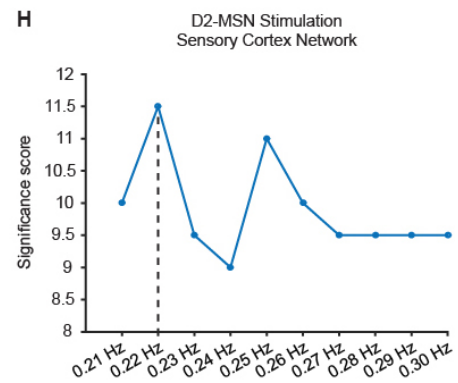
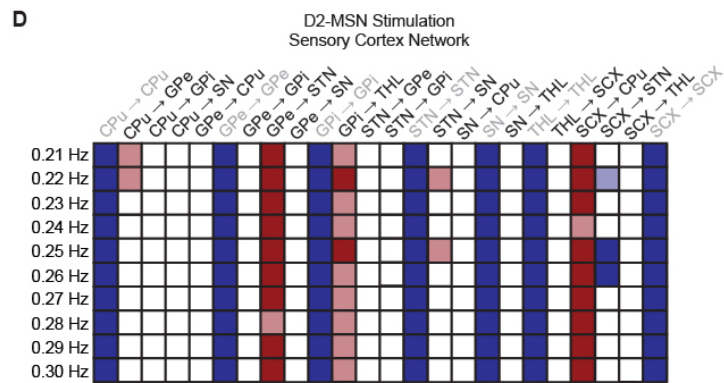
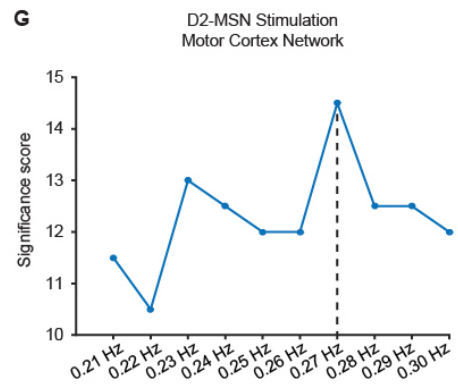
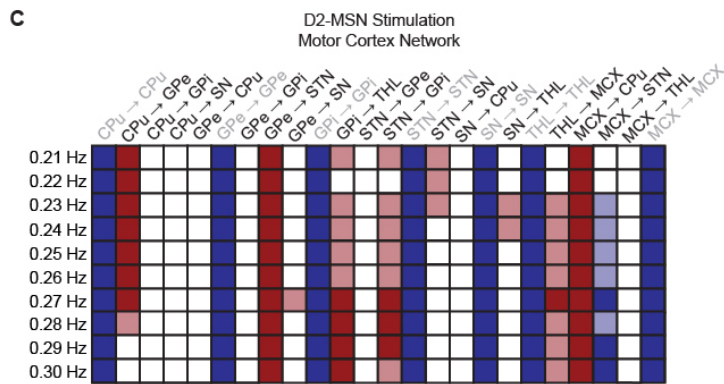
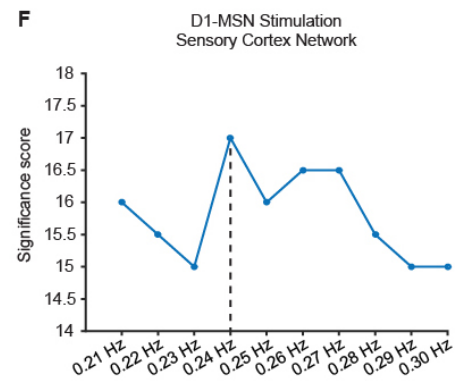
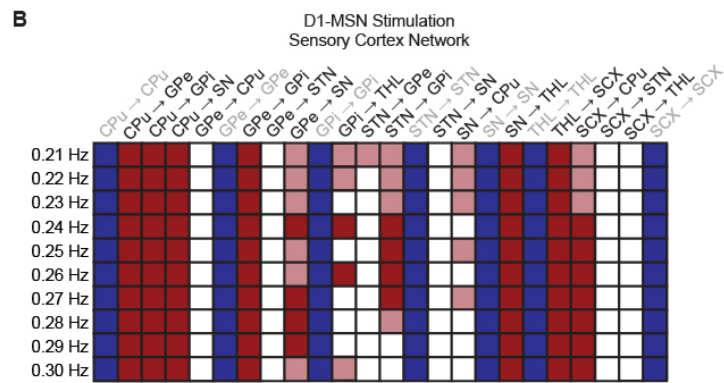
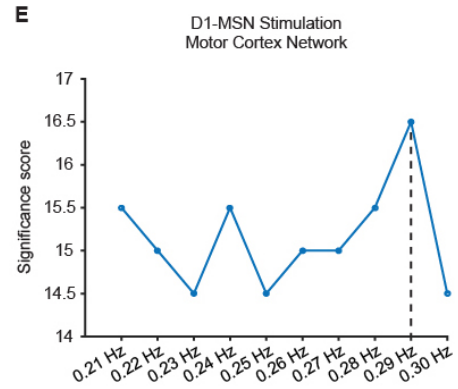
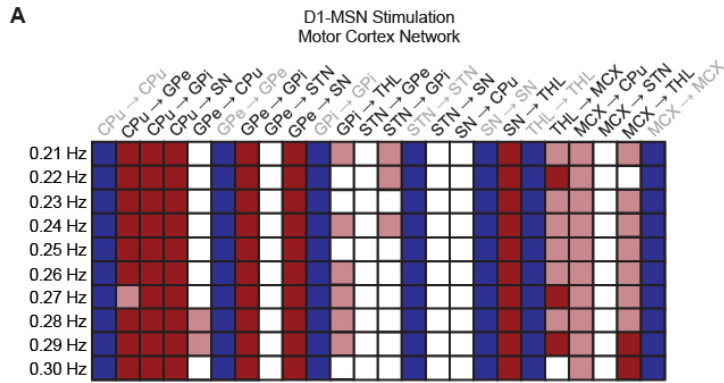


Supplemental Figures and Legends



■ Significant ■ Significant
■ Close-to-significant ■ Close-to-significant

Figure S1, Related to Figures 3 and 4. Illustration of significant and close-to-significant connections during D1- and D2-MSN stimulations for the MCX and SCX network models at each cutoff frequency. A,B, Significant and close-to-significant effective connections during D1-MSN stimulations for MCX and SCX network models, respectively. **C,D,** Significant and close-to-significant effective connections during D2-MSN stimulations for MCX and SCX network models, respectively. Substantial variability in the p-values of some connectivity estimates across cutoff frequencies was observed. In all panels, statistical significance was determined by testing effective connectivity strengths across subjects. Significant, $P < 0.05$; Close-to-significant, $P < 0.10$. **E,F,** Weighted sum number of significant and close-to-significant connections during D1-MSN stimulations for MCX and SCX network models, respectively. The optimal cutoff frequencies, marked with a vertical dashed line, were 0.29 and 0.24 Hz, respectively. **G,H,** Weighted sum number of significant and close-to-significant connections during D2-MSN stimulations for MCX and SCX network models, respectively. The optimal cutoff frequencies, marked with a vertical dashed line, were 0.27 and 0.22 Hz, respectively.

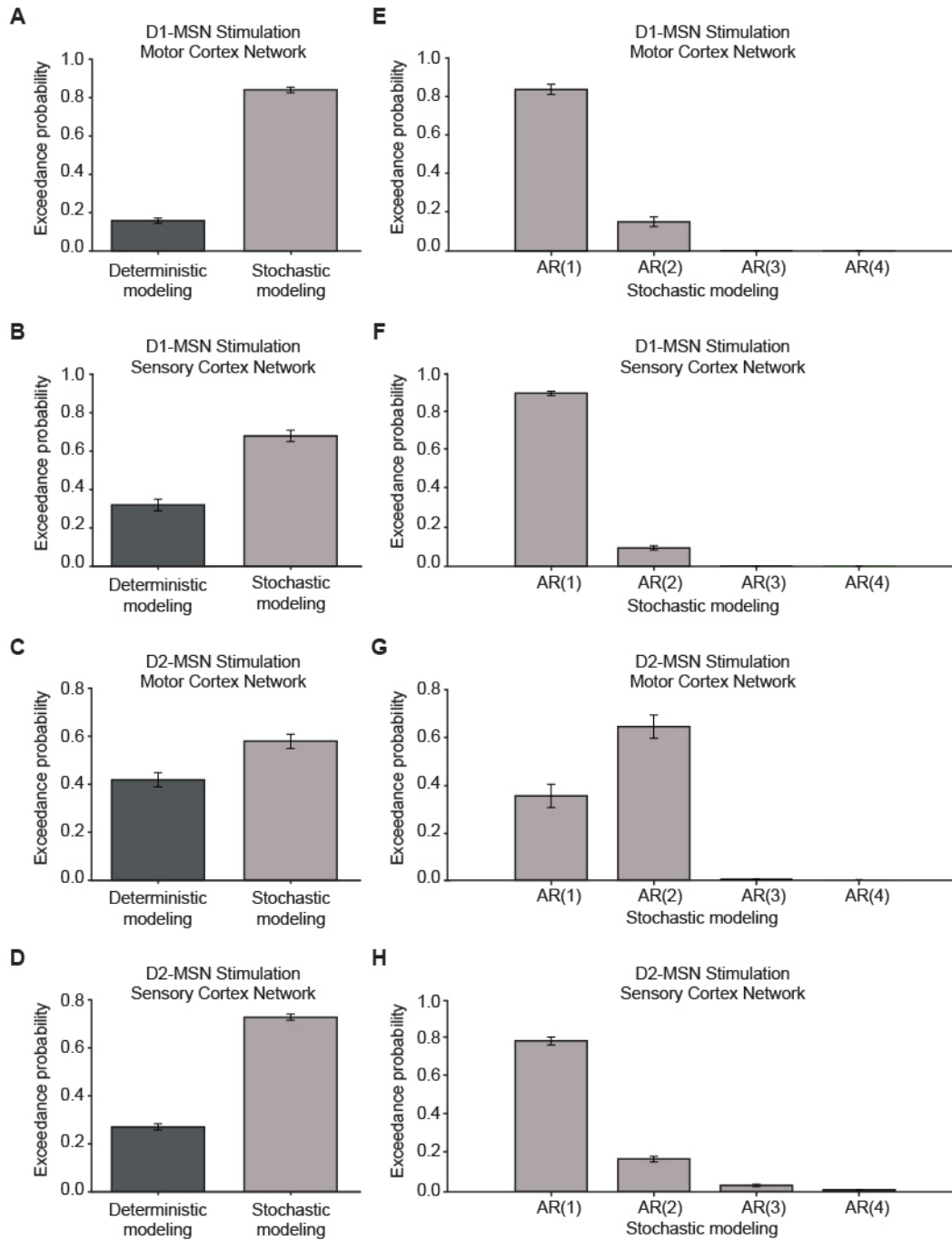


Figure S2, Related to Figures 3 and 4. Comparison between deterministic and stochastic modeling and evaluation of autoregressive models under stochastic assumptions across cutoff frequencies. A-D, Comparison of model exceedance probabilities between deterministic and stochastic modeling. E-H, Illustrative comparison of model exceedance probabilities of

autoregressive processes under stochastic assumptions. Error bars represent the standard error of the mean exceedance probabilities across cutoff frequencies.

Supplemental Tables and Legends

Table S1, Related to Figure 3. Connectivity estimates, 95% confidence intervals across subjects, and statistical significance levels for the D1-MSN simulation network model.

Significant connections reflect the direct pathway. Asterisks indicate significant connectivity estimate after multiple comparison correction (* $P < 0.05$, ** $P < 0.005$, *** $P < 0.001$); “cts” indicates close-to-significant connectivity estimate after multiple comparison correction.

Table S2, Related to Figure 4. Connectivity estimates, 95% confidence intervals across subjects, and statistical significance levels for the D2-MSN simulation network model.

Significant connections reflect the indirect pathway. Asterisks indicate significant connectivity estimate after multiple comparison correction (* $P < 0.05$, ** $P < 0.005$, *** $P < 0.001$). “cts” indicates close-to-significant connectivity estimate after multiple comparison correction.

Table S3, Related to Figure 5. Statistical comparisons of connectivity estimates between MCX and SCX network models. No significant differences were observed. “cts” indicates close-to-significant difference after multiple comparison correction.

Table S4, Related to Figure 6. Statistical comparisons of connectivity estimates between D1- and D2-MSN stimulation network models. Asterisks indicate significant connectivity estimate after multiple comparison correction (* $P < 0.05$, *** $P < 0.001$). “cts” indicates close-to-significant difference after multiple comparison correction.

Table S1

		MCX network case		SCX network case	
		Mean connectivity estimate; 95% CI p-value (uncorrected); p-value (corrected)		Mean connectivity estimate; 95% CI p-value (uncorrected); p-value (corrected)	
CPu →	CPu	-1.8311; (-2.2770, -1.3852) 6.1654×10 ⁻⁶ ; 3.6572×10 ⁻⁵	***	-2.0250; (-2.4503, -1.5996) 1.4687×10 ⁻⁶ ; 1.1749×10 ⁻⁵	***
	GPe	0.4452; (0.1938, 0.6967) 0.0052; 0.0105	*	0.4427; (0.2116, 0.6738) 0.0032; 0.0064	*
	GPI	0.9177; (0.4582, 1.3772) 0.0024; 0.0072	*	0.8454; (0.4587, 1.2320) 0.0013; 0.0031	**
	SN	0.9155; (0.6875, 1.1434) 7.6191×10 ⁻⁶ ; 3.6572×10 ⁻⁵	***	0.9399; (0.6829, 1.1969) 1.8248×10 ⁻⁵ ; 8.7588×10 ⁻⁵	***
GPe →	CPu	-0.1600; (-0.3136, -0.0063) 0.0661; 0.0881	cts	-0.0373; (-0.2004, 0.1259) 0.6629; 0.6917	
	GPe	-0.4998; (-0.7680, -0.2316) 0.0038; 0.0091	*	-0.6057; (-0.8513, -0.3601) 5.2449×10 ⁻⁵ ; 0.0014	**
	GPI	0.6377; (0.3084, 0.9669) 0.0030; 0.0079	*	0.5441; (0.2527, 0.8356) 0.0038; 0.0069	*
	STN	0.1856; (-0.8987, 1.2699) 0.7436; 0.7759		0.3338; (-0.3962, 1.0637) 0.3893; 0.4672	
	SN	0.4556; (0.1680, 0.7432) 0.0100; 0.0185	*	0.3718; (0.0980, 0.6455) 0.0221; 0.0354	*
GPI →	GPI	-1.0409; (-1.1571, -0.9247) 2.1503×10 ⁻⁹ ; 5.1608×10 ⁻⁸	***	-0.9750; (-1.0904, -0.8596) 4.0113×10 ⁻⁹ ; 9.6271×10 ⁻⁸	***
	THL	0.1555; (0.0073, 0.3036) 0.0643; 0.0881	cts	0.1711; (0.0656, 0.2767) 0.0088; 0.0151	*
STN →	GPe	0.0469; (-0.1462, 0.2401) 0.6433; 0.7018		0.1388; (-0.1044, 0.3820) 0.2870; 0.3827	
	GPI	0.2240; (-0.0406, 0.4886) 0.1253; 0.1583		0.1891; (0.0438, 0.3344) 0.0270; 0.0381	*
	STN	-0.4161; (-0.6129, -0.2193) 0.0016; 0.0056	*	-0.5330; (-0.7170, -0.3490) 1.4307×10 ⁻⁴ ; 4.9052×10 ⁻⁴	***
	SN	-0.0732; (-0.2576, 0.1112) 0.4528; 0.5434		-0.0524; (-0.1891, 0.0843) 0.4684; 0.5110	
SN →	CPu	0.0603; (-0.0996, 0.2201) 0.4754; 0.5434		0.0654; (-0.0931, 0.2239) 0.4356; 0.4979	
	SN	-0.7379; (-0.8627, -0.6132) 1.6497×10 ⁻⁷ ; 1.9796×10 ⁻⁶	***	-0.7935; (-0.9694, -0.6177) 2.4906×10 ⁻⁶ ; 1.4944×10 ⁻⁵	***
	THL	0.4234; (0.1895, 0.6574) 0.0046; 0.0100	*	0.4704; (0.3250, 0.6157) 5.4974×10 ⁻⁵ ; 2.1989×10 ⁻⁴	***
THL →	THL	-1.0242; (-1.3371, -0.7113) 4.9756×10 ⁻⁵ ; 1.9902×10 ⁻⁴	***	-0.9839; (-1.3499, -0.6180) 2.6444×10 ⁻⁴ ; 7.9332×10 ⁻⁴	***
	CTX	0.3166; (0.0718, 0.5615) 0.0278; 0.0444	*	0.4666; (0.2293, 0.7038) 0.0027; 0.0058	*
CTX →	CPu	0.5521; (0.1054, 0.9987) 0.0338; 0.0508	cts	0.4752; (0.1183, 0.8320) 0.0243; 0.0364	*
	STN	0.0840; (-0.6121, 0.7801) 0.8174; 0.8174		0.3577; (-0.4231, 1.1386) 0.3884; 0.4672	
	THL	0.2790; (0.0740, 0.4841) 0.0219; 0.0376	*	-0.0041; (-0.2459, 0.2378) 0.9743; 0.9743	
	CTX	-1.4466; (-1.7381, -1.1551) 6.2848×10 ⁻⁸ ; 7.7978×10 ⁻⁶	***	-1.5191; (-1.8306, -1.2077) 1.1564×10 ⁻⁶ ; 1.1749×10 ⁻⁵	***

Table S2

		MCX network case		SCX network case	
		Mean connectivity estimate; 95% CI p-value (uncorrected); p-value (corrected)		Mean connectivity estimate; 95% CI p-value (uncorrected); p-value (corrected)	
CPu →	CPu	-0.8046; (-0.9642, -0.6449) 3.9715×10 ⁻⁶ ; 3.1772×10 ⁻⁵	***	-1.0184; (-1.2866, -0.7503) 3.9189×10 ⁻⁵ ; 3.1351×10 ⁻⁴	***
	GPe	0.3089; (0.0794, 0.5383) 0.0270; 0.0496	*	0.2288; (0.0471, 0.4106) 0.0357; 0.0779	cts
	GPi	0.0025; (-0.2688, 0.2739) 0.9858; 0.9858		-0.0480; (-0.2823, 0.1863) 0.6972; 0.7605	
	SN	0.1026; (-0.0740, 0.2791) 0.2842; 0.3248		0.2217; (-0.0499, 0.4934) 0.1441; 0.2162	
GPe →	CPu	-0.0667; (-0.3817, 0.2482) 0.6876; 0.7175		0.2133; (-0.3528, 0.7793) 0.4791; 0.5717	
	GPe	-1.0799; (-1.3777, -0.7843) 5.3007×10 ⁻⁵ ; 2.1203×10 ⁻⁴	***	-1.1032; (-1.5031, -0.7033) 4.2923×10 ⁻⁴ ; 0.0021	**
	GPi	0.3015; (-0.0431, 0.6462) 0.1206; 0.1702		0.3018; (-0.0959, 0.6995) 0.1711; 0.2416	
	STN	1.1176; (0.7550, 1.4803) 1.9270×10 ⁻⁴ ; 5.7809×10 ⁻⁴	***	0.9814; (0.6392, 1.3237) 3.2561×10 ⁻⁴ ; 0.0020	**
	SN	0.3551; (0.0394, 0.6708) 0.0549; 0.0878	cts	0.2822; (-0.0241, 0.5885) 0.1044; 0.1671	
GPi →	GPi	-1.1923; (-1.3635, -1.0211) 2.5518×10 ⁻⁷ ; 6.1242×10 ⁻⁶	***	-1.2649; (-1.4559, -1.0740) 3.9263×10 ⁻⁷ ; 9.4231×10 ⁻⁶	***
	THL	0.4156; (0.1288, 0.7025) 0.0194; 0.0466	*	0.4196; (0.1374, 0.7018) 0.0172; 0.0413	*
STN →	GPe	-0.0576; (-0.2922, 0.1776) 0.6439; 0.7024		-0.0291; (-0.2946, 0.2363) 0.8346; 0.8346	
	GPi	0.4254; (0.1257, 0.7251) 0.0213; 0.0466	*	0.3710; (0.0116, 0.7303) 0.0737; 0.1263	
	STN	-0.7868; (-0.9784, -0.5952) 2.1061×10 ⁻⁵ ; 1.0109×10 ⁻⁴	***	-0.8004; (-1.1243, -0.4766) 9.1604×10 ⁻⁴ ; 0.0037	**
	SN	0.1889; (-0.0245, 0.4023) 0.1167; 0.1702		0.2563; (0.0459, 0.4667) 0.0407; 0.0815	cts
SN →	CPu	-0.1803; (-0.4899, 1.293) 0.2832; 0.3248		-0.1148; (-0.3202, 0.0906) 0.3017; 0.3811	
	SN	-1.2963; (-1.5479, -1.0447) 3.2999×10 ⁻⁶ ; 3.1772×10 ⁻⁵	***	-2.0027; (-2.8539, -1.1516) 0.0013; 0.0044	**
	THL	0.1981; (-0.0347, 0.4310) 0.1297; 0.1730		0.0733; (-0.4318, 0.5783) 0.7826; 0.8166	
THL →	THL	-1.0121; (-1.3126, -0.7116) 9.9123×10 ⁻⁵ ; 3.3985×10 ⁻⁴	***	-0.9573; (-1.3914, -0.5232) 0.0019; 0.0058	*
	CTX	0.4221; (0.1034, 0.7407) 0.0289; 0.0496	*	0.2764; (-0.1442, 0.6970) 0.2299; 0.3065	
CTX →	CPu	0.6985; (0.2363, 1.1607) 0.0159; 0.0424	*	0.7798; (0.2949, 1.2647) 0.0117; 0.0312	*
	STN	-0.6773; (-1.1879, -0.1667) 0.0287; 0.0496	*	-0.6833; (-1.2871, -0.0796) 0.0537; 0.0992	cts
	THL	-0.2594; (-0.5950, 0.0763) 0.1642; 0.2074		0.1017; (-0.1822, 0.3857) 0.5002; 0.5717	
	CTX	-1.2685; (-1.5615, -0.9754) 1.3802×10 ⁻⁵ ; 8.2811×10 ⁻⁵	***	-2.4844; (-3.1139, -1.8550) 2.8920×10 ⁻⁵ ; 3.1351×10 ⁻⁴	***

Table S3

		MCX vs. SCX network case (D1-MSN Stim.)	MCX vs. SCX network case (D2-MSN Stim.)		
		p-value (uncorrected); p-value (corrected)	p-value (uncorrected); p-value (corrected)		
CPu →	CPu	0.6685; 0.9899		0.1959; 0.9992	
	GPe	0.8807; 0.9899		0.5985; 0.9992	
	GPi	0.5870; 0.9899		0.7853; 0.9992	
	SN	0.7702; 0.9899		0.4802; 0.9992	
GPe →	CPu	0.5951; 0.9899		0.4080; 0.9992	
	GPe	0.9268; 0.9899		0.9278; 0.9992	
	GPi	0.9412; 0.9899		0.9992; 0.9992	
	STN	0.8991; 0.9899		0.5989; 0.9992	
	SN	0.9558; 0.9899		0.7490; 0.9992	
GPi →	GPi	0.6741; 0.9899		0.5856; 0.9992	
	THL	0.9722; 0.9899		0.9850; 0.9992	
STN →	GPe	0.7739; 0.9899		0.8778; 0.9992	
	GPi	0.4432; 0.9899		0.8223; 0.9992	
	STN	0.6519; 0.9899		0.9441; 0.9992	
	SN	0.7721; 0.9899		0.6646; 0.9992	
SN →	CPu	0.6202; 0.9899		0.7338; 0.9992	
	SN	0.8642; 0.9899		0.1362; 0.9992	
	THL	0.9899; 0.9899		0.6652; 0.9992	
THL →	THL	0.7268; 0.9899		0.8411; 0.9992	
	CTX	0.4178; 0.9899		0.5950; 0.9992	
CTX →	CPu	0.9805; 0.9899		0.8147; 0.9992	
	STN	0.5898; 0.9899		0.9883; 0.9992	
	THL	0.1915; 0.9899		0.1248; 0.9992	
	CTX	0.9421; 0.9899		0.0030; 0.0713	cts

Table S4

		D1- vs. D2-MSN stimulations (MCX)		D1- vs. D2-MSN stimulations (SCX)	
		p-value (uncorrected); p-value (corrected)		p-value (uncorrected); p-value (corrected)	
CPu →	CPu	8.2146×10 ⁻⁴ ; 0.0066	*	0.0013; 0.0118	*
	GPe	0.4493; 0.5990		0.1819; 0.2911	
	GPi	0.0046; 0.0276	*	0.0015; 0.0118	*
	SN	3.0674×10 ⁻⁵ ; 7.3618×10 ⁻⁴	***	0.0013; 0.0118	*
GPe →	CPu	0.5884; 0.6905		0.3779; 0.4535	
	GPe	0.0099; 0.0460	*	0.0436; 0.1308	
	GPi	0.1839; 0.3153		0.3371; 0.4513	
	STN	0.1554; 0.3124		0.1560; 0.2910	
	SN	0.6495; 0.6905		0.6730; 0.7023	
GPi →	GPi	0.1562; 0.3124		0.0156; 0.0623	cts
	THL	0.1127; 0.2704		0.0989; 0.2374	
STN →	GPe	0.5052; 0.6382		0.3716; 0.4535	
	GPi	0.3338; 0.5007		0.3384; 0.4513	
	STN	0.0166; 0.0568	cts	0.1576; 0.2910	
	SN	0.0820; 0.2460		0.0218; 0.0747	cts
SN →	CPu	0.1706; 0.3149		0.1818; 0.2911	
	SN	5.4954×10 ⁻⁴ ; 0.0066	*	0.0075; 0.0450	*
	THL	0.1998; 0.3198		0.1248; 0.2723	
THL →	THL	0.9575; 0.9575		0.9271; 0.9271	
	CTX	0.6068; 0.6905		0.4298; 0.4912	
CTX →	CPu	0.6617; 0.6905		0.3236; 0.4513	
	STN	0.1111; 0.2704		0.0590; 0.1573	
	THL	0.0115; 0.0460	*	0.5819; 0.6348	
	CTX	0.4119; 0.5815		0.0102; 0.0487	*

Supplemental Data Files

Data File S1, Related to Figure 1C. Average time series (across subjects) corresponding to eight regions within the basal ganglia-thalamocortical network during D1-MSN stimulations. Each time series includes 30 s of baseline measurements, followed by six periods of 20 s stimulation delivered every minute. Each frame corresponds to 0.75 s.

Data File S2, Related to Figure 1D. Average time series (across subjects) corresponding to eight regions within the basal ganglia-thalamocortical network during D2-MSN stimulations. Each time series includes 30 s of baseline measurements, followed by six periods of 20 s stimulation delivered every minute. Each frame corresponds to 0.75 s.