

Supplementary material

Mamad et al 2018

- **Supplementary Movies 1-4**
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Supplementary Movies:

Movie 1: TMT-induced aversion. Navigation in rectangular-shaped linear track of rat with chronically-implanted tetrodes in the hippocampal CA1 region. The animal was trained to navigate between the southwest and northeast corners, where two pellets were continuously positioned. TMT was placed in particular location of the track, which is denoted in red.

Movie 2: ChR2-induced aversion. Navigation in rectangular-shaped linear track of rat with chronically-implanted tetrodes in hippocampus. The first half of the video shows pre-ChR2 session, measuring baseline behavioral and electrophysiological activity signals. The second half of the video shows light delivery, triggering photoexcitation of BLA neurons. The coordinates of photostimulation (ChR2 arms) are denoted in blue.

Movie 3: ChR2-induced aversion. Pre-ChR2 and ChR2 sessions for second animal.

Movie 4: Extra-field spiking during ChR2 photostimulation of BLA. Analysis software visualization of the animal's path (marked with black line) and the recorded place cell's spiking (denoted with purple dots). The represented speed is 2x real-time. The first half of the video shows 238 seconds of pre-ChR2 session, followed by images of the raw signal and the firing map for the entire 12 minutes baseline session. The second half of the video shows 238 seconds of ChR2 session, followed by images of the raw signal and the firing map for the entire 12 minutes ChR2 session. The coordinates of photostimulation (ChR2 arms) are denoted in blue.

Supplementary Tables:**Supplementary Table 1:** Extra-field TMT spiking ratio and Δ COMa of the place cells' spikes in TMT arms.

Cell#	TMT Mean ratio	TMT Peak ratio	Δ COMa	Cell#	TMT Mean ratio	TMT Peak ratio	Δ COMa
1	0.5	0.35	26.98	28	0.8	0.8	2.95
2	0.82	1.1	9.53	29	0.96	0.96	3.48
3	0.23	0.16	9.34	30	0.43	0.74	28.43
4	0.43	0.43	21.04	31	0.11	0.17	12.86
5	1	1	8.29	32	0.47	0.63	12.75
6	1.05	1.5	0.94	33	0.43	0.46	28.08
7	2	2.9	4.74	34	0.72	0.81	1.92
8	0.07	0.04	20.79	35	0.33	0.11	24.66
9	1	1.04	20.95	36	1.04	0.7	16.06
10	1.25	2.25	0.24	37	0.39	0.44	15.56
11	1.92	2.84	2.32	38	0.31	0.65	25.67
12	0.51	0.86	6.23	39	1.03	0.76	10
13	0.41	0.55	3.06	40	0.12	0.09	57.67
14	0.61	1.09	3.34	41	0.51	0.26	4.81
15	1	0.75	4.41	42	0.2	0.34	7.44
16	0.17	0.19	44.15	43	0.08	0.31	11.6
17	0.25	0.21	4.62	44	0.57	0.55	11.82
18	0.17	0.11	54.68	45	0.38	0.54	7.18
19	1.43	1.18	16.44	46	0.51	0.65	7.93
20	0.38	0.41	23.29	47	0.66	0.82	27.76
21	2.08	2.52	2.11	48	0.89	0.94	4.5
22	1.57	2.5	2.25	49	1.21	2.87	4.34
23	2.36	2.99	2.99	50	0.37	0.19	3.51
24	0.77	0.86	9.59	51	0.24	0.1	8.61
25	0.97	1.01	2.06	52	0.07	0.09	24.2
26	0.32	0.17	9.18	53	0.76	1.42	2.75
27	0.85	1.2	1.04	54	0.87	0.58	0.58

Supplementary Table 2: Intra-field TMT spiking ratio and Δ COMa of the place cells' spikes in TMT arms.

Cell#	TMT Mean ratio	TMT Peak ratio	Δ COMa	Cell#	TMT Mean ratio	TMT Peak ratio	Δ COMa
1	0.72	0.79	9.15	27	1.2	1.59	5.41
2	0.52	0.51	1.22	28	0.79	1.91	8.02
3	2.67	1.33	6.58	29	0.69	1.17	1.18
4	0.69	0.5	17.57	30	0.52	1.14	3.37
5	0.97	1.25	2.22	31	0.62	1.2	2.66
6	0.35	0.41	3.85	32	0.35	0.6	1.17
7	0.88	0.88	17.98	33	1.52	2.89	13.95
8	3.48	4.44	1.54	34	0.09	0.08	1.79
9	2.05	2.99	0.15	35	3.4	3.4	14.36
10	2.33	3.46	5.07	36	1.85	2.5	1.85
11	0.52	0.44	13.12	37	1	1.57	1.37
12	2.83	1.5	2.42	38	0.38	0.4	17.98
13	0.65	0.49	1.5	39	0.33	0.6	6.41
14	0.75	0.75	9.35	40	0.29	0.5	19.19
15	2.26	3.61	9.96	41	1.56	1.89	5.86
16	0.63	0.48	3.72	42	0.78	0.89	17.52
17	0.58	0.67	8.65	43	1.89	1.08	5.57
18	1.6	2.43	3.96	44	0.29	0.33	0.46
19	1.09	3.34	0.01	45	1.38	3.97	1.39
20	3.31	7.32	13.13	46	0.36	0.54	0.36
21	3.5	7.26	5.86	47	0.41	0.44	4.83
22	2.79	3.97	5.37	48	2.58	3.19	7.32
23	1.4	2.58	13.5	49	2.06	1.21	20.56
24	0.71	0.28	4.07	50	0.41	0.67	14.42
25	2.74	5	0.91	51	2.18	4.79	6.15
26	2.2	3.2	17.11	52	0.61	0.7	12.02

Supplementary Table 3: Intra-field TMT spiking ratio and Δ COMa of the place cells' spikes in non-TMT zone.

Cell#	TMT Mean ratio	TMT Peak ratio	Δ COMa	Cell#	TMT Mean ratio	TMT Peak ratio	Δ COMa
1	3.13	2.68	26.98	29	0.23	0.22	2.95
2	1.4	0.64	9.53	30	0.27	0.2	3.48
3	2.1	2.78	9.34	31	0.38	0.42	28.43
4	1.07	1.35	26.03	32	1.35	1.44	12.86
5	3.33	2.35	21.04	33	0.69	1.87	12.75
6	0.67	1.45	0.94	34	0.41	0.33	28.08
7	1.39	2	4.74	35	0.58	1	1.92
8	1.15	0.48	20.79	36	0.58	0.27	24.66
9	0.68	0.67	10.77	37	0.9	0.47	16.06
10	0.77	0.69	3.18	38	0.78	0.3	15.56
11	0.71	0.38	16.28	39	1.32	1.12	25.67
12	1.25	0.65	2.32	40	0.2	0.08	10
13	0.48	0.82	6.23	41	0.1	0.09	57.67
14	0.4	0.62	3.06	42	0.19	0.08	4.81
15	0.6	0.71	3.34	43	0.25	0.17	7.44
16	3.57	2.63	4.41	44	0.03	0.02	11.6
17	0.85	0.46	44.15	45	1.07	0.71	11.82
18	0.42	0.36	4.62	46	1.21	0.4	7.18
19	0.96	0.79	54.68	47	0.22	0.22	7.93
20	0.66	0.63	16.44	48	0.88	1.09	27.76
21	1.24	0.67	23.29	49	1.04	1.5	4.5
22	2.54	2.5	2.11	50	1.92	2.23	4.34
23	1.79	1.33	1.39	51	0.44	0.44	3.51
24	3.38	4.18	3.31	52	0.6	0.54	8.61
25	1.02	0.68	9.59	53	4.2	4.17	24.2
26	2.8	5.26	2.06	54	0.45	0.25	2.75
27	0.4	0.12	9.18	55	1.38	0.82	1.95
28	0.72	0.84	1.04	56			

Supplementary Table 4: Extra-field TMT spiking ratio and Δ COMa of the place cells' spikes in non-TMT zone.

Cell#	TMT Mean ratio	TMT Peak ratio	Δ COMa	Cell#	TMT Mean ratio	TMT Peak ratio	Δ COMa
1	1.55	1.87	9.15	27	0.26	0.24	8.02
2	0.81	1.17	1.22	28	0.16	0.09	1.18
3	2.63	1.67	6.58	29	0.39	0.15	3.37
4	2	3.25	2.22	30	0.96	2.82	2.66
5	0.44	0.33	3.85	31	4.62	5.39	1.17
6	3.33	6.06	17.98	32	0.86	1.67	13.95
7	0.43	0.33	1.54	33	0.5	0.41	1.79
8	1.25	2.09	0.15	34	0.46	1.25	14.36
9	1.12	1.25	5.07	35	1.18	1.13	1.85
10	0.47	0.5	13.12	36	1.14	1.14	1.37
11	0.86	0.91	2.42	37	0.59	0.4	17.98
12	0.83	0.75	1.5	38	0.65	0.4	6.41
13	2.33	1.27	9.35	39	0.35	0.13	19.19
14	0.88	1.5	9.96	40	0.22	0.12	5.86
15	2.93	5.56	3.72	41	0.18	0.06	17.52
16	0.36	1	8.65	42	0.59	0.5	5.57
17	1.06	1.03	3.96	43	1.1	1.88	0.46
18	0.21	0.08	0.01	44	0.26	0.22	1.39
19	0.51	0.2	13.13	45	1.02	0.92	0.36
20	2.41	4	5.86	46	0.44	0.33	4.83
21	0.84	1	5.37	47	0.35	0.22	7.32
22	1.67	1	13.5	48	0.94	0.94	1.77
23	3.12	2.2	4.07	49	2.82	3.56	20.56
24	1.98	1.98	0.91	50	1.99	4.39	14.42
25	0.58	0.22	17.11	51	1.82	3.05	6.15
26	1.05	1	5.41	52	1.18	0.86	12.02

Supplementary Table 5. Unidirectional ethanol spiking comparison and Δ COM for clockwise fields:

Cell#	Mean rate	Peak rate	Δ COM	Cell#	Mean rate	Peak rate	Δ COM
1	0.020	0.013	7.00	41	0.123	0.103	0.00
2	0.660	0.516	6.71	42	-0.049	-0.206	16.28
3	0.141	0.100	0.00	43	0.440	0.498	6.00
4	0.167	0.130	0.00	44	-0.024	0.144	5.00
5	-0.368	-0.400	0.00	45	0.037	0.116	3.00
6	-0.137	-0.143	0.00	46	-0.356	-0.576	6.71
7	0.200	0.241	4.00				
8	-0.289	-0.204	4.00				
9	-0.195	-0.425	7.00				
10	0.134	0.355	7.00				
11	-0.238	-0.313	3.00				
12	-0.210	-0.053	13.00				
13	0.294	0.227	6.00				
14	0.535	0.107	4.24				
15	0.150	0.220	2.00				
16	0.497	0.678	7.62				
17	-0.309	-0.357	0.00				
18	-0.268	0.506	10.44				
19	-0.421	-0.425	0.00				
20	-0.551	-0.634	5.00				
21	-0.260	-0.507	4.00				
22	0.380	0.434	3.00				
23	0.217	0.350	3.00				
24	-0.032	-0.044	6.71				
25	0.000	0.038	0.00				
26	0.013	-0.095	10.00				
27	0.343	0.313	4.24				
28	0.080	-0.067	9.22				
29	-0.135	-0.168	3.00				
30	0.088	0.078	5.00				
31	-0.147	-0.240	5.00				
32	0.054	-0.036	7.00				
33	-0.070	0.053	16.00				
34	-0.233	-0.104	4.24				
35	-0.154	0.007	7.21				
36	0.040	0.041	10.44				
37	0.058	-0.109	0.00				
38	0.250	0.402	7.00				
39	0.061	0.026	3.00				
40	0.025	0.089	3.00				

Supplementary Table 6: Figure 5-2. Unidirectional ethanol spiking comparison and Δ COM, counter-clockwise fields:

Cell#	Mean rate	Peak rate	Δ COM	Cell#	Mean rate	Peak rate	Δ COM
1	0.208	0.046	6.00				
2	-0.241	-0.320	6.00				
3	0.191	0.054	6.00				
4	-0.245	-0.212	5.00				
5	-0.097	0.009	4.00				
6	0.216	0.099	4.24				
7	0.040	0.202	3.00				
8	-0.300	-0.150	7.62				
9	0.333	0.500	3.00				
10	-0.412	-0.336	9.00				
11	-0.092	-0.189	9.00				
12	0.615	0.783	3.00				
13	0.027	-0.003	0.00				
14	-0.303	-0.201	7.00				
15	0.031	0.184	10.44				
16	0.351	0.400	3.00				
17	-0.193	0.016	6.00				
18	0.543	0.519	10.44				
19	0.000	-0.077	4.24				
20	0.183	0.154	0.00				
21	0.028	0.071	4.24				
22	0.482	0.550	3.00				
23	0.162	0.038	3.00				
24	0.167	0.282	10.44				
25	0.169	0.167	8.49				
26	-0.200	-0.067	5.00				
27	-0.027	-0.053	6.00				
28	-0.255	-0.246	10.44				
29	0.043	0.029	3.00				
30	-0.362	-0.483	5.66				
31	-0.102	0.058	6.00				
32	-0.028	-0.039	6.71				
33	-0.052	-0.067	3.00				
34	-0.206	-0.335	13.00				
35	0.053	-0.196	7.00				
36	0.437	0.025	9.22				
37	-0.075	-0.064	0.00				
38	0.012	-0.017	4.00				
39	-0.364	-0.361	0.00				
40	-0.175	-0.088	0.00				

Supplementary Table 7: Unidirectional TMT-SW spiking comparison and Δ COM for clockwise fields:

Cell#	Mean rate	Peak rate	Δ COM	Cell#	Mean rate	Peak rate	Δ COM
1	-0.128	-0.096	0.00	41	0.125	0.200	6.00
2	0.048	0.170	10.00	42	0.038	0.012	3.00
3	-0.485	-0.534	67.54	43	-0.089	-0.033	3.00
4	-0.061	0.029	79.25	44	-0.277	-0.088	7.62
5	0.356	0.337	0.00	45	0.167	0.275	56.08
6	0.286	0.026	4.00	46	0.308	0.175	7.21
7	0.111	0.092	17.46	47	0.355	0.377	16.00
8	0.333	0.079	32.00	48	0.000	-0.078	30.48
9	-0.145	-0.372	32.14	49	-0.231	-0.311	6.71
10	-0.078	0.023	3.00	50	0.034	-0.709	35.13
11	0.117	-0.003	70.60	51	0.803	0.754	71.61
12	-0.407	-0.499	6.32	52	-0.263	-0.032	55.95
13	0.021	0.153	13.60				
14	0.361	0.453	3.00				
15	-0.190	-0.187	9.49				
16	0.496	0.534	0.00				
17	0.343	0.596	72.45				
18	-0.226	-0.524	0.00				
19	-0.444	-0.295	4.24				
20	0.538	0.619	8.06				
21	0.150	0.262	7.00				
22	0.448	0.370	11.00				
23	0.137	0.074	55.95				
24	0.429	0.189	41.34				
25	-0.516	-0.473	24.00				
26	-0.533	-0.456	30.68				
27	0.000	0.231	22.20				
28	-0.167	0.091	9.00				
29	-0.247	-0.218	10.44				
30	0.314	0.370	8.06				
31	-0.016	0.163	3.00				
32	-0.462	-0.433	43.17				
33	-0.159	-0.098	0.00				
34	0.490	0.429	69.77				
35	-0.152	0.424	29.27				
36	0.443	0.538	4.00				
37	-0.083	-0.183	4.00				
38	0.000	0.000	0.00				
39	-0.680	-0.273	30.87				
40	-0.038	0.100	0.00				

Supplementary Table 8: Unidirectional TMT-SW spiking comparison and Δ COM, counter-clockwise fields:

Cell#	Mean rate	Peak rate	Δ COM	Cell#	Mean rate	Peak rate	Δ COM
1	-0.471	-0.478	4.00	40	0.135	-0.216	55.00
2	-0.247	-0.288	0.00	41	-0.165	-0.424	61.03
3	0.407	0.444	76.85	42	-0.745	-0.740	32.25
4	0.081	0.297	0.00	43	-0.214	0.081	70.60
5	-0.263	-0.351	78.24	44	-0.200	0.077	9.00
6	0.864	0.922	20.40	45	-0.589	-0.712	55.80
7	0.778	0.741	0.00	46	0.135	-0.216	55.00
8	0.368	0.000	35.00				
9	0.544	0.717	16.00				
10	0.231	0.403	5.00				
11	-0.205	0.072	5.39				
12	-0.391	-0.259	0.00				
13	-0.277	0.000	69.86				
14	0.105	0.207	0.00				
15	0.300	0.034	0.00				
16	0.143	0.042	29.15				
17	-0.341	-0.427	6.00				
18	0.302	0.229	64.85				
19	0.037	-0.024	75.29				
20	0.448	0.267	41.44				
21	0.250	0.416	9.00				
22	0.121	0.194	0.00				
23	-0.095	0.000	16.28				
24	0.091	0.302	76.55				
25	0.000	0.167	8.06				
26	-0.135	-0.081	0.00				
27	0.118	-0.114	7.62				
28	-0.364	-0.354	9.90				
29	-0.357	-0.538	54.92				
30	-0.487	-0.200	7.62				
31	-0.051	-0.087	4.24				
32	0.143	0.156	19.00				
33	0.128	0.231	11.00				
34	-0.420	-0.495	3.00				
35	0.204	0.178	7.00				
36	0.014	-0.109	10.44				
37	0.942	0.859	64.85				
38	0.518	0.479	3.00				
39	0.191	0.172	10.44				
40	-0.508	-0.653	0.00				

Supplementary Table 11: Extra-field ChR2 spiking ratio and Δ COMa of the place cells' spikes in ChR2 arms:

Cell#	ChR2 Mean ratio	ChR2 Peak ratio	Δ COMa	Cell#	ChR2 Mean ratio	ChR2 Peak ratio	Δ COMa
1	1.11	1.27	5.35	20	0.16	0.08	24.8
2	1.25	1.4	3.77	21	0.69	0.69	4.9
3	1.44	1.51	5.77	22	1.18	1.26	4.36
4	1.85	1.37	2.5	23	0.74	1.5	10.71
5	0.24	0.14	15.3	24	0.6	0.6	22.84
6	0.4	0.28	6.42	25	4.63	2.25	4.83
7	1.11	1.03	1.91	26	3.38	1.32	6.12
8	2.25	2.25	0.84	27	1.89	0.9	0.31
9	1.22	1.82	7	28	1.47	1.29	8.24
10	0.61	0.22	19.98	29	1.02	1.5	6.31
11	3.63	2.11	7.88	30	0.09	0.03	35.98
12	0.45	0.39	3.42	31	1.7	1.4	30.23
13	0.79	0.79	9.01	32	1.16	1.52	9.13
14	0.6	0.6	3.54	33	0.66	0.26	5.65
15	1.21	2.23	22.4	34	0.33	0.1	23.15
16	0.28	0.31	34.73	35	0.66	0.33	13.63
17	4.4	3.55	0.53	36	1.06	1.1	4.33
18	2	1.3	1.02	37	0.57	0.31	7.89
19	0.73	0.36	16.87	38	0.67	0.67	17.14

Supplementary Table 12: Intra-field ChR2 spiking ratio and Δ COMa of the place cells' spikes in ChR2 arms:

Cell#	ChR2 Mean ratio	ChR2 Peak ratio	Δ COMa	Cell#	ChR2 Mean ratio	ChR2 Peak ratio	Δ COMa
1	1	2.23	3.98	22	0.75	0.57	2.74
2	0.43	0.7	9.09	23	1.65	3	14.66
3	1.17	1.5	15.53	24	0.46	0.83	26.21
4	2.79	2.34	7.69	25	0.17	0.25	9.42
5	1.2	1.05	1.17	26	1.84	2	5.81
6	0.98	0.99	8.21	27	1.5	1	2.37
7	0.92	1.25	1.22	28	1.43	1.74	1.65
8	0.91	1.12	1.59	29	1.12	1.88	6.51
9	1.07	0.57	5.46	30	0.56	0.56	6.42
10	0.7	0.32	12.57	31	1.5	1.06	15.42
11	0.14	0.04	31.44	32	1.19	1	5.2
12	1.58	1.72	5.74	33	1.44	1.43	0.51
13	1.11	1.14	9.87	34	1.01	1.5	14.79
14	1.51	1	1.53	35	0.9	2	0.8
15	0.64	0.43	5.51	36	1.68	2	16.4
16	1.4	1.5	0.19	37	1.29	1.5	8.2
17	0.98	1.5	0.19	38	1.53	3.75	2.49
18	0.37	0.29	16.3	39	0.88	1	2.67
19	1.04	1.29	7.41	40	0.6	0.52	6.23
20	0.49	1.33	6	41	0.78	0.52	2.18
21	0.82	1.08	4.23				

Supplementary Table 13: Intra-field ChR2 spiking ratio and Δ COMa of the place cells' spikes in non-ChR2 zone:

Cell#	ChR2 Mean ratio	ChR2 Peak ratio	Δ COMa	Cell#	ChR2 Mean ratio	ChR2 Peak ratio	Δ COMa
1	0.87	1.32	5.35	26	2.93	3.5	37.11
2	0.55	0.56	3.77	27	2	3.21	4.83
3	0.5	0.23	8.31	28	0.93	1.21	6.12
4	0.58	0.66	5.77	29	1.94	2.33	0.31
5	2.74	4	2.5	30	0.79	0.92	8.51
6	1.35	1.27	15.3	31	0.62	0.29	14.46
7	1.45	2.33	6.42	32	1.64	1.5	8.55
8	0.99	0.95	1.91	33	1.01	0.56	9.03
9	1.75	1.98	0.84	34	1.12	1.35	8.24
10	1.07	0.93	23.71	35	0.6	0.52	6.31
11	0.88	1.15	19.98	36	1.54	1.95	35.98
12	2.46	4.63	7.88	37	3.03	4.72	30.23
13	0.51	0.38	3.42	38	0.39	0.46	9.13
14	4.18	2.63	9.01	39	1.18	1.27	5.65
15	0.78	0.5	3.54	40	0.5	0.67	23.15
16	0.77	0.67	22.4	41	0.53	0.43	4.06
17	1.34	1	34.73	42	0.42	0.33	13.63
18	0.96	2.06	0.53	43	1.06	1.11	35.65
19	1.19	1	1.02	44	0.93	0.87	4.36
20	1.91	0.8	16.87	45	2.63	3	4.33
21	0.79	1	11.51	46	1.54	1.67	7.89
22	0.89	1.11	24.8	47	0.95	1	1.52
23	1.96	1.37	4.9	48	0.38	0.6	17.14
24	3.17	4.17	4.36	49	2.24	2.52	22.59
25	0.88	0.53	10.71				

Supplementary Table 14: Extra-field ChR2 spiking ratio and Δ COMa of the place cells' spikes in non-ChR2 zone:

Cell#	ChR2 Mean ratio	ChR2 Peak ratio	Δ COMa	Cell#	ChR2 Mean ratio	ChR2 Peak ratio	Δ COMa
1	0.79	1.44	3.98	22	1.11	0.58	2.74
2	1.43	3.01	9.09	23	0.1	0.09	14.66
3	0.31	0.42	15.53	24	1.37	3.7	26.21
4	1.28	1.49	7.69	25	1.02	1.11	9.42
5	1.07	1.25	1.17	26	1.07	1	5.81
6	1.41	0.71	8.21	27	1.27	1.22	2.37
7	1.05	0.5	1.22	28	0.86	0.56	1.65
8	0.65	1	1.59	29	0	0.01	6.51
9	1.21	1.24	5.46	30	0.64	0.64	6.42
10	1.96	1.5	12.57	31	1.39	1.25	15.42
11	1.69	1.73	31.44	32	0.69	0.79	5.2
12	1.35	1.09	5.74	33	0.75	0.78	0.51
13	3.03	3.13	9.87	34	2.8	2	14.79
14	2.18	5.65	1.53	35	3.22	5.77	0.8
15	0.89	0.83	5.51	36	0.79	0.77	12.48
16	1.2	0.56	0.19	37	0.77	0.6	16.4
17	0.67	0.45	0.19	38	0.92	1.25	8.2
18	1.9	1.93	16.3	39	1.45	1.68	2.49
19	2.81	2.75	7.41	40	2.29	5	2.67
20	0.92	1.11	6	41	1.53	2.7	6.23
21	0.51	0.85	4.23	42	0.38	0.25	2.18

Supplementary Table 15: Unidirectional YFP spiking comparison and Δ COM for clockwise fields:

Cell#	Mean rate	Peak rate	Δ COM	Cell#	Mean rate	Peak rate	Δ COM
1	-0.259	-0.220	5.00	41	0.184	0.286	0.00
2	0.036	-0.055	0.00	42	0.074	-0.024	4.00
3	0.089	-0.035	10.00	43	0.033	-0.028	3.00
4	0.444	0.399	10.44	44	0.512	0.031	21.47
5	0.052	0.000	5.10				
6	-0.250	-0.206	3.00				
7	0.091	0.023	4.24				
8	-0.674	-0.802	39.46				
9	-0.169	-0.305	3.00				
10	0.190	0.140	3.00				
11	0.059	0.132	0.00				
12	0.228	0.161	9.00				
13	-0.271	-0.309	4.24				
14	0.143	0.200	0.00				
15	0.262	0.280	10.00				
16	0.240	0.357	3.00				
17	0.429	0.400	4.24				
18	0.680	0.558	3.00				
19	-0.263	-0.256	0.00				
20	-0.077	-0.079	6.00				
21	0.035	0.065	3.00				
22	0.182	0.016	6.00				
23	-0.025	0.358	18.11				
24	0.333	0.488	6.00				
25	-0.433	-0.299	0.00				
26	-0.068	-0.179	0.00				
27	-0.333	-0.482	4.00				
28	0.537	0.571	7.00				
29	-0.048	0.116	10.44				
30	-0.058	0.124	5.00				
31	0.147	0.143	0.00				
32	0.163	0.000	8.06				
33	-0.321	-0.579	16.28				
34	-0.077	-0.103	4.00				
35	0.114	0.329	0.00				
36	-0.421	-0.195	0.00				
37	-0.440	-0.319	0.00				
38	-0.306	-0.263	7.00				
39	0.150	0.282	3.00				
40	-0.042	0.034	0.00				

Supplementary Table 16: Unidirectional YFP spiking comparison and Δ COM, counter-clockwise fields:

Cell#	Mean rate	Peak rate	Δ COM	Cell#	Mean rate	Peak rate	Δ COM
1	0.037	-0.055	0.00				
2	-0.281	-0.257	7.00				
3	0.167	0.026	14.32				
4	-0.383	-0.283	13.00				
5	-0.010	0.036	2.83				
6	-0.005	-0.102	3.00				
7	0.059	-0.152	13.34				
8	0.259	0.261	3.00				
9	-0.008	0.099	10.00				
10	-0.009	-0.161	3.00				
11	-0.086	-0.013	0.00				
12	-0.023	-0.011	0.00				
13	-0.309	-0.091	6.00				
14	0.200	0.390	0.00				
15	0.054	0.131	6.71				
16	0.350	0.284	3.00				
17	0.319	0.293	0.00				
18	0.035	-0.153	3.00				
19	0.118	0.010	13.60				
20	0.000	-0.298	3.00				
21	0.100	0.539	4.24				
22	0.405	0.432	4.00				
23	0.188	0.091	16.16				
24	0.371	0.290	0.00				
25	0.232	0.359	4.00				
26	0.100	0.231	0.00				
27	-0.143	0.083	0.00				
28	-0.475	-0.405	3.00				
29	-0.256	-0.473	4.00				
30	-0.161	-0.029	3.00				
31	0.125	-0.032	4.00				
32	0.486	0.379	7.00				
33	0.231	0.434	5.00				
34	-0.770	-0.815	3.00				
35	0.208	0.304	0.00				
36	-0.684	-0.600	6.00				
37	-0.660	-0.597	10.44				
38	0.302	0.333	3.00				
39	0.102	-0.004	0.00				
40	0.028	0.333	5.66				

Supplementary Table 17: Unidirectional Chr2 spiking comparison and Δ COM for clockwise fields:

Cell#	Mean rate	Peak rate	Δ COM	Cell#	Mean rate	Peak rate	Δ COM
1	-0.437	-0.472	4.24	41	-0.500	-0.694	45.10
2	-0.080	-0.004	0.00	42	0.534	0.277	26.00
3	-0.179	-0.282	6.00	43	-0.183	-0.011	66.85
4	0.388	0.415	74.06	44	0.531	0.613	10.00
5	0.355	0.083	39.05	45	-0.564	-0.500	4.00
6	-0.355	-0.304	6.71	46	0.000	0.000	4.00
7	0.205	0.053	7.00	47	-0.200	-0.160	5.10
8	-0.143	-0.190	9.43	48	0.500	0.465	86.27
9	-0.472	-0.541	75.80	49	0.300	0.347	60.88
10	-0.263	-0.288	3.00	50	-0.392	-0.471	95.46
11	-0.185	-0.083	7.62	51	0.667	0.799	73.41
12	-0.250	-0.244	3.00	52	0.046	-0.059	5.00
13	-0.212	-0.324	3.00	53	1.000	0.972	63.06
14	0.096	0.014	7.00	54	0.767	0.836	7.62
15	0.288	0.307	10.00	55	0.116	-0.269	55.54
16	-0.438	-0.446	22.00	56	0.464	0.454	4.00
17	-0.565	-0.721	3.00	57	-0.212	-0.194	6.71
18	0.600	0.475	7.00	58	0.042	-0.045	50.54
19	0.733	0.857	48.00	59	0.230	0.308	6.00
20	-0.080	0.183	4.24	60	0.012	0.173	3.00
21	0.500	0.545	4.24	61	-0.438	-0.603	6.00
22	0.088	-0.074	65.92	62	0.167	0.200	57.01
23	-0.866	-0.761	48.09	63	0.182	0.422	2.00
24	0.000	0.353	13.00	64	-0.539	-0.581	5.00
25	-0.571	-0.619	76.55	65	-0.366	-0.449	3.00
26	-0.121	-0.021	3.00	66	0.231	0.280	74.06
27	-0.023	-0.031	55.80	67	-0.171	-0.261	0.00
28	0.457	0.371	0.00	68	0.150	0.117	32.14
29	0.500	0.783	64.20	69	0.479	0.466	71.06
30	0.234	0.327	41.23	70	0.156	0.113	0.00
31	0.311	0.117	51.04	71	-0.143	-0.039	2.00
32	-0.259	0.240	22.00	72	0.136	0.168	42.15
33	0.247	0.232	10.00	73	-0.040	0.131	16.28
34	0.008	-0.188	3.16	74	0.116	0.379	26.00
35	0.547	0.485	0.00	75	-0.280	-0.149	7.00
36	-0.186	-0.091	56.86	76	0.811	0.867	18.03
37	0.164	0.311	10.44	77	-0.035	0.003	4.24
38	0.726	0.795	43.91	78	0.481	0.534	0.00
39	0.185	0.228	3.00	79	-0.098	0.018	2.24
40	0.176	-0.250	2.24	80	-0.474	-0.450	7.00

Supplementary Table 18: Unidirectional ChR2 spiking comparison and Δ COM, counter-clockwise fields:

Cell#	Mean rate	Peak rate	Δ COM	Cell#	Mean rate	Peak rate	Δ COM
1	-0.083	-0.049	75.69	41	0.622	0.762	3.00
2	-0.143	0.036	3.00	42	0.138	0.129	20.00
3	0.607	0.790	19.00	43	0.000	-0.011	4.00
4	-0.286	0.148	73.41	44	-0.211	-0.200	3.00
5	-0.295	-0.175	66.85	45	-0.570	-0.465	68.01
6	0.226	0.273	3.00	46	-0.014	0.127	0.00
7	-0.780	-0.728	10.30	47	-0.207	-0.383	8.06
8	0.425	0.506	10.00	48	-0.639	-0.538	32.14
9	0.154	0.368	76.55	49	-0.316	-0.092	3.00
10	0.132	0.000	4.24	50	0.000	-0.370	3.00
11	0.333	0.111	32.14	51	-0.091	0.184	51.00
12	0.683	0.632	5.66	52	-0.176	-0.205	7.07
13	-0.352	-0.564	36.12	53	-0.539	-0.581	5.00
14	0.000	0.157	3.00	54	0.323	0.406	4.00
15	0.158	0.000	86.37	55	0.306	0.359	10.00
16	-0.111	-0.290	28.28	56	0.254	0.262	7.00
17	0.600	0.345	48.85	57	0.376	0.517	5.66
18	-0.754	-0.822	42.58	58	-0.522	-0.597	9.49
19	-0.100	0.043	70.29	59	-0.288	-0.470	13.00
20	0.800	0.917	16.28	60	-0.731	-0.670	52.09
21	0.200	0.273	23.00	61	-0.412	-0.226	16.00
22	-0.739	-0.766	42.11	62	0.455	0.443	0.00
23	-0.125	-0.184	77.52	63	0.321	0.085	4.00
24	-0.004	-0.009	12.00	64	-0.143	-0.178	3.00
25	-0.162	-0.081	10.44	65	0.003	0.005	4.00
26	0.392	0.429	7.00	66	0.250	0.467	84.17
27	0.897	0.965	60.17	67	0.301	0.144	4.24
28	-0.120	-0.035	6.00	68	0.223	0.348	35.51
29	-0.548	-0.554	9.49	69	0.004	-0.019	3.00
30	0.690	0.575	8.06	70	0.429	0.435	23.00
31	0.425	0.451	9.00	71	-0.053	0.000	3.00
32	0.254	0.311	65.97	72	0.742	0.841	63.64
33	-0.484	-0.621	10.00	73	0.118	0.206	4.00
34	0.923	0.913	16.28	74	-0.257	-0.095	76.55
35	-0.009	-0.214	1.41				
36	-0.123	-0.136	6.71				
37	0.362	0.492	9.85				
38	0.297	0.242	9.85				
39	0.429	0.497	29.61				
40	0.636	-0.056	25.02				

