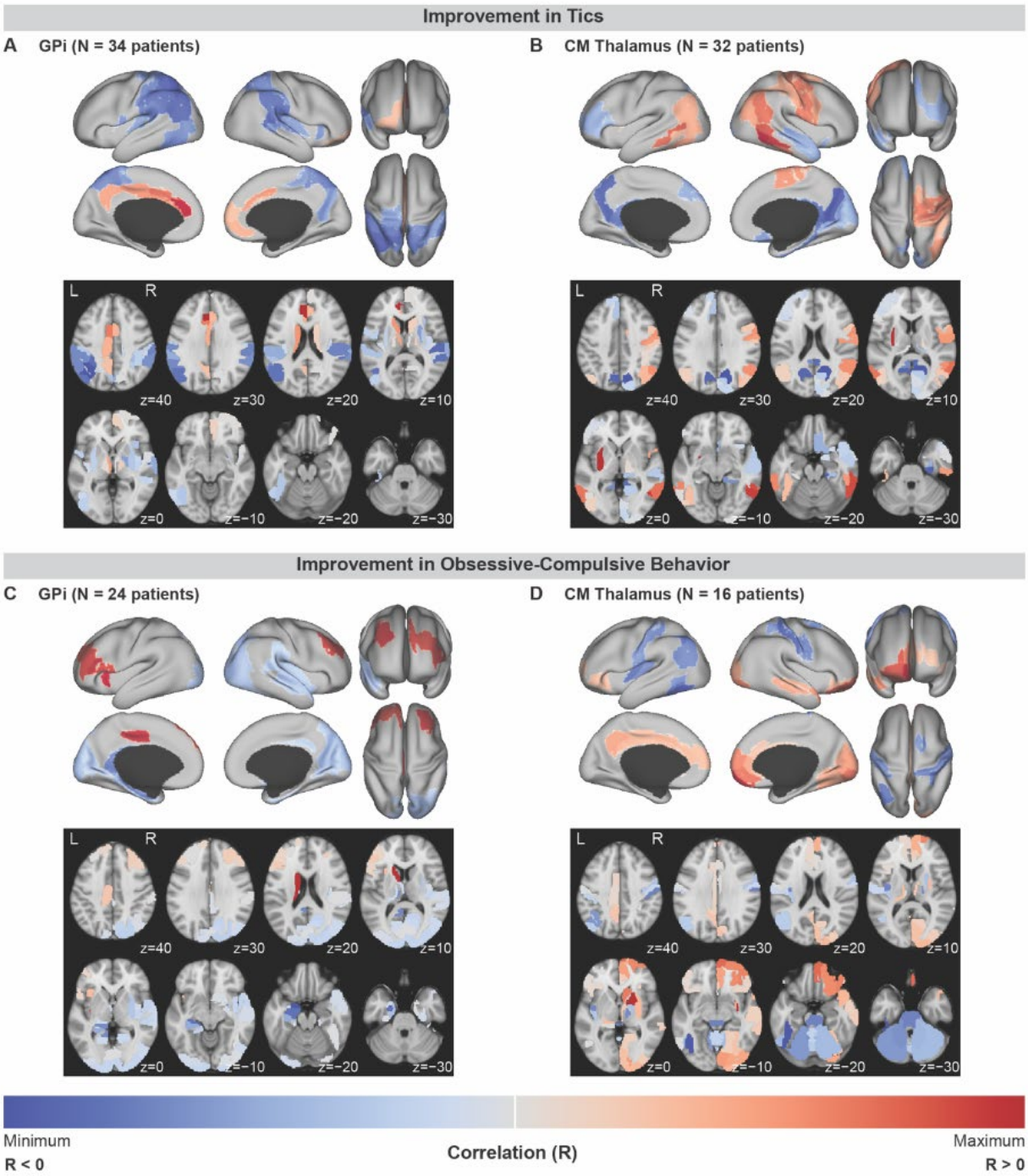

Supplementary Fig. 1. Top regions correlated with symptom improvement used for "reverse" tractography. Top row – improvement in tics: (A) Across patients implanted in GPi, the top positively correlated regions included cingulate cortex, orbitofrontal cortex, and dorsal caudate; the top negatively correlated regions included inferior and superior parietal lobule, primary motor cortex, primary sensory cortex, and putamen. **(B)** Across patients implanted in CM thalamus, the top positively correlated regions included dorsolateral putamen, parietal-temporal-occipital regions, supplementary motor area, primary motor cortex, and primary sensory cortex; the top negatively correlated regions were cingulate cortex, precuneus, and the parahippocampal gyrus. **Bottom row – improvement in obsessive-compulsive behavior: (C)** Across patients implanted in GPi, the top positively correlated regions included dorsolateral prefrontal cortex, dorsal caudate, and dorsal cingulate cortex; the top negatively correlated regions included amygdala, posterior cingulate cortex, insula, and occipital cortex. **(D)** Across patients implanted in CM thalamus, the top positively correlated regions included ventral caudate and putamen, medial and lateral orbitofrontal cortex, anterior and dorsal cingulate cortex, occipital cortex, and middle temporal gyrus; the top negatively correlated regions included fusiform gyrus, primary motor cortex, and primary sensory cortex.

Table 1: Top regions correlated with percent change in YGTSS Total Score following DBS of globus pallidus internus (N = 34 patients)

Range of q-values (FDR-corrected p-values): q = 0.064-0.066.

Rank	Parcel Number	Hemisphere	Parcellation Area	F-score	R
1	179	Left	Cingulate cortex – pregenual (BA32)	10.139	0.491
2	183	Left	Cingulate cortex – caudodorsal BA24	7.799	0.443
3	227	Left	Dorsal caudate	7.043	0.425
4	231	Left	Thalamus – medial prefrontal region	6.551	0.412
5	177	Left	Cingulate cortex – rostroventral BA24	6.322	0.406
6	137	Left	Inferior parietal lobule – rostrodorsal BA39	6.252	-0.404
7	133	Left	Intraparietal area (BA7)	6.180	-0.402
8	185	Left	Cingulate cortex – caudal BA24	6.068	0.399
9	184	Right	Cingulate cortex – caudodorsal BA24	5.930	0.395
10	72	Right	Superior temporal gyrus (BA41/42)	5.904	-0.395
11	129	Left	Superior parietal lobule – lateral BA5	5.820	-0.392
12	124	Right	Caudoposterior superior temporal sulcus	5.757	-0.390
13	125	Left	Superior parietal lobule – rostral BA7	5.737	-0.390
14	143	Left	Inferior parietal lobule – rostroventral BA39	5.735	-0.390
15	180	Right	Cingulate cortex – pregenual (BA32)	5.711	0.389
16	146	Right	Inferior parietal lobule – rostroventral BA40	5.516	-0.383
17	141	Left	Inferior parietal lobule – caudal BA40	5.427	-0.381
18	139	Left	Inferior parietal lobule – rostrodorsal BA40	5.408	-0.380
19	153	Left	Precuneus – BA31	5.398	0.380
20	142	Right	Inferior parietal lobule – caudal BA40	5.334	-0.378
21	131	Left	Superior parietal lobule – postcentral BA7	5.235	-0.375
22	222	Right	Globus pallidus	5.134	-0.372
23	128	Right	Superior parietal lobule – caudal BA7	5.004	-0.368
24	76	Right	Superior temporal gyrus – caudal BA22	4.982	-0.367
25	148	Right	Precuneus – medial BA7	4.967	-0.367
26	145	Left	Inferior parietal lobule – rostroventral BA40	4.958	-0.366
27	126	Right	Superior parietal lobule – rostral BA7	4.918	-0.365
28	149	Left	Precuneus – medial BA5	4.862	-0.363
29	234	Right	Thalamus – premotor region	4.702	0.358
30	130	Right	Superior parietal lobule – lateral BA5	4.692	-0.358
31	150	Right	Precuneus – medial BA5	4.671	-0.357
32	228	Right	Dorsal caudate	4.647	0.356
33	147	Left	Precuneus – medial BA7	4.582	-0.354
34	42	Right	Orbitofrontal cortex – medial BA14	4.556	0.353
35	71	Left	Superior temporal gyrus – BA41/42	4.529	-0.352
36	168	Right	Dorsal agranular insula	4.506	-0.351
37	107	Left	Fusiform gyrus – lateroventral BA37	4.445	-0.349
38	230	Right	Dorsolateral putamen	4.432	-0.349
39	132	Right	Superior parietal lobule – postcentral BA7	4.423	-0.348
40	159	Left	Postcentral gyrus – BA2	4.369	-0.347
41	134	Right	Superior parietal lobule – intraparietal BA7	4.337	-0.345
42	161	Left	Postcentral gyrus – BA1/2/3 (trunk region)	4.312	-0.345
43	91	Left	Inferior temporal gyrus – extreme lateroventral BA37	4.297	-0.344
44	127	Left	Superior parietal lobule – caudal BA7	4.287	-0.344
45	201	Left	Lateral occipital cortex – V5/MT+	4.282	-0.344
46	61	Left	Precentral gyrus – BA4 (tongue and larynx)	4.259	-0.343
47	229	Left	Dorsolateral putamen	4.256	-0.343
48	140	Right	Inferior parietal lobule – rostrodorsal BA40	4.223	-0.341
49	164	Right	Hypergranula insula	4.159	-0.339
50	122	Right	Caudoposterior superior temporal sulcus	4.153	-0.339
51	172	Right	Dorsal granular insula	4.024	-0.334
52	65	Left	Paracentral lobule – BA1/2/3 (lower limb region)	4.017	-0.334
53	97	Left	Inferior temporal gyrus – ventrolateral BA37	3.989	-0.333

54	66	Right	Paracentral lobule – BA1/2/3 (lower limb region)	3.980	-0.333
55	59	Left	Precentral gyrus – BA4 (trunk region)	3.887	-0.329
56	245	Left	Thalamus – lateral prefrontal region	3.882	0.329
57	163	Left	Hypergranular insula	3.873	-0.329
58	44	Right	Orbitofrontal cortex – orbital BA12/BA47	3.777	0.325
59	14	Right	Superior frontal gyrus – medial BA10	3.738	0.323
60	57	Left	Precentral gyrus – BA4 (upper limb region)	3.730	-0.323
61	74	Right	Superior temporal gyrus – TE1.0 and TE1.2	3.729	-0.323
62	28	Right	Middle frontal gyrus – lateral BA10	3.721	0.323
63	152	Right	Precuneus – dorsomedial parietooccipital sulcus	3.669	-0.321
64	232	Right	Thalamus – medial prefrontal region	3.626	0.319

Table 2: Top regions correlated with percent change in YGTSS Total Score following bilateral DBS of centromedial thalamus (N = 32 patients)

Range of q-values (FDR-corrected p-values): q = 0.289-0.292.

Rank	Parcel Number	Hemisphere	Parcellation Area	F-score	R
1	229	Left	Dorsolateral putamen	3.756	0.334
2	98	Right	Inferior temporal gyrus – ventrolateral BA37	3.502	0.323
3	100	Right	Inferior temporal gyrus – caudolateral BA20	3.378	0.318
4	92	Right	Inferior temporal gyrus – extreme lateroventral BA37	3.363	0.317
5	152	Right	Precuneus – dorsomedial parietooccipital sulcus	3.040	-0.303
6	86	Right	Middle temporal gyrus – dorsolateral BA37	2.967	0.300
7	85	Left	Middle temporal gyrus – dorsolateral BA37	2.912	0.297
8	147	Left	Precuneus – medial BA7	2.894	-0.297
9	112	Right	Parahippocampal gyrus – caudal BA35/36	2.891	-0.296
10	151	Left	Precuneus – dorsomedial parietooccipital sulcus	2.848	-0.294
11	182	Right	Cingulate cortex – ventral BA23	2.762	-0.290
12	99	Left	Temporal gyrus – caudolateral of BA20	2.709	0.288
13	58	Right	Precentral gyrus – BA4 (upper limb)	2.619	0.283
14	144	Right	Inferior parietal lobule – rostroventral BA39	2.592	0.282
15	54	Right	Precentral gyrus – BA4 (head and face)	2.558	0.280
16	158	Right	Postcentral gyrus – BA1/2/3 (tongue and larynx)	2.499	0.277
17	102	Right	Inferior temporal gyrus – caudoventral of BA20	2.481	0.276
18	60	Right	Precentral gyrus – BA4 (trunk region)	2.446	0.275
19	156	Right	Postcentral gyrus – BA1/2/3 (upper limb, head, and face)	2.422	0.273
20	56	Right	Precentral gyrus – caudal dorsolateral BA6	2.421	0.273
21	181	Left	Cingulate cortex – ventral BA23	2.421	-0.273
22	120	Right	Parahippocampal gyrus – area TH (medial PPHC)	2.377	-0.271
23	62	Right	Precentral gyrus – BA4 (tongue and larynx)	2.292	0.266
24	10	Right	Superior frontal gyrus – medial BA6	2.076	0.254
25	68	Right	Paracentral lobule – BA4 (lower limb)	2.058	0.253
26	50	Right	Orbitofrontal cortex – BA13	2.054	-0.253
27	110	Right	Parahippocampal gyrus – rostral BA35/36	2.033	-0.252
28	138	Right	Inferior parietal lobule – rostrodorsal BA39	2.004	0.250
29	107	Left	Fusiform gyrus – lateroventral BA37	1.904	0.244
30	114	Right	Parahippocampal gyrus – area TL (lateral PPHC)	1.886	-0.243
31	240	Right	Thalamus – posterior parietal region	1.843	-0.241
32	11	Left	Superior frontal gyrus – medial BA9	1.771	-0.236
33	136	Right	Inferior parietal lobule – caudal BA39	1.742	0.234
34	160	Right	Postcentral gyrus – BA2	1.738	0.234
35	64	Right	Precentral gyrus – caudal ventrolateral BA6	1.709	0.232
36	80	Right	Superior temporal gyrus – rostral BA22	1.695	-0.231
37	198	Right	Ventromedial parietooccipital sulcus	1.665	-0.229
38	88	Right	Middle temporal gyrus – anterior superior temporal sulcus	1.661	-0.229

39	162	Right	Postcentral gyrus – BA1/2/3 (trunk region)	1.558	0.222
40	78	Right	Superior temporal gyrus – lateral BA38	1.553	-0.222
41	201	Left	V5/MT+	1.536	0.221
42	143	Left	Inferior parietal lobule – rostroventral BA39	1.533	0.221
43	5	Left	Superior frontal gyrus – lateral BA9	1.532	-0.220
44	8	Right	Superior frontal gyrus – dorsolateral BA6	1.528	0.220
45	194	Right	Medioventral occipital cortex – caudal cuneus gyrus	1.507	-0.219
46	208	Right	Lateral occipital cortex – medial superior occipital gyrus	1.497	-0.218
47	31	Left	Inferior frontal gyrus – inferior frontal sulcus	1.448	-0.215
48	127	Left	Superior parietal lobule – caudal BA7	1.423	-0.213
49	212	Right	Medial amygdala	1.362	-0.208
50	166	Right	Ventral agranular insula	1.362	-0.208
51	19	Left	Middle frontal gyrus – BA46	1.339	-0.207
52	21	Left	Middle frontal gyrus – ventral BA9/BA46	1.305	-0.204
53	234	Right	Thalamus – premotor region	1.301	0.204
54	140	Right	Inferior parietal lobule – rostrodorsal BA40	1.294	0.203
55	192	Right	Medioventral occipital cortex – rostral cuneus gyrus	1.278	-0.202
56	35	Left	Inferior frontal gyrus – rostral BA45	1.254	-0.200
57	204	Right	Lateral occipital cortex – occipital polar cortex	1.238	-0.199
58	236	Right	Thalamus – sensory region	1.235	0.199
59	33	Left	Inferior frontal gyrus – caudal BA45	1.220	-0.198
60	113	Left	Parahippocampal gyrus – area TL (lateral PPHC)	1.196	-0.196
61	84	Right	Middle temporal gyrus – rostral BA21	1.194	-0.196
62	243	Left	Thalamus – caudal temporal region	1.191	-0.195
63	97	Left	Inferior temporal gyrus – ventrolateral BA37	1.186	0.195
64	233	Left	Thalamus – premotor region	1.150	0.192

Table 3: Top regions correlated with percent change in Y–BOCS Total Score following bilateral DBS of globus pallidus internus (N = 24 patients)

Range of q-values (FDR-corrected p-values): q = 0.139-0.140.

Rank	Parcel Number	Hemisphere	Parcellation Area	F-score	R
1	211	Left	Medial amygdala	9.825	-0.556
2	215	Left	Rostral hippocampus	8.423	-0.526
3	181	Left	Cingulate cortex – ventral BA23	7.485	-0.504
4	241	Left	Thalamus – occipital region	7.405	-0.502
5	217	Left	Caudal hippocampus	6.112	-0.466
6	115	Left	Parahippocampal gyrus – entorhinal cortex	5.114	-0.434
7	230	Right	Dorsolateral putamen	4.662	-0.418
8	210	Right	Lateral occipital cortex – lateral superior occipital gyrus	4.122	-0.397
9	208	Right	Lateral occipital cortex – medial superior occipital gyrus	4.116	-0.397
10	119	Left	Parahippocampal gyrus – area TH (medial PPHC)	3.867	-0.387
11	74	Right	Superior temporal gyrus – TE1.0 and TE1.2	3.796	-0.384
12	152	Right	Precuneus – dorsomedial parietooccipital sulcus	3.788	-0.383
13	200	Right	Medioventral occipital cortex – middle occipital gyrus	3.770	-0.383
14	80	Right	Superior temporal gyrus – rostral BA22	3.725	-0.381
15	194	Right	Medioventral occipital cortex – caudal cuneus gyrus	3.691	-0.379
16	170	Right	Ventral dysgranular and granular insula	3.619	-0.376
17	203	Left	Lateral occipital cortex – occipital polar cortex	3.619	-0.376

18	193	Left	Medioventral occipital cortex – caudal cuneus gyrus	3.597	-0.375
19	164	Right	Hypergranular insula	3.582	-0.374
20	204	Right	Lateral occipital cortex – occipital polar cortex	3.543	-0.372
21	227	Left	Dorsal caudate	3.519	0.371
22	198	Right	Ventromedial parietooccipital sulcus	3.420	-0.367
23	136	Right	Superior parietal lobule – caudal BA39	3.295	-0.361
24	202	Right	Lateral occipital cortex – V5MT+	3.292	-0.361
25	76	Right	Superior temporal gyrus – caudal BA22	3.245	-0.359
26	112	Right	Parahippocampal gyrus – caudal BA35/36	3.245	-0.359
27	239	Left	Thalamus – posterior parietal area	3.238	-0.358
28	237	Left	Thalamus – rostral temporal area	3.204	-0.357
29	197	Left	Ventromedial parietooccipital sulcus	3.154	-0.354
30	117	Left	Temporal agranular insular cortex	3.130	-0.353
31	205	Left	Inferior occipital gyrus	3.125	-0.353
32	128	Right	Superior parietal lobule – caudal BA7	3.077	-0.350
33	78	Right	Superior temporal gyrus – lateral BA38	2.972	-0.345
34	88	Right	Middle temporal gyrus – anterior superior temporal sulcus	2.912	-0.342
35	207	Left	Lateral occipital cortex – medial superior occipital gyrus	2.900	-0.341
36	72	Right	Superior temporal gyrus – BA41/42	2.887	-0.341
37	124	Right	Caudoposterior superior temporal sulcus	2.871	-0.340
38	199	Left	Lateral occipital cortex – middle occipital gyrus	2.857	-0.339
39	213	Left	Lateral amygdala	2.827	-0.337
40	111	Left	Parahippocampal gyrus – caudal BA35/36	2.801	-0.336
41	176	Right	Cingulate cortex – dorsal BA23	2.750	-0.333
42	172	Right	Dorsal granular insula	2.749	-0.333
43	167	Left	Dorsal agranular insula	2.702	0.331
44	224	Right	Nucleus accumbens	2.671	-0.329
45	110	Right	Parahippocampal gyrus – rostral BA35/36	2.651	-0.328
46	118	Right	Parahippocampal gyrus – area TI (temporal agranular insula)	2.642	-0.327
47	138	Right	Inferior parietal lobule – rostrodorsal BA39	2.640	-0.327
48	148	Right	Precuneus – medial BA7	2.639	-0.327
49	185	Left	Cingulate cortex – caudal BA24	2.624	0.326
50	31	Left	Inferior frontal gyrus – inferior frontal sulcus	2.593	0.325
51	116	Right	Parahippocampal gyrus – entorhinal cortex	2.579	-0.324
52	16	Right	Middle frontal gyrus – dorsal BA9/46	2.564	0.323
53	206	Right	Lateral occipital cortex – inferior occipital gyrus	2.559	-0.323
54	108	Right	Fusiform gyrus – lateroventral BA37	2.516	-0.320
55	24	Right	Middle frontal gyrus – ventrolateral BA8	2.508	0.320
56	21	Left	Middle frontal gyrus – ventral BA9/46	2.478	0.318
57	33	Left	Inferior frontal gyrus – caudal BA45	2.474	0.318
58	5	Left	Superior frontal gyrus – lateral BA9	2.471	0.318
59	127	Left	Superior parietal lobule – caudal BA7	2.467	-0.318
60	39	Left	Inferior frontal gyrus – ventral BA44	2.460	0.317
61	192	Right	Medioventral occipital cortex – rostral cuneus gyrus	2.427	-0.315
62	146	Right	Inferior parietal lobule – rostroventral BA40	2.414	-0.314
63	191	Left	Medioventral occipital cortex – rostral cuneus gyrus	2.374	-0.312
64	15	Left	Middle frontal gyrus – dorsal BA9/46	2.349	0.311

Table 4: Top regions correlated with percent change in Y–BOCS Total Score following bilateral DBS of centromedial thalamus (N = 16 patients)

Across all regions, q-values (FDR-corrected p-values): q = 0.149.

Rank	Parcel Number	Hemisphere	Parcellation Area	F-score	R
1	226	Right	Ventromedial putamen	10.619	0.657
2	48	Right	Orbitofrontal cortex – medial BA11	8.369	0.612
3	220	Right	Ventral caudate	7.700	0.596
4	44	Right	Orbitofrontal cortex – orbital BA12/47	7.438	0.589
5	28	Right	Middle frontal gyrus – lateral BA10	7.253	0.584
6	46	Right	Orbitofrontal cortex – lateral BA11	7.128	0.581
7	190	Right	Medioventral occipital cortex – caudal lingual gyrus	6.472	0.562
8	42	Right	Orbitofrontal cortex – medial BA14	6.195	0.554
9	206	Right	Lateral occipital cortex – inferior occipital gyrus	5.950	0.546
10	14	Right	Superior frontal gyrus – Medial BA10	5.534	0.532
11	78	Right	Superior temporal gyrus – lateral BA38	5.157	0.519
12	204	Right	Lateral occipital cortex – occipital polar cortex	5.029	0.514
13	230	Right	Dorsolateral putamen	4.988	0.513
14	239	Left	Thalamus – posterior parietal region	4.777	0.504
15	194	Right	Medioventral occipital cortex – caudal cuneus gyrus	4.573	0.496
16	192	Right	Medioventral occipital cortex – rostral cuneus gyrus	4.570	0.496
17	106	Right	Fusiform gyrus – medioventral BA37	4.551	0.495
18	153	Left	Precuneus – BA31	4.332	0.486
19	232	Right	Thalamus – medial prefrontal region	4.213	0.481
20	82	Right	Middle temporal gyrus – caudal BA21	3.973	0.470
21	188	Right	Cingulate cortex – subgenual BA32	3.908	0.467
22	200	Right	Lateral occipital cortex – middle occipital gyrus	3.798	0.462
23	107	Left	Fusiform gyrus – lateroventral BA37	3.764	-0.460
24	196	Right	Medioventral occipital cortex – rostral lingual gyrus	3.720	0.458
25	198	Right	Ventromedial parietooccipital sulcus	3.638	0.454
26	88	Right	Middle temporal gyrus – anterior superior temporal sulcus	3.558	0.450
27	175	Left	Cingulate gyrus – dorsal area 23	3.411	0.443
28	160	Right	Postcentral gyrus – BA2	3.375	-0.441
29	249	-	Brainstem	3.370	-0.440
30	183	Left	Cingulate cortex – caudodorsal BA24	3.361	0.440
31	171	Left	Dorsal granular insula	3.337	-0.439
32	234	Left	Thalamus – premotor area	3.286	-0.436
33	7	Left	Cerebellum white matter	3.254	-0.434
34	52	Right	Orbitofrontal cortex – lateral BA12/47	3.243	0.434
35	137	Left	Inferior parietal lobule – rostrodorsal BA39	3.215	-0.432
36	247	Left	Cerebellum gray matter	3.192	-0.431
37	179	Left	Cingulate cortex – pregenual BA32	3.014	0.421
38	13	Left	Superior frontal gyrus – medial BA10	3.006	0.420
39	51	Left	Orbitofrontal cortex – lateral BA12/47	2.969	0.418
40	251	Right	Cerebellum white matter	2.966	-0.418
41	91	Left	Inferior temporal gyrus – extreme lateroventral BA37	2.950	-0.417
42	177	Left	Cingulate cortex – rostroventral BA24	2.917	0.415
43	185	Left	Cingulate cortex – subgenual BA32	2.905	0.415
44	250	Right	Cerebellum gray matter	2.898	-0.414
45	162	Right	Postcentral gyrus – BA1/2/3 (trunk region)	2.850	-0.411
46	222	Right	Globus pallidus	2.849	-0.411
47	37	Left	Inferior frontal gyrus – opercular BA44	2.818	0.409
48	54	Right	Precentral gyrus – BA4 (head and face region)	2.803	-0.408
49	163	Left	Hypergranular insula	2.770	-0.406

50	255	-	Cerebellar vermal lobules VI-VII	2.716	-0.403
51	143	Left	Inferior parietal lobule – rostroventral BA39	2.710	-0.403
52	35	Left	Inferior frontal gyrus – rostral BA45	2.705	0.402
53	159	Left	Postcentral gyrus – BA2	2.652	-0.399
54	254	-	Cerebellar vermal lobules I-V	2.604	-0.396
55	157	Left	Postcentral gyrus – BA1/2/3 (tongue and larynx region)	2.551	-0.393
56	156	Right	Postcentral gyrus – BA1/2/3 (upper limb, head, and face region)	2.547	-0.392
57	180	Right	Cingulate cortex – pregenual BA32	2.514	0.390
58	8	Right	Superior frontal gyrus – dorsolateral BA6	2.502	-0.389
59	178	Right	Cingulate cortex – rostroventral BA24	2.462	0.387
60	130	Right	Superior parietal lobule – lateral BA5	2.409	-0.383
61	241	Left	Thalamus – occipital region	2.388	0.382
62	155	Left	Postcentral gyrus – BA1/2/3 (upper limb, head, and face region)	2.365	-0.380
63	97	Left	Inferior temporal gyrus – ventrolateral BA37	2.346	-0.379
64	19	Left	Middle frontal gyrus – BA4	2.333	0.3780