Table S1. Datasets. Functional analyses were performed on eight main and 14 additional datasets. For the main datasets, activity traces were extracted for all identifiable neurons. For the 14 additional datasets, only neurons of interest were tracked. * – main datasets; ** – 203 is a partial dataset extended for the neuron-neuron and neuron-behavior correlation analyses presented in Figure 3L and Table S5.

Index	Male	Hermaphrodite	Description
109*	ZM9624	OH11119	Includes searching, courtship, copulation, and resting. 56 identified cells tracked across 2719 volumes (543 seconds).
153*	ZM9624	ADS1006	Includes searching, courtship, copulation, and resting. 68 identified cells tracked across 1325 volumes (265 seconds).
185*	ZM9624	ADS1013	Includes searching and courtship. 62 identified cells tracked across 2976 volumes (595 seconds).
137*	ZM9624	ADS1006	Includes searching and courtship. 66 identified cells tracked across 1294 volumes (258 seconds).
182*	ZM9624	ADS1013	Includes searching, courtship, copulation, and resting. 57 identified cells tracked across 2977 volumes (595 seconds).
184*	ZM9624	ADS1006	Includes searching, courtship, copulation, and resting. 61 identified cells tracked across 3000 volumes (600 seconds).
714*	ZM9624	ADS1006	Includes courtship, copulation, and resting. 54 identified cells tracked across 2472 volumes (494 seconds).
2457*	ZM9624	BB92	Includes searching, courtship, copulation, and resting. 51 identified cells tracked across 2901 volumes (580 seconds).
205	ZM9624	ADS1006	Includes searching, courtship. 15 identified cells tracked across 1332 volumes (266 seconds).
264	ADS1002 x OH13105	ADS1006	Includes courtship, copulation, and resting. 15 identified cells tracked across 450 volumes (90 seconds).
262	ADS1002 x OH13105	ADS1006	Includes searching, courtship, copulation, and resting. 16 identified cells tracked across 1060 volumes (212 seconds).
260	ADS1002 x OH13105	ADS1006	Includes courtship. 5 identified cells tracked across 355 volumes (71 seconds).
258	ADS1002 x OH13105	ADS1006	Includes courtship. 2 identified cells tracked across 181 volumes (36 seconds).
300	ZM9624	ADS1003	Includes courtship. 13 identified cells tracked across 1630 volumes (326 seconds).
263	ADS1002 x OH13645	ADS1006	Includes courtship. 3 identified cells tracked across 651 volumes (130 seconds).
277	ADS1002 x OH13645	ADS1006	Includes courtship. 3 identified cells tracked across 950 volumes (160 seconds).
203**	ZM9624	ADS1006	Includes courtship, copulation, and resting. 33 identified cells tracked across 2083 volumes (416 seconds) + additional 16 cells tracked for a part of courtship and copulation and resting.
259	ADS1002 x OH13645	ADS1006	Includes courtship. 2 identified cells tracked across 1530 volumes (306 seconds).
183	ZM9624	ADS1006	Includes courtship. 14 identified cells tracked across 597 volumes (119 seconds).
1851	ZM9624	BB92	Includes searching, courtship. 18 identified cells tracked across 917 volumes (183 seconds).
1852	ZM9624	BB92	Includes searching, courtship. 10 identified cells tracked across 913 volumes (182 seconds).
2455	ZM9624	BB92	Includes searching, courtship, copulation, and resting. 17 identified cells tracked across 887 volumes (177 seconds).

Table S2. Neuron identification. Related to Figure 1. 57 neuron types and the intestinal cell nucleus int9R were identified based on their morphology, position, and expression of specific fluorescent markers. 's' – sensory neuron, 'i' – interneuron, 'm' – motoneuron. Confidence scores: *** certain, ** confident, * probable.

Neuron ID	Neuron type	Identification criteria	Confidence score	Comments
AS10	m	unc-47 expression (OH13105), unc-17 expression (LX929), (RM3325), position	**	
AS11	m	unc-47 expression (OH13105), unc-17 expression (LX929), (RM3325), position	***	
CA08	m	Weak unc-47 expression (OH13105), position	***	
CA09	m	Weak unc-47 expression (OH13105), no unc-25 expression (CZ13799), position	***	
CP08	i	Weak unc-47 expression (OH13105), position	*	
CP09	i	Strong unc-47 expression (OH13105), no unc-17 expression (RM3325), position	***	
DA07	m	unc-129 expression (OH12930), position	**	
DB07	m	unc-129 expression (OH12930), position	***	
DD06	m	Strong unc-47 expression (OH13105), strong unc-25 expression (CZ13799), cho-1 expression (OH13646), position	***	
DVA	s, i	No eat-4 expression, position	*	
DVB	i, m	Expression of DVB marker OH15097, activity, position	***	
DX1	i	Morphology, position, no unc-47 expression (OH13105)	**	
DX2	i	Morphology, position, no unc-47 expression (OH13105)	**	
DX3/4	i	Morphology, position	**	
EF1	i	Strong unc-47 expression (OH13105), position	***	EF1 is considered anterior to EF2
EF2	i	Strong unc-47 expression (OH13105), position	***	
EF3	i	Strong unc-47 expression (OH13105), no cho-1 expression (OH13646), position	***	
HOA	s	Strong eat-4 expression (OH13645), position	***	
HOB	s	pkd-2 expression (MT11318), position	***	
int9R		Morphology – nucleus localizes to int9R, gtl-1 expression (CG460)	***	Intestinal cell
PCAL/R	s, m	Strong eat-4 expression (OH13645)	***	
PCBL/R	s, m	Strong unc-47 expression (OH13105), position	***	
PCCL/R	s, m	Strong unc-47 expression (OH13105), position	***	
PDA	m	position	*	
PDB	i, m	kal-1 expression (OH904), unc-47 expression (OH13105), position	***	
PDC	i, m	Morphology, unc-47 expression (OH13105), position	***	
PGA	i	unc-47 expression (OH13105), no cho-1 expression (OH13646), position	**	
PHAL/R	s	Lipophilic dye uptake, srg-13 expression (BC12695), no gpa-6 expression (NL1603), position	***	Unlike in the hermaphrodite, in the male PHA lies posterior to PHB
PHBL/R	s	Lipophilic dye uptake, gpa-6 expression (NL1603), no srg-13 expression (BC12695), position	**	
PHCL/R	s	Strong eat-4 expression (OH13645), dop-1 expression (OH2411), ida-1 expression (BL5717), position	***	
PHDL/R	s	Strong unc-17 expression (LX929), (RM3325), position	***	
PLML/R	s	mec-4 expression (QW1068), dop-1 expression (OH1960), position	***	
PVPR	i	No unc-47 expression (OH13105), position	*	

Neuron ID	Neuron type	Identification criteria	Confidence score	Comments
PVT	i	Expression of PVT marker OH15097, no cho-1 expression (OH13646), position	***	PVT appears on the right side of the male, unlike in Sulston et al., 1980.
PVV	i, m	Strong eat-4 expression (OH13645), position	***	
PVX	i	Morphology, nlp-14 expression (HA353), position	***	
PVY	i	Morphology, position	***	
PVZ	i, m	unc-47 expression (OH13105), cho-1 expression (OH13646), position	**	
R1AL/R	s	No expression of pkd-2 (MT11318), nucleus morphology, position	***	
R1BL/R	s	Expression of pkd-2 (MT11318), nucleus morphology, position	***	
R2AL/R	s	No expression of pkd-2 (MT11318), nucleus morphology, position	***	
R2BL/R	s	Expression of pkd-2 (MT11318), nucleus morphology, weak eat4 expression (OH13645), no unc-47 expression (OH13105), position	***	
R3AL/R	s	trp-4 expression (OH10235), unc-47 expression (OH13105), cho- 1 expression (OH13646), position	*	
R4AL/R	s	No sto-3 expression (QW1876), position	**	
R6AL/R	s	trp-4 expression (OH10235), position	***	
R8BL/R	s	sto-3 expression (QW1876), no unc-47 expression (OH13105), position	***	
R9BL/R	s	unc-47 expression (OH13105), position	**	
SPCL/R	s, m	position	***	
SPDL/R	s, m	position	**	
SPVL/R	s	position	**	
VA10	m	unc-17 expression (RM3325)	***	
VA11	m	unc-17 expression (RM3325), no unc-47 expression (OH13105), position	***	
VA12	m	cho-1 expression (OH13646), position	*	
VB11	m	unc-17 expression (RM3325), position, activity	***	
VD11	m	Strong unc-47 expression (OH13105), strong unc-25 expression (CZ13799), position	***	
VD12	m	Strong unc-47 expression (OH13105), strong unc-25 expression (CZ13799), position	***	
VD13	m	Strong unc-47 expression (OH13105), strong unc-25 expression (CZ13799), position	**	

Table S3. Predicting continuous behavioral features from neuronal activities. Related to Figure 2. Prediction accuracy (R^2) for models built and tested using all neurons. R^2 values were obtained from fitting predictions to the observed continuous features from each left-out dataset.

Behavioral feature	Dataset index							
	109	153	185	137	182	184	714	2457
Velocity	0.33	0.36	0.43	0.61	0.11	0.52	0.28	0.45
Tail Curvature	0.24	0.38	0.37	0.13	0.52	0.22	0.46	0.23
Sliding velocity	0.24	0.27	0.42	0.41	0.02	0.56	0.19	0.33
Distance to tips	0.36	0.21	0.35	0.24	0.35	0.38	0.19	0.36
Distance to vulva	0.31	0.5	0.42	0.25	0.4	0.49	0.12	0.36
Spicules	0.36	0.6	0.04	0.04	0	0.36	0.16	0.13

Table S4. Predicting continuous behaviors from partial neuronal activity sets. Related to Figure 2. For each continuous behavioral feature, individual neurons were ranked by their importance for predicting those features. In each row of the table corresponding to neuron A, mean R^2 values are shown as follows: R^2_k – models built using activities of neuron A; R^2_e – models built using activities of all neurons except neuron A; R^2_{sa} models built by using activity of neuron A and activities all neurons with a higher rank; R^2_{se} models built by using activities of neurons whose ranks are lower than the rank of A.

Rank	Velocity					Tail curvature					Sliding velocity					Distance to tips					Distance to vulva					Spicules				
All neurons	Mean $R^2 = 0.39$					Mean $R^2 = 0.32$					Mean $R^2 = 0.30$					Mean $R^2 = 0.31$					Mean $R^2 = 0.36$					Mean $R^2 = 0.21$				
	ID	R^2_k	R^2_e	R^2_{sa}	R^2_{se}	ID	R^2_k	R^2_e	R^2_{sa}	R^2_{se}	ID	R^2_k	R^2_e	R^2_{sa}	R^2_{se}	ID	R^2_k	R^2_e	R^2_{sa}	R^2_{se}	ID	R^2_k	R^2_e	R^2_{sa}	R^2_{se}	ID	R^2_k	R^2_e	R^2_{sa}	R^2_{se}
1	PHC	0.25	0.38	0.25	0.39	VA11	0.02	0.3	0.02	0.32	PHC	0.18	0.25	0.18	0.3	PVV	0.22	0.24	0.22	0.31	PCB	0.27	0.36	0.27	0.36	SPC	0.23	0.19	0.23	0.21
2	PVY	0.03	0.38	0.27	0.38	AS11	0.03	0.31	0.07	0.3	PVX	0.02	0.28	0.21	0.25	VB11	0.01	0.31	0.2	0.24	PVX	0.21	0.34	0.27	0.36	AS11	0.03	0.21	0.23	0.2
3	DB07	0.17	0.37	0.33	0.38	PVZ	0.06	0.31	0.05	0.29	PCA	0.16	0.29	0.27	0.24	AS11	0.04	0.3	0.21	0.24	PVY	0.13	0.35	0.34	0.35	HOA	0.19	0.21	0.37	0.19
4	VB11	0.12	0.37	0.36	0.36	PVY	0.03	0.3	0.15	0.29	AS11	0.1	0.3	0.28	0.19	EF2	0.2	0.31	0.31	0.23	PHA	0.04	0.35	0.37	0.34	CA08	0.05	0.21	0.37	0.2
5	DA07	0.14	0.39	0.38	0.33	AS10	0.03	0.31	0.17	0.28	VB11	0.1	0.3	0.29	0.18	PLM	0.08	0.29	0.32	0.23	HOA	0.26	0.37	0.36	0.33	VB11	0.34	0.21	0.37	0.2
6	PVPR	0.06	0.37	0.38	0.33	PVX	0.09	0.31	0.2	0.27	PVV	0.06	0.29	0.32	0.17	PCB	0.05	0.3	0.32	0.23	VA12	0.13	0.33	0.37	0.34	VA11	0.08	0.22	0.37	0.19
7	DD06	0.01	0.39	0.38	0.32	R3A	0.08	0.32	0.19	0.26	SPC	0.03	0.31	0.32	0.16	PVT	0.08	0.31	0.32	0.22	VB11	0.04	0.33	0.36	0.31	PVY	0.12	0.21	0.37	0.2
8	AS11	0.21	0.39	0.38	0.31	DA07	0.07	0.32	0.21	0.26	PVT	0.06	0.3	0.32	0.16	HOA	0.17	0.3	0.35	0.22	AS10	0.17	0.35	0.36	0.27	CA09	0.17	0.21	0.35	0.2
9	VA12	0.05	0.39	0.38	0.32	VA12	0.03	0.3	0.22	0.26	AS10	0.04	0.31	0.32	0.16	R4A	0.1	0.29	0.37	0.22	HOB	0.03	0.35	0.37	0.25	EF2	0.03	0.22	0.34	0.16
10	EF2	0.17	0.37	0.39	0.3	DB07	0.02	0.31	0.21	0.24	DVB	0.04	0.31	0.33	0.17	DA07	0.02	0.3	0.37	0.19	PVV	0.11	0.35	0.38	0.23	R4A	0.03	0.21	0.34	0.16
11	VA11	0.15	0.39	0.4	0.29	PVV	0.1	0.31	0.25	0.23	DD06	0.03	0.3	0.33	0.17	DX2	0.1	0.31	0.38	0.19	PCC	0.1	0.36	0.37	0.23	AS10	0.04	0.21	0.34	0.17
12	EF1	0.13	0.39	0.39	0.28	VB11	0.02	0.32	0.25	0.21	PVZ	0.05	0.31	0.33	0.17	HOB	0.09	0.31	0.38	0.19	DB07	0.13	0.35	0.39	0.23	PVZ	0.05	0.2	0.34	0.17
13	PVT	0.12	0.39	0.39	0.27	PLM	0.02	0.32	0.25	0.21	EF1	0.03	0.31	0.33	0.16	PHA	0.02	0.29	0.38	0.17	PVPR	0.05	0.36	0.39	0.23	PGA	0.32	0.21	0.32	0.16
14	PCA	0.09	0.39	0.39	0.27	DD06	0.06	0.32	0.23	0.21	R9B	0.07	0.31	0.33	0.17	SPC	0.1	0.3	0.4	0.16	DD06	0.04	0.36	0.38	0.22	PCB	0.12	0.23	0.32	0.13
15	R2A	0.12	0.39	0.39	0.28	R4A	0.02	0.32	0.23	0.2	VD12	0.02	0.31	0.33	0.17	PDB	0.02	0.31	0.4	0.16	DA07	0.08	0.36	0.38	0.22	PVT	0.08	0.21	0.32	0.14
16	R6A	0.11	0.39	0.38	0.28	EF2	0.01	0.32	0.24	0.2	VA12	0.03	0.31	0.33	0.17	PGA	0.01	0.31	0.4	0.16	PVT	0.11	0.36	0.38	0.23	DD06	0.1	0.21	0.32	0.14
17	int9R	0.01	0.39	0.38	0.28	PDB	0.07	0.32	0.26	0.21	PVY	0	0.31	0.32	0.17	VA12	0.02	0.31	0.39	0.16	DX2	0.06	0.36	0.39	0.24	R6A	0.05	0.21	0.33	0.14
18	AS10	0.03	0.39	0.38	0.28	DVB	0.04	0.32	0.27	0.2	R1AR	0.13	0.31	0.32	0.18	R2A	0.11	0.31	0.39	0.16	PGA	0.06	0.36	0.39	0.24	PHA	0.06	0.21	0.33	0.13
19	DVA	0.19	0.38	0.38	0.28	PHA	0.02	0.32	0.27	0.18	HOA	0.04	0.31	0.32	0.15	VD11	0.03	0.3	0.38	0.15	PDA	0.02	0.36	0.39	0.25	R9B	0.12	0.21	0.33	0.13
20	PVV	0.06	0.39	0.39	0.25	VA10	0.1	0.32	0.28	0.18	CA08	0.06	0.31	0.32	0.15	PCC	0.05	0.31	0.38	0.13	R4A	0.09	0.36	0.37	0.24	DVB	0.21	0.22	0.32	0.12
21	PHA	0.04	0.39	0.38	0.25	PCA	0.03	0.32	0.29	0.18	DVA	0.07	0.3	0.32	0.15	AS10	0.08	0.31	0.38	0.14	CA08	0.04	0.36	0.37	0.23	SPD	0.04	0.21	0.32	0.08
22	PGA	0.02	0.39	0.38	0.25	DVA	0.02	0.32	0.28	0.18	EF2	0.07	0.31	0.32	0.14	PHD	0.01	0.3	0.38	0.14	PHC	0.04	0.35	0.38	0.23	PVX	0.02	0.21	0.31	0.07
23	SPC	0.13	0.38	0.39	0.25	R9B	0.02	0.32	0.28	0.18	PGA	0.03	0.31	0.31	0.14	PVX	0.11	0.3	0.38	0.13	R1B	0.02	0.35	0.38	0.23	PCC	0.06	0.21	0.31	0.07
24	VD11	0.17	0.39	0.39	0.24	PCB	0.03	0.32	0.28	0.17	SPD	0.03	0.31	0.31	0.14	CA09	0.02	0.31	0.38	0.13	DVA	0.09	0.35	0.39	0.22	PCA	0.08	0.22	0.31	0.07
25	R9B	0.13	0.37	0.4	0.23	R1AL	0.03	0.32	0.28	0.17	PCB	0.03	0.3	0.32	0.14	DVA	0.05	0.32	0.38	0.14	R9B	0.1	0.36	0.39	0.2	PDB	0.03	0.22	0.31	0.1
26	PDA	0.06	0.39	0.4	0.19	PHC	0.03	0.32	0.28	0.17	DX2	0.08	0.28	0.34	0.14	VD12	0.08	0.31	0.37	0.14	PVZ	0.03	0.36	0.4	0.21	R1AR	0.03	0.22	0.31	0.1
27	R1AR	0.03	0.37	0.41	0.19	EF3	0.01	0.32	0.28	0.17	R3A	0.04	0.31	0.34	0.11	PVY	0.02	0.31	0.35	0.15	CA09	0.21	0.35	0.41	0.21	DX2	0.02	0.21	0.3	0.1
28	R4A	0.14	0.39	0.41	0.16	VD13	0.1	0.29	0.31	0.18	PVPR	0.01	0.3	0.34	0.09	PHC	0.07	0.3	0.35	0.15	PDB	0.1	0.36	0.41	0.19	R1AL	0.02	0.21	0.29	0.11
29	PVX	0.09	0.39	0.41	0.15	int9R	0.04	0.32	0.31	0.13	int9R	0.01	0.31	0.34	0.08	PVPR	0.03	0.31	0.35	0.15	SPC	0.04	0.36	0.41	0.18	VA10	0.07	0.21	0.29	0.11
30	CA09	0.02	0.39	0.4	0.14	R8B	0.06	0.32	0.33	0.13	PLM	0.02	0.31	0.34	0.08	R8B	0.06	0.31	0.35	0.16	VA11	0.14	0.36	0.42	0.19	R2A	0.03	0.21	0.28	0.11
31	EF3	0.15	0.38	0.4	0.14	DX2	0.07	0.32	0.32	0.1	R2A	0.01	0.31	0.34	0.09	VD13	0.11	0.31	0.34	0.16	EF3	0.03	0.37	0.42	0.19	EF3	0.23	0.21	0.28	0.11
32	R1AL	0.11	0.39	0.4	0.13	CA08	0.03	0.32	0.33	0.1	PHA	0.06	0.31	0.34	0.09	R2B	0.1	0.31	0.34	0.16	R2B	0.17	0.35	0.42	0.2	R3A	0.03	0.21	0.28	0.06
33	PVZ	0.04	0.39	0.4	0.13	R2A	0	0.32	0.33	0.1	DA07	0.01	0.3	0.34	0.08	R3A	0.05	0.31	0.33	0.15	EF2	0.09	0.36	0.41	0.15	PDA	0.05	0.21	0.27	0.05
34	DX2	0.06	0.39	0.4	0.13	VD12	0.02	0.31	0.33	0.11	VD13	0.02	0.31	0.34	0.06	CA08	0.01	0.31	0.33	0.15	PDC	0.07	0.36	0.41	0.16	VA12	0.04	0.21	0.28	0.05
35	R3A	0.08	0.38	0.4	0.13	R1AR	0.02	0.32	0.33	0.1	VA10	0.04	0.31	0.34	0.07	R9B	0.11	0.3	0.34	0.15	R3A	0.11	0.35	0.41	0.17	DVA	0.07	0.21	0.27	0.05
36	PDB	0.04	0.38	0.41	0.13	HOA	0.12	0.32	0.33	0.11	PCC	0.01	0.31	0.34	0.07	R6A	0.04	0.31	0.33	0.14	DVB	0.15	0.36	0.41	0.18	EF1	0.02	0.23	0.26	0.05
37	PLM	0.12	0.39	0.41	0.13	PCC	0.05	0.32	0.33	0.06	DB07	0.04	0.31	0.33	0.07	R1AL	0.06	0.31	0.33	0.15	PLM	0.15	0.35	0.41	0.15	R2B	0.06	0.21	0.25	0.05
38	PHD	0.02	0.38	0.41	0.11	PVPR	0.05	0.32	0.34	0.06	R4A	0.04	0.3	0.33	0.07	R1AR	0.09	0.31	0.33	0.15	SPD	0.06	0.36	0.4	0.14	VD11	0.07	0.22	0.24	0.05
39	HOA	0.04	0.39	0.41	0.11	HOB	0.02	0.32	0.33	0.04	R8B	0.02	0.31	0.33	0.06	DD06	0.03	0.31	0.34	0.15	EF1	0.01	0.36	0.41	0.12	R1B	0.1	0.21	0.25	0.06
40	VA10	0.04	0.39	0.41	0.1	CA09	0.06	0.32	0.33	0.05	PDB	0.02	0.3	0.33	0.07	EF1	0.09	0.31	0.33	0.15	AS11	0.09	0.36	0.41	0.11	HOB	0.09	0.22	0.25	0.07
41	CA08	0.14	0.39	0.41	0.11	R2B	0	0.32	0.33	0.03	VD11	0.05	0.31	0.33	0.05	PVZ	0.1	0.3	0.34	0.14	PCA	0.03	0.36	0.41	0.1	DB07	0.05	0.21	0.25	0.08
42	PCC	0.03	0.39	0.41	0.05	PGA	0.05	0.32	0.33	0.03	EF3	0.03	0.31	0.33	0.04	EF3	0.06	0.31	0.34	0.13	VD13	0.08	0.36	0.41	0.11	R8B	0.08	0.21	0.24	0.09
43	PDC	0.02	0.39	0.41	0.05	EF1	0.02	0.32	0.33	0.04	CA09	0.04	0.31	0.33	0.04	int9R	0.06	0.31	0.34	0.13	VD11	0.05	0.36	0.4	0.12	VD12	0.08	0.22	0.23	0.11
44	R8B	0.04	0.39	0.4	0.06	R6A	0.01	0.31	0.34	0.04	R1B	0.01	0.31	0.33	0.03	VA11	0.06	0.31	0.33	0.12	R2A	0.12	0.37	0.39	0.12	PVV	0.04	0.21	0.23	0.11
45	VD12	0.1	0.39	0.4	0.05	PHD	0.01	0.32	0.33	0.03	R2B	0.01	0.31	0.33	0.03	VA10	0.06	0.3	0.33	0.12	PHD	0.06	0.36	0.39	0.11	DA07	0.06	0.21	0.23	0.11
46	PCB	0.02	0.39	0.4	0.03	SPD	0.03	0.32	0.33	0.03	PDC	0.02	0.31	0.32	0.03	PDC	0.07	0.31	0.33	0.12	int9R	0.11	0.36	0.39	0.11	PHC	0.06	0.21	0.22	0.13
47	R2B	0.04	0.39	0.4	0.05	VD11	0.06	0.32	0.33	0.04	VA11	0.04	0.31	0.32	0.03	R1B	0.01	0.31	0.33	0.12	R1AR	0.07	0.36	0.39	0.14	int9R	0.1	0.21	0.22	0.13
48	VD13	0.02	0.39	0.4	0.03	R1B	0.03	0.32	0.33	0.03	PDA	0.01	0.31	0.31	0.01	SPD	0.06	0.31	0.32	0.13	VD12	0.08	0.36	0.38	0.16	PLM	0.08	0.21	0.22	0.1
49	HOB	0.02	0.39	0.39	0.03	PDA	0.02	0.32	0.33	0.04	R6A	0.02	0.31	0.31	0.01	PDA	0.13	0.31	0.32	0.11	VA10	0.09	0.36	0.38	0.15	PHD	0.06	0.21	0.22	0.07
50	DVB	0.02	0.39	0.39	0.04	PVT	0.02	0.32	0.32	0.04	PHD	0.02	0.31	0.31	0.02	DB07	0.07	0.31	0.31	0.04	R6A	0.06	0.36	0.37	0.12	PDC	0.04	0.22	0.21	0.06
51	R1B	0.03	0.39	0.39	0.03	PDC	0	0.32	0.32	0.06	R1AL	0.02	0.31	0.31	0.02	PCA	0.05	0.31	0.31	0.04	R1AL	0.09	0.37	0.37	0.11	VD13	0.05	0.21	0.21	0.07
52	SPD	0.02	0.39	0.39	0.02	SPC	0.06	0.32	0.32	0.06	HOB	0.02	0.31	0.31	0.02	DVB	0.05	0.31	0.31	0.05	R8B	0.1	0.37	0.36	0.1	PVPR	0.09	0.21	0.21	0.09

Table S5. State-specific correlations. Related to Figure 3. We calculated cross-correlation matrices for each behavioral state and dataset. We compared Euclidean and correlation distances between these correlation matrices grouped by behavioral state or dataset to Euclidean and correlation distances between randomly selected matrices.

Groupping	Neuron-to-neuron correlations				Neuron-to-behavior correlations			
	Euclidean distance		Correlation distance		Euclidean distance		Correlation distance	
	t statistic	FDR-corrected p-values	t statistic	FDR-corrected p-values	t statistic	FDR-corrected p-values	t statistic	FDR-corrected p-values
By state								
Searching	t(27.11)=-1.69, p=0.102	p=0.136	t(27.1)=-0.62, p=0.544	p=0.544	t(27.01)=-2.65, p=0.013	p=0.018	t(27.01)=-2.16, p=0.04	p=0.053
Scanning	t(35.06)=-7.66, p<0.0001	p<0.0001	t(35.07)=-8.56, p<0.0001	p<0.0001	t(35.01)=-11.39, p<0.0001	p<0.0001	t(35.01)=-12.38, p<0.0001	p<0.0001
Copulation	t(20.05)=-3.73, p=0.001	p=0.003	t(20.05)=-3.69, p=0.001	p=0.003	t(20.01)=0.08, p=0.938	p=0.938	t(20.01)=0.37, p=0.719	p=0.719
Resting	t(20.11)=-0.09, p=0.929	p=0.929	t(20.11)=1, p=0.329	p=0.438	t(20.01)=-3.44, p=0.003	p=0.005	t(20.01)=-2.79, p=0.011	p=0.022
By dataset								
1	t(5.02)=0.35, p=0.74	p=0.864	t(5.02)=0.48, p=0.651	p=0.896	t(5)=-0.21, p=0.84	p=0.840	t(5)=0.22, p=0.837	p=0.837
3	t(5.03)=-0.42, p=0.691	p=0.864	t(5.02)=-0.16, p=0.876	p=0.896	t(5)=-1.28, p=0.257	p=0.762	t(5)=-1.26, p=0.264	p=0.788
5	t(5)=-1.31, p=0.247	p=0.576	t(5)=-1.78, p=0.136	p=0.460	t(5)=0.29, p=0.784	p=0.840	t(5)=0.64, p=0.553	p=0.788
6	t(5.05)=-0.14, p=0.893	p=0.893	t(5.04)=0.14, p=0.896	p=0.896	t(5)=-0.65, p=0.544	p=0.762	t(5)=-0.44, p=0.677	p=0.790
7	t(5)=-0.66, p=0.539	p=0.864	t(5)=-0.96, p=0.383	p=0.670	t(5)=-0.86, p=0.429	p=0.762	t(5)=-1.05, p=0.343	p=0.788
8	t(2.01)=-3.14, p=0.088	p=0.324	t(2.01)=-3.28, p=0.081	p=0.460	t(2)=0.8, p=0.506	p=0.762	t(2)=0.69, p=0.563	p=0.788
9	t(5.07)=-2.07, p=0.093	p=0.324	t(5.07)=-1.48, p=0.197	p=0.460	t(5)=0.88, p=0.419	p=0.762	t(5)=1.05, p=0.34	p=0.788

Table S6. Community interaction motifs across different circuit partitioning schemes. Related to Figure 4. Synaptic interaction motifs between functional communities delineated with link clustering. The fraction of assortative ("a"), disassortative ("d"), and core-periphery ("cp") motifs was calculated for 10 different partitioning schemes. For comparison, we calculated community interaction motifs when the community membership was shuffled. Empirical probability that the fraction of assortative and disassortative interactions from 1000 shuffled iterations (S_a and S_d respactively) is larger than the fraction of observed assortative and disassortative interactions (O_a and O_d).

number of communities	observed			shuffled			probability	
				Electrical				
	a	d	cp	a	d	cp	$S_a > O_a$	$S_d > O_d$
7	0.86	0.1	0.05	0.15	0.36	0.5	0	0.937
8	0.86	0.07	0.07	0.14	0.37	0.49	0	0.973
9	0.83	0.06	0.11	0.14	0.37	0.49	0	0.993
11	0.84	0.05	0.11	0.14	0.37	0.49	0	1
13	0.73	0.06	0.21	0.14	0.39	0.47	0	1
15	0.76	0.05	0.2	0.14	0.4	0.46	0	1
16	0.76	0.04	0.2	0.14	0.4	0.46	0	1
17	0.75	0.04	0.21	0.14	0.39	0.47	0	1
18	0.76	0.04	0.2	0.14	0.4	0.47	0	1
19	0.76	0.03	0.2	0.14	0.38	0.48	0	1
				Chemical				
	a	d	cp	a	d	cp	$S_a > O_a$	$S_d > O_d$
7	0.33	0.14	0.52	0.15	0.36	0.49	0.057	0.877
8	0.29	0.18	0.54	0.15	0.36	0.49	0.09	0.87
9	0.28	0.14	0.58	0.14	0.37	0.49	0.084	0.937
11	0.44	0.13	0.44	0.14	0.37	0.49	0.002	0.98
13	0.43	0.1	0.47	0.14	0.38	0.48	0.002	1
15	0.47	0.13	0.4	0.13	0.41	0.46	0	0.997
16	0.45	0.12	0.43	0.14	0.4	0.47	0	0.998
17	0.46	0.1	0.44	0.14	0.39	0.47	0	1
18	0.47	0.09	0.44	0.14	0.39	0.48	0	1
19	0.48	0.1	0.42	0.14	0.38	0.48	0	0.999