nature neuroscience

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Main Figures: 5

Supplementary Figures: 5

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
+ -												

		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 #
+ -	Fig 2b	bootstrapping	Results para 2, online methods para 5,6	1000	Percentage of OFF penetrations with 0.2, 0.3 and 0.4mm thickness vs Predicted percentage of OFF penetrations with 0.2, 0.3 and 0.4mm thickness for OFF/ON = 2	Results para 2, online methods para 5,6	40.5%+/-3.5%, 23.2%+/-3%	Fig.2b	p<0.001	Results para 2,Fig.2b, figure legend, online methods para 6	N/A	N/A
+ -	Fig 2b	bootstrapping	Results para 2, online methods para 5,6	1000	Percentage of OFF penetrations with 0.2, 0.3 and 0.4mm thickness vs Predicted percentage of OFF penetrations with 0.2, 0.3 and 0.4mm thickness for OFF/ON = 1	Results para 2, online methods para 5,6	40.5%+/-3.5%, 8.2%+/-2%	Fig.2b	p<0.001	Results para 2, Fig.2b, figure legend, online methods para 6	N/A	N/A
+ -	Fig 2b	bootstrapping	Results para 2, online methods para 5,6	1000	Percentage of ON penetrations with 0.2, 0.3 and 0.4mm thickness vs Predicted percentage of ON penetrations with 0.2, 0.3 and 0.4mm thickness for OFF/ON = 2	Results para 2, online methods para 5,6	20.4%+/-2.7%, 2.1%+/-1.1%	Fig.2b	p<0.001	Results para 2, Fig.2b, figure legend, online methods para 6	N/A	N/A
+ -	Fig 2b	bootstrapping	Results para 2, online methods para 5,6	1000	Percentage of ON penetrations with 0.2, 0.3 and 0.4mm thickness vs Predicted percentage of ON penetrations with 0.2, 0.3 and 0.4mm thickness for OFF/ON = 1	Results para 2, online methods para 5,6	20.4%+/-2.7%, 8.2%+/-2%	Fig.2b	p<0.001	Results para 2, Fig.2b, figure legend, online methods para 6	N/A	N/A
+ -	Fig 2b	bootstrapping	Results para 2, online methods para 5,6	1000	Percentage of ON/ OFF mixed penetrations with 0.2, 0.3 and 0.4mm thickness vs Predicted percentage of ON/ OFF penetrations with 0.2, 0.3 and 0.4mm thickness for OFF/ON = 2	Results para 2, online methods para 5,6	39%+/-3.5%, 74.8%+/-3.1%,	Fig.2b	p<0.001	Results para 2, Fig.2b, figure legend, online methods para 6	N/A	N/A

+ -	Fig 2b	bootstrapping	Results para 2, online methods para 5,6	1000	Percentage of ON/OFF mixed penetrations with 0.2, 0.3 and 0.4mm thickness vs Predicted percentage of ON/OFF mixed penetrations with 0.2, 0.3 and 0.4mm thickness for OFF/ON = 1	Results para 2, online methods para 5,6	39%+/-3.5%, 83.6%+/-2.6%,	Fig.2b	p<0.001	Results para 2,Fig.2b, figure legend, online methods para 6	N/A	N/A
+ -	Fig 2c	bootstrapping	Results para 3 online methods para 7	1000	Horizontal dimension of ON domains versus horizontal dimension of OFF domains	Results para 3, online methods para 7	0.28,0.36	Fig.2c, figure legend	p=0.002	Results para 3, figure legend, online methods para 7	N/A	N/A
+ -	Fig 3	Hartigan test	Results para 4	832	Contrast polarity contralateral eye 18 cats	Results para 4, Fig.3	N/A	N/A	p=0.0413	Results para 4, Fig. 3	N/A	N/A
+ -	Fig 3	Hartigan test	Results para 4	584	Contrast polarity ipsilateral eye 18 cats	Results para 4, Fig. 3	N/A	N/A	p<0.001	Results para 4, Fig.3	N/A	N/A
+ -	Fig 3	Hartigan test	Results para 4	238	Contrast polarity binocular recordings 18 cats	Results para 4,	N/A	N/A	p=0.0066	Results para 4,	N/A	N/A
+ -	Fig 3	Hartigan test	Results para 4	238	Contrast polarity binocular recordings 18 cats	Results para 4,	N/A	N/A	p=0.0015	Results para 4,	N/A	N/A
+ -	Fig 4c left	Two-sided Wilcoxon-rank-sum test	Results para 6	310, 151	Spatial correlation paired multiunits separated by 100-300 microns	Fig.4c	0.61,0.42	Results para 6,Fig.4c	p<0.0001	Results para 6,Fig.4c	N/A	N/A
+ -	Fig 4c left	Two-sided Wilcoxon-rank-sum test	Online methods para 9	151,151	Spatial correlation paired multiunits separated by 300 microns	Online methods para 9	0.42,0.0556	Online methods para 9	p<0.0001	Online methods para 9	N/A	N/A
+ -	Fig 4c left	Two-sided Wilcoxon-rank-sum test	Online methods para 10	310,310	Spatial correlation paired multiunits separated by 100 microns	Online methods para 10	0.61,0.0556	Online methods para 10	p<0.0001	Online methods para 10	N/A	N/A
+ -	Fig 4d left	Two-sided Wilcoxon-rank-sum test	Results para 6	91, 33	Spatial correlation paired single units separated by 100-300 microns	Fig.4d	0.26,0.1	Results para 6,Fig.4d	p=0.0074	Results para 6,Fig.4c	N/A	N/A
+ -	Fig 4d left	Two-sided Wilcoxon-rank-sum test	Online methods para 10	91,91	Spatial correlation paired single units separated by 100microns	Online methods para 10	0.26,0.1	Online methods para 10	p<0.0001	Online methods para 10	N/A	N/A
+ -	Fig 4e left	Two-sided Wilcoxon-rank-sum test	Results para 6	178, 58	Orientation correlation paired multiunits separated by 100-300 microns	Fig.4e	0.95,0.89	Results para 6,Fig.4e	p<0.0001	Fig.4e	N/A	N/A
+ -	Fig 4f left	Two-sided Wilcoxon-rank-sum test	Results para 6	117, 44	Orientation correlation paired single units separated by 100-300 microns	Fig.4f	0.78,0.70	Results para 6,Fig.4e	p=0.0012	Fig.4f	N/A	N/A

+ -	Fig 4g right	Two-sided Wilcoxon-rank-sum test	Results para 7	1590, 3989	Distance of paired cortical receptive field subregions multiunit	Results para 7	error bars are mean +/- SEM	Fig.4g	P<0.0001	Fig legend	N/A	N/A
+ -	Fig 4h right	Two-sided Wilcoxon-rank-sum test	Results para 7	161, 396	Distance of paired cortical receptive field subregions single unit	Results para 7	error bars are mean +/- SEM	Fig.4h	p<0.0001 p=0.0001 p=0.0236 p=0.5853	Fig legend	N/A	N/A
+ -	Fig 5b	Two-sided Wilcoxon-rank-sum test	Results para 11	2038,502	Phase difference of paired multiunits with same contrast polarity vs Phase difference of paired multiunits with different contrast polarity	Fig.5b	N/A	N/A	p<0.001	Fig legend	N/A	N/A
+ -	Fig 5c	Two-sided Wilcoxon-rank-sum test	Results para 11	152,64	Phase difference of paired singleunits with same contrast polarity vs Phase difference of paired singleunits with different contrast polarity	Fig.5c	N/A	N/A	p<0.001	Fig legend	N/A	N/A
+ -	Fig 5d	Two-sided Wilcoxon-rank-sum test	Results para 11	2038,502	RF subregion overlap of paired multiunits with same contrast polarity vs RF subregion overlap of paired multiunits with different contrast polarity	Fig.5d	67% ,24%	Results para 11	p<0.001	Results para 11, Fig legend	N/A	N/A
+ -	Fig 5e	Two-sided Wilcoxon-rank-sum test	Results para 11	152,64	RF subregion overlap of paired singleunits with same contrast polarity vs RF subregion overlap of paired singleunits with different contrast polarity	Fig.5e	58% , 30%	Results para 11	p<0.001	Results para 11, Fig legend	N/A	N/A
+ -	Fig 5f	Two-sided Wilcoxon-rank-sum test	Results para 11	2038,502	RF subregion distance of paired multiunits with same contrast polarity vs RF subregion distance of paired multiunits with different contrast polarity	Fig.5f	N/A	N/A	p<0.001	Fig legend	N/A	N/A
+ -	Fig 5g	Two-sided Wilcoxon-rank-sum test	Results para 11	152,64	RF subregion distance of paired singleunits with same contrast polarity vs RF subregion distance of paired singleunits with different contrast polarity	Fig.5g	N/A	N/A	p<0.001	Fig legend	N/A	N/A
+ -	Fig S3b	Two-sided Wilcoxon-rank-sum test	Fig legend	26	Paired cortical sites within the same orientation domain absolute phase	Fig legend	N/A	N/A	p<0.0001	Fig legend	N/A	N/A

+ -	Fig S3c	Two-sided Wilcoxon-rank-sum test	Fig legend	33	Paired cortical sites within the same orientation domain relative phase	Fig legend	N/A	N/A	p=0.0061	Fig legend	N/A	N/A
+ -	Fig S4c	Chi-square	Fig legend	105, 15	Paired cortical sites phase difference at high spatial frequency	Fig legend	N/A	N/A	p<0.001	Fig legend	N/A	N/A
+ -	Fig S5	Two-sided Wilcoxon rank sum test	Fig legend	1725, 966	Distance of paired LGN receptive fields	Fig S5	N/A	N/A	P<0.001	Fig S5, Fig legend	N/A	N/A

Representative figures

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

   If so, what figure(s)?

   N/A

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 #)?

   N/A

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.

   N/A

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

   Where (section, paragraph #)?

   Yes. Paragraph #5-7 ,9,10 in online methods and Figure panels. All figures show sample size, p values and correlation coefficients.

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

      Yes. Paragraph #5-7 ,9,10 in online methods and Figure panels.

   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 #)?

      Yes. Paragraph #5-7 ,9,10 in online methods and Figure panels.

   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 #)?

      We did not measure the group variances but look similar (e.g. Figure 4, 5).

d. Are tests specified as one- or two-sided?	Two-sided
e. Are there adjustments for multiple comparisons?	N/A
3. Are criteria for excluding data points reported? Was this criterion established prior to data collection? Where is this described (section, paragraph #)?	Yes. The criteria for data selection are reported in online methods , paragraph #3, 4. The criteria were not established prior to data collection.
4. 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 #)?	N/A.
5. 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 #)?	N/A.
6. For experiments in live vertebrates, is a statement of compliance with ethical guidelines/regulations included? Where (section, paragraph #)?	Yes. Paragraph #1 of online methods
7. Is the species of the animals used reported? Where (section, paragraph #)?	Yes. Reported in the online methods, paragraph #1.
8. Is the strain of the animals (including background strains of KO/ transgenic animals used) reported? Where (section, paragraph #)?	N/A
9. Is the sex of the animals/subjects used reported? Where (section, paragraph #)?	Yes. Reported in the online methods, paragraph #1.
10. Is the age of the animals/subjects reported? Where (section, paragraph #)?	N/A
11. For animals housed in a vivarium, is the light/dark cycle reported? Where (section, paragraph #)?	N/A
12. For animals housed in a vivarium, is the housing group (i.e. number of animals per cage) reported? Where (section, paragraph #)?	N/A

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

    Where (section, paragraph #)?

N/A

14. 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

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

    Where (section, paragraph #)?

N/A

    a. How were the criteria for exclusion defined?

       Where is this described (section, paragraph #)?

N/A

    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

    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. If cell lines were used to reflect the properties of a particular tissue or disease state, is their source identified?

    Where (section, paragraph #)?

N/A

    a. Were they recently authenticated?

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

N/A

Data deposition

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.

1. Are accession codes for deposit dates provided?

   Where (section, paragraph #)?

N/A

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.

1.Visionworks was used to generate visual stimuli.
2.Multichannel Acquisition Processor (MAP) Data Acquisition from Plexon (Plexoninc, MI) was used to collect data.
3.Offline Sorter was used to sort single units.
4.Neuroexplorer and Matlab were used to analyze data.
5. We used Matlab scripts to calculate spatial correlation, contrast polarity and RF overlap (equations 1-3 in online methods). We also used Matlab scripts to measure spatial correlations that would be expected by chance (paragraph #3 in online methods) and for Gabor fits (paragraph #11 in online methods)

2. Is computer source code/software provided with the paper or deposited in a public repository? Indicate in what form this is provided or how it can be obtained.

The computer source code will be made available upon request.

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