

Identifying maximal beta power from directional subthalamic local field potentials in Parkinson's disease

Supplementary material

ID	Sex	Age (y)	Disease duration (y since diagnosis)	Clinical phenotype	Symptom dominant side	MDS-UPDRS-III pre-surgery off/on	MDS-UPDRS-III 12 months post-surgery, med-off, stim-off/ on	Recording sessions		
1	f	70	11	M	right	49/30	44/16			IPG-12
2	f	43	2	A/R	left	36/11	19/13			IPG-12
3	f	71	13	TD	right	42/7	51/29			IPG-12
4	m	73	15	A/R	left	67/43	56/27	EXT	IPG-0	IPG-12
5	m	69	18	A/R	right	40/25	41/30	EXT	IPG-0	IPG-12
6	m	67	5	M	right	24/13	38/34		IPG-0	IPG-12
7	m	58	15	A/R	left	69/39	38/35	EXT	IPG-0	IPG-12
8	f	65	6	M	right	68/22	30/20	EXT	IPG-0	IPG-12
9	m	55	4	A/R	right	69/29	48/33	EXT	IPG-0	IPG-12
10	f	72	12	A/R	right	43/25	-	-	IPG-0	
11	m	45	7	A/R	right	76/33	-	EXT	IPG-0	
12	m	57	6	M	right	45/13	57/24			IPG-12
13	m	60	14	A/R	right	35/15	42/11			IPG-12
14	m	57	10	A/R	right	74/42	43/X			IPG-12
15	m	68	8	A/R	right	44/16	54/24			IPG-12
16	m	55	13	M	right	36/13	43/18			IPG-12
17	f	71	12	M	right	31/17	31/17	EXT	IPG-0	IPG-12
18	m	57	9	A/R	left	33/19	37/34	EXT	IPG-0	IPG-12
19	m	66	4	M	left	58/32	53/31	EXT	IPG-0	IPG-12
20	f	67	7	TD	left	51/23	40/28			IPG-12
21	m	53	15	A/R	right	64/27	52/32	EXT	IPG-0	IPG-12
22	m	61	6	M	right	33/15	40/27		IPG-0	IPG-12
23	f	63	11	A/R	left	36/15	-	EXT		
24	m	74	20	A/R	left	52/18	30/23	EXT	IPG-0	IPG-12
25	m	65	10	A/R	left	76/21	60/53	EXT	IPG-0	IPG-12
26	m	53	10	A/R	right	34/13	35/17	-	IPG-0	IPG-12
27	f	70	17	TD	right	52/10	49/32	-	IPG-0	IPG-12
28	m	52	13	M	left	34/18	-	EXT		
29	f	66	9	M	left	50/26	-	EXT		
30	f	64	5	A/R	right	31/13	-	EXT	IPG-0	
31	m	51	10	M	right	90/55	-	EXT		
32	m	70	6	M	right	73/36	-	EXT	IPG-0	
33	m	68	9	A/R	both	40/30	-	EXT	IPG-0	
34	m	42	21	M	left	90/42	-	EXT		
35	f	56	10	M	left	59/27	-	EXT		
36	m	44	11	A/R	left	52/30	-	EXT		

Supplementary Table S1: Clinical and demographic details from 36 PD patients (mean $\pm$ SD age 61 ± 9.10 years, disease duration 10 ± 4.57 years, MDS-UPDRS-III medication-off before surgery 51.56 ± 17.68). LFP recordings were performed from externalized leads (EXT, $n=44$), shortly after surgery from the IPG (IGP-0, $n=40$) and 12 months after surgery (IPG-12, $n=48$). f = female, m = male, M = mixed, TD = tremor-dominant, A/R = akinetic-rigid PD phenotype, y = years.

ID	Stimulation contacts, amplitude LSTN	Stimulation contacts, amplitude RSTN	Stimulation pulse width, frequency	Contact with maximal pseudo-monopolar beta power LSTN / RSTN
1	2- 3-, 1.05 mA	2- 3-, 1.05 mA	40 μ s, 100 Hz	1B / 3
2	1-, 1.5 mA	0-, 1.5 mA	60 μ s, 130 Hz	1A / 1A
3	0- 1B -, 1.9 mA	0- 1B -, 2.1 mA	60 μ s, 130 Hz	1C / 1A
4	1-, 4.7 mA	1-, 4.3 mA	40 μ s, 90 Hz	1A / 2A
5	2-, 2.5 mA	2-, 2.3 mA	60 μ s, 125 Hz	1A / 2A
6	1A - 1B -, 5.1 mA	2A - 2B -, 4.5 mA	60 μ s, 125 Hz	1A / 1A
7	1C - 2C -, 2.5 mA	1-, 2.6 mA	60 μ s, 125 Hz	1A / 2A
8	2C -, 0.9 mA	1C - 2C -, 1.4 mA	60 μ s, 125 Hz	1A / 2A
9	2-, 2.8 mA	2-, 2.8 mA	60 μ s, 130 Hz	1C / 3
12	2A - 2B - 3-, 2.8 mA	2A - 2B - 3-, 3.1 mA	60 μ s, 125 Hz	2A / 2B
13	1- 2-, 2.3 mA	1- 2-, 2.3 mA	60 μ s, 100 Hz	1C / 1C
14	2-, 3.4 mA	2-, 2.7 mA	60 μ s, 130 Hz	2B / 1A
15	2-, 2 mA	1-, 2 mA	60 μ s, 110 Hz	3 / 1B
16	1- 3-, 1 mA	2-, 1.8 mA	60 μ s, 110 Hz	1A / 2A
17	1- 2-, 1.5 mA	1- 2-, 1.2 mA	60 μ s, 90 Hz	2C / 2C
18	1-, 2.8 mA	0-, 2.8 mA	40 μ s, 130 Hz	1B / 1B
19	1-, 1 mA	1-, 3 mA	60 μ s, 130 Hz	2A / 0
20	2B - 2C - 3-, 2.3 mA	2B - 2C - 3-, 2.6 mA	60 μ s, 110 Hz	1A / 1B
21	1+ 2- 3+, 2.5 mA	1B - 2B -, 5.7 mA	60 μ s, 130 Hz	2C / 2B
22	1-, 2.5 mA	1-, 2.5 mA	60 μ s, 100 Hz	2C / 1C
24	1-, 2.2 mA	2-, 2.6 mA	60 μ s, 125 Hz	0 / 1B
25	2-, 2.7 mA	2-, 2.7 mA	60 μ s, 90 Hz	2A / 2A
26	1-, 2.4 mA	1-, 2.3 mA	60 μ s, 85 Hz	2A / 2A
27	2- 3-, 1.9 mA	2- 3-, 1.7 mA	60 μ s, 100 Hz	2A / 2A

Supplementary Table S2. Stimulation parameters and contacts with maximal pseudo-monopolar beta power using the Euclidean method at 12 months post-surgery. For hemispheres with directional stimulation, active contacts are written in bold. If no contact in the two middle levels was active for chronic stimulation or a bipolar stimulation setting was used, the contacts are in gray color and corresponding hemispheres were excluded from the analysis. Directional stimulation was used in 12 of 48 hemispheres. Three hemispheres were excluded due to bipolar stimulation or no active middle level stimulation contact.

***specparam* parameters: (1)**

Externalized LFPs:

- Frequency range 2-45 Hz (because of the plateau at higher frequencies)
- peak_width_limits = [3, 20.0], max_n_peaks = 3, min_peak_height = 0.1, aperiodic_mode = "fixed".
- DBS leads: 44
- Total number of fitted channels: 308 (6 directional contacts and uppermost ring contact per lead)
- Specparam error mean $\pm$ SEM: 0.069 ± 0.002
- Specparam r squared mean $\pm$ SEM: 0.9501 ± 0.003

IPG-12 LFPs:

- Frequency range 2-95 Hz
- peak_width_limits = [3, 20.0], max_n_peaks = 4, min_peak_height = 0.1, aperiodic_mode = "fixed".
- DBS leads: 48
- Total number of fitted channels: 576 (12 bipolar channels per lead)
- Specparam error mean $\pm$ SEM: 0.075 ± 0.0005
- Specparam r squared mean $\pm$ SEM: 0.976 ± 0.0006

Power spectra were fitted without respecting a knee in the aperiodic component, since recent studies have shown the absence of a knee in the aperiodic component in the STN (2).

References

1. Donoghue T, Haller M, Peterson EJ, Varma P, Sebastian P, Gao R, et al. Parameterizing neural power spectra into periodic and aperiodic components. *Nat Neurosci.* 2020;23(12):1655-65.
2. Bush A, Zou J, Lipski WJ, Kokkinos V, Richardson RM. Broadband aperiodic components of local field potentials reflect inherent differences between cortical and subcortical activity. *bioRxiv.* 2023.