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Main Figures: 7

Supplementary Figures: 10

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.

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 #
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 #	
+ -	1b	Paired t-test	Figure legend	13	13 mice	Figure legend	error bars are mean \pm s.e.m.	Figure legend	p < 0.001	Figure legend	t(12)=-11.929 t(12)=-11.929 t(12)=-8.442	Figure legend
+ -	1c	Paired t-test	Figure legend	13	13 mice	Figure legend	lower and upper quartile and whiskers (lower and upper extremes minus lower and upper quartile)	Figure legend	p = 0.029	Figure legend	t(12)=-2.480	Figure legend
+ -	1d inset	Paired t-test	Figure legend	13	13 mice	Figure legend	lower and upper quartile and whiskers (lower and upper extremes minus lower and upper quartile)	Figure legend	p = 0.016	Figure legend	t(12)=2.762	Figure legend
+ -	2C	Paired t-test	Figure legend	13	13 mice	Figure legend	lower and upper quartile and whiskers (lower and upper extremes minus lower and upper quartile)	Figure legend	p < 0.001	Figure legend	t(12)=-14.884	Figure legend
+ -	2d	Paired t-test	Figure legend	12	12mice	Figure legend	lower and upper quartile and whiskers (lower and upper extremes minus lower and upper quartile)	Figure legend	p < 0.001	Figure legend	t(11)=-6.805	Figure legend
+ -	3b	Paired t-test	Figure legend	13	13 mice	Figure legend	lower and upper quartile and whiskers (lower and upper extremes minus lower and upper quartile)	Figure legend	p < 0.001	Figure legend	t(12)=6.134	Figure legend
+ -	3c, right	Mann-Whitney Test	Figure legend	7	7 mice	Figure legend	lower and upper quartile and whiskers (lower and upper extremes minus lower and upper quartile)	Figure legend	p < 0.001	Figure legend	U= 0	Figure legend
+ -	3d	Pearson R	Figure legend	13	13 mice	Figure legend	correlation	Figure legend	p < 0.001	Figure legend	r= 0.88	Figure legend
+ -	3e	One sample t-test	Figure legend	13	13 mice	Figure legend	error bars are mean \pm s.e.m.	Figure legend	right: p < 0.001 left p < 0.001	Figure legend	right: t(12)=19.207 left: t(12)=16.615	Figure legend

+ -	4c	Paired t-test	Figure legend	13	13 mice	Figure legend	lower and upper quartile and whiskers (lower and upper extremes minus lower and upper quartile)	Figure legend	$p < 0.001$	Figure legend	$t(12)=6.077$	Figure legend
+ -	4d	Paired t-test	Figure legend	12	12 mice	Figure legend	lower and upper quartile and whiskers (lower and upper extremes minus lower and upper quartile)	Figure legend	$p = 0.003$	Figure legend	$t(11)=3.334$	Figure legend
+ -	4e	One sample t-test	Figure legend	13	13 mice	Figure legend	error bars are mean \pm s.e.m.	Figure legend	right: $p < 0.001$ left $p < 0.001$	Figure legend	right: $t(12)=10.976$ left: $t(12)=34.372$	Figure legend
+ -	5c inset	Paired t-test	Figure legend	13	13 mice	Figure legend	lower and upper quartile and whiskers (lower and upper extremes minus lower and upper quartile)	Figure legend	$p = 0.002$	Figure legend	$t(12)=3.933$	Figure legend
+ -	5d inset	Paired t-test	Figure legend	12	12 mice	Figure legend	lower and upper quartile and whiskers (lower and upper extremes minus lower and upper quartile)	Figure legend	$p < 0.001$	Figure legend	$t(12)=-5.940$	Figure legend
+ -	6b bottom	Rayleigh test $\ln(Z)$	Figure legend	92	92 cells	Figure legend	distribution	Figure legend	$p < 0.05$	Figure legend	$\ln(Z) = 1.097$	Figure legend
+ -	6g bottom	Rayleigh test $\ln(Z)$	Figure legend	72	72 cells	Figure legend	distribution	Figure legend	$p < 0.05$	Figure legend	$\ln(Z) = 1.097$	Figure legend
+ -	6c inset	Mann-Whitney Test	Figure legend	180 and 911	pairs of phase-locked and non phase-locked dmPFC and BLA recorded neurons	Figure legend	error bars are mean \pm s.e.m.	Figure legend	$p < 0.001$	Figure legend	$U = 50313$ $U = 7893$	Figure legend
+ -	6h inset	Mann-Whitney Test	Figure legend	180 and 911	pairs of phase-locked and non phase-locked dmPFC and BLA recorded neurons	Figure legend	error bars are mean \pm s.e.m.	Figure legend	$p < 0.001$	Figure legend	$U = 16200$ $U = 9413$	Figure legend
+ -	6e bottom	Rayleigh test $\ln(Z)$	Figure legend	35	35 cells	Figure legend	distribution	Figure legend	$p < 0.05$	Figure legend	$\ln(Z) = 1.097$	Figure legend
+ -	6j bottom	Rayleigh test $\ln(Z)$	Figure legend	15	15 cells	Figure legend	distribution	Figure legend	$p < 0.05$	Figure legend	$\ln(Z) = 1.097$	Figure legend
+ -	7c	Two way repeated measures ANOVA	Figure legend	8 and 8	8 Chr2 and 8 GFP mice	Figure legend	error bars are mean \pm s.e.m.	Figure legend	group effect: $p = 0.367$ time effect: $p = 0.001$ group x time interaction: $p = 0.0036$	Figure legend	group effect: $F(1,14) = 0.868$ time effect: $F(1,2) = 8.926$ group x time interaction: $F(1,28) = 6.925$	Figure legend
+ -	7c	Unpaired t-test	Figure legend	8 and 8	8 Chr2 and 8 GFP mice	Figure legend	error bars are mean \pm s.e.m.	Figure legend	Day1 stim: $p = 0.002$ Day2 No stim: $p = 0.013$	Figure legend	Day1 stim: $t(14)=3.712$ Day2 No stim: $t(14)=2.758$	Figure legend

+ -	7d	One way repeated measures ANOVA	Figure legend	6	6 mice	Figure legend	error bars are mean ± s.e.m.	Figure legend	p < 0.001	Figure legend	F(5,4) = 8.618	Figure legend
+ -	7d	Paired t-test	Figure legend	6	6 mice	Figure legend	error bars are mean ± s.e.m.	Figure legend	4 Hz vs 1 Hz: p = 0.0019 4 Hz vs 8 Hz: p = 0.0053 4 Hz vs 10 Hz: p < 0.001 4 Hz vs 12 Hz: p = 0.01	Figure legend	4 Hz vs 1 Hz: t(5)=5.927 4 Hz vs 8 Hz: t(5)=4.712 4 Hz vs 10 Hz: t(5)=7.632 4 Hz vs 12 Hz: t(5)=4.009	Figure legend
+ -	7d	Paired t-test	Figure legend	6	6 mice	Figure legend	error bars are mean ± s.e.m.	Figure legend	4 Hz stationary vs 4 Hz stochastic p = 0.016	Figure legend	t(5)=3.533	Figure legend
+ -	7e	Paired t-test	Figure legend	6	6 mice	Figure legend	lower and upper quartile and whiskers (lower and upper extremes minus lower and upper quartile)	Figure legend	p = 0.385	Figure legend	t(5)=0.951	Figure legend
+ -	7f and Supp 10g	Mann-Whitney test	Figure legend	31	pairs of phase-locked dmPFC and BLA recorded neurons	Figure legend	lower and upper quartile and whiskers (lower and upper extremes minus lower and upper quartile)	Figure legend	right: p = 0.03 left p = 0.004	Figure legend	left: U = 326 right: U = 278	Figure legend
+ -	Supp 4b	Paired t-test	Figure legend	13	13 mice	Figure legend	error bars are mean ± s.e.m.	Figure legend	p < 0.001	Figure legend	t(12)=-4.871	Figure legend
+ -	Supp 2b	One way repeated measures ANOVA	Figure legend	4	4 mice	Figure legend	error bars are mean ± s.e.m.	Figure legend	p = 0.0372	Figure legend	F(3,4) =3.617	Figure legend
+ -	Supp 2c	One way repeated measures ANOVA	Figure legend	4	4 mice	Figure legend	error bars are mean ± s.e.m.	Figure legend	p = 0.0153	Figure legend	F(3,4) =4.794	Figure legend
+ -	Supp 3b	Paired t-test	Figure legend	6	6 mice	Figure legend	error bars are mean ± s.e.m.	Figure legend	p < 0.001	Figure legend	t(5)=-11.639	Figure legend
+ -	Supp 3e	Paired t-test	Figure legend	6	6 mice	Figure legend	error bars are mean ± s.e.m.	Figure legend	p < 0.001	Figure legend	t(5)=-6.039	Figure legend
+ -	Supp 5d top	One way repeated measures ANOVA	Figure legend	6	6 mice	Figure legend	error bars are mean ± s.e.m.	Figure legend	p = 0.165	Figure legend	F(2,5) = 2.167	Figure legend
+ -	Supp 5d bottom	ANOVA and Paired t-test	Figure legend	6	6 mice	Figure legend	error bars are mean ± s.e.m.	Figure legend	ANOVA: p < 0.001 T-tests: Test1 vs inact. : p < 0.001 Inact. vs Test2 : p = 0.006	Figure legend	ANOVA: F(2,5) = 19.245 T-tests:Test1 vs inact. : t(5)=6.155 Inact. vs Test2 :t(5)=4.173	Figure legend
+ -	Supp 5f bottom	ANOVA and Paired t-test	Figure legend	80, 100 and 120	80, 100 and 120 cells	Figure legend	error bars are mean ± s.e.m.	Figure legend	ANOVA: p = 0.004 T-tests:Test1 vs inact. :p = 0.043 Inact. vs Test2 :p = 0.004	Figure legend	ANOVA: F(2,5) = 9.858 T-tests:Test1 vs inact. : t(5)=2.956 Inact. vs Test2 :t(5)=4.347	Figure legend
+ -	Supp 6f	Paired t-test	Figure legend	13	13 mice	Figure legend	error bars are mean ± s.e.m.	Figure legend	p < 0.001	Figure legend	t(12)=4.417	Figure legend

+ -	Supp 10b	Mann-Whitney test	Figure legend	8	8 mice	Figure legend	error bars are mean \pm s.e.m.	Figure legend	Day 1 vs Day 3: $p = 0.002$ Day 2 vs Day 3: $p < 0.001$	Figure legend	U = 2 U = 0	Figure legend
+ -	Supp 10c	Paired t-test	Figure legend	4	4 mice	Figure legend	error bars are mean \pm s.e.m.	Figure legend	$p = 0.578$	Figure legend	$t(3) = 0.623$	Figure legend
+ -	Supp 10e	Paired t-test	Figure legend	5	5 mice	Figure legend	error bars are mean \pm s.e.m.	Figure legend	$p = 0.511$	Figure legend	$t(4) = -0.721$	Figure legend
+ -	Supp 10f	Paired t-test	Figure legend	5	5 mice	Figure legend	error bars are mean \pm s.e.m.	Figure legend	Day 2 CS+ no light vs CS+ light: $p = 0.013$ Day 2 CS+ no light vs Day 3 CS+ no light: $p = 0.341$	Figure legend	Day 2 CS+ no light vs CS+ light: $t(4) = -4.265$ Day 2 CS+ no light vs Day 3 CS+ no light: $t(4) = -1.080$	Figure legend
+ -	Supp 4e	Pearson R	Figure legend	13	13 mice	Figure legend	correlation	Figure legend	$p = 0.974$	Figure legend	$r = 0.01$	Figure legend
+ -	Supp 4g	Paired t-test	Figure legend	5	5 mice	Figure legend	error bars are mean \pm s.e.m.	Figure legend	$P = 0.926$	Figure legend	$t(4) = 0.098$	Figure legend
+ -	Supp 5 f top	One way repeated measures ANOVA	Figure legend	80, 100 and 120	80, 100 and 120 cells	Figure legend	error bars are mean \pm s.e.m.	Figure legend	$p = 0.329$	Figure legend	$F(2,5) = 1,245$	Figure legend
+ -	Supp 9 i	Pearson R	Figure legend	50	50 points	Figure legend	correlation	Figure legend	$p < 0.001$	Figure legend	$r = 0.79$	Figure legend

► Representative figures

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

If so, what figure(s)?

not applicable

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 #)?

Yes, described in figure legend for Fig. 2-5, 7 and Supplementary Fig. 1-7, 9-10.

► 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.

Yes, described in Methods - Statistical analyses section, paragraph 2

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

Where (section, paragraph #)?

Yes, described in Methods - statistical analyses section, paragraph 1 and 2

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

Yes, described in Methods - Statistical analyses section, paragraph 1
Statistical test for each experiment is defined in Fig. and Supplementary Fig. legends.

- 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, described in Methods - Statistical analyses section, paragraph 1
- 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, described in Methods - Statistical analyses section, paragraph 1
- d. Are tests specified as one- or two-sided?
- Yes
- e. Are there adjustments for multiple comparisons?
- Yes , Bonferroni corrected
3. Are criteria for excluding data points reported?
Was this criterion established prior to data collection?
Where is this described (section, paragraph #)?
- Yes, described in Methods - Anatomical analysis section, paragraph 1
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 #)?
- Described in Methods - Behaviour section, paragraph 2 and 4
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 #)?
- Described in Methods - Behaviour section, paragraph 1
6. For experiments in live vertebrates, is a statement of compliance with ethical guidelines/regulations included?
Where (section, paragraph #)?
- Described in Methods - Animal section, paragraph 1
7. Is the species of the animals used reported?
Where (section, paragraph #)?
- Described in Methods - Animal section, paragraph 1
8. Is the strain of the animals (including background strains of KO/transgenic animals used) reported?
Where (section, paragraph #)?
- Described in Methods - Animal section, paragraph 1
9. Is the sex of the animals/subjects used reported?
Where (section, paragraph #)?
- Described in Methods - Animal section, paragraph 1
10. Is the age of the animals/subjects reported?
Where (section, paragraph #)?
- Described in Methods - Animal section, paragraph 1

11. For animals housed in a vivarium, is the light/dark cycle reported?
Where (section, paragraph #)?
- Described in Methods - Animal section, paragraph 1
12. For animals housed in a vivarium, is the housing group (i.e. number of animals per cage) reported?
Where (section, paragraph #)?
- Described in Methods - Animal section, paragraph 1
13. For behavioral experiments, is the time of day reported (e.g. light or dark cycle)?
Where (section, paragraph #)?
- Described in Methods - Animal section, paragraph 1
14. Is the previous history of the animals/subjects (e.g. prior drug administration, surgery, behavioral testing) reported?
Where (section, paragraph #)?
- Described in Methods - Animal section, paragraph 1
- a. If multiple behavioral tests were conducted in the same group of animals, is this reported?
Where (section, paragraph #)?
- Described in Methods - Behaviour section, paragraph 3, 4, 5
15. If any animals/subjects were excluded from analysis, is this reported?
Where (section, paragraph #)?
- Described in Methods - Local field potential and EMG analyses section, paragraph 2
- a. How were the criteria for exclusion defined?
Where is this described (section, paragraph #)?
- Described in Methods - Local field potential and EMG analyses section, paragraph 2
- 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 #)?
- not applicable

► Reagents

1. Have antibodies been validated for use in the system under study (assay and species)?
- Not applicable
- a. Is antibody catalog number given?
Where does this appear (section, paragraph #)?
- Not applicable
- b. Where were the validation data reported (citation, supplementary information, Antibodypedia)?
Where does this appear (section, paragraph #)?
- Not applicable

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 #)?

Not applicable

- 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.

Not applicable

- 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 #)?

Not applicable

► 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](#).

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

1. Are accession codes for deposit dates provided?

Where (section, paragraph #)?

Not applicable

► 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.

Method - Local field potentials and EMG analyses section, paragraph 1-5

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.

Not applicable

▶ Human subjects

1. Which IRB approved the protocol?
Where is this stated (section, paragraph #)?
2. Is demographic information on all subjects provided?
Where (section, paragraph #)?
3. Is the number of human subjects, their age and sex clearly defined?
Where (section, paragraph #)?
4. Are the inclusion and exclusion criteria (if any) clearly specified?
Where (section, paragraph #)?
5. How well were the groups matched?
Where is this information described (section, paragraph #)?
6. Is a statement included confirming that informed consent was obtained from all subjects?
Where (section, paragraph #)?
7. For publication of patient photos, is a statement included confirming that consent to publish was obtained?
Where (section, paragraph #)?

▶ 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?
 - a. If yes, is the number rejected and reasons for rejection described?
Where (section, paragraph #)?
2. Is the number of blocks, trials or experimental units per session and/or subjects specified?
Where (section, paragraph #)?
3. Is the length of each trial and interval between trials specified?

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.
5. Is the task design clearly described?
Where (section, paragraph #)?
6. How was behavioral performance measured?
7. Is an ANOVA or factorial design being used?
8. For data acquisition, is a whole brain scan used?
If not, state area of acquisition.
- a. How was this region determined?
9. Is the field strength (in Tesla) of the MRI system stated?
- a. Is the pulse sequence type (gradient/spin echo, EPI/spiral) stated?
- b. Are the field-of-view, matrix size, slice thickness, and TE/TR/flip angle clearly stated?
10. Are the software and specific parameters (model/functions, smoothing kernel size if applicable, etc.) used for data processing and pre-processing clearly stated?
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 #)?
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 #)?
13. How were anatomical locations determined, e.g., via an automated labeling algorithm (AAL), standardized coordinate database (Talairach daemon), probabilistic atlases, etc.?
14. Were any additional regressors (behavioral covariates, motion etc) used?
15. Is the contrast construction clearly defined?
16. Is a mixed/random effects or fixed inference used?

- a. If fixed effects inference used, is this justified?
17. Were repeated measures used (multiple measurements per subject)?
- a. If so, are the method to account for within subject correlation and the assumptions made about variance clearly stated?
18. If the threshold used for inference and visualization in figures varies, is this clearly stated?
19. Are statistical inferences corrected for multiple comparisons?
- a. If not, is this labeled as uncorrected?
20. Are the results based on an ROI (region of interest) analysis?
- a. If so, is the rationale clearly described?
- b. How were the ROI's defined (functional vs anatomical localization)?
21. Is there correction for multiple comparisons within each voxel?
22. For cluster-wise significance, is the cluster-defining threshold and the corrected significance level defined?

► Additional comments

Additional Comments