SUPPLEMENTAL INFORMATION

Supplemental Figures

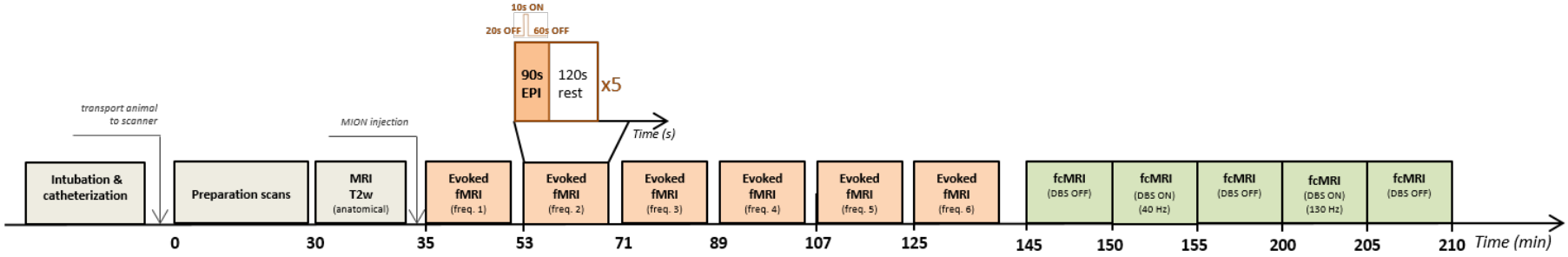

Figure S1. Experimental protocol. In preparation for fMRI procedures, rats were endotracheally intubated for mechanical ventilation and tail vein catheterization was applied for injection of the contrast agent (MION). Animals were then placed within a head-holder, and harnessed to a small animal cradle, after which they were transported to the MR scanner. Scanning started with a series of preparation scans to optimize location and magnetic field homogeneity. T_2-weighted images (T2w) were obtained for anatomical reference. Immediately prior to fMRI scan acquisition, rats were administered MION. A series of evoked fMRI scans with simultaneous DBS were obtained with a rest period of at least two minutes between each scan to allow for neurovascular recovery. Stimulation frequencies were varied in a pseudo-randomized order (freq. 1-6). Immediately following evoked fMRI scan acquisition, fcMRI scans were conducted in each subject. These scan series consisted of five, 5 minute scans during which either no stimulation or continuous DBS (40 or 130 Hz) was applied.

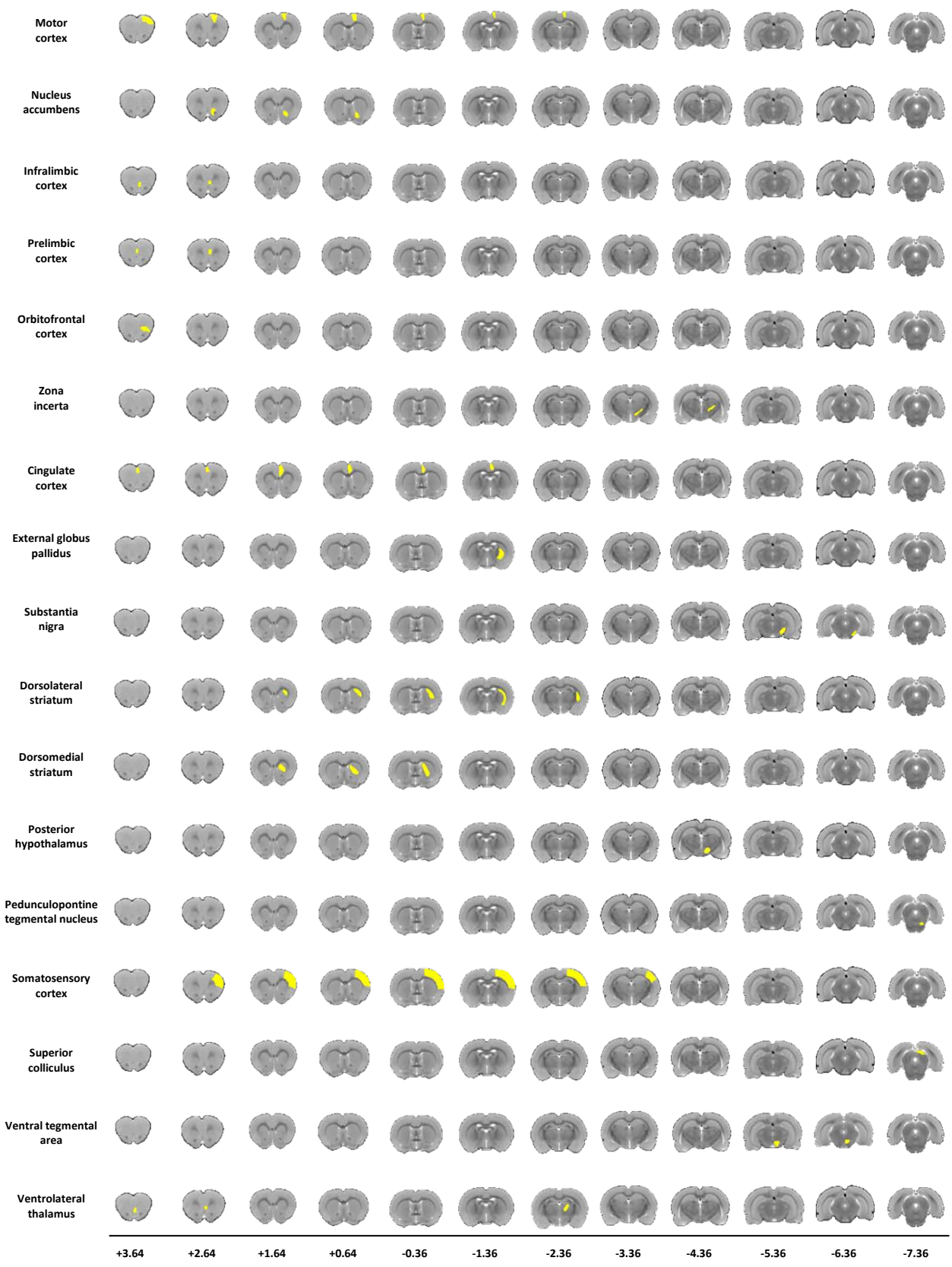

Figure S2. Seventeen anatomically-defined regions of interest (ROIs), used for the analysis of evoked-fMRI CBV traces (see **Figures 3-4, S6-7**), overlaid on the anatomical MR-template. Slice locations (reference to the Bregma in mm) are labeled at the bottom of the figure

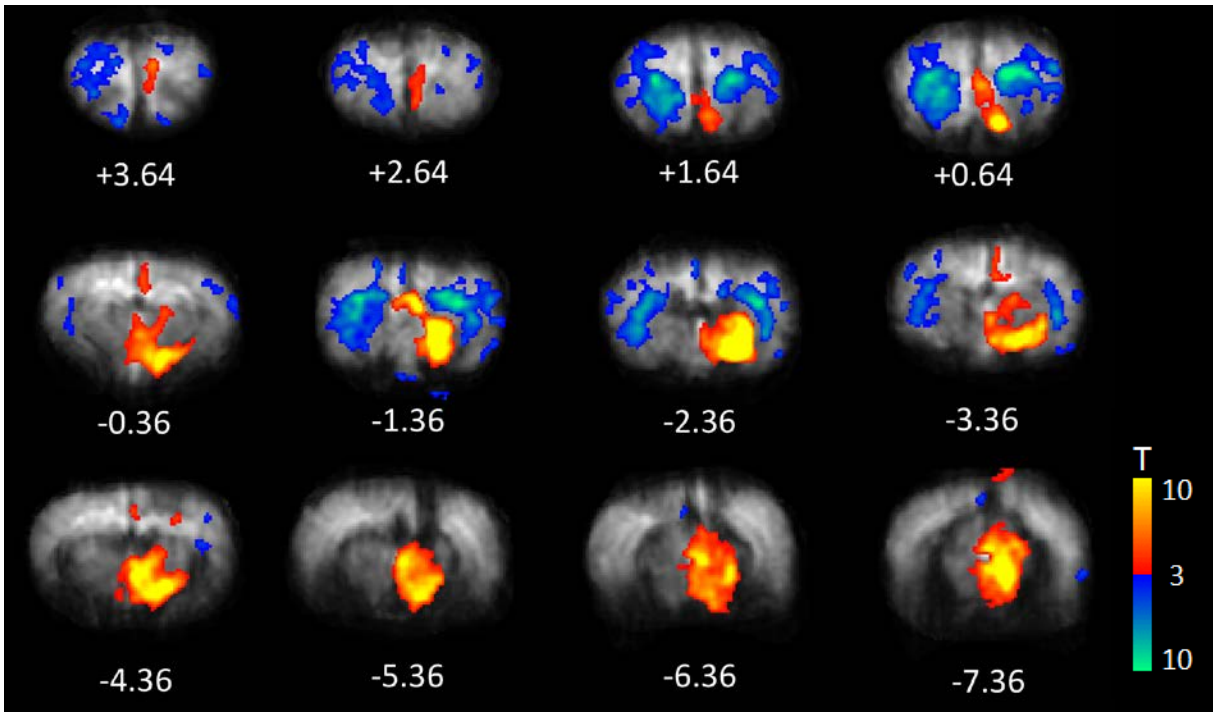

Figure S3. SNr-DBS-evoked functional activation maps (130 Hz) overlaying on representative group-averaged EPI images. For comparison, the template-overlaid images are presented in **Figure 2B**. Additional details regarding these images is located in the **Figure 2** caption. Numbers below each slice refer to anteroposterior slice location (reference to the Bregma in mm).

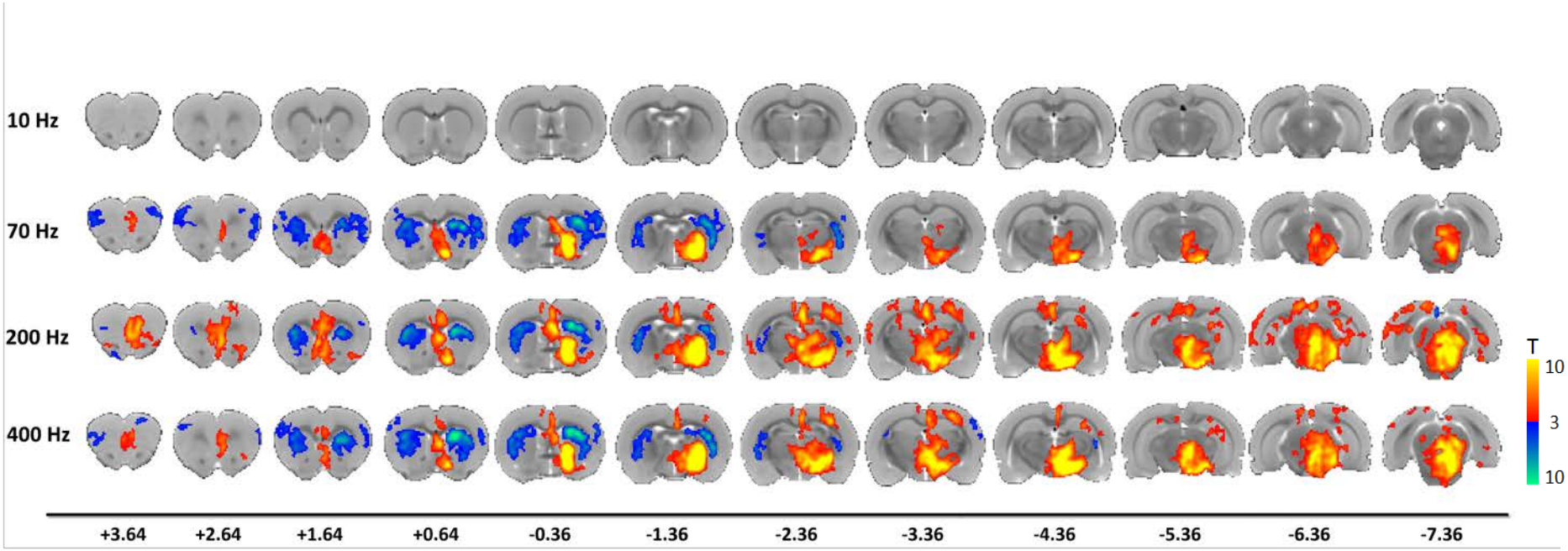

Figure S4. Functional activation maps of CBV modulation by SNr-DBS at 10, 70, 200, and 400 Hz. Note that SNr-DBS delivered at 10 Hz results in no significant CBV changes in any voxel. 70-200 Hz SNr-DBS resulted in CBV modulation within the targeted area as well as additional cortical and subcortical regions across the brain, including negative CBV signals within the striatum. Additional details regarding these images is located in the **Figure 2** caption. Slice locations (reference to the Bregma in mm) are labeled at the bottom of the figure.

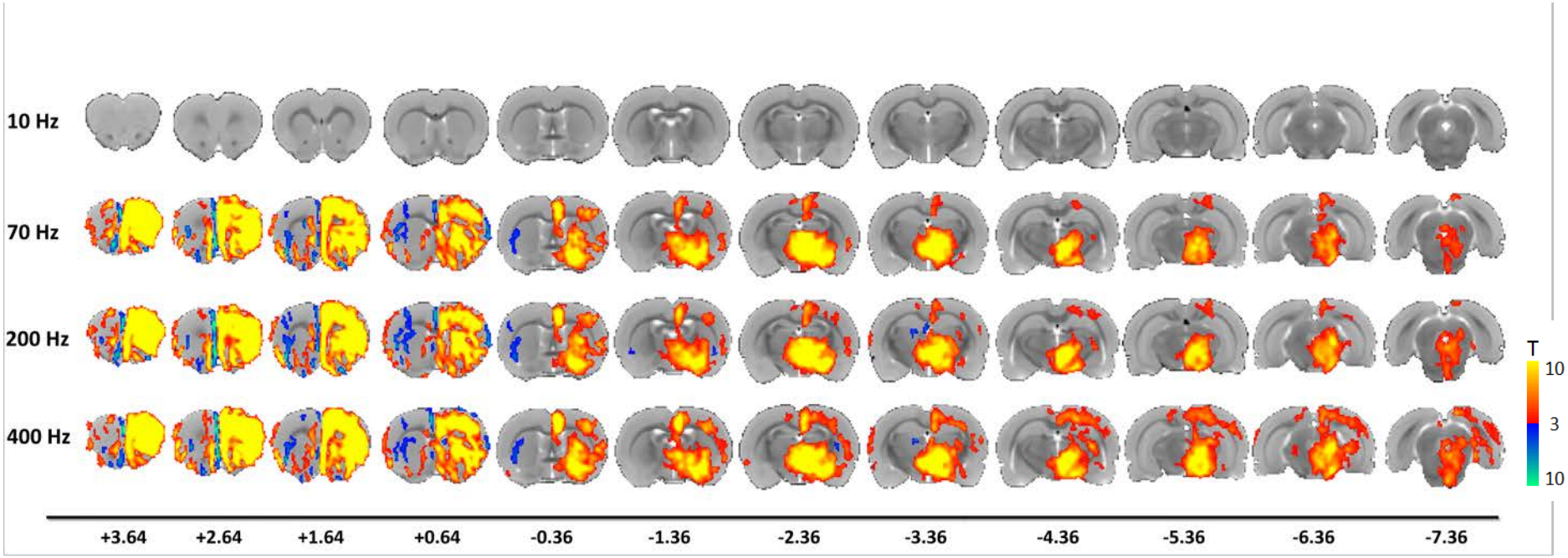

Figure S5. Functional activation maps of CBV modulation by GPe-DBS at 10, 70, 200, and 400 Hz. Note that GPe-DBS delivered at 10 Hz results in no significant CBV changes in any voxel. 70-200 Hz GPe-DBS resulted in CBV modulation within the targeted area as well as additional cortical and subcortical regions across the brain, including large prefrontal CBV increases and negative CBV signals within the striatum. Additional details regarding these images is located in the **Figure 2** caption. Slice locations (reference to the Bregma in mm) are labeled at the bottom of the figure.

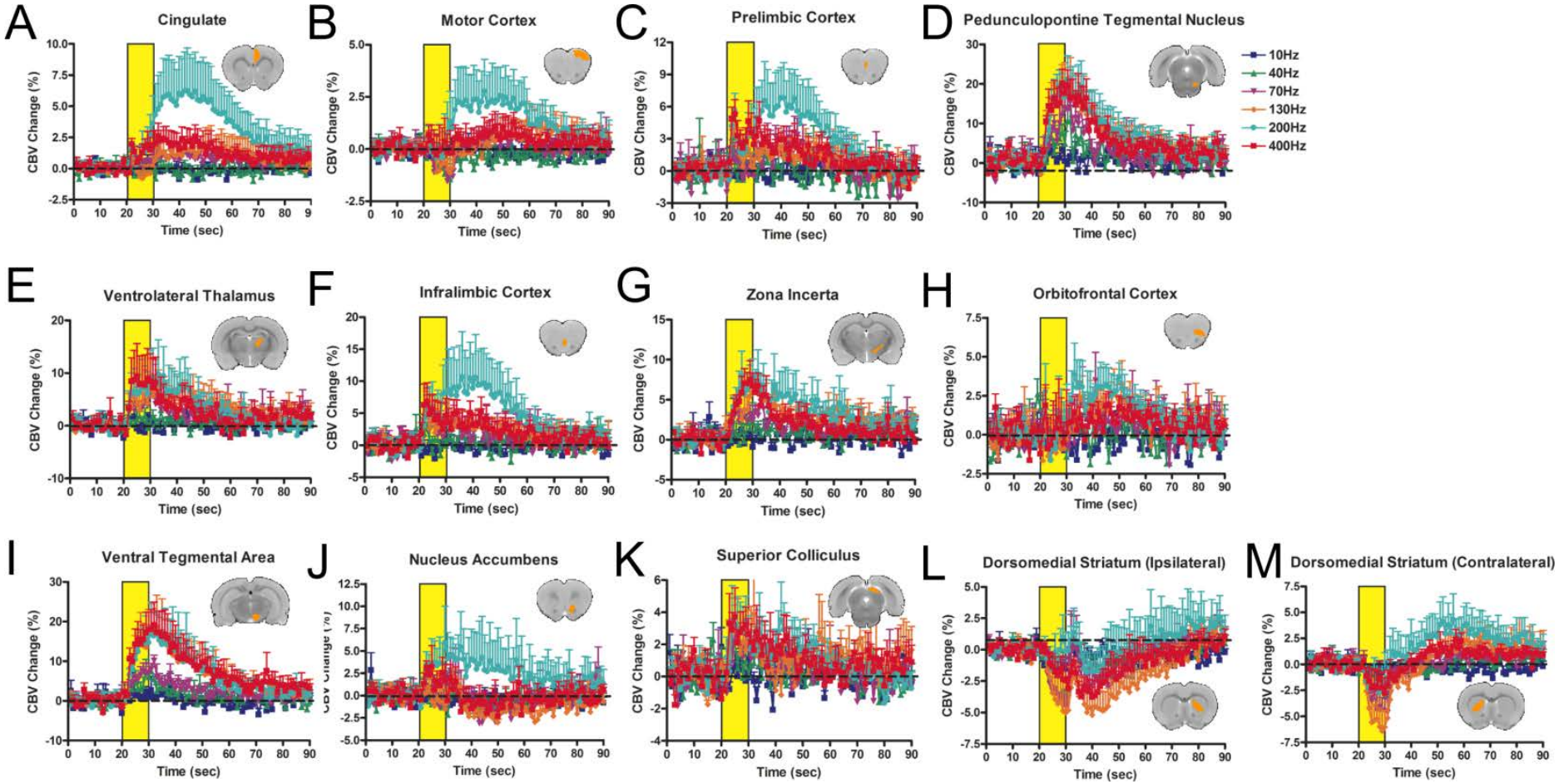

Figure S6. SNr-DBS evoked CBV changes at additional anatomically-defined regions of interest. (**A**) Cingulate (**B**) Motor cortex (**C**) Prelimbic cortex (**D**) Pedunculopontine tegmental nucleus (**E**) Ventrolateral thalamus (**F**) Infralimbic cortex (**G**) Zona incerta (**H**) Orbitofrontal cortex (**I**) Ventral tegmental area (**J**) Nucleus accumbens (**K**) Superior colliculus (**L**) Ipsilateral dorsomedial striatum (**M**) Contralateral dorsomedial striatum.

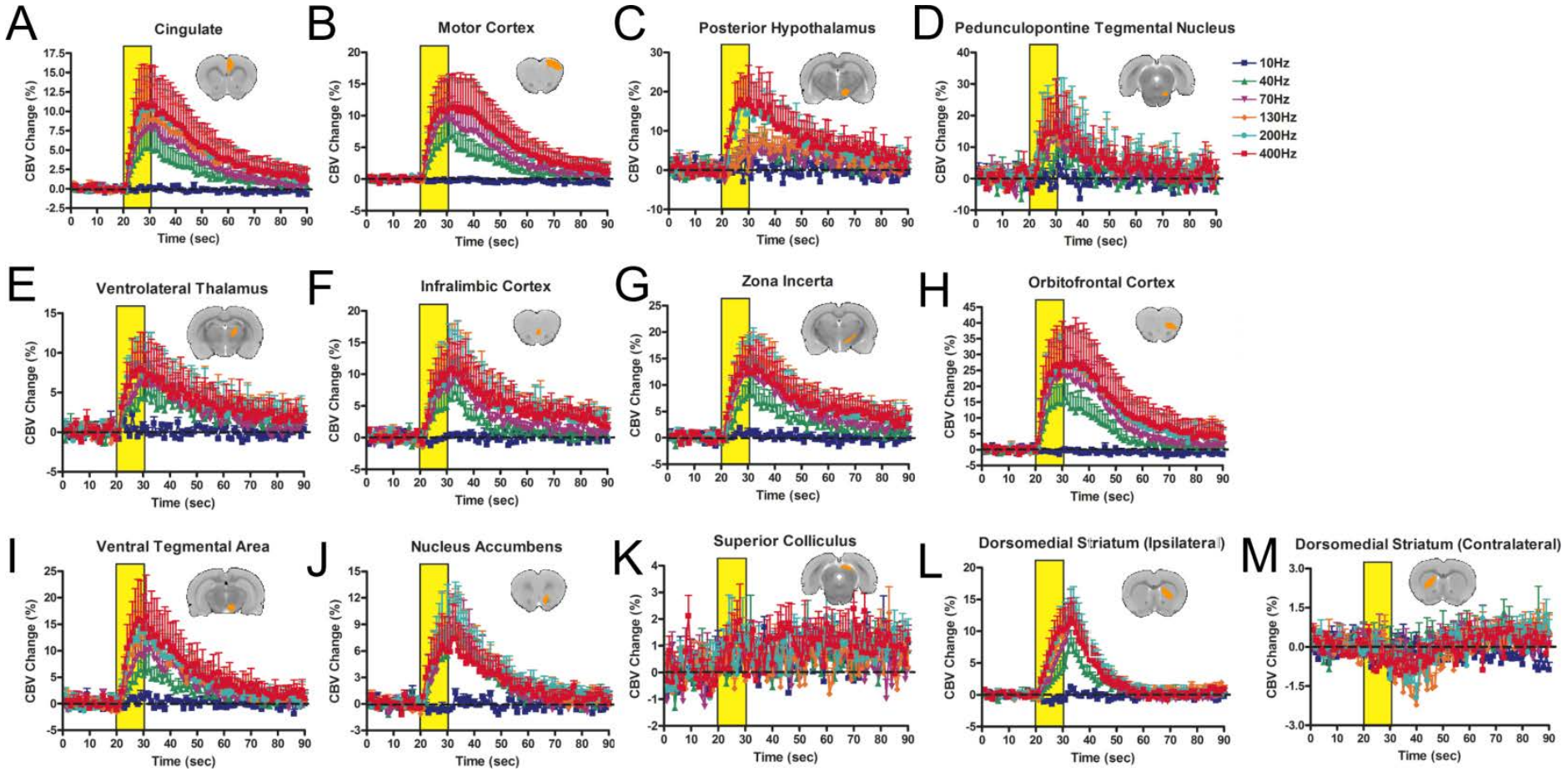

Figure S7. GPe-DBS evoked CBV changes at additional anatomically-defined regions of interest. (**A**) Cingulate (**B**) Motor cortex (**C**) Prelimbic cortex (**D**) Pedunculopontine tegmental nucleus (**E**) Ventrolateral thalamus (**F**) Infralimbic cortex (**G**) Zona incerta (**H**) Orbitofrontal cortex (**I**) Ventral tegmental area (**J**) Nucleus accumbens (**K**) Superior colliculus (**L**) Ipsilateral dorsomedial striatum (**M**) Contralateral dorsomedial striatum.

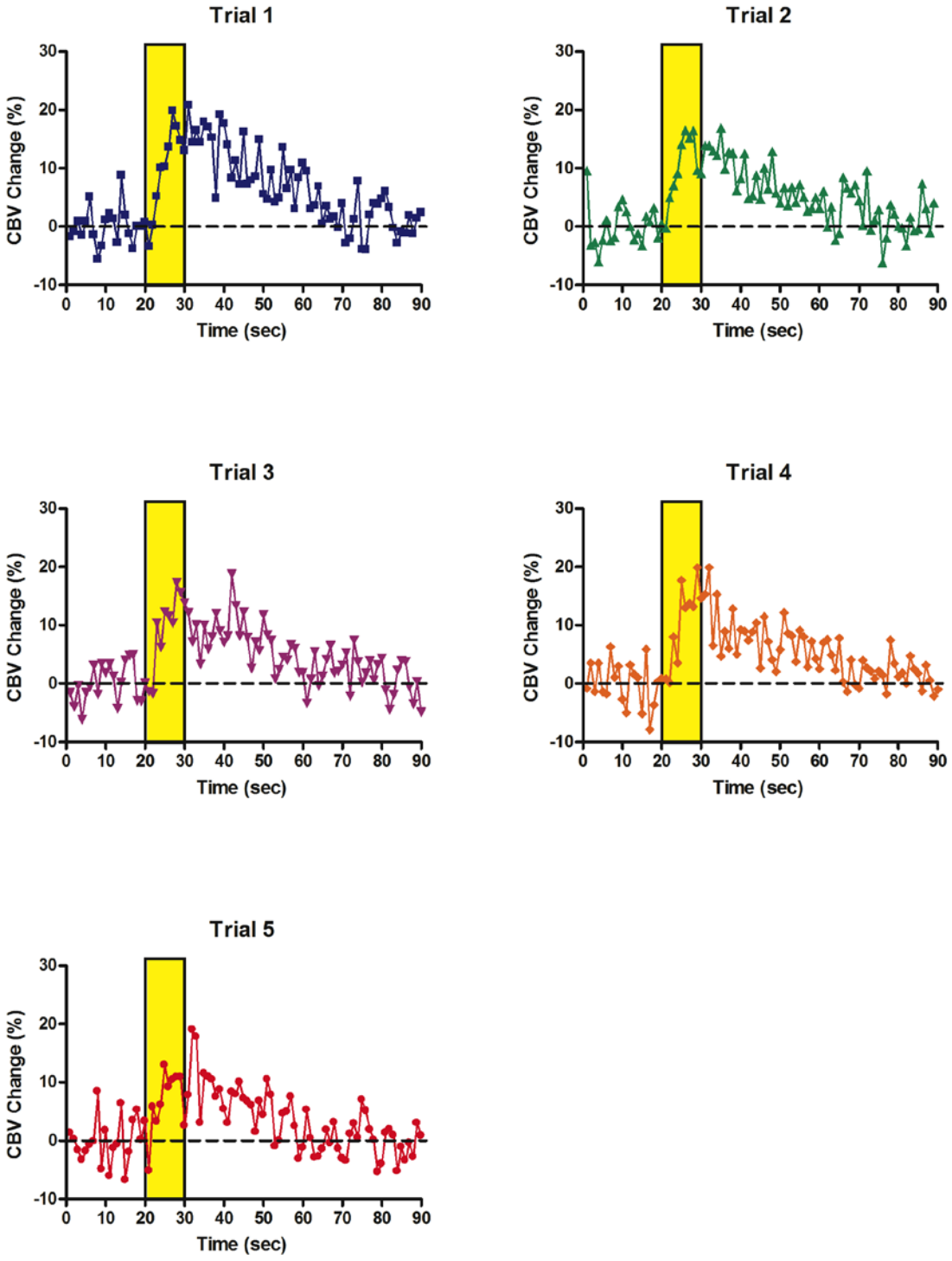

Figure S8. Representative example of CBV changes in response to DBS across five sequential scan sessions in a single subject (130 Hz GPe-DBS, Substantia Nigra region of interest).

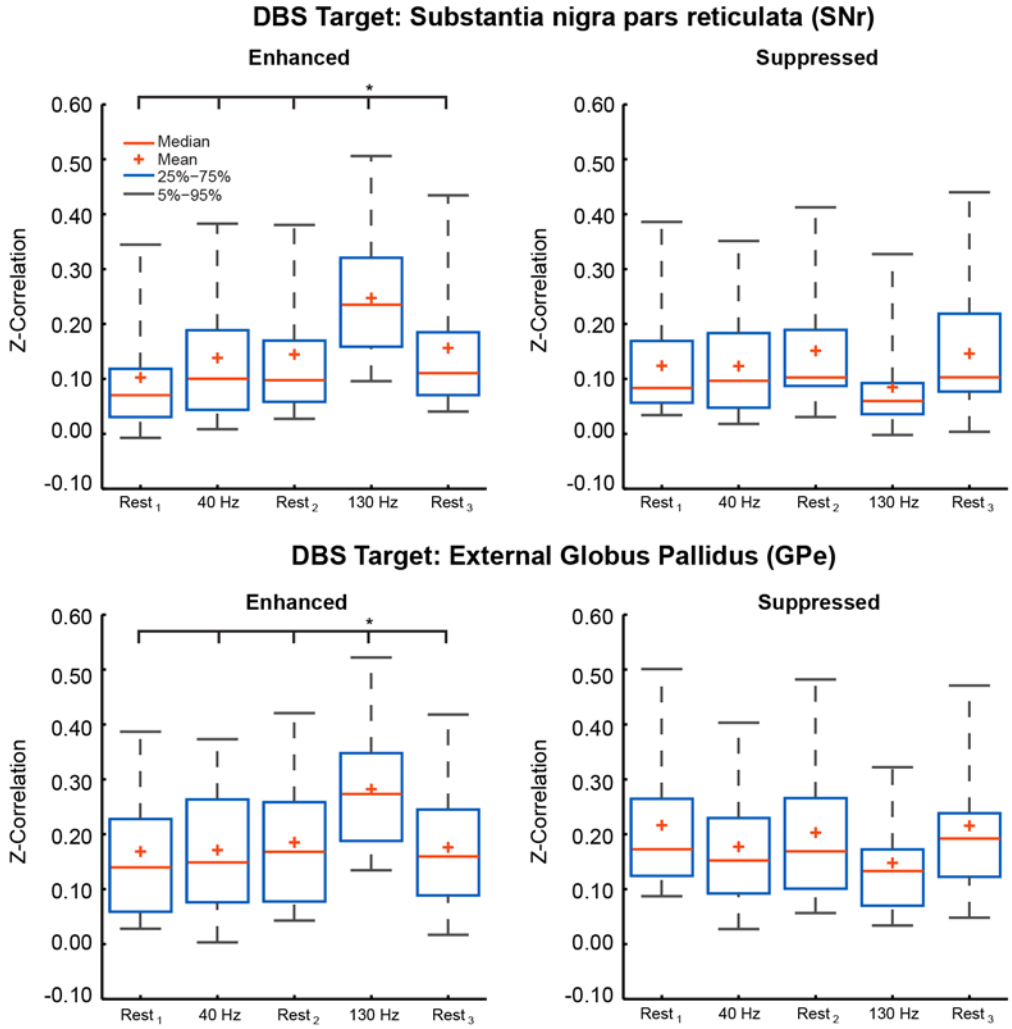

Figure S9. fcMRI Modulation via DBS of the SNr and GPe – without Global Signal Regression (GSR). Previously identified significant enhanced and suppressed connections (see **Figure 5B** and Supporting Material: **Supplemental Tables S1-2**) were re-analyzed using data without GSR in the pre-processing pipeline. The main-effect of condition for both DBS targets was maintained for enhanced but not for suppressed connections; SNr: $F_{Enhanced}(4,165) = 6.81$, $p < 0.001$ and $F_{Suppressed}(4,75) = 0.92$, $p = 0.460$; GPe: $F_{Enhanced}(4,190) = 5.71$, $p < 0.001$ and $F_{Suppressed}(4,190) = 1.85$, $p = 0.121$. For the enhanced connections, 130 Hz was significantly different from all other conditions for both DBS targets; * SNr $p \leq 0.016$, GPe ≤ 0.006.

Supplemental Tables

Table S1. SNr-DBS significantly (rANOVA, $p \leq 0.01$ uncorrected, $\Delta_{Z\text{-correlation}} \geq 0.10$) modulated individual connections corresponding to **Figure 5A.** Data sorted based on network grouping and modulation strength. ROI abbreviations are listed in **Figure 5 caption**.

DBS Target: Substantia nigra pars reticulata (SNr)

Enhancement - increased correlation

$Rest_1$	40Hz	$Rest_2$	130Hz	$Rest_3$	Δ	P-Value	Connection		Network
-0.01	0.06	-0.01	0.29	-0.02	0.31	5.76E-03	33	21	1
-0.02	0.02	-0.01	0.20	0.00	0.22	1.97E-03	39	21	1
0.08	0.03	0.07	0.23	0.08	0.20	7.66E-03	39	33	1
-0.02	0.02	-0.07	0.11	0.04	0.18	5.09E-03	77	64	1
-0.10	0.02	-0.05	0.03	-0.04	0.13	8.61E-03	84	72	1
0.07	0.02	0.07	0.15	0.06	0.13	7.52E-03	83	61	1
-0.04	0.00	-0.06	0.05	0.01	0.11	7.53E-03	62	29	1
0.04	0.04	0.05	0.13	-0.02	0.14	9.28E-03	49	48	2
-0.08	-0.03	0.01	-0.03	0.06	0.15	4.27E-03	60	2	3
0.00	0.00	0.00	0.04	-0.10	0.14	8.86E-04	54	23	3
0.02	-0.01	0.00	0.12	0.01	0.13	4.79E-03	90	43	3
-0.02	-0.05	-0.02	0.07	0.01	0.12	4.34E-03	45	12	3
-0.10	-0.04	0.01	0.12	-0.02	0.22	8.79E-03	85	77	4
-0.05	0.03	-0.04	0.17	-0.04	0.22	4.53E-05	28	5	4
-0.01	0.07	-0.09	0.12	-0.07	0.21	2.82E-05	15	5	4
0.00	0.15	-0.01	0.03	-0.05	0.19	7.96E-03	31	18	4
-0.05	0.02	-0.02	0.14	-0.04	0.19	9.84E-03	15	3	4
-0.08	-0.05	-0.04	0.10	-0.02	0.18	8.01E-03	85	63	4
-0.01	0.01	-0.02	0.16	-0.01	0.18	1.28E-03	31	21	4
0.00	0.01	-0.02	0.14	-0.01	0.16	6.46E-03	25	3	4
0.00	0.01	-0.02	0.12	-0.04	0.16	4.74E-03	28	3	4
0.00	-0.09	-0.05	0.06	-0.08	0.15	1.35E-03	63	42	4
-0.05	0.01	-0.06	0.09	0.03	0.15	4.11E-03	84	69	4
-0.04	0.00	-0.05	0.10	-0.03	0.14	1.44E-03	55	4	4
-0.05	-0.06	0.01	0.08	0.01	0.14	9.49E-03	17	15	4
-0.06	-0.01	0.00	0.08	-0.01	0.13	1.15E-03	68	66	4
0.18	0.21	0.17	0.30	0.26	0.13	6.23E-03	83	71	4
-0.03	-0.03	-0.03	0.09	-0.01	0.12	7.32E-04	30	28	4
-0.03	0.00	0.00	0.08	0.01	0.11	3.71E-03	40	9	4
-0.05	-0.05	0.03	0.03	0.07	0.11	1.42E-03	83	23	4
-0.02	0.06	0.03	0.09	0.03	0.11	6.12E-03	43	1	4
-0.07	-0.02	-0.04	0.04	0.04	0.11	1.86E-03	67	51	4
-0.06	-0.01	-0.01	0.05	0.00	0.11	9.74E-03	52	22	4
-0.03	-0.03	-0.02	0.03	0.07	0.10	5.70E-03	44	9	4

Suppression - increased anti-correlation

$Rest_1$	40Hz	$Rest_2$	130Hz	$Rest_3$	Δ	P-Value	Connection		Network
0.01	0.04	-0.09	-0.06	-0.03	0.13	4.21E-03	32	25	1
0.00	0.03	-0.02	-0.09	-0.04	0.12	2.35E-03	70	32	1
-0.04	0.00	-0.08	-0.14	-0.07	0.14	7.08E-03	50	26	2
0.03	0.00	0.01	-0.12	0.02	0.15	6.31E-03	55	28	3
0.02	-0.03	0.07	-0.01	0.00	0.10	2.96E-03	73	65	3
0.08	-0.03	0.12	-0.08	0.05	0.20	5.15E-04	77	5	4
0.09	0.03	0.10	-0.09	-0.01	0.19	6.79E-03	66	5	4
0.02	0.01	0.05	-0.12	0.04	0.17	3.20E-03	63	3	4
0.06	-0.04	-0.04	-0.03	-0.11	0.17	1.54E-03	63	41	4
-0.07	0.00	-0.06	-0.16	-0.04	0.16	7.03E-03	32	13	4
-0.02	-0.01	0.06	-0.09	0.07	0.16	3.45E-03	55	39	4
-0.01	-0.01	0.02	-0.10	0.01	0.12	4.25E-03	84	11	4
-0.05	0.02	-0.05	-0.09	0.03	0.12	4.99E-03	48	24	4
0.01	-0.09	0.01	-0.10	-0.04	0.11	3.65E-03	45	19	4
-0.05	-0.03	0.00	-0.08	0.02	0.10	3.95E-03	56	5	4
0.00	-0.01	0.03	-0.07	-0.05	0.10	8.34E-03	87	75	4

Connection		
Ipsilateral	ROI	Controlateral
1	PLC	46
2	ILC	47
3	OFC	48
4	CC	49
5	Insula	50
6	NAc	51
7	AS	52
8	vPall	53
9	Sept	54
10	lHyp	55
11	Amyg	56
12	BNST	57
13	MDT	58
14	vHipp	59
15	VTA	60
16	AD	61
17	AOB	62
18	DLS	63
19	DMS	64
20	ENT	65
21	GPe	66
22	Motor	67
23	OT	68
24	PAG	69
25	PPtg	70
26	PC	71
27	Piriform	72
28	pHyp	73
29	pThal	74
30	S2	75
31	SN	76
32	Somato	77
33	STN	78
34	TeA	79
35	VL	80
36	VPL Thal	81
37	VPM	82
38	Visual	83
39	ZI	84
40	dHipp	85
41	dRaphe	86
42	lHab	87
43	mPOA	88
44	SC	89
45	vHyp	90

Network	
1	Sensorimotor
2	Executive
3	Limbic
4	Between

Table S2. GPe-DBS significantly (rANOVA, $p \leq 0.01$ uncorrected, $\Delta_{Z\text{-correlation}} \geq 0.10$) modulated individual connections corresponding to **Figure 5A**. Data sorted based on network grouping and modulation strength. ROI abbreviations are listed in **Figure 5 caption**.

DBS Target: External Globus Pallidus (GPe)

Enhancement - increased correlation

$Rest_1$	40Hz	$Rest_2$	130Hz	$Rest_3$	Δ	P-Value	Connection		Network
0.05	0.08	0.07	0.27	0.03	0.24	6.51E-03	38	16	1
-0.03	-0.04	-0.02	0.19	0.00	0.24	2.06E-03	39	22	1
-0.03	-0.01	-0.02	0.14	-0.03	0.18	3.88E-03	77	16	1
-0.06	0.01	-0.06	0.10	-0.03	0.16	5.35E-03	77	64	1
0.04	0.03	0.02	0.18	0.02	0.16	3.05E-03	61	38	1
0.03	-0.03	-0.05	0.10	-0.03	0.15	4.92E-03	33	22	1
-0.06	0.06	-0.01	-0.02	-0.09	0.15	4.30E-04	62	39	1
0.17	0.19	0.10	0.22	0.18	0.12	2.23E-03	66	63	1
0.05	0.01	0.03	0.18	0.05	0.18	3.47E-04	31	15	3
-0.04	-0.03	-0.05	0.08	0.00	0.13	7.92E-03	15	2	3
-0.04	0.01	0.02	0.09	0.03	0.13	6.32E-03	58	11	3
-0.07	0.01	0.06	0.02	-0.01	0.12	6.89E-03	68	42	3
0.00	-0.04	0.00	0.06	-0.03	0.11	5.92E-03	42	2	3
0.00	-0.03	0.04	0.27	0.04	0.31	3.10E-03	22	5	4
0.00	-0.03	-0.01	0.14	-0.06	0.21	2.91E-03	39	5	4
0.00	-0.02	-0.03	0.17	-0.02	0.19	1.85E-04	10	5	4
-0.02	0.01	0.00	0.15	-0.02	0.18	2.68E-03	33	5	4
-0.05	0.02	0.03	0.12	0.00	0.17	1.42E-05	39	12	4
-0.03	-0.07	-0.03	0.10	0.00	0.17	3.17E-04	15	3	4
-0.03	0.02	-0.06	0.11	-0.01	0.16	5.71E-03	22	15	4
0.16	0.20	0.15	0.31	0.16	0.16	3.86E-03	33	28	4
-0.06	0.00	-0.01	0.09	0.01	0.15	5.88E-03	28	3	4
0.01	0.00	0.03	0.15	0.00	0.15	5.88E-03	27	7	4
-0.03	-0.02	-0.02	0.12	-0.02	0.14	6.00E-03	59	38	4
-0.08	-0.11	-0.07	0.03	-0.10	0.14	4.60E-03	77	51	4
-0.10	-0.14	-0.07	-0.01	-0.08	0.13	1.33E-03	85	51	4
-0.04	-0.05	-0.06	0.07	-0.03	0.13	7.99E-03	41	27	4
0.01	0.06	0.07	0.14	0.04	0.13	1.85E-03	68	62	4
-0.08	-0.07	-0.03	0.05	-0.07	0.13	2.06E-03	64	14	4
-0.09	-0.12	0.00	0.00	-0.04	0.12	4.00E-03	63	40	4
-0.04	-0.01	-0.05	0.07	-0.04	0.12	1.84E-03	85	77	4
0.01	0.02	0.00	0.05	-0.07	0.12	9.66E-04	74	43	4
-0.08	0.03	0.04	0.00	-0.02	0.11	1.10E-03	68	49	4
-0.08	0.03	0.03	0.02	-0.02	0.11	2.42E-03	84	14	4
-0.06	0.00	0.00	0.05	0.00	0.11	1.81E-03	71	20	4
-0.06	-0.01	-0.08	0.03	-0.04	0.11	4.93E-03	77	65	4
-0.04	0.03	-0.07	0.03	-0.06	0.10	5.81E-03	87	85	4
-0.06	-0.07	-0.03	0.04	-0.06	0.10	4.41E-03	85	62	4
-0.01	-0.03	-0.02	0.05	0.07	0.10	7.58E-03	85	57	4

Suppression - increased anti-correlation

$Rest_1$	40Hz	$Rest_2$	130Hz	$Rest_3$	Δ	P-Value	Connection		Network
0.23	0.20	0.20	-0.04	0.19	0.27	1.49E-03	77	32	1
-0.02	-0.06	0.04	-0.18	-0.03	0.22	1.62E-03	61	22	1
-0.04	-0.01	-0.05	-0.22	-0.01	0.21	1.25E-03	38	22	1
0.08	0.03	0.05	-0.11	0.01	0.19	5.67E-03	67	22	1
0.02	-0.02	0.01	-0.15	0.00	0.17	1.53E-03	39	38	1
-0.05	-0.02	-0.08	-0.19	-0.06	0.17	2.71E-04	83	22	1
0.01	-0.06	-0.01	0.01	0.08	0.15	7.21E-03	75	64	1
0.01	0.00	-0.04	-0.10	0.04	0.14	3.21E-04	38	33	1
0.05	-0.02	-0.08	0.01	0.01	0.13	2.90E-04	74	16	1
0.04	0.02	-0.07	-0.05	-0.01	0.12	5.08E-03	83	37	1
-0.01	0.02	0.06	-0.04	0.03	0.10	9.98E-03	44	37	1
-0.06	-0.02	-0.02	-0.18	-0.04	0.16	4.19E-03	71	5	2
-0.15	-0.09	-0.14	-0.24	-0.20	0.15	8.23E-03	85	5	2
0.03	0.13	0.06	0.00	0.01	0.13	7.32E-03	88	68	3
0.05	-0.06	0.00	-0.06	0.06	0.13	9.49E-04	65	2	3
0.00	-0.03	-0.03	-0.12	-0.05	0.12	2.42E-03	59	8	3
0.02	-0.07	-0.01	-0.06	0.04	0.11	1.17E-03	58	12	3
-0.02	-0.07	-0.02	-0.26	-0.05	0.24	5.72E-03	38	5	4
0.06	0.06	0.06	-0.18	0.03	0.24	4.67E-05	77	5	4
0.07	0.00	-0.01	-0.16	-0.04	0.23	8.59E-04	38	28	4
-0.05	-0.07	0.01	-0.16	0.05	0.21	1.06E-05	77	15	4
-0.07	-0.04	-0.04	-0.21	-0.02	0.19	1.37E-03	16	3	4
0.03	-0.06	-0.02	-0.15	-0.03	0.18	1.09E-03	71	22	4
-0.05	0.02	0.00	-0.14	-0.01	0.16	2.57E-03	22	20	4
0.01	0.05	-0.02	-0.11	0.02	0.16	2.81E-03	81	15	4
-0.12	-0.04	-0.03	-0.19	-0.05	0.16	5.09E-03	61	5	4
-0.02	-0.01	0.00	-0.15	0.00	0.16	9.54E-03	38	10	4
-0.03	-0.03	-0.03	-0.18	-0.04	0.15	3.42E-03	85	22	4
0.05	0.01	-0.02	-0.10	0.03	0.15	4.43E-03	85	15	4
0.06	0.03	0.03	-0.08	0.05	0.14	6.31E-03	39	14	4
0.01	0.04	-0.02	-0.10	0.03	0.14	9.59E-04	31	16	4
-0.02	0.04	0.00	-0.10	-0.02	0.13	6.48E-03	34	22	4
0.04	-0.05	0.01	-0.09	0.00	0.13	5.55E-03	24	21	4
-0.01	-0.11	0.01	-0.04	0.02	0.13	7.19E-03	65	21	4
0.07	-0.05	0.01	-0.05	-0.02	0.12	1.21E-03	81	31	4
-0.05	0.01	0.04	-0.07	-0.02	0.11	9.04E-03	77	24	4
0.01	0.01	0.03	-0.08	0.03	0.11	3.03E-03	72	5	4
0.08	0.03	0.00	-0.02	-0.02	0.10	2.88E-03	81	41	4
0.02	0.02	-0.04	-0.05	-0.08	0.10	4.23E-03	84	3	4

Connection		
Ipsilateral	ROI	Controlateral
1	PLC	46
2	ILC	47
3	OFC	48
4	CC	49
5	Insula	50
6	NAc	51
7	AS	52
8	vPall	53
9	Sept	54
10	lHyp	55
11	Amyg	56
12	BNST	57
13	MDT	58
14	vHipp	59
15	VTA	60
16	AC	61
17	AOB	62
18	DLS	63
19	DMS	64
20	ENT	65
21	GPe	66
22	Motor	67
23	OT	68
24	PAG	69
25	PPtg	70
26	PC	71
27	Piriform	72
28	pHyp	73
29	pThal	74
30	S2	75
31	SN	76
32	Somato	77
33	STN	78
34	TeA	79
35	VL	80
36	VPL Thal	81
37	VPM	82
38	Visual	83
39	ZI	84
40	dHipp	85
41	dRaphe	86
42	lHab	87
43	mPOA	88
44	SC	89
45	vHyp	90

Network	
1	Sensorimotor
2	Executive
3	Limbic
4	Between

Table S3. Summary statistics for post-hoc comparison (two-sample t-tests: Rest vs. 40 Hz, Rest vs. 130 Hz, and 40 Hz vs. 130 Hz) across significantly modulated connections (**Table S1 and S2**) grouped by DBS target (SNr and GPe) and modulation direction (Enhanced: increased correlation; Suppressed: increased anti-correlation).

DBS Target: Substantia nigra pars reticulata (SNr)

Enhancement - increased correlation

t-test	df	t	p-value
Rest vs 40 Hz	134	-1.56	1.20E-01
Rest vs 130 Hz	134	-9.70	**3.51E-17**
40 Hz vs 130 Hz	66	-6.20	**4.10E-08**

Suppression - increased anti-correlation

t-test	df	t	p-value
Rest vs 40 Hz	62	0.58	5.63E-01
Rest vs 130 Hz	62	6.42	**2.14E-08**
40 Hz vs 130 Hz	30	6.33	**5.63E-07**

DBS Target: External Globus Pallidus (GPe)

Enhancement - increased correlation

t-test	df	t	p-value
Rest vs 40 Hz	154	-0.79	4.30E-01
Rest vs 130 Hz	154	-9.74	**9.07E-18**
40 Hz vs 130 Hz	76	-6.26	**2.06E-08**

Suppression - increased anti-correlation

t-test	df	t	p-value
Rest vs 40 Hz	154	0.70	4.82E-01
Rest vs 130 Hz	154	10.00	**1.83E-18**
40 Hz vs 130 Hz	76	7.23	**3.28E-10**