nature neuroscience

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Manuscript Number:	NN-A57571B	# Supplementary Figures:	12
Manuscript Type:	Article	# Supplementary Tables:	0
		# Supplementary Videos:	0

Reporting Checklist for Nature Neuroscience

This checklist is used to ensure good reporting standards and to improve the reproducibility of published results. For more information, please read Reporting Life Sciences Research.

Please note that in the event of publication, it is mandatory that authors include all relevant methodological and statistical information in the manuscript.

▶ Statistics reporting, by figure

- Please specify the following information for each panel reporting quantitative data, and where each item is reported (section, e.g. Results, & paragraph number).

- Each figure legend should ideally contain an exact sample size (n) for each experimental group/condition, where n is an exact number and not a range, a clear definition of how n is defined (for example x cells from x slices from x animals from x litters, collected over x days), a description of the statistical test used, the results of the tests, any descriptive statistics and clearly defined error bars if applicable.

- For any experiments using custom statistics, please indicate the test used and stats obtained for each experiment.

- Each figure legend should include a statement of how many times the experiment shown was replicated in the lab; the details of sample collection should be sufficiently clear so that the replicability of the experiment is obvious to the reader.

- For experiments reported in the text but not in the figures, please use the paragraph number instead of the figure number.

Note: Mean and standard deviation are not appropriate on small samples, and plotting independent data points is usually more informative. When technical replicates are reported, error and significance measures reflect the experimental variability and not the variability of the biological process; it is misleading not to state this clearly.

	TEST USED		n			DESCRIPTIVE STATS (AVERAGE, VARIANCE)		P VALUE		DEGREES OF FREEDOM & F/t/z/R/ETC VALUE	
FIGURE NUMBER	WHICH TEST?	SECTION & PARAGRAPH #	EXACT VALUE	DEFINED?	SECTION & PARAGRAPH #	REPORTED?	SECTION & PARAGRAPH #	EXACT VALUE	SECTION & PARAGRAPH #	VALUE	SECTION & PARAGRAPH #
example 1a	one-way ANOVA	Fig. legend	9, 9, 10, 15	mice from at least 3 litters/group	Methods para 8	error bars are mean +/- SEM	Fig. legend	p = 0.044	Fig. legend	F(3, 36) = 2.97	Fig. legend
example results, para 6	unpaired t-test	Results para 6	15	slices from 10 mice	Results para 6	error bars are mean +/- SEM	Results para 6	p = 0.0006	Results para 6	t(28) = 2.808	Results para 6
+/- 1e	N/A	N/A	5, 5, 5, 5, 5, 6, 6, 7, 6, 6, 5, 6	trials for 12 directions	Fig. legend	error bars are mean +/- SEM.	Fig. legend	N/A	N/A	N/A	N/A

	FIGURE NUMBER	TEST USED		n			DESCRIPTIVE STATS (AVERAGE, VARIANCE)		P VALUE		DEGREES OF FREEDOM & F/t/z/R/ETC VALUE	
		WHICH TEST?	SECTION & PARAGRAPH #	EXACT VALUE	DEFINED?	SECTION & PARAGRAPH #	REPORTED?	SECTION & PARAGRAPH #	EXACT VALUE	SECTION & PARAGRAPH #	VALUE	SECTION & PARAGRAPH #
+ -	2c	Linear regression	Fig. legend	12	conditions from 1 cell in 1 mice	Fig. legend	all data points are plotted in fig.	N/A	7.3533e-8	Fig. legend	R2 = 0.9507, F(1,10) = 192.6514	Fig. legend
+ -	2c	Pearson correlation	Fig. legend	12	conditions from 1 cell in 1 mice	Fig. legend	all data points are plotted in fig.	N/A	7.3533e-8	Fig. legend	r = 0.9750	Fig. legend
+ -	2d	two-tailed Kolmogorov–Smirnov test	Fig. legend	87 for tEPSC and 52 for Vm	cells from 58 mice for tEPSC and 41 mice for Vm	Fig. legend	the distribution of all data points are plotted in fig.	N/A	0.3009	Fig. legend	K-S stat (137)= 0.1704	Fig. legend
+ -	2b	N/A	N/A	8, 7, 7, 7, 6, 7, 7, 7, 7, 7, 6, 6	trials for 12 directions	Fig. legend	error bars are mean +/- SEM.	Fig. legend	N/A	N/A	N/A	N/A
+ -	2e	two-tailed Wilcoxon matched-pairs signed rank test	Fig. legend	23	cells from 21 mice	Fig. legend	all data points are plotted in fig.	N/A	0.1793	Fig. legend	W(22) = 90	Fig. legend
+ -	2e	Pearson correlation	Fig. legend	23	cells from 21 mice	Fig. legend	all data points are plotted in fig.	N/A	7.7797e-18	Fig. legend	r = 0.9860	Fig. legend
+ -	2i	two-tailed Mann Whitney test	Fig. legend	15 for DS cells and 26 for non-DS cells	cells from 13 mice for DS cells and 20 mice for non-DS cells	Fig. legend	all data points are plotted in fig, error bars are mean +/- SEM.	Fig. legend	0.4136	Fig. legend	U(39) = 164	Fig. legend
+ -	3a	two-tailed Wilcoxon matched-pairs signed rank test	Fig. legend	22	cells from 21 mice	Fig. legend	all data points are plotted in fig.	N/A	0.3369	Fig. legend	W(21) = 61	Fig. legend
+ -	3a	Pearson correlation	Fig. legend	41	cells from 28 mice	Fig. legend	all data points are plotted in fig.	N/A	5.8967e-15	Fig. legend	r = 0.8910	Fig. legend
+ -	3d	two-tailed Wilcoxon matched-pairs signed rank test	Fig. legend	23	cells from 22 mice	Fig. legend	all data points are plotted in fig.	N/A	0.3001	Fig. legend	W(22) = 70	Fig. legend
+ -	3d	Pearson correlation	Fig. legend	41	cells from 28 mice	Fig. legend	all data points are plotted in fig.	N/A	3.3444e-9	Fig. legend	r = 0.7723	Fig. legend
+ -	4d	two-tailed Wilcoxon matched-pairs signed rank test	Fig. legend	15	cells from 13 mice	Fig. legend	all data points are plotted in fig.	N/A	0.1070	Fig. legend	W(14) = 58	Fig. legend
+ -	4d	Pearson correlation	Fig. legend	15	cells from 13 mice	Fig. legend	all data points are plotted in fig.	N/A	0.0028	Fig. legend	r = 0.7143	Fig. legend
+ -	4f	N/A	N/A	15	cells from 13 mice	Fig. legend	error bars are mean +/- SEM.	Fig. legend	N/A	N/A	N/A	N/A
+ -	5c	Chi-squared test	Fig. legend	648 for WT and 566 for KO	cells from 9 mice for WT and 13 mice for KO	Fig. legend	Percent ratios are plotted in fig.	N/A	<0.0001	Fig. legend	χ2(1) = 17.3	Fig. legend

+/-												
+ -	5g	two-tailed Mann Whitney test	Fig. legend	310 for WT and 407 for KO	cells from 5 mice for WT and 8 mice for KO	Fig. legend	error bars are mean +/- SEM	Fig. legend	< 0.0001, 0.0001, 0.3994, 0.6016, 0.5459, 0.0002, < 0.0001, < 0.0001, < 0.0001, < 0.0001, < 0.0001, < 0.0001 for -90, -60, -30, 0, 30, 60, 90, 120, 150, 180, 210, and 240 deg, respectively	Fig. legend	U(715) = 39924, 48745, 60769, 61650, 61425, 52787, 41822, 31207, 26976, 25123, 25575 31104 for -90, -60, -30, 0, 30, 60, 90, 120, 150, 180, 210, and 240 deg, respectively	Fig. legend
+ -	5h	two-tailed Kolmogorov-Smirnov test	Fig. legend	310 for WT and 407 for KO	cells from 5 mice for WT and 8 mice for KO	Fig. legend	the distribution of all data points are plotted in fig.	N/A	3.8637e-59	Fig. legend	K-S stat (715) = 0.6139	Fig. legend
+ -	5i	two-tailed Kolmogorov−Smirnov test	Fig. legend	315 for WT and 505 for KO	cells from 5 mice for WT and 8 mice for KO	Fig. legend	the distribution of all data points are plotted in fig.	N/A	1.5633e-33	Fig. legend	K-S stat (818) = 0.4392	Fig. legend
+ -	S2i	two-tailed Wilcoxon matched-pairs signed rank test	Fig. legend	5	LFP recordings from 5 mice	Fig. legend	all data points are plotted in fig.		0.8125 for amplitude and 0.3125 for initial slope	Fig. legend	W (4) = 3 for amplitude and 9 for initial slope	Fig. legend
+ -	S1b	N/A	N/A	7, 6, 7, 6, 6, 7, 5, 6, 7, 6, 5, 7	trials for 12 directions	Fig. legend	error bars are mean +/- SEM.	Fig. legend	N/A	N/A	N/A	N/A
+ -	S3c	Linear regression	Fig. legend	5	voltage levels from 1 cell in 1 mice	Fig. legend	all data points are plotted in fig.	N/A	2.6275e-4	Fig. legend	R2 = 0.9927, F(1,3) = 410.6056	Fig. legend
+ -	S3c	Pearson correlation	Fig. legend	5	voltage levels from 1 cell in 1 mice	Fig. legend	all data points are plotted in fig.	N/A	2.6275e-4	Fig. legend	r = 0.9964	Fig. legend
+ -	S4b	N/A	N/A	7, 7, 6, 6, 8, 6, 7, 6, 6, 6, 6, 7	trials for 12 directions	Fig. legend	error bars are mean +/- SEM.	Fig. legend	N/A	N/A	N/A	N/A
+ -	S6b	Linear regression	Fig. legend	6	current levels from 1 cell in 1 mice	Fig. legend	all data points are plotted in fig.	N/A	4.3177e-5	Fig. legend	R2 = 0.9893, F(1,4) = 369.4470	Fig. legend
+ -	S6b	Pearson correlation	Fig. legend	6	current levels from 1 cell in 1 mice	Fig. legend	all data points are plotted in fig.	N/A	4.3177e-5	Fig. legend	r = 0.9946	Fig. legend
+ -	S6e	two-tailed Mann Whitney test	Fig. legend	15 for DS cells and 26 for non-DS cells	cells from 13 mice for DS cells and 20 mice for non-DS cells	Fig. legend	all data points are plotted in fig, error bars are mean +/- SEM.	Fig. legend	0.8411	Fig. legend	U(39) = 187	Fig. legend
+ -	S7c	two-tailed Wilcoxon matched-pairs signed rank test	Fig. legend	15	cells from 13 mice	Fig. legend	all data points are plotted in fig.	N/A	0.0026	Fig. legend	W(14) = 100	Fig. legend
+ -	S7c	Pearson correlation	Fig. legend	15	cells from 13 mice	Fig. legend	all data points are plotted in fig.	N/A	5.7430e-5	Fig. legend	r = 0.8511	Fig. legend
+ -	S10c	two-tailed Kolmogorov−Smirnov test	Fig. legend	316 for WT cells and 476 for KO	cells from 5 mice for WT and 8 mice for KO	Fig. legend	the distribution of all data points are plotted in fig.	Fig. legend	6.3208e-11	Fig. legend	K-S stat (790) = 0.2500	Fig. legend
+ -	S10f	two-tailed Kolmogorov−Smirnov test	Fig. legend	331 for WT cells and 561 for KO	cells from 5 mice for WT and 8 mice for KO	Fig. legend	the distribution of all data points are plotted in fig.	Fig. legend	0.0137	Fig. legend	K-S stat (890) = 0.1084	Fig. legend

+ -	S10i	two-tailed Kolmogorov –Smirnov test	Fig. legend	238 for WT cells and 426 for KO	cells from 5 mice for WT and 8 mice for KO	Fig. legend	the distribution of all data points are plotted in fig.	Fig. legend	0.5909	Fig. legend	K-S stat (662) = 0.0618	Fig. legend

▶ Representative figures

1. Are any representative images shown (including Western blots and immunohistochemistry/staining) in the paper?

   If so, what figure(s)?

   > Fig. 1a-e; Fig. 2a-c; Fig. 4a-c; Fig. 5a, b, d, e; Supp. Fig. 1a, b; Suppl. Fig. 2a-d, g, h; Supp. Fig. 3a-c; Supp. Fig. 4a, b; Supp. Fig. 5a, b; Supp. Fig. 6a, b; Supp. Fig. 7a, b; Supp. Fig. 8a-c; Supp. Fig. 9a-c.

2. For each representative image, is there a clear statement of how many times this experiment was successfully repeated and a discussion of any limitations in repeatability?

   If so, where is this reported (section, paragraph #)?

   > Images are example traces, plots, cell morphology, calcium imaging field of view or schematics for experiments whose N values are reported in the legends and methods. All experiments were highly reproducible.

▶ Statistics and general methods

1. Is there a justification of the sample size?

   If so, how was it justified?

   Where (section, paragraph #)?

   Even if no sample size calculation was performed, authors should report why the sample size is adequate to measure their effect size.

   > No statistical methods were used to predetermine sample sizes, but our sample sizes are similar to those reported in the field. This is stated in Methods, "Statistics".

2. Are statistical tests justified as appropriate for every figure?

   Where (section, paragraph #)?

   > Statistics are clearly stated in figure legend and Methods section where appropriate.

   a. If there is a section summarizing the statistical methods in the methods, is the statistical test for each experiment clearly defined?

   > Yes, in the Methods section titled "Statistics".

   b. Do the data meet the assumptions of the specific statistical test you chose (e.g. normality for a parametric test)?

   Where is this described (section, paragraph #)?

   > Only non-parametric tests were used. This is described in the Methods section titled "Statistics", 1st paragraph.

   c. Is there any estimate of variance within each group of data?

   Is the variance similar between groups that are being statistically compared?

   Where is this described (section, paragraph #)?

   > Yes, all data are reported with standard error of the mean. This is described in the Methods section titled "Statistics", 1st paragraph.

   d. Are tests specified as one- or two-sided?

   > All statistics used are two-sided, specified in Methods section titled "Statistics".

   e. Are there adjustments for multiple comparisons?

   > No.

3. To promote transparency, *Nature Neuroscience* has stopped allowing bar graphs to report statistics in the papers it publishes. If you have bar graphs in your paper, please make sure to switch them to dot-plots (with central and dispersion statistics displayed) or to box-and-whisker plots to show data distributions.

We use dot-plots or dot-plots superimposed on bar graphs to show the data.

4. Are criteria for excluding data points reported?

Was this criterion established prior to data collection?

Where is this described (section, paragraph #)?

For whole-cell data, this is described in the Methods section titled "In vivo whole-cell recording", 2nd paragraph and "Data analysis", 6th paragraph. For imaging data, this is described in the Methods section titled "Data analysis", 4th paragraph. The criteria (i.e., responsive, stable recording, low series resistance) are standard in the field.

5. Define the method of randomization used to assign subjects (or samples) to the experimental groups and to collect and process data.

If no randomization was used, state so.

Where does this appear (section, paragraph #)?

Yes. This is described in the "Statistics" section of Methods, and in the Methods section titled "Visual stimulation" , 2nd paragraph, and "Retinal calcium imaging and data analysis", 1st paragraph.

6. Is a statement of the extent to which investigator knew the group allocation during the experiment and in assessing outcome included?

If no blinding was done, state so.

Where (section, paragraph #)?

No such group allocation for electrophysiology and histology experiments and quantification. This is stated in Methods "Data analysis", 1st paragraph.
For SC imaging experiments and analysis, experimenters were blind to the animals' genotype. This is stated in Methods "Data analysis", 4th paragraph.

7. For experiments in live vertebrates, is a statement of compliance with ethical guidelines/regulations included?

Where (section, paragraph #)?

Yes, in Methods section "Animal Preparation", 1st paragraph. All procedures were in accordance with the US National Institutes of Health (NIH) guidelines for the care and use of laboratory animals, and were approved by Northwestern University and the University of Chicago Institutional Animal Care and Use Committees.

8. Is the species of the animals used reported?

Where (section, paragraph #)?

Yes, in Methods section "Animal Preparation", 1st paragraph.

9. Is the strain of the animals (including background strains of KO/ transgenic animals used) reported?

Where (section, paragraph #)?

Yes, in Methods section "Animal Preparation", 1st paragraph.

10. Is the sex of the animals/subjects used reported?

Where (section, paragraph #)?

Yes, in Methods section "Animal Preparation", 1st paragraph.

11. Is the age of the animals/subjects reported?

Where (section, paragraph #)?

Yes, in Methods section "Animal Preparation", 2nd paragraph; "Retinal calcium imaging and data analysis", 1st paragraph.

12. For animals housed in a vivarium, is the light/dark cycle reported?

Where (section, paragraph #)?

Yes, in Methods section "Animal Preparation", 1st paragraph.

13. For animals housed in a vivarium, is the housing group (i.e. number of animals per cage) reported?

Where (section, paragraph #)?

> Yes, in Methods section "Animal Preparation", 1st paragraph.

14. For behavioral experiments, is the time of day reported (e.g. light or dark cycle)?

Where (section, paragraph #)?

> N/A

15. Is the previous history of the animals/subjects (e.g. prior drug administration, surgery, behavioral testing) reported?

Where (section, paragraph #)?

> N/A

   a. If multiple behavioral tests were conducted in the same group of animals, is this reported?

     Where (section, paragraph #)?

> N/A

16. If any animals/subjects were excluded from analysis, is this reported?

Where (section, paragraph #)?

> see answer to question 4.

   a. How were the criteria for exclusion defined?

     Where is this described (section, paragraph #)?

> see answer to question 4.

   b. Specify reasons for any discrepancy between the number of animals at the beginning and end of the study.

     Where is this described (section, paragraph #)?

> N/A

▶ Reagents

1. Have antibodies been validated for use in the system under study (assay and species)?

> N/A. No antibodies were used.

   a. Is antibody catalog number given?

     Where does this appear (section, paragraph #)?

> N/A

   b. Where were the validation data reported (citation, supplementary information, Antibodypedia)?

     Where does this appear (section, paragraph #)?

> N/A

2. Cell line identity

   a. Are any cell lines used in this paper listed in the database of commonly misidentified cell lines maintained by ICLAC and NCBI Biosample?

     Where (section, paragraph #)?

> N/A. No cell lines were used.

b. If yes, include in the Methods section a scientific justification of their use--indicate here in which section and paragraph the justification can be found.

N/A

c. For each cell line, include in the Methods section a statement that specifies:

- the source of the cell lines

- have the cell lines been authenticated? If so, by which method?

- have the cell lines been tested for mycoplasma contamination?

Where (section, paragraph #)?

N/A

▶ Data availability

Provide a Data availability statement in the Methods section under "Data availability", which should include, where applicable:
• Accession codes for deposited data
• Other unique identifiers (such as DOIs and hyperlinks for any other datasets)
• At a minimum, a statement confirming that all relevant data are available from the authors
• Formal citations of datasets that are assigned DOIs
• A statement regarding data available in the manuscript as source data
• A statement regarding data available with restrictions

See our data availability and data citations policy page for more information.

Data deposition in a public repository is mandatory for:

a. Protein, DNA and RNA sequences
b. Macromolecular structures
c. Crystallographic data for small molecules
d. Microarray data

Deposition is strongly recommended for many other datasets for which structured public repositories exist; more details on our data policy are available here. We encourage the provision of other source data in supplementary information or in unstructured repositories such as Figshare and Dryad.

We encourage publication of Data Descriptors (see Scientific Data) to maximize data reuse.

Where is the Data Availability statement provided (section, paragraph #)?

Data availability is stated in Methods section titled "Data and Code availability".

▶ Computer code/software

Any custom algorithm/software that is central to the methods must be supplied by the authors in a usable and readable form for readers at the time of publication. However, referees may ask for this information at any time during the review process.

1. Identify all custom software or scripts that were required to conduct the study and where in the procedures each was used.

   > Custom Matlab codes were used in the study. See Methods "Visual stimulation", "Data analysis", and "Retinal calcium imaging and data analysis" for details.

2. If computer code was used to generate results that are central to the paper's conclusions, include a statement in the Methods section under "**Code availability**" to indicate whether and how the code can be accessed. Include version information as necessary and any restrictions on availability.

   > The codes are available upon request. The statement is included. Methods section titled "Statistics, Data and Code availability".

▶ Human subjects

1. Which IRB approved the protocol?

   Where is this stated (section, paragraph #)?

   > N/A

2. Is demographic information on all subjects provided?

   Where (section, paragraph #)?

   > N/A

3. Is the number of human subjects, their age and sex clearly defined?

   Where (section, paragraph #)?

   > N/A

4. Are the inclusion and exclusion criteria (if any) clearly specified?

   Where (section, paragraph #)?

   > N/A

5. How well were the groups matched?

   Where is this information described (section, paragraph #)?

   > N/A

6. Is a statement included confirming that informed consent was obtained from all subjects?

   Where (section, paragraph #)?

   > N/A

7. For publication of patient photos, is a statement included confirming that consent to publish was obtained?

   Where (section, paragraph #)?

   > N/A

▶ fMRI studies

For papers reporting functional imaging (fMRI) results please ensure that these minimal reporting guidelines are met and that all this information is clearly provided in the methods:

1. Were any subjects scanned but then rejected for the analysis after the data was collected?

   N/A

   a. If yes, is the number rejected and reasons for rejection described?

      Where (section, paragraph #)?

      N/A

2. Is the number of blocks, trials or experimental units per session and/or subjects specified?

   Where (section, paragraph #)?

   N/A

3. Is the length of each trial and interval between trials specified?

   N/A

4. Is a blocked, event-related, or mixed design being used? If applicable, please specify the block length or how the event-related or mixed design was optimized.

   N/A

5. Is the task design clearly described?

   Where (section, paragraph #)?

   N/A

6. How was behavioral performance measured?

   N/A

7. Is an ANOVA or factorial design being used?

   N/A

8. For data acquisition, is a whole brain scan used?

   If not, state area of acquisition.

   N/A

   a. How was this region determined?

      N/A

9. Is the field strength (in Tesla) of the MRI system stated?

   N/A

   a. Is the pulse sequence type (gradient/spin echo, EPI/spiral) stated?

      N/A

   b. Are the field-of-view, matrix size, slice thickness, and TE/TR/flip angle clearly stated?

      N/A

10. Are the software and specific parameters (model/functions, smoothing kernel size if applicable, etc.) used for data processing and pre-processing clearly stated?

    N/A

11. Is the coordinate space for the anatomical/functional imaging data clearly defined as subject/native space or standardized stereotaxic space, e.g., original Talairach, MNI305, ICBM152, etc? Where (section, paragraph #)?

N/A

12. If there was data normalization/standardization to a specific space template, are the type of transformation (linear vs. nonlinear) used and image types being transformed clearly described? Where (section, paragraph #)?

N/A

13. How were anatomical locations determined, e.g., via an automated labeling algorithm (AAL), standardized coordinate database (Talairach daemon), probabilistic atlases, etc.?

N/A

14. Were any additional regressors (behavioral covariates, motion etc) used?

N/A

15. Is the contrast construction clearly defined?

N/A

16. Is a mixed/random effects or fixed inference used?

N/A

    a. If fixed effects inference used, is this justified?

N/A

17. Were repeated measures used (multiple measurements per subject)?

N/A

    a. If so, are the method to account for within subject correlation and the assumptions made about variance clearly stated?

N/A

18. If the threshold used for inference and visualization in figures varies, is this clearly stated?

N/A

19. Are statistical inferences corrected for multiple comparisons?

N/A

    a. If not, is this labeled as uncorrected?

N/A

20. Are the results based on an ROI (region of interest) analysis?

N/A

    a. If so, is the rationale clearly described?

N/A

    b. How were the ROI's defined (functional vs anatomical localization)?

N/A

21. Is there correction for multiple comparisons within each voxel?

N/A

22. For cluster-wise significance, is the cluster-defining threshold and the corrected significance level defined?

N/A

▶ Additional comments

Additional Comments

N/A