Supplementary material to

A key region in the human parietal cortex for processing proprioceptive hand feedback during reaching movements

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S1 Permutation tests

The rationale behind using a permutation test procedure was to obtain a corrected α-level for our data, which would yield at most 5% false positive accumulated over all conditions. For each measure (*CorrX*, *ReachTime*, etc.) and separately for force-perturbed and unperturbed trials, we performed one permutation test as described in the following. First, we obtained the distribution of p values under the null hypothesis by permuting 10000 times the conditions (sensory feedback, stimulation site, and TMS stimulation (y/n)) and the participants for the collapsed dataset (collapsed over the conditions of no interest target position and perturbation direction). For each permutation, we calculated 2-sided t-tests between the TMS and no TMS data for each feedback condition and stimulation site, which accumulated yielded the distribution of p values under the null hypothesis given our data. The highest p value in the bottom 5% of this distribution was then taken as the corrected α-level. As 10000 is not even close to the full permutation of the combination of all conditions, we validated this procedure by repeating it several times and as the results changed only after the fourth decimal place, we considered the method as sufficient exact for our purposes.

S2 Data normalization

For illustration purposes (Fig. 3a&b, and S2), we used a simplified normalization procedure to spatially and temporally normalize the position data. Each trial was objected to these procedures individually from movement on- to offset (i.e. when the velocity raised above or fell below 2cm/s, respectively). For the spatial normalization, we divided the full path length in 100 equidistant sections, and then interpolated the corresponding x- and y-coordinates with weighted means from the adjacent measured positions. This allowed us to simply average over the position data for the figures. The temporal normalization was analogue, using the movement time instead of the path length. Note that all quantitative measures reported in the article are independent of this normalization procedure.

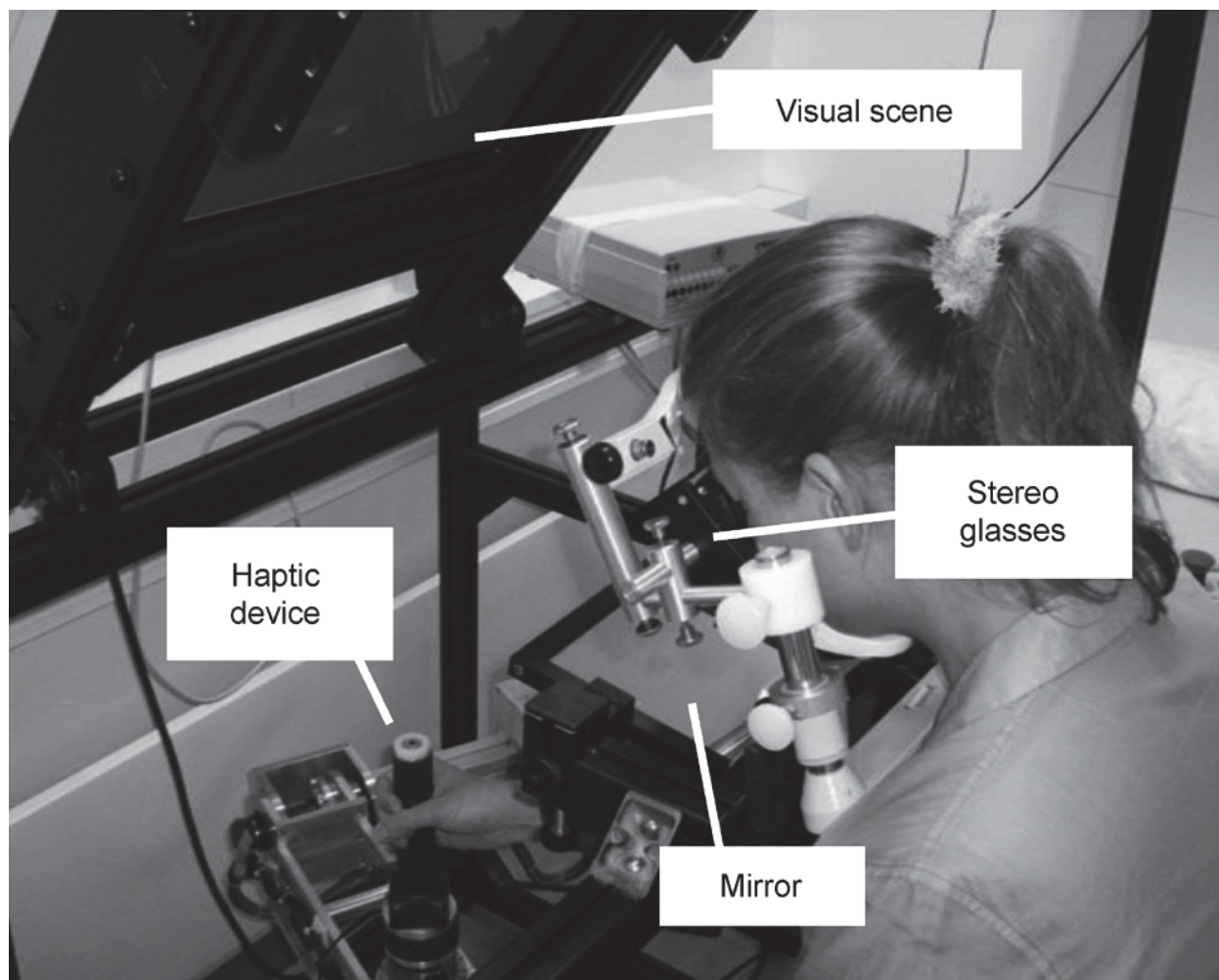*Figure S1*   Picture of the setup with a participant. During the experiment, a black cloth prevented vision of the robot and the reaching hand. Note that the participant is seated comfortably, with chin and forehead supported.
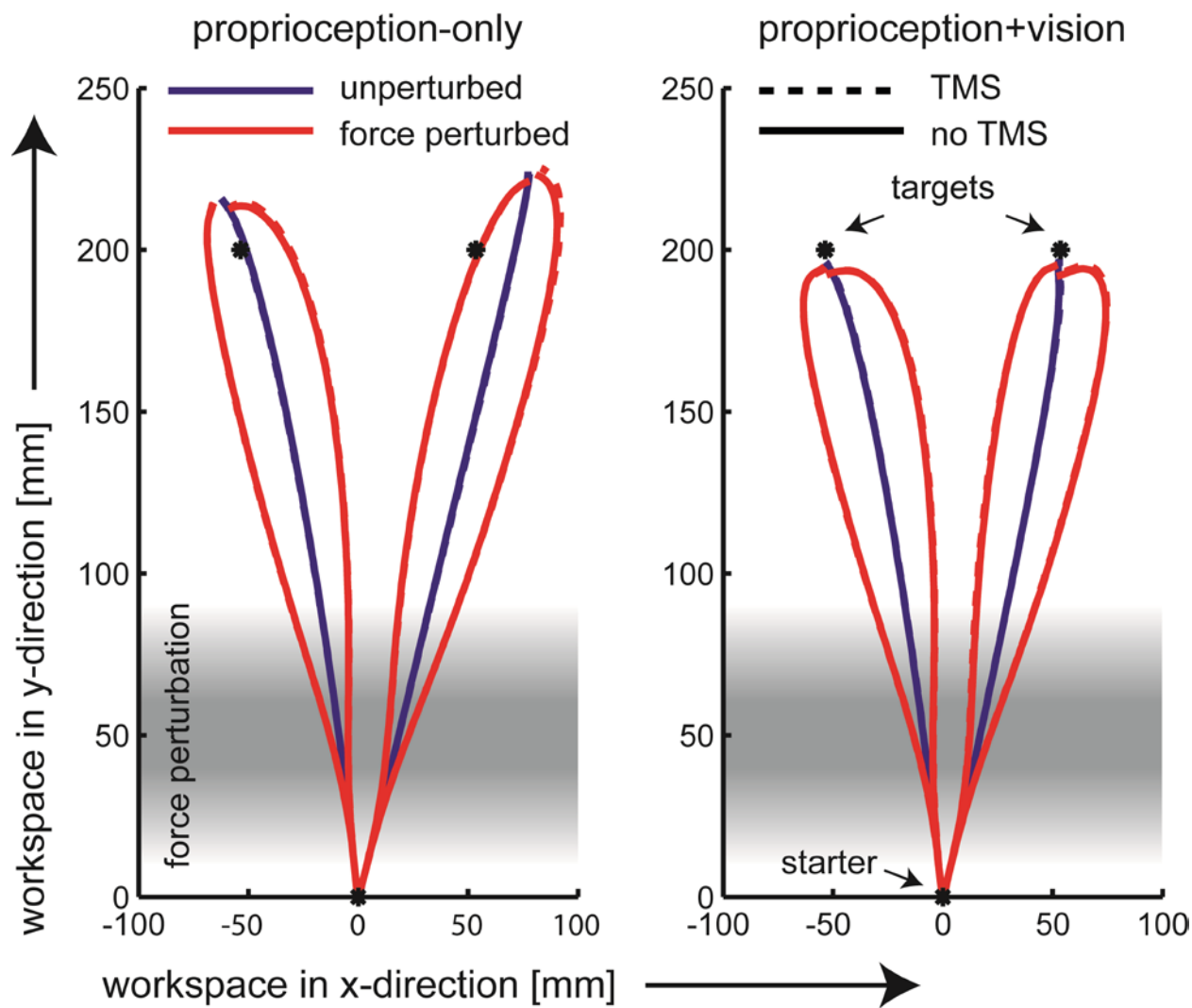
Figure S2   Trajectory data pooled over all TMS stimulation sites, normalized over path. A) depicts the data for the proprioception-only trials, B) depicts the proprioception+vision trials.

Table S1 Details about adjusted coil positions and their justification. Originally, the coil was adjusted parallel to the central sulcus with the handle pointing downwards, e.g. the long axis of the figure-8 coil was oriented parallel to the central sulcus. Clockwise rotations of the coils are denoted with positive values.

participant	stimulation site	adjustment	justification
S1	SMG$_{inferior}$	-45°	head rest interfered with initial position
S2	aIPS$_{right}$	45°	head rest interfered with initial position
	mIPS$_{middle}$	-45°	head rest interfered with initial position
S3	SMG$_{middle}$	-45°	head rest interfered with initial position
	SMG$_{inferior}$	-45°	head rest interfered with initial position
S4	SMG$_{inferior}$	-45°	head rest interfered with initial position
S6	SMG$_{inferior}$	-45°	head rest interfered with initial position
S7	SMG$_{inferior}$	-45°	head rest interfered with initial position
S8	SMG$_{inferior}$	-45°	head rest interfered with initial position

Table S2 Summary of the effects of TMS on all measurements (TMS – no TMS). Reported *p*-values are uncorrected, significant effects after multiple comparison correction (α = .0056) are marked **red**.

perturbed

		CorrX [mm]			VarX [mm]			ErrorY [mm]			VarY [mm]			MaxDev [mm]		
		mean	SEM	p	mean	SEM	p	mean	SEM	p	mean	SEM	p	mean	SEM	p
proprioception-only	$mIPS_{anterior}$	0.81	0.43	0.049	-0.57	0.54	0.838	0.19	0.90	0.421	-0.60	0.32	0.953	1.35	0.62	0.031
	$mIPS_{middle}$	0.79	0.73	0.155	0.48	0.63	0.234	-0.15	1.10	0.551	0.95	0.44	0.032	-0.10	0.50	0.581
	$mIPS_{posterior}$	**2.19**	**0.59**	**0.003**	0.27	0.47	0.289	0.88	1.45	0.279	-0.30	0.46	0.735	0.32	0.57	0.294
	$aIPS$	1.29	0.97	0.111	0.83	0.83	0.173	0.91	1.12	0.221	0.20	0.57	0.368	0.21	0.42	0.314
	$aIPS_{posterior}$	0.55	0.63	0.204	-0.59	0.61	0.819	0.96	1.30	0.240	-1.60	0.54	0.991	-0.37	0.62	0.716
	$SMG_{superior}$	0.93	0.93	0.173	0.46	0.68	0.262	1.55	1.18	0.113	0.18	0.75	0.408	-0.01	0.87	0.505
	SMG_{middle}	0.08	0.91	0.467	0.14	0.83	0.436	0.85	0.95	0.198	0.40	0.49	0.218	0.74	0.76	0.179
	$SMG_{inferior}$	0.13	1.50	0.466	-0.38	0.72	0.697	2.41	1.18	0.038	0.92	0.74	0.122	0.28	0.99	0.391
	$aIPS_{right}$	0.20	0.33	0.282	-0.19	0.45	0.659	-0.26	1.32	0.576	-0.40	0.49	0.780	0.91	0.60	0.084
proprioception+vision	$mIPS_{anterior}$	-0.19	0.40	0.674	-0.09	0.37	0.598	0.19	0.40	0.323	0.18	0.61	0.385	0.05	0.38	0.449
	$mIPS_{middle}$	0.13	0.38	0.367	-0.17	0.43	0.649	-0.35	0.57	0.722	0.71	0.60	0.135	0.32	0.52	0.278
	$mIPS_{posterior}$	-0.10	0.31	0.622	0.28	0.36	0.230	0.32	0.32	0.171	-0.72	0.29	0.981	0.22	0.49	0.333
	$aIPS$	-0.32	0.26	0.872	0.40	0.34	0.136	-0.37	0.55	0.744	-0.51	0.38	0.890	1.17	0.69	0.064
	$aIPS_{posterior}$	-0.24	0.37	0.733	-0.32	0.33	0.821	0.41	0.59	0.255	0.59	0.53	0.149	-0.49	0.40	0.869
	$SMG_{superior}$	0.08	0.75	0.460	0.33	0.50	0.263	-0.09	0.47	0.576	1.06	0.41	0.016	-0.45	0.43	0.836
	SMG_{middle}	0.56	0.39	0.097	0.44	0.53	0.217	0.53	0.62	0.207	-0.64	0.55	0.861	0.22	0.38	0.292
	$SMG_{inferior}$	-0.96	0.73	0.888	-0.36	0.31	0.861	-0.53	0.47	0.851	0.07	0.71	0.463	0.17	0.42	0.348
	$aIPS_{right}$	-0.63	0.53	0.864	-0.17	0.39	0.661	0.75	0.28	0.015	0.40	0.40	0.170	0.45	0.52	0.205

unperturbed

		ErrorX [mm]			VarX [mm]			ErrorY [mm]			VarY [mm]		
		mean	SEM	p	mean	SEM	p	mean	SEM	p	mean	SEM	p
proprioception-only	$mIPS_{anterior}$	-1.20	1.78	0.740	1.35	0.80	0.065	-0.17	1.17	0.557	0.02	0.98	0.493
	$mIPS_{middle}$	1.41	1.05	0.108	0.73	0.71	0.169	-1.65	1.12	0.911	0.62	0.94	0.265
	$mIPS_{posterior}$	1.60	1.20	0.109	-0.98	0.84	0.862	0.08	1.48	0.480	-0.22	0.98	0.587
	$aIPS$	0.85	1.44	0.287	0.40	1.13	0.365	-0.20	1.07	0.572	-1.16	0.99	0.863
	$aIPS_{posterior}$	1.22	0.88	0.101	0.76	0.67	0.146	2.09	0.89	0.024	0.75	1.19	0.274
	$SMG_{superior}$	-0.19	1.48	0.550	0.29	1.24	0.412	1.73	1.31	0.111	-1.02	1.00	0.832
	SMG_{middle}	0.35	0.74	0.326	-0.44	1.30	0.628	0.51	1.11	0.329	0.49	1.63	0.386
	$SMG_{inferior}$	0.03	1.01	0.488	0.25	0.75	0.373	1.51	1.90	0.224	0.60	1.24	0.319
	$aIPS_{right}$	1.01	1.04	0.179	-1.95	0.94	0.965	-0.04	1.10	0.514	-0.49	0.86	0.707
proprioception+vision	$mIPS_{anterior}$	-0.38	0.55	0.745	-0.12	0.29	0.647	0.44	0.69	0.270	-0.13	0.56	0.590
	$mIPS_{middle}$	-0.81	0.40	0.962	-0.45	0.51	0.799	1.22	0.59	0.037	0.32	0.45	0.249
	$mIPS_{posterior}$	-0.12	0.77	0.563	-0.60	0.65	0.807	0.68	0.96	0.248	-0.40	1.01	0.649
	$aIPS$	-0.11	0.80	0.552	0.68	0.34	0.038	0.26	1.28	0.423	0.53	0.50	0.162
	$aIPS_{posterior}$	-0.35	0.71	0.683	0.23	0.34	0.262	-0.15	0.91	0.563	-0.36	0.55	0.734
	$SMG_{superior}$	0.89	0.42	0.034	-0.12	0.34	0.635	0.36	0.79	0.330	0.59	0.65	0.194
	SMG_{middle}	-0.57	0.35	0.928	-0.37	0.44	0.786	1.78	0.74	0.021	0.66	0.47	0.098
	$SMG_{inferior}$	0.34	0.58	0.287	0.16	0.52	0.386	-0.45	0.49	0.811	-0.03	0.67	0.520
	$aIPS_{right}$	-0.75	0.53	0.904	0.13	0.51	0.406	-0.23	0.93	0.595	-0.25	0.71	0.631

perturbed		ReachTime [ms]			DecTime [ms]			AccTime [ms]		
		mean	SEM	p	mean	SEM	p	mean	SEM	p
proprioception-only	mIPS$_{anterior}$	-7.19	7.77	0.809	-7.92	8.10	0.822	0.73	2.07	0.366
	mIPS$_{middle}$	-4.48	5.42	0.784	-6.02	7.25	0.785	1.54	2.74	0.295
	mIPS$_{posterior}$	-1.09	7.03	0.560	-3.77	6.12	0.723	2.68	3.56	0.236
	aIPS	14.12	9.46	0.087	10.16	11.62	0.204	3.95	2.76	0.095
	aIPS$_{posterior}$	-4.63	6.21	0.762	-3.81	7.69	0.683	-0.82	2.20	0.640
	SMG$_{superior}$	-5.34	8.13	0.735	-1.05	7.24	0.556	-4.29	2.24	0.954
	SMG$_{middle}$	11.71	7.71	0.084	15.79	8.32	0.047	-4.08	2.63	0.920
	SMG$_{inferior}$	6.04	13.12	0.329	8.41	13.41	0.274	-2.37	1.87	0.879
	aIPS$_{right}$	3.85	5.52	0.252	4.70	5.23	0.197	-0.85	2.45	0.631
proprioception+vision	mIPS$_{anterior}$	-4.78	7.90	0.719	-6.04	8.00	0.764	1.26	1.84	0.256
	mIPS$_{middle}$	11.72	10.60	0.151	7.29	10.74	0.258	4.43	2.57	0.062
	mIPS$_{posterior}$	-2.20	9.66	0.587	-3.68	8.33	0.665	1.49	2.69	0.298
	aIPS	**25.98**	**7.80**	**0.005**	**26.66**	**7.05**	**0.003**	-0.68	2.97	0.588
	aIPS$_{posterior}$	-5.27	11.36	0.672	-5.96	11.54	0.690	0.70	3.35	0.420
	SMG$_{superior}$	-9.97	6.37	0.922	-9.10	6.73	0.894	-0.87	1.85	0.675
	SMG$_{middle}$	-0.42	12.54	0.513	2.98	12.39	0.408	-3.40	1.86	0.948
	SMG$_{inferior}$	16.98	9.42	0.055	15.79	8.33	0.047	1.19	2.94	0.348
	aIPS$_{right}$	4.87	11.90	0.347	8.89	10.67	0.215	-4.02	2.77	0.907

unperturbed		ReachTime [ms]			DecTime [ms]			AccTime [ms]		
		mean	SEM	p	mean	SEM	p	mean	SEM	p
proprioception-only	mIPS$_{anterior}$	9.74	14.47	0.260	11.97	15.12	0.226	-2.23	6.12	0.637
	mIPS$_{middle}$	-2.37	9.61	0.594	3.86	8.77	0.336	-6.23	3.01	0.964
	mIPS$_{posterior}$	-16.20	13.29	0.871	-14.32	10.91	0.887	-1.88	3.34	0.706
	aIPS	26.79	12.67	0.034	29.66	14.46	0.037	-2.87	3.20	0.802
	aIPS$_{posterior}$	6.12	11.81	0.309	7.85	11.64	0.260	-1.73	3.50	0.683
	SMG$_{superior}$	-3.17	9.57	0.625	0.22	10.34	0.492	-3.39	3.71	0.806
	SMG$_{middle}$	7.99	10.87	0.242	11.63	10.37	0.147	-3.64	3.87	0.813
	SMG$_{inferior}$	2.47	7.07	0.368	16.45	7.05	0.024	-13.98	3.25	0.999
	aIPS$_{right}$	16.11	16.47	0.178	18.80	17.09	0.152	-2.68	2.76	0.820
proprioception+vision	mIPS$_{anterior}$	-12.65	12.51	0.829	-12.56	12.13	0.835	-0.09	2.72	0.513
	mIPS$_{middle}$	-10.28	12.85	0.777	-12.00	13.48	0.800	1.72	3.72	0.328
	mIPS$_{posterior}$	17.24	19.82	0.205	20.28	18.12	0.148	-3.04	2.89	0.838
	aIPS	19.08	13.02	0.090	13.80	12.36	0.148	5.28	2.63	0.040
	aIPS$_{posterior}$	9.63	5.57	0.061	9.05	5.72	0.076	0.58	1.80	0.378
	SMG$_{superior}$	-10.08	10.42	0.819	-10.03	9.33	0.843	-0.05	2.34	0.508
	SMG$_{middle}$	-7.87	14.71	0.696	-8.26	13.44	0.722	0.40	3.42	0.455
	SMG$_{inferior}$	-1.29	11.32	0.544	-1.50	11.27	0.551	0.21	2.54	0.468
	aIPS$_{right}$	10.84	14.20	0.234	8.79	13.10	0.261	2.05	4.52	0.331