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>
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</thead>
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<tr>
<td>FIGURE NUMBER</td>
<td>WHICH TEST</td>
<td>SECTION &amp; PARAGRAPH #</td>
<td>EXACT VALUE</td>
<td>DEFINED?</td>
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<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>
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<tr>
<td>results para 6</td>
<td>unpaired t-test</td>
<td>Results para 6</td>
<td>15 slices from 10 mice</td>
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Nature Neuroscience: doi:10.1038/nn.4250
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<tr>
<th>FIGURE NUMBER</th>
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<th>DEGREES OF FREEDOM &amp; F/t/z/R/ETC VALUE</th>
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<td>tagged neurons (firing rate)</td>
<td>Methods para 8</td>
<td>error bars are mean +/- SEM</td>
<td>Figure 2a</td>
<td>P=0.98, P=0.99, P=0.02, P=0.001, P=1.0e-5</td>
<td>F(5,326)=12.05</td>
</tr>
<tr>
<td>2b</td>
<td>Tukey multiple comparisons of means post-hoc</td>
<td>Methods para 16</td>
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<td>Figure 2a</td>
<td>P=5.2e-8</td>
<td>t(131)=5.77</td>
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<td>2b</td>
<td>linear regression (slope different from zero)</td>
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<td>28,17,18, 18,22,30</td>
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<td>Methods para 8</td>
<td>fitted slope: beta1=-0.19</td>
<td>Main text para 5</td>
<td>P=1.0e-10</td>
<td>Legends Fig. 2</td>
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<td>Methods para 8</td>
<td>error bars are mean +/- SEM</td>
<td>Figure 2a</td>
<td>P=4.1e-12</td>
<td>t(330)=7.20</td>
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<td>Methods para 8</td>
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<td>Main text para 5</td>
<td>P=1.1e-11</td>
<td>Legends Fig. 2</td>
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<tr>
<td>2b</td>
<td>one-way ANOVA</td>
<td>Methods para 16</td>
<td>28,17,18, 18,22,30</td>
<td>tagged neurons (spatial coherence)</td>
<td>Methods para 8</td>
<td>error bars are mean +/- SEM</td>
<td>Figure 2b</td>
<td>P=0.29, P=0.13, P=0.003, P=6.0e-5, P=9.0e-5</td>
<td>F(5,127)=15.18</td>
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<td>2b</td>
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<td>alternative neurons (spatial coherence)</td>
<td>Methods para 8</td>
<td>error bars are mean +/- SEM</td>
<td>Figure 2b</td>
<td>P=0.41, P=0.30, P=0.003, P=1.0e-5, P=1.0e-5</td>
<td>F(5,326)=16.15</td>
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<td>alternative neurons in days 2-6, compared to day 1 (spatial coherence)</td>
<td>Methods para 8</td>
<td>error bars are mean +/- SEM</td>
<td>Figure 2b</td>
<td>P=0.98, P=0.99, P=0.02, P=0.001, P=1.0e-5</td>
<td>F(5,326)=12.05</td>
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</table>

**Legend:**
- t-test
- One-way ANOVA
- Tukey multiple comparisons of means post-hoc
- Linear regression (slope different from zero)
- Alternative neurons (firing rate)
- Tagged neurons in days 2-6, compared to day 1 (firing rate)
- Tagged neurons (spatial coherence)
- Tagged mice vs Control on Dox mice (ArchT-GFP+ cells)
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<td>control ON Dox mice in test 1 vs pre-test and test 2 vs pre-test (CPP score)</td>
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<td>8,8,8</td>
<td>control wt mice in pre-test, test 1, test 2 (CPP score)</td>
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<td>control wt mice in test 1 vs pre-test and test 2 vs pre-test (CPP score)</td>
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<td>control wt, control ON Dox, tagged mice for test 2 (CPP score)</td>
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<td>Firing rate between tagged, alternative andunchanged neurons (circle)</td>
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<tr>
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<td>tagged vs alternative neurons in square</td>
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<td>Supp Fig. 2f</td>
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<td>Unchanged neurons (firing rate)</td>
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<td>Methods para 16</td>
<td>110,79,100,91,11,6,122</td>
<td>Unchanged neurons (spatial coherence)</td>
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<td>tagged vs alternative neuron firing rate in light-IN condition</td>
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<td>2,2</td>
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<td>Method</td>
<td>P-value</td>
<td>Description</td>
<td>P-value</td>
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<td>8d</td>
<td>Fisher’s Z test (population map similarity)</td>
<td>P=3.3e-6; P=0.59;</td>
<td>place cell pairs in Baseline vs Days 1-2 and Days 5-6 from tagged mice (population map similarity)</td>
<td>P=0.59; P=0.77;</td>
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<tr>
<td>8d</td>
<td>Fisher’s Z test (population map similarity)</td>
<td>P=0.015; P=0.02;</td>
<td>place cell pairs in Baseline vs Days 1-2 and Days 5-6 from control mice (population map similarity)</td>
<td>P=0.015; P=0.01;</td>
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<td>9f</td>
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<td>P=0.005</td>
<td>Tagged versus Alternative neurons (Days 1 to 3)</td>
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<td>P=0.04</td>
<td>Tagged versus Alternative neurons (Days 4 to 6)</td>
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<td>9h</td>
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<td>P=0.31</td>
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<td>Saline mice vs Cocaine mice (% LacZ)</td>
<td>P=0.45</td>
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<td>10e</td>
<td>t-test</td>
<td>P=0.04</td>
<td>Saline mice vs Cocaine mice (% Fos among LacZ)</td>
<td>P=0.04</td>
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<td>t-test</td>
<td>P=0.77</td>
<td>Control mice in saline vs cocaine-paired enclosure (mean firing rate)</td>
<td>P=0.77</td>
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<td>11c</td>
<td>one-way ANOVA</td>
<td>P=0.015</td>
<td>Tagged neurons in days 1 to 6 (firing rate)</td>
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<td>11c</td>
<td>Tukey post hoc multiple comparisons</td>
<td>P=0.59; P=0.03;</td>
<td>Tagged neurons in days 2 to 4, compared to day 1 (firing rate)</td>
<td>P=0.59; P=0.03;</td>
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<tr>
<td>11c</td>
<td>one-way ANOVA</td>
<td>P=0.002</td>
<td>Alternative neurons in days 1 to 4 (firing rate)</td>
<td>P=0.002</td>
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<tr>
<td>11c</td>
<td>Tukey post hoc multiple comparisons</td>
<td>P=0.63; P=0.02;</td>
<td>Alternative neurons in days 2 to 4, compared to day 1 (firing rate)</td>
<td>P=0.63; P=0.02;</td>
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<tr>
<td>11d</td>
<td>one-way ANOVA</td>
<td>P=1.2e-5</td>
<td>Tagged mice in Pre-test, Test 1 and Test 2 (CPP score)</td>
<td>P=1.2e-5</td>
</tr>
</tbody>
</table>

Note: P-values and test statistics are indicated for each comparison.
Supplementary Figure 11d - Tukey post hoc multiple comparisons

Methods para 16

6

Control mice in Test 1 vs Pre-test and Test 2 vs Pre-test (CPP score)

Supplementary Figure 11d

error bars are mean +/- SEM

P=1.7e-6

Supplementary Figure 11d

F(2,15)=36.40 -

Supplementary Figure 11d - Tukey post hoc multiple comparisons

Methods para 16

6

Control mice in Test 1 vs Pre-test and Test 2 vs Pre-test (CPP score)

Supplementary Figure 11d

error bars are mean +/- SEM

P=1.0e-5, P=4.3e-6

Supplementary Figure 11d

Supplementary Figure 11d - t-test

Methods para 16

6,6

Tagged mice vs Control mice for Test 2 (CPP score)

Supplementary Figure 11d

error bars are mean +/- SEM

P=1.8e-5

Supplementary Figure 11d

t(11)=7.17 -

Supplementary Figure 11d - t-test

Methods para 16

6,6

Control mice extinction versus drug-priming (CPP score)

Supplementary Figure 11d

error bars are mean +/- SEM

P=0.005

Supplementary Figure 11d

t(5)=-4.66 -

Supplementary Figure 11d - t-test

Methods para 16

6,6

Tagged mice vs Control mice for drug-priming (CPP score)

Supplementary Figure 11d

error bars are mean +/- SEM

P=3.3e-5

Supplementary Figure 11d

t(11)=6.71 -

Supplementary Figure 11d

Supplementary Figure 11d - t-test

Methods para 16

6,6

Tagged mice vs Control mice (novel place preference score)

Supplementary Figure 11e

error bars are mean +/- SEM

P=0.58

Supplementary Figure 11e

t(10)=0.56 -

Supplementary Figure 11f - one-way ANOVA

Methods para 16

6

cFos-tTA mice in Pre-test, Test 1, Test 2 (novel place preference score)

Supplementary Figure 11f

error bars are mean +/- SEM

P=4.1e-6

Supplementary Figure 11f

F(2,15)=31.73 -

Supplementary Figure 11f - Tukey post hoc multiple comparisons

Methods para 16

6

cFos-tTA mice in Test 1 vs Pre-test and Test 2 vs Pre-test (novel place preference score)

Supplementary Figure 11f

error bars are mean +/- SEM

P=0.58, P=6.9e-6

Supplementary Figure 11f

- -

Representative figures

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

If so, what figure(s)?

Fig. 1c
Fig. 1d
Fig. 2c
Fig. 2d
Fig. 3b
Supplementary Fig. 1
Supplementary Fig. 4c
Supplementary Fig. 5b,c
Supplementary Fig. 6a,b
Supplementary Fig. 7b
Supplementary Fig. 9a,b
Supplementary Fig. 10c
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 #)?

> Each image is part of the data set used for statistical analysis, and the number of repeated experiments is the n reported in the main text and the methods.

### Statistics and general methods

1. Is there a justification of the sample size?
   If so, how was it justified?
   Where (section, paragraph #)?

> We chose the sample size based on similar publications in the field.

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

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?

   > In the methods, paragraph #16.

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

   > Based on previous publications, most of the data points were compared across experimental conditions (i.e. different environments, photo-silencing conditions and mice groups) using t-tests, ANOVA or Fisher’s Z test as appropriate. We also used non-parametric tests (Kolmogorov-Smirnov) to compare probability distributions.

   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 #)?

   > The standard error of the mean is reported for each analysis.

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

   > Used tests were two-sided as specified in the methods, paragraph #16.

   e. Are there adjustments for multiple comparisons?

   > We used a Tukey’s post-hoc test for multiple comparisons as specified in the methods, paragraph #16.

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

   > No data points were excluded. However inclusion criteria for well-isolated single units from extracellular recordings were used as published in previous studies and described in the methods section paragraph #8.
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 #)?

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 #)?

6. For experiments in live vertebrates, is a statement of compliance with ethical guidelines/regulations included? Where (section, paragraph #)?

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

8. Is the strain of the animals (including background strains of KO/transgenic animals used) reported? Where (section, paragraph #)?

9. Is the sex of the animals/subjects used reported? Where (section, paragraph #)?

10. Is the age of the animals/subjects reported? Where (section, paragraph #)?

11. For animals housed in a vivarium, is the light/dark cycle reported? Where (section, paragraph #)?

12. For animals housed in a vivarium, is the housing group (i.e. number of animals per cage) reported? Where (section, paragraph #)?

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

14. Is the previous history of the animals/subjects (e.g. prior drug administration, surgery, behavioral testing) reported? Where (section, paragraph #)?

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cFos::ArchT mice were assigned to the behavioural groups (tagged versus control ON Dox) so that the average initial conditioned preference score was similar between groups (Fig. 3). Other comparisons were performed within subjects across conditions.

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In the methods paragraph #15.

In the methods section paragraph #1.

In the abstract, main text paragraph #2 and the methods section paragraph #1.

In the main text paragraph #2 and the methods section paragraph #1.

In the methods section paragraph #1, 4, 12, 13.

All mice used were adults (i.e. at least 12 weeks) as specified in the methods paragraph #1.

The light/dark cycle was 12/12h as stated in the methods paragraph #1.

Mice were bred in house and kept with their litter-mates until used in the procedure, as stated in the methods section #1.

Behavioral experiments were performed during day time (light cycle) as stated in the methods section #1.

In the methods section paragraph #1.
a. If multiple behavioral tests were conducted in the same
group of animals, is this reported?
  Where (section, paragraph #)?

Different sets of mice have been used in spatial exploration of open
field environments and CPP tasks.

15. If any animals/subjects were excluded from analysis, is this reported?
  Where (section, paragraph #)?

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)?

a. Is antibody catalog number given?
  Where does this appear (section, paragraph #)?

Yes

b. Where were the validation data reported (citation,
  supplementary information, Antibodypedia)?
  Where does this appear (section, paragraph #)?

The details the used antibodies (supplier, catalog number) have
been previously published in the studies reported in the Methods.

Reported from the companies that provide the antibodies
(publications referenced in the methods).

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

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 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 #)?
   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.
   Analyses were performed using available softwares as specified in the methods section paragraphs #8,11,16 (Klustakwik, fast ICA, R environment)

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.
   N/A

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?  
   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? 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