the superior part of postcentral gyrus with 91% of the voxels within the postcentral gyrus and 9% within the paracentral lobule. The ANOVA performed on the BOLD response showed a significant 2-way interaction between Perspective and Object [$F(1,20)=7.05$; $p<0.02$] as well as a significant interaction between Object and Stroking [$F(1,20)=7.4$; $p<0.01$]. The former interaction was accounted for by the greater BOLD *decrease* for the body conditions in the Down-group (-0.63%) with respect to the body conditions in the Up-group (-0.22%; $p<0.02$). The latter interaction was accounted for by the synchrony-related difference in the BOLD response, but only between the control conditions, i.e. greater BOLD decrease in the no-body/synchronous (-0.66%) with respect to the no-body/asynchronous (-0.21%; $p<0.02$) condition, showing no involvement in self-identification or self-location.

In the cluster at the left and right occipital gyri *(Occ)* the activations were found in the right (45%) and the left (21%) medial occipital lobes, and the right (11%) and left (18%) lateral occipital lobes. The ANOVA performed on the BOLD response showed a significant 3-way interaction between Perspective, Object, and Stroking [$F(1,20)=9.48$; $p<0.006$]. However, and in contrast to TPJ, the post-hoc comparison for the 3-way interaction showed that in the Up-group the BOLD response in the body/asynchronous condition (2.01%) was higher with respect to the body/synchronous *and* the control conditions (all $p<0.04$). Yet, in contrast to TPJ, no such differences in the BOLD response due to Object or Stroking were found in the Down-group (all $p>0.1$), suggesting activity in the occipital lobe does not reflect self-location or self-identification.

This fMRI analysis showed that the only two brain regions where the BOLD response reflected changes in self-location as manipulated by the factors Synchrony, Body, and Perspective were the left and right TPJ. Whereas, the BOLD response in left EBA and right EBA reflected some aspects of our experimental manipulations of self-location, both BOLD signals did not reflect self-location as the differences in BOLD response between synchronous and asynchronous stroking were not selective for the body condition

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