Journal of Comparative Physiology A

Online Resource 1

A connectomic census of axo-axonic inhibition in *Drosophila*: control of nociceptors is concentrated in one body-wide inhibitor

João Pedro do Couto Caetano, Juliana da Rosa Perez, Fátima Caroline dos Santos Welter, Vilson Farias Junior, Rodrigo Mendes Rezende, Fernanda Silveira Prado, Lucas Damé Simões, Artur Ramos Molina

Corresponding author: João Pedro do Couto Caetano, Postgraduate Program in Dentistry, School of Dentistry, Federal University of Pelotas, Pelotas, Brazil; e-mail: jpcaetano8@gmail.com

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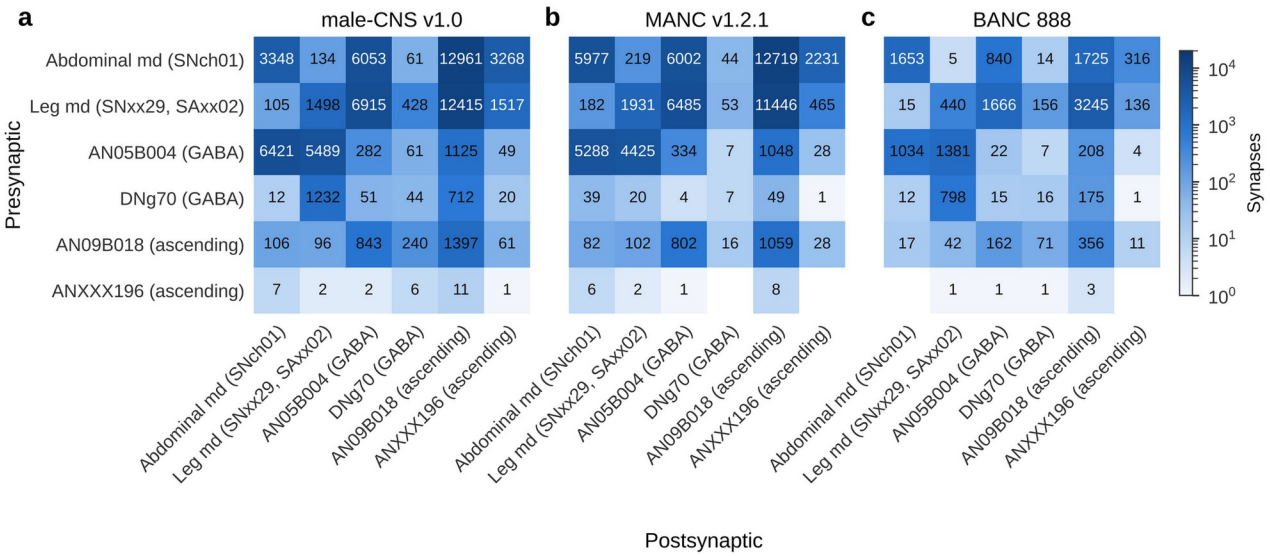


Fig. S1 Connectivity of the nociceptive circuit in the three connectomes. Number of synapses between the cell groups of the circuit in male-CNS v1.0 (**a**), MANC v1.2.1 (**b**) and BANC 888 (**c**); rows are presynaptic and columns postsynaptic, and colour is scaled logarithmically. *md*, multidendritic. In BANC the abdominal md group was identified by cross-dataset type matching, which proved unreliable for this class, and it was excluded from the BANC simulations

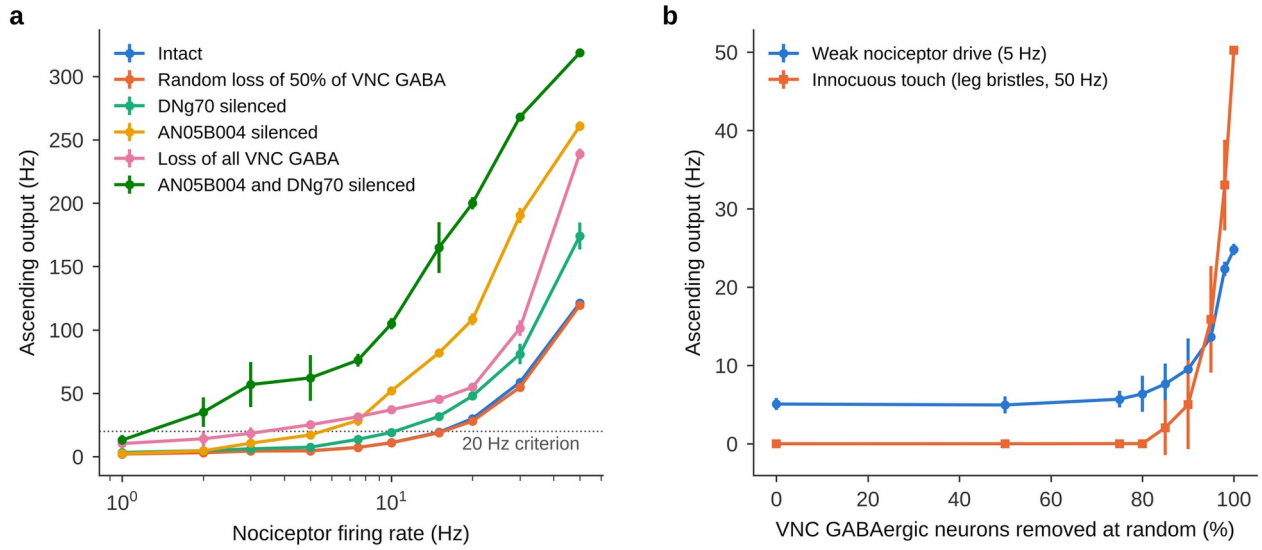


Fig. S2 Stimulus-response curves and graded GABAergic loss in the network model. **a** Mean firing rate of the ascending nociceptive projection neurons as a function of the firing rate of abdominal md nociceptors (logarithmic horizontal axis), for the intact network and five silencing conditions; mean and standard deviation of four trials. The dotted line marks the 20 Hz criterion used to define the stimulus-response threshold. **b** Ascending output as GABAergic neurons of the ventral nerve cord (*VNC*) are removed at random, under weak nociceptor drive (5 Hz) and under innocuous touch of the leg bristles (50 Hz); mean and standard deviation of three random draws per point. The abrupt rise under touch at near-complete loss reflects global network hyperexcitation (main text, Table 3)

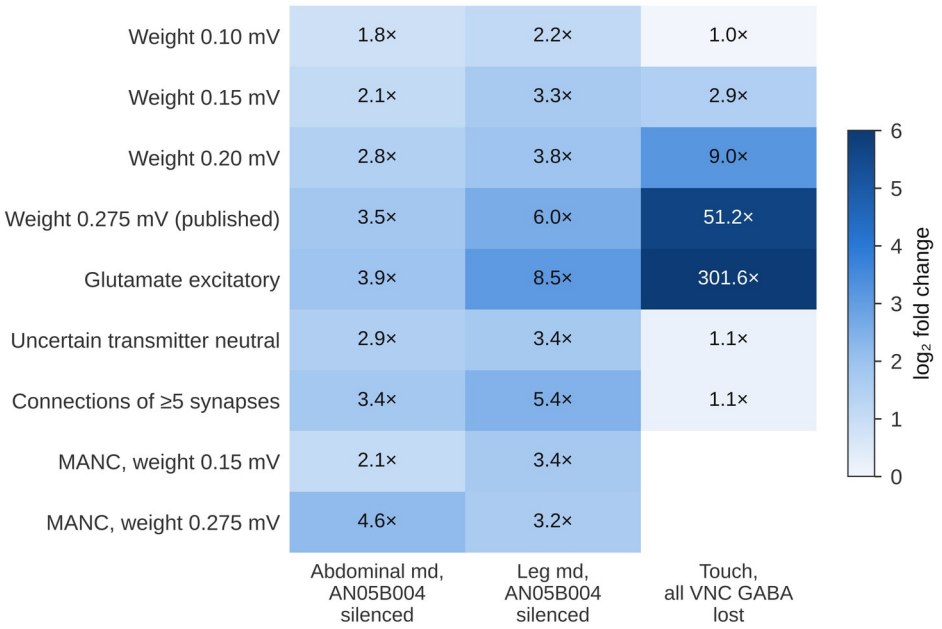


Fig. S3 Robustness of the silencing effect across model variants. Fold change in ascending nociceptive output on silencing AN05B004 under abdominal and leg md drive, and fold change in the ascending response to touch after loss of all GABAergic neurons of the ventral nerve cord, for each model variant; colour is scaled to the base-2 logarithm of the fold change. The large values in the touch column reflect global hyperexcitation (main text, Table 3) and are reported as a negative control. Empty cells were not simulated

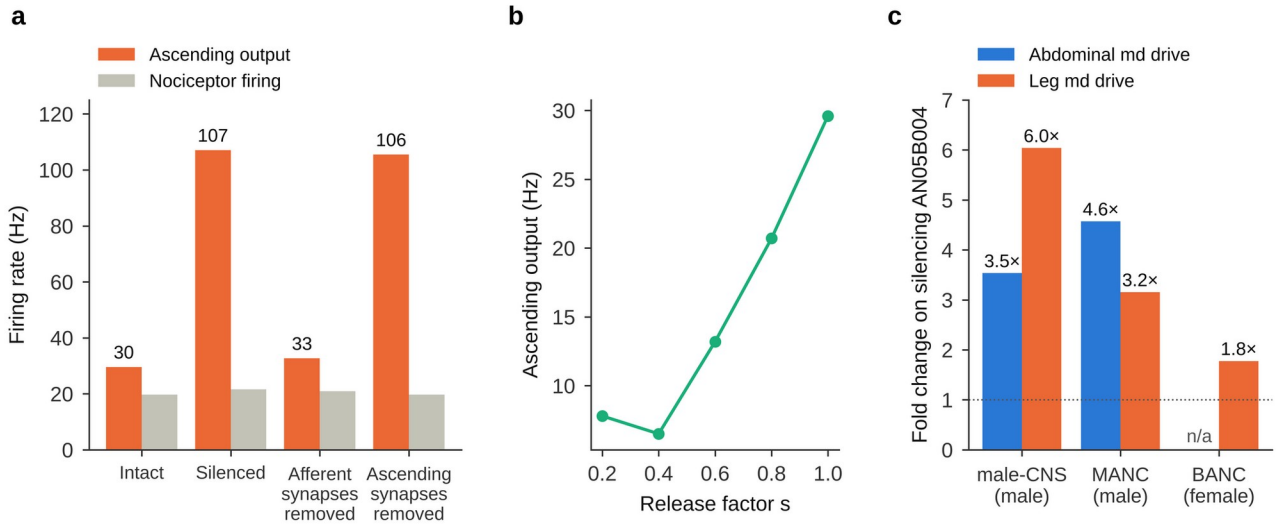


Fig. S4 Decomposition of the silencing effect and replication across connectomes. **a** Ascending output and nociceptor firing under 20 Hz abdominal md drive with the network intact, with AN05B004 silenced, and with only the synapses of AN05B004 onto the afferents, or only those onto the ascending neurons, removed. **b** Ascending output as a function of the release factor *s* applied to the output synapses of the nociceptive afferents, an explicit implementation of presynaptic inhibition. **c** Fold change on silencing AN05B004 at 0.275 mV per synapse under abdominal and leg md drive in the three connectomes. The BANC abdominal pathway was not simulated (*n/a*). The dotted line marks no change

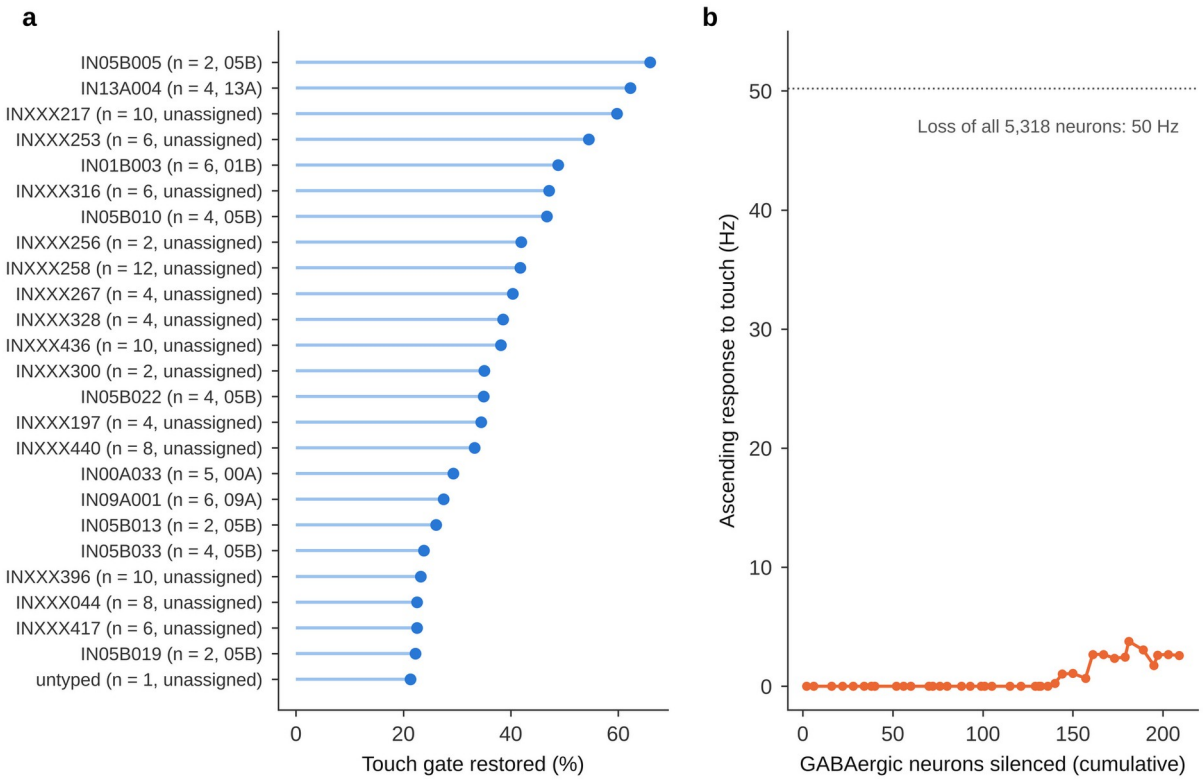


Fig. S5 Screens of GABAergic cell types for the tactile pathway. **a** Sufficiency screen: percentage of the response of the ascending nociceptive neurons to innocuous touch of the leg bristles (50 Hz) that is suppressed when a single GABAergic cell type is retained after removal of all GABAergic neurons of the ventral nerve cord. The 25 most effective of 252 cell types tested are shown, with the number of neurons and the hemilineage of each. **b** Necessity screen: ascending response to touch as the most protective cell types are silenced cumulatively. The dotted line marks the response after loss of all 5,318 GABAergic neurons. Because the response to touch after complete GABAergic loss reflects global hyperexcitation, this screen is reported as a negative control

Table S1 Census of inhibitory input by afferent class in the three connectomes

Dataset	Afferent class	Afferents (n)	Input synapses	GABA (%)	GABA cell types (n)	Largest GABA source	Share of input (%)	N50	HHI
male-CNS	Nociceptive (multidendritic)	77	24,706	66.9	121	AN05B004	57.0	1	0.733
male-CNS	Proprioceptive, hair plate	113	11,218	83.8	144	IN19A041	20.5	3	0.126
male-CNS	Thermosensory	25	12,862	23.4	18	lLN2F_b	16.8	1	0.538
male-CNS	Olfactory	2,639	431,288	27.8	56	lLN2F_b	14.5	1	0.334
male-CNS	Hygrosensory	66	17,231	26.5	26	lLN2F_b	12.7	2	0.325
male-CNS	Proprioceptive, campaniform	426	90,205	79.9	497	IN06B017	11.0	11	0.040
male-CNS	Proprioceptive, chordotonal	425	46,314	77.8	332	IN09A012	9.7	9	0.040
male-CNS	Gustatory	1,428	283,851	31.4	243	IN05B002	6.5	7	0.067
male-CNS	Tactile (bristle, body)	2,558	350,517	50.2	364	IN01B001	4.0	11	0.033
male-CNS	Cephalic mechanosensory	1,733	132,841	63.9	364	SAD113	2.8	20	0.018
male-CNS	Visual	6,091	215,825	2.5	18	C2	2.1	1	0.720
MANC	Nociceptive (multidendritic)	82	27,565	51.2	186	AN05B004	40.8	1	0.642
MANC	Proprioceptive, campaniform	518	126,934	67.3	470	IN06B017	16.5	7	0.077
MANC	Proprioceptive, hair plate	149	26,295	70.1	383	IN19A041	10.8	6	0.060
MANC	Proprioceptive, chordotonal	560	78,612	66.9	484	IN09A012	5.6	11	0.030
MANC	Tactile (bristle, body)	3,648	584,689	38.7	463	IN05B002	3.2	13	0.028
BANC	Thermosensory	31	8,292	39.0	30	lLN2F_b	23.2	1	0.415
BANC	Olfactory	3,007	159,969	35.5	76	lLN2F_b	23.0	1	0.440
BANC	Hygrosensory	90	10,999	24.3	30	lLN2F_b	15.1	1	0.410
BANC	Nociceptive (multidendritic)	251	21,993	53.8	268	AN05B004	15.1	4	0.106
BANC	Proprioceptive, campaniform	576	43,836	76.3	634	IN06B017	14.0	9	0.052
BANC	Proprioceptive, chordotonal	2,131	81,588	80.5	793	CB1231	7.8	26	0.021
BANC	Proprioceptive, hair plate	320	29,153	78.4	463	IN19A098	7.3	10	0.036
BANC	Gustatory	1,456	108,900	49.7	379	IN05B002	4.4	9	0.041
BANC	Tactile (bristle, body)	6,058	307,539	59.6	748	AN01B002	4.0	17	0.023
BANC	Visual	1,846	37,982	2.0	58	untyped	0.6	2	0.190

GABA (%), share of total input from GABAergic neurons; *N50*, smallest number of GABAergic cell types supplying at least half of the GABAergic input of the class; *HHI*, Herfindahl-Hirschman index of the GABAergic input shares. MANC contains the ventral nerve cord only. In BANC the nociceptive class is the annotated multidendritic neuron class, defined more broadly than in the male datasets; *untyped*, source neurons without a cell-type annotation

Table S2 Output of the GABAergic cell types of hemilineage 05B onto each afferent class (male-CNS v1.0)

Cell type	n	Output synapses	Nociceptive (%)	Chordotonal (%)	Campaniform (%)	Hair plate (%)	Tactile bristle (%)	Gustatory (%)	All afferents (%)
AN05B004	2	26,776	52.6	0.0	0.1	0.0	0.0	0.1	52.8
AN05B058	2	3,865	0.9	0.0	0.0	0.0	0.5	0.0	1.4
IN05B028	6	18,392	0.6	0.2	2.9	0.0	21.6	2.2	27.5
AN05B053	4	10,160	0.5	0.0	0.0	0.0	15.1	0.0	15.6
AN05B046	1	2,445	0.4	0.0	0.0	0.0	4.8	0.0	5.2
AN05B076	2	3,728	0.4	0.0	0.0	0.0	0.0	26.1	26.5
AN05B045	2	5,314	0.3	0.0	0.1	0.0	7.6	0.0	8.0
AN05B069	2	3,025	0.2	0.0	0.0	0.0	0.2	0.0	0.4
IN05B005	2	13,548	0.2	0.0	0.0	0.2	0.4	0.0	0.8
AN05B108	4	6,633	0.1	0.0	0.0	0.0	0.3	0.0	0.4
AN05B029	1	4,100	0.1	0.0	0.0	0.0	30.7	1.2	32.0
AN05B054_a	2	4,475	0.1	0.0	0.0	0.0	0.8	0.0	0.9
AN05B040	1	3,108	0.1	0.0	0.0	0.0	16.2	0.3	16.6
AN05B005	2	19,237	0.1	0.0	0.3	0.0	0.9	0.0	1.3
AN05B023a	2	11,251	0.1	0.0	0.0	0.0	0.0	61.6	61.7
AN05B009	4	32,336	0.1	0.0	0.0	0.0	2.6	0.0	2.7
DNg20	2	3,527	0.1	0.0	0.0	0.0	1.2	0.6	1.9
IN05B064_a	2	1,699	0.1	0.0	0.0	0.0	0.0	0.0	0.1
AN05B071	2	3,500	0.1	0.2	0.0	0.0	0.0	0.0	0.3
AN05B063	4	5,417	0.1	0.0	0.2	0.0	0.2	0.0	0.5
AN05B036	2	5,149	0.0	0.0	0.0	0.0	4.8	0.0	4.8
AN05B035	2	6,910	0.0	0.0	0.0	0.0	0.0	15.6	15.6
AN05B027	1	2,427	0.0	0.0	0.0	0.0	5.1	0.0	5.1
AN05B026	1	2,720	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AN05B024	1	3,199	0.0	0.0	0.0	0.0	0.1	0.0	0.1
AN05B025	2	10,666	0.0	0.0	0.0	0.0	0.0	0.2	0.2
AN05B023d	2	12,880	0.0	0.0	0.0	0.0	0.0	1.0	1.0
AN05B023c	2	9,737	0.0	0.0	0.0	0.0	0.0	0.9	0.9
AN05B010	1	6,534	0.0	0.0	0.0	0.0	0.4	0.2	0.6
AN05B023b	2	6,923	0.0	0.0	0.0	0.0	0.0	29.3	29.3
AN05B021	2	8,309	0.0	0.0	0.0	0.0	0.0	0.1	0.1
AN05B017	1	2,226	0.0	0.0	0.0	0.0	42.2	0.0	42.2
AN05B049_c	2	2,861	0.0	0.0	0.0	0.0	1.6	0.0	1.6
AN05B049_a	2	3,263	0.0	0.0	0.0	0.0	0.5	0.0	0.5
AN05B048	2	3,214	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AN05B044	2	2,488	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AN05B056	2	3,159	0.0	0.0	0.0	0.0	0.8	0.0	0.8
AN05B054_b	4	5,704	0.0	0.0	0.0	0.0	0.6	0.0	0.6
AN05B050_c	4	6,927	0.0	0.0	0.0	0.0	0.7	1.9	2.6
AN05B052	3	6,289	0.0	0.0	0.0	0.0	0.1	0.4	0.5
AN05B050_b	2	3,539	0.0	0.0	0.0	0.0	0.0	2.5	2.5
AN05B050_a	2	3,265	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AN05B049_b	2	3,598	0.0	0.1	0.0	0.0	1.5	0.0	1.6
AN05B059	1	1,494	0.0	0.0	0.1	0.0	0.0	0.0	0.1
AN05B068	7	6,834	0.0	0.0	0.4	0.0	1.6	0.6	2.6
AN05B067	1	1,696	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AN05B060	1	970	0.0	0.0	0.0	0.0	0.0	0.3	0.3
AN05B062	4	5,592	0.0	0.0	0.1	0.0	0.1	0.0	0.2
AN05B081	2	3,036	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AN05B006	3	26,117	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AN05B007	1	10,665	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AN05B015	2	8,338	0.0	0.0	0.3	0.0	0.4	0.0	0.7
AN05B083	1	1,010	0.0	0.0	0.0	0.0	0.0	1.1	1.1
AN05B101	4	21,506	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AN05B078	3	4,032	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GNG038	2	4,385	0.0	0.0	0.0	0.0	0.0	52.7	52.7
GNG526	2	3,782	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GNG564	2	3,579	0.0	0.0	0.0	0.0	0.0	1.8	1.8
IN05B001	2	23,005	0.0	2.0	0.4	0.0	22.9	8.1	33.4
DNge153	2	6,184	0.0	0.1	0.0	0.0	0.2	20.0	20.3
IN05B002	2	26,788	0.0	0.0	0.0	0.0	0.1	69.3	69.4
IN05B003	2	11,679	0.0	0.0	0.5	0.0	0.0	0.0	0.5
IN05B008	2	8,502	0.0	0.0	0.0	0.0	0.0	0.0	0.0
IN05B010	4	36,159	0.0	0.0	0.1	0.0	0.9	1.6	2.6
IN05B011a	2	13,474	0.0	0.0	0.0	0.0	0.5	41.1	41.6
IN05B011b	2	7,260	0.0	0.0	0.0	0.0	0.0	48.6	48.6
IN05B012	2	15,911	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DNxl114	2	7,311	0.0	0.0	0.0	0.0	1.8	0.8	2.6
IN05B013	2	6,066	0.0	0.1	0.0	0.0	45.7	0.8	46.6
IN05B016	4	15,608	0.0	0.1	33.1	0.0	5.1	0.1	38.4

Cell type	n	Output synapses	Nociceptive (%)	Chordotonal (%)	Campaniform (%)	Hair plate (%)	Tactile bristle (%)	Gustatory (%)	All afferents (%)
IN05B018	2	3,025	0.0	0.0	0.0	0.0	9.4	0.2	9.6
IN05B017	6	12,916	0.0	0.0	0.0	0.0	55.9	3.7	59.6
IN05B020	2	5,975	0.0	0.0	0.0	0.0	39.5	0.1	39.6
IN05B021	2	4,226	0.0	0.0	0.0	0.0	0.0	0.0	0.0
IN05B022	4	12,061	0.0	0.0	0.0	0.0	0.0	22.3	22.3
IN05B019	2	6,951	0.0	0.0	0.1	0.0	66.6	3.9	70.6
IN05B024	2	6,327	0.0	0.0	0.0	0.0	2.8	0.1	2.9
IN05B030	2	10,335	0.0	0.0	0.0	0.0	0.0	0.0	0.0
IN05B031	2	6,971	0.0	0.0	0.0	0.0	0.0	0.0	0.0
IN05B032	4	5,949	0.0	2.4	0.7	0.0	0.0	0.0	3.1
IN05B033	4	12,452	0.0	0.0	0.3	0.0	52.5	0.9	53.7
IN05B034	2	6,006	0.0	0.0	0.2	0.0	0.0	0.0	0.2
IN05B036	2	5,078	0.0	0.1	0.0	0.0	24.5	0.2	24.8
GNG264	2	2,440	0.0	0.0	0.0	0.0	0.0	0.2	0.2
IN05B037	2	4,282	0.0	0.0	0.0	0.0	0.0	0.0	0.0
IN05B038	2	5,990	0.0	0.0	24.8	0.0	0.1	0.0	24.9
IN05B041	2	5,859	0.0	0.0	0.0	0.0	0.0	0.0	0.0
IN05B039	2	6,051	0.0	0.0	0.0	0.0	0.0	0.0	0.0
IN05B043	2	3,996	0.0	0.0	0.1	0.0	0.0	0.0	0.1
IN05B051	2	3,161	0.0	0.0	0.0	0.0	0.0	0.0	0.0
IN05B055	1	1,007	0.0	0.0	2.9	0.0	8.9	0.0	11.8
IN05B042	4	7,565	0.0	0.0	0.0	0.0	0.0	0.0	0.0
IN05B057	3	4,285	0.0	0.0	0.0	0.0	0.0	0.0	0.0
IN05B061	3	3,637	0.0	0.0	0.2	0.0	0.0	0.1	0.3
IN05B064_b	4	2,334	0.0	0.0	0.0	0.0	0.0	0.0	0.0
IN05B065	5	5,535	0.0	0.0	0.0	0.0	0.0	0.0	0.0
IN05B066	4	3,942	0.0	0.0	0.0	0.0	0.0	0.0	0.0
IN05B070	6	5,770	0.0	0.0	0.0	0.0	0.0	0.2	0.2
IN05B072_a	3	1,896	0.0	0.1	0.1	0.0	0.0	0.0	0.2
IN05B072_b	2	1,632	0.0	0.0	0.0	0.0	0.0	0.0	0.0
IN05B072_c	1	1,396	0.0	0.0	0.0	0.0	0.0	0.0	0.0
IN05B073	2	1,337	0.0	0.0	0.0	0.0	0.0	0.0	0.0
IN05B074	2	1,524	0.0	0.0	0.0	0.0	0.0	0.0	0.0
IN05B075	3	2,924	0.0	0.1	0.0	0.0	0.0	0.0	0.1
IN05B077	1	1,009	0.0	0.0	0.0	0.0	0.0	5.5	5.5
IN05B080	2	2,014	0.0	0.0	0.0	0.0	0.0	0.2	0.2
IN05B082	1	871	0.0	0.0	0.0	0.0	0.0	0.0	0.0
IN05B084	2	2,630	0.0	0.0	0.0	0.0	0.0	0.0	0.0
IN05B085	4	3,486	0.0	0.0	0.0	0.0	0.0	0.0	0.0
IN05B086	2	1,834	0.0	0.0	0.0	0.0	0.0	0.0	0.0
IN05B087	2	1,553	0.0	0.0	0.0	0.0	0.0	0.0	0.0
IN05B088	6	2,931	0.0	0.0	0.1	0.0	0.0	0.0	0.1
IN05B089	4	1,584	0.0	0.0	0.1	0.0	0.0	0.0	0.1
IN05B090	14	8,908	0.0	0.0	0.2	0.0	0.0	0.0	0.2
IN05B091	9	5,765	0.0	0.0	0.0	0.0	0.0	0.0	0.0
IN05B093	2	1,357	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Percentages are shares of the total output synapses of each cell type. The 116 cell types with more than 500 output synapses are listed, ordered by the share directed to nociceptive afferents

Table S3 Silencing effect of each GABAergic cell type contacting the nociceptive pathway

Cell type	n	Synapses onto pathway	Ascending output when silenced (Hz)	Fold change	Rank
AN05B004	2	15,264	108.3	3.57	1
DNg70	2	2,060	47.9	1.60	2
INXXX267	4	85	33.5	1.13	3
INXXX253	6	69	30.4	1.03	4
IN00A002	3	22	30.2	1.02	5
IN05B021	2	23	30.2	1.02	6
INXXX345	2	11	30.1	1.02	7
DNge131	2	29	30.1	1.02	8
IN01B014	4	16	30.1	1.02	9
AN00A006	5	11	30.1	1.02	10
AN05B009	4	18	30.1	1.02	11
AN05B076	2	201	30.1	1.02	12
AN05B069	2	12	30.1	1.02	13
IN05B002	2	12	30.1	1.02	14
INXXX460	4	81	30.1	1.02	15
AN05B058	2	46	30.1	1.02	16
AN27X021	2	42	30.1	1.02	17
AN05B053	4	59	30.1	1.02	18
AN05B021	2	30	30.1	1.02	19
AN05B023a	2	35	30.1	1.02	20
IN01B081	5	47	30.1	1.02	21
INXXX217	10	100	30.1	1.02	22
IN05B028	6	107	30.1	1.02	23
INXXX316	6	24	30.1	1.02	24
AN09A007	2	24	30.1	1.02	25
AN05B062	4	22	30.1	1.02	26
AN05B108	4	29	30.1	1.02	27
AN05B025	2	32	30.1	1.02	28
IN01B003	6	26	30.1	1.02	29
INXXX197	4	33	30.1	1.02	30
IN01B065	20	17	30.1	1.02	31
AN01B002	6	22	30.1	1.02	32
IN05B084	2	18	30.1	1.02	33
IN01B012	6	19	30.1	1.02	34
IN01B062	4	19	30.1	1.02	35
AN05B045	2	22	30.1	1.02	36
INXXX258	12	34	30.1	1.02	37
IN01B074	7	61	30.1	1.02	38
INXXX429	12	63	30.1	1.02	39
IN05B011a	2	17	30.1	1.02	40
IN01B078	5	16	30.1	1.02	41
ANXXX404	2	15	30.1	1.02	42
INXXX450	4	20	30.1	1.02	43
AN06B039	7	14	30.1	1.02	44
IN01B061	7	13	30.1	1.02	45
INXXX409	4	122	30.0	1.01	46
INXXX440	8	22	30.0	1.01	47
INXXX213	4	15	30.0	1.01	48
INXXX369	7	35	29.9	1.01	49
DNg59	2	78	29.9	1.01	50
IN00A024	6	24	29.9	1.01	51
AN05B040	1	13	29.8	1.01	52
IN05B033	4	12	29.8	1.01	53
IN12B011	4	11	29.7	1.00	54
INXXX341	8	17	29.7	1.00	55
DNg98	2	125	29.7	1.00	56
IN09A007	4	14	29.7	1.00	57
IN13B007	2	11	29.7	1.00	58
DNge142	2	180	29.7	1.00	59
IN05B022	4	62	29.7	1.00	60
IN12B071	8	10	29.6	1.00	61
INXXX436	10	275	29.6	1.00	62
AN05B046	1	19	29.6	1.00	63
INXXX328	4	30	29.6	1.00	64
INXXX183	2	12	29.6	1.00	65
INXXX397	4	61	29.5	1.00	66
IN00A033	5	159	29.1	0.98	67
IN05B005	2	304	28.9	0.98	68
AN05B005	2	42	28.2	0.96	69
DNg102	4	22	28.2	0.95	70
AN05B006	3	13	27.7	0.94	71

The 71 GABAergic cell types making at least 10 synapses onto the nociceptive pathway (abdominal md afferents and the ascending neurons AN09B018 and ANXXX196) were silenced one at a time under 20 Hz abdominal md drive; intact ascending output 30.0 Hz

Table S4 Robustness of the silencing effect across model variants and connectomes

Dataset	Model variant	Drive and manipulation	Intact (Hz)	Manipulated (Hz)	Fold change
male-CNS	Weight 0.10 mV	Abdominal md, AN05B004 silenced	41.7	76.8	1.8
male-CNS	Weight 0.10 mV	Leg md, AN05B004 silenced	28.0	63.3	2.2
male-CNS	Weight 0.10 mV	Touch, all VNC GABA removed	0.0	0.0	1.0
male-CNS	Weight 0.15 mV	Abdominal md, AN05B004 silenced	41.3	88.5	2.1
male-CNS	Weight 0.15 mV	Leg md, AN05B004 silenced	20.9	71.0	3.3
male-CNS	Weight 0.15 mV	Touch, all VNC GABA removed	0.0	1.9	2.9
male-CNS	Weight 0.20 mV	Abdominal md, AN05B004 silenced	37.1	106.7	2.8
male-CNS	Weight 0.20 mV	Leg md, AN05B004 silenced	21.7	86.0	3.8
male-CNS	Weight 0.20 mV	Touch, all VNC GABA removed	0.0	8.0	9.0
male-CNS	Weight 0.275 mV (published)	Abdominal md, AN05B004 silenced	29.6	107.1	3.5
male-CNS	Weight 0.275 mV (published)	Leg md, AN05B004 silenced	9.9	64.8	6.0
male-CNS	Weight 0.275 mV (published)	Touch, all VNC GABA removed	0.0	50.2	51.2
male-CNS	Glutamate excitatory	Abdominal md, AN05B004 silenced	36.1	142.4	3.9
male-CNS	Glutamate excitatory	Leg md, AN05B004 silenced	12.2	111.6	8.5
male-CNS	Glutamate excitatory	Touch, all VNC GABA removed	0.0	300.6	301.6
male-CNS	Uncertain transmitter neutral	Abdominal md, AN05B004 silenced	38.6	115.6	2.9
male-CNS	Uncertain transmitter neutral	Leg md, AN05B004 silenced	20.6	72.2	3.4
male-CNS	Uncertain transmitter neutral	Touch, all VNC GABA removed	0.0	0.1	1.1
male-CNS	Connections of at least 5 synapses	Abdominal md, AN05B004 silenced	31.1	109.5	3.4
male-CNS	Connections of at least 5 synapses	Leg md, AN05B004 silenced	13.6	78.1	5.4
male-CNS	Connections of at least 5 synapses	Touch, all VNC GABA removed	0.0	0.1	1.1
MANC	Weight 0.15 mV	Abdominal md, AN05B004 silenced	60.1 ± 2.2	126.6 ± 4.0	2.1
MANC	Weight 0.15 mV	Leg md, AN05B004 silenced	19.1 ± 2.0	66.8 ± 2.0	3.4
MANC	Weight 0.275 mV	Abdominal md, AN05B004 silenced	75.5 ± 1.7	348.7 ± 2.2	4.6
MANC	Weight 0.275 mV	Leg md, AN05B004 silenced	28.5 ± 1.7	92.1 ± 2.9	3.2
BANC	Weight 0.15 mV	Abdominal md, AN05B004 silenced	0.0 ± 0.0	0.0 ± 0.0	n/a
BANC	Weight 0.15 mV	Leg md, AN05B004 silenced	14.3 ± 1.6	22.5 ± 2.2	1.5
BANC	Weight 0.275 mV	Abdominal md, AN05B004 silenced	0.0 ± 0.0	0.0 ± 0.0	n/a
BANC	Weight 0.275 mV	Leg md, AN05B004 silenced	32.3 ± 3.2	58.1 ± 3.3	1.8

Values are the mean firing rate of the ascending nociceptive projection neurons (mean ± standard deviation where available). Fold changes are computed as (manipulated + 1)/(intact + 1) when the intact output is zero. The BANC abdominal pathway produced no ascending output (*n/a*) because its cholinergic SNch01 neurons make only 14 synapses onto the ascending neurons. *VNC*, ventral nerve cord

Table S5 Single-type screens of GABAergic cell types for the tactile pathway

Cell type	n	Hemilineage	Touch response, only this type retained (Hz)	Touch response suppressed (%)	Nociceptive response, type silenced (Hz)	Touch response, type silenced (Hz)
IN05B005	2	05B	17.1	65.9	28.2	0.0
IN13A004	4	13A	19.0	62.3	28.8	0.0
INXXX217	10	unassigned	20.2	59.8	28.8	0.0
INXXX253	6	unassigned	22.8	54.5	29.0	0.0
IN01B003	6	01B	25.7	48.8	28.8	0.0
INXXX316	6	unassigned	26.5	47.1	28.8	0.0
IN05B010	4	05B	26.8	46.7	29.0	0.0
INXXX256	2	unassigned	29.2	41.9	28.9	0.0
INXXX258	12	unassigned	29.2	41.7	28.8	0.0
INXXX267	4	unassigned	30.0	40.3	32.5	0.0
INXXX328	4	unassigned	30.8	38.5	28.7	0.0
INXXX436	10	unassigned	31.0	38.1	28.9	0.0
INXXX300	2	unassigned	32.6	35.1	28.8	0.0
IN05B022	4	05B	32.7	35.0	28.5	0.0
INXXX197	4	unassigned	32.9	34.5	28.8	0.0
INXXX440	8	unassigned	33.5	33.3	29.0	0.0
IN00A033	5	00A	35.5	29.3	28.0	0.0
IN09A001	6	09A	36.4	27.5	29.0	0.0
IN05B013	2	05B	37.1	26.1	28.7	0.0
IN05B033	4	05B	38.2	23.8	29.0	0.0
INXXX396	10	unassigned	38.6	23.2	28.8	0.0
INXXX044	8	unassigned	38.9	22.5	28.8	0.0
INXXX417	6	unassigned	38.9	22.5	28.6	0.0
IN05B019	2	05B	39.0	22.2	29.0	0.0
untyped	1	unassigned	39.5	21.3	28.7	0.0
INXXX213	4	unassigned	41.5	17.3	28.8	0.0
AN05B108	4	05B	42.0	16.2	29.5	0.0
IN01B014	4	01B	42.8	14.6	28.9	0.0
IN19A001	6	19A	42.9	14.5	29.0	0.0
INXXX369	7	unassigned	43.3	13.7	28.9	0.0
INXXX409	4	unassigned	43.7	13.0	29.0	0.0
IN13B021	6	13B	43.8	12.7	28.8	0.0
IN13A007	6	13A	43.8	12.7	28.8	0.0
IN13B005	6	13B	44.0	12.4	29.1	0.0
INXXX345	2	unassigned	44.3	11.7	29.1	0.0
IN09A006	8	09A	44.7	11.0	29.0	0.0
IN01B012	6	01B	44.7	11.0	28.8	0.0
INXXX158	2	unassigned	45.0	10.4	27.8	0.0
INXXX280	6	unassigned	45.3	9.8	28.9	0.0
IN00A024	6	00A	45.3	9.7	29.0	0.0
IN05B021	2	05B	46.0	8.3	29.0	0.0
IN09A014	6	09A	46.0	8.3	28.9	0.0
IN01B046_a	4	01B	46.2	7.9	28.8	0.0
INXXX397	4	unassigned	46.4	7.5	28.9	0.0
IN00A045	6	00A	46.5	7.4	28.9	0.0
IN00A027	4	00A	46.5	7.3	28.5	0.0
IN13B007	2	13B	46.6	7.2	29.0	0.0
IN05B028	6	05B	46.7	7.1	28.8	0.0
IN00A031	9	00A	46.8	6.9	29.0	0.0
IN12B007	6	12B	46.8	6.9	28.8	0.0
IN05B024	2	05B	46.9	6.6	29.0	0.0
INXXX343	2	unassigned	47.2	6.1	28.7	0.0
IN01B046_b	4	01B	47.2	6.1	28.8	0.0
IN05B034	2	05B	47.4	5.6	30.6	0.0
IN13B010	5	13B	47.5	5.4	28.8	0.0
IN13A003	6	13A	47.6	5.2	28.6	0.0
INXXX336	2	unassigned	47.9	4.6	27.5	0.0
AN05B036	1	05B	47.9	4.5	28.8	0.0
IN00A002	3	00A	48.0	4.4	29.2	0.0
IN05B017	6	05B	48.1	4.2	29.0	0.0
INXXX183	2	unassigned	48.1	4.2	28.8	0.0
IN05B001	2	05B	48.2	4.1	28.8	0.0
IN05B030	2	05B	48.2	4.0	28.8	0.0
IN05B020	2	05B	48.2	3.9	28.8	0.0
IN12B005	4	12B	48.2	3.9	28.8	0.0
INXXX124	2	unassigned	48.2	3.9	28.8	0.0
IN09A003	6	09A	48.2	3.9	28.8	0.0
IN01B061	7	01B	48.5	3.5	28.8	0.0
IN01B026	8	01B	48.5	3.5	28.8	0.0
INXXX263	4	unassigned	48.5	3.5	28.8	0.0

Cell type	n	Hemilineage	Touch response, only this type retained (Hz)	Touch response suppressed (%)	Nociceptive response, type silenced (Hz)	Touch response, type silenced (Hz)
IN01B002	6	01B	48.5	3.4	28.8	0.0
INXXX004	2	unassigned	48.5	3.4	28.8	0.0
IN12B036	14	12B	48.5	3.4	28.8	0.0
IN05B036	2	05B	48.5	3.3	28.8	0.0
IN19A011	6	19A	48.6	3.3	28.8	0.0
IN05B039	2	05B	48.6	3.2	28.7	0.0
IN06B059	14	06B	48.8	2.9	28.8	0.0
INXXX385	3	unassigned	48.8	2.9	28.9	0.0
INXXX460	4	unassigned	48.8	2.8	28.8	0.0
INXXX340	2	unassigned	48.8	2.8	28.8	0.0
IN01B062	4	01B	48.8	2.7	28.8	0.0
IN01B022	6	01B	48.9	2.5	28.8	0.0
IN12B029	5	12B	49.0	2.5	28.8	0.0
IN01B020	9	01B	49.0	2.5	28.8	0.0
IN13B050	8	13B	49.0	2.4	28.8	0.0
IN12B032	4	12B	49.0	2.4	28.8	0.0
INXXX448	19	unassigned	49.0	2.4	27.9	0.0
IN01B017	4	01B	49.0	2.3	29.0	0.0
IN12B003	6	12B	49.1	2.3	29.0	0.0
IN13B104	2	13B	49.2	2.1	28.8	0.0
IN05B070	5	05B	49.2	2.1	28.8	0.0
IN00A009	4	00A	49.2	2.1	29.0	0.0
IN12B031	7	12B	49.2	2.0	28.8	0.0
IN13B013	6	13B	49.2	2.0	28.8	0.0
IN01B027_b	4	01B	49.3	1.8	28.8	0.0
IN05B084	2	05B	49.3	1.8	28.8	0.0
INXXX443	6	unassigned	49.3	1.8	28.8	0.0
IN03B021	6	03B	49.3	1.8	29.0	0.0
IN06B001	1	06B	49.3	1.8	29.0	0.0
IN01B027_a	4	01B	49.3	1.8	28.8	0.0
IN13B026	9	13B	49.3	1.7	28.8	0.0
INXXX225	2	unassigned	49.3	1.7	28.8	0.0
INXXX320	2	unassigned	49.3	1.7	28.8	0.0
INXXX334	4	unassigned	49.3	1.7	28.8	0.0
INXXX450	4	unassigned	49.5	1.5	28.8	0.0
IN01B023_b	2	01B	49.5	1.5	28.8	0.0
INXXX394	4	unassigned	49.5	1.4	28.7	0.0
INXXX406	4	unassigned	49.5	1.4	28.8	0.0
INXXX346	4	unassigned	49.5	1.4	28.8	0.0
INXXX428	4	unassigned	49.5	1.3	28.8	0.0
IN12B071	8	12B	49.5	1.3	28.8	0.0
IN13B029	6	13B	49.5	1.3	28.8	0.0
INXXX319	2	unassigned	49.5	1.3	29.0	0.0
IN01B027_d	2	01B	49.6	1.3	28.8	0.0
IN13B056	10	13B	49.6	1.3	28.8	0.0
IN12B038	8	12B	49.6	1.2	28.8	0.0
INXXX399	4	unassigned	49.6	1.2	29.0	0.0
IN12B081	8	12B	49.6	1.2	28.8	0.0
INXXX360	3	unassigned	49.6	1.2	28.8	0.0
IN05B075	3	05B	49.6	1.2	28.8	0.0
IN09A043	18	09A	49.6	1.2	28.8	0.0
IN13B017	6	13B	49.7	1.1	28.8	0.0
INXXX424	4	unassigned	49.7	1.1	28.8	0.0
IN05B042	4	05B	49.7	1.1	28.9	0.0
IN26X002	6	26X	49.7	1.1	29.0	0.0
IN13B008	2	13B	49.7	1.0	29.0	0.0
IN01B015	2	01B	49.7	1.0	28.8	0.0
IN12B033	5	12B	49.7	1.0	28.8	0.0
IN01B034	3	01B	49.7	1.0	28.8	0.0
INXXX063	1	unassigned	49.8	0.9	28.8	0.0
INXXX388	2	unassigned	49.8	0.9	28.8	0.0
IN12B075	8	12B	49.8	0.9	28.8	0.0
IN09A015	2	09A	49.8	0.9	28.8	0.0
IN13B011	6	13B	49.8	0.8	28.9	0.0
IN01B030	2	01B	49.8	0.8	28.8	0.0
IN13B030	4	13B	49.8	0.8	28.8	0.0
IN06B029	12	06B	49.8	0.8	28.9	0.0
INXXX268	3	unassigned	49.8	0.8	28.9	0.0
INXXX452	7	unassigned	49.8	0.7	29.0	0.0
INXXX429	12	unassigned	49.8	0.7	28.8	0.0
IN01B042	8	01B	49.8	0.7	28.8	0.0
INXXX337	2	unassigned	49.8	0.7	28.8	0.0

Cell type	n	Hemilineage	Touch response, only this type retained (Hz)	Touch response suppressed (%)	Nociceptive response, type silenced (Hz)	Touch response, type silenced (Hz)
IN06B024	4	06B	49.8	0.7	29.0	0.0
IN19A093	15	19A	49.9	0.6	28.8	0.0
IN13A024	6	13A	49.9	0.6	28.8	0.0
IN09A024	7	09A	49.9	0.6	28.8	0.0
IN03B071	12	03B	49.9	0.6	28.8	0.0
IN01B053	5	01B	49.9	0.6	28.8	0.0
IN13A029	9	13A	49.9	0.6	28.8	0.0
INXXX341	8	unassigned	49.9	0.5	28.8	0.0
INXXX270	2	unassigned	49.9	0.5	28.8	0.0
IN13A038	13	13A	49.9	0.5	28.8	0.0
IN03B058	21	03B	50.0	0.5	28.8	0.0
IN06B047	17	06B	50.0	0.5	29.1	0.0
IN01B033	8	01B	50.0	0.5	28.8	0.0
INXXX282	2	unassigned	50.0	0.5	28.8	0.0
IN00A066	2	00A	50.0	0.5	29.0	0.0
IN01B027_c	2	01B	50.0	0.4	28.8	0.0
IN00A063	7	00A	50.0	0.4	29.0	0.0
IN17B015	4	17B	50.0	0.4	28.8	0.0
IN01B074	7	01B	50.0	0.4	28.8	0.0
INXXX447,INXXX449	4	unassigned	50.0	0.4	29.0	0.0
IN12B002	6	12B	50.0	0.4	27.6	0.0
IN01B019_b	2	01B	50.0	0.4	28.8	0.0
IN12B035	8	12B	50.0	0.3	28.8	0.0
IN05B011a	2	05B	50.0	0.3	28.8	0.0
IN11A001	2	11A	50.0	0.3	28.5	0.0
IN06A139	3	06A	50.0	0.3	28.6	0.0
IN03B089	18	03B	50.1	0.3	28.6	0.0
IN06A022	13	06A	50.1	0.3	28.8	0.0
IN12B027	11	12B	50.1	0.3	28.8	0.0
IN13B052	5	13B	50.1	0.3	28.8	0.0
IN13B027	7	13B	50.1	0.3	28.8	0.0
IN01B059_b	4	01B	50.1	0.2	28.8	0.0
IN01B040	3	01B	50.1	0.2	28.8	0.0
IN06B056	9	06B	50.1	0.2	28.8	0.0
IN17B003	2	17B	50.1	0.2	28.8	0.0
IN01B083_c	4	01B	50.1	0.2	28.8	0.0
IN01B027_e	2	01B	50.1	0.2	28.8	0.0
IN12B009	2	12B	50.1	0.2	28.8	0.0
INXXX395	4	unassigned	50.1	0.2	28.8	0.0
IN12B079_c	6	12B	50.1	0.2	28.8	0.0
IN01B080	16	01B	50.1	0.2	28.8	0.0
IN09A039	18	09A	50.1	0.2	28.8	0.0
IN03B069	14	03B	50.1	0.2	28.8	0.0
IN13A050	14	13A	50.1	0.1	28.8	0.0
IN19A117	21	19A	50.1	0.1	28.8	0.0
IN19A016	12	19A	50.1	0.1	28.8	0.0
IN05B011b	2	05B	50.2	0.1	28.8	0.0
INXXX415	6	unassigned	50.2	0.1	28.2	0.0
IN01B049	6	01B	50.2	0.1	28.8	0.0
IN05B002	2	05B	50.2	0.1	28.8	0.0
IN01B025	6	01B	50.2	0.1	28.8	0.0
IN01B100	4	01B	50.2	0.1	28.8	0.0
IN19A057	5	19A	50.2	0.0	28.8	0.0
IN03B066	17	03B	50.2	0.0	28.8	0.0
IN03B060	30	03B	50.2	0.0	28.8	0.0
untyped, 19A	34	19A	50.2	0.0	28.9	0.0
IN13A068	13	13A	50.2	0.0	28.8	0.0
IN03B072	14	03B	50.2	0.0	28.8	0.0
IN06A082	18	06A	50.2	0.0	28.8	0.0
IN12B068_a	6	12B	50.2	-0.0	28.8	0.0
IN12B069	6	12B	50.2	-0.0	28.8	0.0
IN01B099	4	01B	50.2	-0.1	28.8	0.0
IN01B095	31	01B	50.2	-0.1	28.8	0.0
IN19A098	14	19A	50.2	-0.1	28.8	0.0
IN06A075	14	06A	50.2	-0.1	28.8	0.0
IN01B090	17	01B	50.2	-0.1	28.8	0.0
IN01B091	3	01B	50.2	-0.1	28.8	0.0
IN12B057	4	12B	50.2	-0.1	28.8	0.0
IN01B077_b	2	01B	50.2	-0.1	28.8	0.0
IN12B022	6	12B	50.2	-0.1	28.8	0.0
IN01B094	2	01B	50.2	-0.1	28.8	0.0

Cell type	n	Hemilineage	Touch response, only this type retained (Hz)	Touch response suppressed (%)	Nociceptive response, type silenced (Hz)	Touch response, type silenced (Hz)
IN01B047	2	01B	50.2	-0.1	28.8	0.0
IN13A059	13	13A	50.2	-0.1	28.8	0.0
IN01B064	4	01B	50.2	-0.1	28.8	0.0
IN06A113	15	06A	50.2	-0.1	28.8	0.0
IN19A041	16	19A	50.2	-0.1	28.8	0.0
IN12B072	14	12B	50.2	-0.1	28.8	0.0
IN03B091	13	03B	50.2	-0.1	28.8	0.0
IN01B073	7	01B	50.2	-0.1	28.8	0.0
IN01B083_b	2	01B	50.2	-0.1	28.8	0.0
IN01B081	5	01B	50.2	-0.1	28.8	0.0
IN01B092	3	01B	50.2	-0.1	28.8	0.0
IN01B027_f	2	01B	50.2	-0.1	28.8	0.0
IN01B019_a	3	01B	50.2	-0.1	28.8	0.0
IN01B079	5	01B	50.2	-0.1	28.8	0.0
IN13B058	10	13B	50.2	-0.1	28.8	0.0
IN05B080	2	05B	50.3	-0.2	28.8	0.0
IN05B043	2	05B	50.3	-0.2	28.8	0.0
IN06B066	25	06B	50.3	-0.2	28.8	0.0
IN09A064	13	09A	50.3	-0.2	28.7	0.0
IN06A059	22	06A	50.3	-0.2	28.8	0.0
untyped, 01B	6	01B	50.3	-0.2	28.8	0.0
IN06A132	13	06A	50.4	-0.3	28.8	0.0
IN13A045	16	13A	50.4	-0.4	28.9	0.0
IN06A005	2	06A	50.4	-0.4	29.0	0.0
IN11B005	2	11B	50.4	-0.4	28.5	0.0
IN13B088	4	13B	50.4	-0.4	28.8	0.0
IN09A013	6	09A	50.5	-0.5	28.8	0.0
IN01B078	5	01B	50.5	-0.6	28.8	0.0
IN19A114	14	19A	50.5	-0.6	28.7	0.0
IN09A060	12	09A	50.5	-0.6	28.8	0.0
IN01B075	3	01B	50.6	-0.7	28.8	0.0
IN09A011	2	09A	50.6	-0.8	28.9	0.0
IN13A008	6	13A	50.8	-1.1	29.0	0.0
IN03B011	2	03B	51.1	-1.8	28.8	0.0
IN09A007	4	09A	51.8	-3.1	28.8	0.0
IN12B011	4	12B	53.0	-5.6	28.9	0.0
IN13B014	6	13B	53.4	-6.5	28.8	0.0
IN05B090	14	05B	53.6	-6.8	28.8	0.0
IN01B065	20	01B	57.5	-14.4	28.8	0.0

Sufficiency: all GABAergic neurons of the ventral nerve cord were removed except the cell type listed, under 50 Hz innocuous touch of the leg bristles; the response after removal of all 5,318 neurons is 50.2 Hz. Necessity: the cell type was silenced alone, under 20 Hz abdominal md drive and under touch. Reported as a negative control (see main text)