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.

<table>
<thead>
<tr>
<th>TEST USED</th>
<th>n</th>
<th>DESCRIPTIVE STATS (AVERAGE, VARIANCE)</th>
<th>P VALUE</th>
<th>DEGREES OF FREEDOM &amp; F/T/Z/R/ETC VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIGURE NUMBER</td>
<td>WHICH TEST?</td>
<td>SECTION &amp; PARAGRAPH #</td>
<td>EXACT VALUE</td>
<td>DEFINED?</td>
</tr>
<tr>
<td>1a</td>
<td>one-way ANOVA</td>
<td>Fig. legend</td>
<td>9, 9, 10, 15 mice from at least 3 litters/group</td>
<td>Methods para 8</td>
</tr>
<tr>
<td>results para 6</td>
<td>unpaired t-test</td>
<td>Results para 6</td>
<td>15 slices from 10 mice</td>
<td>Results para 6</td>
</tr>
<tr>
<td>&gt; 2a</td>
<td>descriptive stats only</td>
<td>n/a</td>
<td>20 participants</td>
<td>Results para 1</td>
</tr>
</tbody>
</table>

Nature Neuroscience: doi:10.1038/nn.3994
### Representative figures

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

   If so, what figure(s)?

   **no**

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.

   **We did not undertake a formal prospective power analysis, but set the sample size to a value (n=20) in the typical range for comparable previous experiments, as described in Methods para 1.**
2. Are statistical tests justified as appropriate for every figure?
   Where (section, paragraph #)?

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

   Statistical procedures are described and justified throughout the Results section (para 1-3, 8-11, and 13-18) and further details are provided in the Methods section.

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

   The statistical test is specified in conjunction with each reported p-value.

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

   Where is this described (section, paragraph #)?

   We include a measure of variance (typically interquartile range) wherever descriptive statistics are reported. None of our analyses compare independent groups.

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

   Where does this appear (section, paragraph #)?

   F tests are 1-sided; all other tests are 2-sided.

   e. Are there adjustments for multiple comparisons?

   Where (section, paragraph #)?

   Our fMRI analyses use whole-brain permutation tests on cluster-based statistics to define the empirical null distribution controlling for multiple comparisons across voxels (Methods para 29). Cardiac analyses use a similar method to control for multiple comparisons across timepoints (Methods para 30).

3. Are criteria for excluding data points reported?
   Was this criterion established prior to data collection?
   Where is this described (section, paragraph #)?

   Two participants were excluded because of head movement during MRI scanning (Methods, para 1). This criterion was determined by examining the distribution of head-movement values, without reference to the analyses of interest.

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 (There was no group assignment and no between-subject manipulation.)

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 #)?

   n/a

7. Is the species of the animals used reported?
   Where (section, paragraph #)?

   n/a
<table>
<thead>
<tr>
<th></th>
<th>Question</th>
<th>Where (section, paragraph #)?</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>Is the strain of the animals (including background strains of KO/ transgenic animals used) reported?</td>
<td>n/a</td>
</tr>
<tr>
<td>9</td>
<td>Is the sex of the animals/subjects used reported?</td>
<td>Methods para 1</td>
</tr>
<tr>
<td>10</td>
<td>Is the age of the animals/subjects reported?</td>
<td>Methods para 1</td>
</tr>
<tr>
<td>11</td>
<td>For animals housed in a vivarium, is the light/dark cycle reported?</td>
<td>n/a</td>
</tr>
<tr>
<td>12</td>
<td>For animals housed in a vivarium, is the housing group (i.e. number of animals per cage) reported?</td>
<td>n/a</td>
</tr>
<tr>
<td>13</td>
<td>For behavioral experiments, is the time of day reported (e.g. light or dark cycle)?</td>
<td>n/a</td>
</tr>
<tr>
<td>14</td>
<td>Is the previous history of the animals/subjects (e.g. prior drug administration, surgery, behavioral testing) reported?</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>a. If multiple behavioral tests were conducted in the same group of animals, is this reported?</td>
<td>n/a</td>
</tr>
<tr>
<td>15</td>
<td>If any animals/subjects were excluded from analysis, is this reported?</td>
<td>Methods para 1</td>
</tr>
<tr>
<td></td>
<td>a. How were the criteria for exclusion defined?</td>
<td>Two participants were excluded because of head movement during MRI scanning (Methods, para 1). This criterion was determined by examining the distribution of head-movement values, without reference to the analyses of interest.</td>
</tr>
<tr>
<td></td>
<td>b. Specify reasons for any discrepancy between the number of animals at the beginning and end of the study.</td>
<td>n/a</td>
</tr>
</tbody>
</table>
Reagents

1. Have antibodies been validated for use in the system under study (assay and species)?
   a. Is antibody catalog number given?
      Where does this appear (section, paragraph #)?
   b. Where were the validation data reported (citation, supplementary information, Antibodypedia)?
      Where does this appear (section, paragraph #)?

2. If cell lines were used to reflect the properties of a particular tissue or disease state, is their source identified?
   a. Were they recently authenticated?
      Where is this information reported (section, paragraph #)?

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 #)?

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.
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.

Human subjects

1. Which IRB approved the protocol?
   Where is this stated (section, paragraph #)?
   University of Pennsylvania Internal Review Board (Methods para 1)

2. Is demographic information on all subjects provided?
   Where (section, paragraph #)?
   Methods para 1

3. Is the number of human subjects, their age and sex clearly defined?
   Where (section, paragraph #)?
   Methods para 1

4. Are the inclusion and exclusion criteria (if any) clearly specified?
   Where (section, paragraph #)?
   Methods para 1

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 #)?
   Methods para 1

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?
   yes
   a. If yes, is the number rejected and reasons for rejection described?
      Where (section, paragraph #)?
      Methods para 1
2. Is the number of blocks, trials or experimental units per session and/or subjects specified?
   Where (section, paragraph #)?
   Methods para 1-4

3. Is the length of each trial and interval between trials specified?
   Methods para 1-4 and Figure 1

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.
   The experiment used a slow event-related design (which did not require special optimization procedures).

5. Is the task design clearly described?
   Where (section, paragraph #)?
   Methods para 1-4 and Figure 1

6. How was behavioral performance measured?
   Performance was quantified in terms of (1) number of seconds participants were willing to wait in the absence of reward, and (2) reaction times when rewards were delivered.

7. Is an ANOVA or factorial design being used?
   yes

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

   a. How was this region determined?
   n/a

9. Is the field strength (in Tesla) of the MRI system stated?
   Methods para 21 (under the subheading "MRI data acquisition and preprocessing")

   a. Is the pulse sequence type (gradient/spin echo, EPI/spiral) stated?
   Methods para 21 (under the subheading "MRI data acquisition and preprocessing")

   b. Are the field-of-view, matrix size, slice thickness, and TE/TR/flip angle clearly stated?
   Methods para 21 (under the subheading "MRI data acquisition and preprocessing")

10. Are the software and specific parameters (model/functions, smoothing kernel size if applicable, etc.) used for data processing and pre-processing clearly stated?
   Methods para 22 (under the subheading "MRI data acquisition and preprocessing")

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 #)?
   We normalized the data to MNI space, as described in Methods para 22 (under the subheading "MRI data acquisition and preprocessing")

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 #)?
   Methods para 22 (under the subheading "MRI data acquisition and preprocessing")

13. How were anatomical locations determined, e.g., via an automated labeling algorithm (AAL), standardized coordinate database (Talairach daemon), probabilistic atlases, etc.? 
   Anatomical locations were determined by reference to the group-average structural image after coregistration to MNI coordinate space.
14. Were any additional regressors (behavioral covariates, motion etc) used?
   We included regressors for low-frequency drift and head motion, as described in Methods para 23 (under the subheading "fMRI analysis")

15. Is the contrast construction clearly defined?
   yes

16. Is a mixed/random effects or fixed inference used?
   We used mixed/random effects inference.
   a. If fixed effects inference used, is this justified?
      n/a

17. Were repeated measures used (multiple measurements per subject)?
   Yes
   a. If so, are the method to account for within subject correlation and the assumptions made about variance clearly stated?
      None of our statistical methods assume independence of within-subject measurements. Group analyses treat subject as a random factor.

18. If the threshold used for inference and visualization in figures varies, is this clearly stated?
   All brain images are thresholded at the corrected p<0.05 level. The same threshold is used for visualization and for inference.

19. Are statistical inferences corrected for multiple comparisons?
   Yes
   a. If not, is this labeled as uncorrected?
      n/a

20. Are the results based on an ROI (region of interest) analysis?
    Only where specified (Results para 11 and Fig. 4b).
    a. If so, is the rationale clearly described?
       yes
       b. How were the ROI’s defined (functional vs anatomical localization)?
          ROIs were taken from a previous quantitative meta-analysis.

21. Is there correction for multiple comparisons within each voxel?
    No

22. For cluster-wise significance, is the cluster-defining threshold and the corrected significance level defined?
    Yes (Methods para 29; final paragraph under the subheading "fMRI analysis")

Additional comments

Additional Comments
n/a