Data Article

Dataset of 24-subject EEG recordings during viewing of real-world objects and planar images of the same items

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Abstract

Here we present a collection of electroencephalographic (EEG) data recorded from 24 observers (14 females, 10 males, mean age: 25.4) while observing individually-presented stimuli comprised of 96 real-world objects, and 96 images of the same items printed in high-resolution. EEG was recorded from 128 scalp channels. Six additional external electrodes were used to record vertical and horizontal electrooculogram, as well as the signal from the left and right mastoid. EEG has been pre-processed, segmented in non-overlapping epochs, and independent component analysis (ICA) has been conducted to reject artifacts. Moreover, supplemental pre-processing steps have been completed to facilitate the analysis of event-related potentials (ERP). These data are linked to the article “Distinct visuo-motor brain dynamics for real-world objects versus planar images”. Alongside this data we provide the custom-written Matlab® code that can be used to fully reproduce all analyses and figures presented in the linked research article.

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Data are available online at: https://web.gin.g-node.org/doi/RealObjectsEEG. This dataset is structured in two main folders (/data and /scripts), each containing several subfolders. This dataset include pre-processed EEG timeseries segmented in epochs corresponding to the experimental trials and marked with event codes for identifying the experimental events. The corresponding files (under /data/ersp_analyses) are provided in EEGLAB [2] format and can be loaded into EEGLAB [2] using ‘Load existing dataset’ from the ‘File’ menu. To visualize channel timeseries, use ‘Channel data (scroll)’ from the ‘Plot’ menu (Fig. 1).

For a description of the event codes and the corresponding experimental events, please see Fig. 2, Table 1 and paragraph 2.2 below. Behavioral data, trial information, and other EEG-related data such as event-codes and latencies, are included in data summary files (under /data/data_summary; see Paragraph 2.3 below). We also included the analysis scripts that were used to process the data and generate the figures and results described in the related article [1]. These scripts can be found under /scripts and are organized within different subfolders that correspond to the different analyses and figures described in Ref. [1] (see Paragraph 2.4 below). In order to run the analysis code described in this paper and reproduce the results of [1], the Matlab® software package is required as well as EEGLAB [2] with the following plug-ins: ERPLAB [3], Mass Univariate ERP Toolbox [4], BDF-import, CleanLine, FIRfilt. As a preliminary operation we recommend to add the path of the upper-level folder (ro_eeg_data_repository), including all subfolders, to the current Matlab® path. It

### Value of the data

- This is currently the only existing dataset of EEG data during observation of real-world objects and matched images of the same objects. Due to the complexity of presenting real-world objects under controlled viewing conditions, while simultaneously recording EEG, data collection required an experimental apparatus which was custom-built over six months, and also required three experimenters to conduct each recording session. Other researchers may now benefit from the data without the lengthy preparation and collection phases.
- This dataset consists of high-density EEG recording that can be used to conduct additional analyses than those presented in the related article [1], including, but not limited to, source estimation analysis and multi-variate pattern analysis (MVPA).
- Behavioral ratings of object familiarity and frequency-of-use, which were collected from the same set of participants (after completing the EEG study), are attached to this dataset. These measures were not presented in the attached article [1] but may prove useful for additional analysis directions that have not yet been explored.
- Cortical brain dynamics in response to the observation of real world objects may be used as a benchmark against which researchers can compare responses to objects presented in different display format, including augmented or virtual reality, or responses to objects in other cognitive tasks.

### Details

| Subject area | Neuroscience, Psychology |
|--------------|--------------------------|
| More specific subject area | Cognitive neuroscience, Visual perception, Sensorimotor processing, Non-invasive brain Imaging |
| Type of data | Electrocencephalography data, Analysis scripts (Matlab® code) |
| How data was acquired | EEG was recorded using a 128-channel system (Biosemi ActiveTwo) plus four electrooculogram electrodes and two (i.e., left and right) mastoid electrodes |
| Data format | Pre-processed EEG, custom-written Matlab® code |
| Experimental factors | Twenty-four right-handed young adults (14 females, 10 males) with a mean age of 25.4 years old (standard deviation: 7.5) |
| Experimental features | Human observers viewed real-world three-dimensional (3-D) objects or closely matched 2-D images of the same items and performed delayed verbal ratings of: ‘how much physical effort would it take to use this specific object according to its normal function?’, on a scale from 1 (not effortful) to 10 (very effortful) |
| Data source location | University of Nevada, Reno, NV, United States |
| Data accessibility | Data are available online at: https://web.gin.g-node.org/doi/RealObjectsEEG (doi: 10.12751/g-node.bcccab) |
| Related research article | Marini, F., Breeding, K.A., Snow, J.C. (2019). Distinct visuo-motor brain dynamics for real-world objects versus planar images. NeuroImage. doi: 10.1016/j.neuroimage.2019.02.026 |

### 1. Data

Data are available online at: https://web.gin.g-node.org/doi/RealObjectsEEG. This dataset is structured in two main folders (/data and /scripts), each containing several subfolders. This dataset include pre-processed EEG timeseries segmented in epochs corresponding to the experimental trials and marked with event codes for identifying the experimental events. The corresponding files (under /data/ersp_analyses) are provided in EEGLAB [2] format and can be loaded into EEGLAB [2] using ‘Load existing dataset’ from the ‘File’ menu. To visualize channel timeseries, use ‘Channel data (scroll)’ from the ‘Plot’ menu (Fig. 1). For a description of the event codes and the corresponding experimental events, please see Fig. 2, Table 1 and paragraph 2.2 below. Behavioral data, trial information, and other EEG-related data such as event-codes and latencies, are included in data summary files (under /data/data_summary; see Paragraph 2.3 below). We also included the analysis scripts that were used to process the data and generate the figures and results described in the related article [1]. These scripts can be found under /scripts and are organized within different subfolders that correspond to the different analyses and figures described in Ref. [1] (see Paragraph 2.4 below). In order to run the analysis code described in this paper and reproduce the results of [1], the Matlab® software package is required as well as EEGLAB [2] with the following plug-ins: ERPLAB [3], Mass Univariate ERP Toolbox [4], BDF-import, CleanLine, FIRfilt. As a preliminary operation we recommend to add the path of the upper-level folder (ro_eeg_data_repository), including all subfolders, to the current Matlab® path. It
may be necessary to edit the path at line 4 of the script `RO_EEG_LoadSettings.m` (under/scripts/helpers) to reflect the actual path of the `ro_eeg_data_repository` folder.

2. Experimental design, materials, and methods

The experimental design, task, and data acquisition procedures are described in the linked article [1].

2.1. Data pre-processing

Raw data were digitized at 1 KHz and imported into EEGLAB 14.1.2 [2] using the BDF plugin. Data were re-referenced to the mastoids average during importing. Then, data were bandpass filtered (1–100 Hz) using:

```matlab
>> EEG = pop_eegfiltnew(EEG, 1, 100, 3380, 1, [], 1);
```

Noisy channels were interpolated with the following commands:

```matlab
>> [~, chan2interp] = pop_rejchan(EEG, 'elec', [1:128], 'threshold', 8, 'norm', 'on', 'measure', 'prob');
>> EEG = pop_interp(EEG, chan2interp, 'spherical');
```
Line noise was attenuated:

\[
\text{EEG} = \text{pop\_cleante\_EEG}('\text{bandwidth}', 2, '\text{chanlist}', [1:134], '\text{compute\_power}', 1, '\text{linefreqs}', [60 120], '\text{norm\_Spectrum}', 0, 'p', 0.01, 'pad', 2, 'plot\_figures', 0, 'scan\_for\_lines', 1, 'sig\_type', 'Channels', 'tau', 100, 'verb', 1, 'wins\_size', 4, 'wins\_step', 1));
\]

Epochs were created from -800 ms to 2000 ms relative to stimulus onset:

\[
\text{EEG} = \text{pop\_epoch}('\text{EEG}', 1:192, [-0.8 2], 'newname', 'fullePOCHS', 'epoch\_info', 'yes');
\]

Epochs containing artifacts were rejected using a voltage-based threshold:

\[
\text{EEG} = \text{pop\_eegthresh}('\text{EEG}', 1, [1:71 75 76 77 84 85:90 97 98:128], [300, 300, -0.8, 2, 0, 0]);
\]

Independent component analysis (ICA) was performed:

\[
\text{EEG} = \text{pop\_runica}('\text{EEG}', 'extended', 1, 'interrupt', 'on', 'pca', \text{EEG.nbchan}-\text{numel(chan2interp)});
\]

Components containing artifacts (i.e., eye movements, muscular activity, etc.) were identified by an expert and rejected (see Fig. 3 for a representative example). Prior to the expert's review of the data set for component rejection, equivalent current dipole source estimation was conducted to provide the expert with additional information useful for component rejection (such as the scalp topography and the amount of residual variance for each component). The criteria that were followed for identifying

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**Fig. 2.** Schematic representation of a single experimental trial with EEG event codes and their corresponding time-points and meaning. The figure includes a brief description of the experimenters and subjects' tasks at any given moment within a trial.

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Table 1

| id  | displ | cat      | name        | id  | displ | cat      | name        | id  | displ | cat      | name        |
|-----|-------|----------|-------------|-----|-------|----------|-------------|-----|-------|----------|-------------|
| 1   | real  | garage   | chisels     | 49  | real  | kitchen  | pasta fork  | 97  | image | garage   | chisels     |
| 2   | real  | garage   | chisels     | 50  | real  | kitchen  | pasta fork  | 98  | image | garage   | chisels     |
| 3   | real  | garage   | chisels     | 51  | real  | kitchen  | pasta fork  | 99  | image | garage   | chisels     |
| 4   | real  | garage   | file        | 52  | real  | kitchen  | fork        | 100 | image | garage   | file        |
| 5   | real  | garage   | file        | 53  | real  | kitchen  | fork        | 101 | image | garage   | file        |
| 6   | real  | garage   | file        | 54  | real  | kitchen  | fork        | 102 | image | garage   | file        |
| 7   | real  | garage   | file        | 55  | real  | kitchen  | grater      | 103 | image | garage   | file        |
| 8   | real  | garage   | file        | 56  | real  | kitchen  | grater      | 104 | image | garage   | file        |
| 9   | real  | garage   | file        | 57  | real  | kitchen  | grater      | 105 | image | garage   | file        |
| 10  | real  | garage   | paint sponge| 58  | real  | kitchen  | chef knife  | 106 | image | garage   | paint sponge |
| 11  | real  | garage   | paint sponge| 59  | real  | kitchen  | chef knife  | 107 | image | garage   | paint sponge |
| 12  | real  | garage   | paint sponge| 60  | real  | kitchen  | chef knife  | 108 | image | garage   | paint sponge |
| 13  | real  | garage   | hand clamps | 61  | real  | kitchen  | ladle       | 109 | image | garage   | hand clamps |
| 14  | real  | garage   | hand clamps | 62  | real  | kitchen  | ladle       | 110 | image | garage   | hand clamps |
| 15  | real  | garage   | hand clamps | 63  | real  | kitchen  | ladle       | 111 | image | garage   | hand clamps |
| 16  | real  | garage   | handsaw     | 64  | real  | kitchen  | lighter     | 112 | image | garage   | handsaw     |
| 17  | real  | garage   | handsaw     | 65  | real  | kitchen  | lighter     | 113 | image | garage   | handsaw     |
| 18  | real  | garage   | handsaw     | 66  | real  | kitchen  | lighter     | 114 | image | garage   | handsaw     |
| 19  | real  | garage   | paintbrush  | 67  | real  | kitchen  | pizza cutter| 115 | image | garage   | paintbrush  |
| 20  | real  | garage   | paintbrush  | 68  | real  | kitchen  | pizza cutter| 116 | image | garage   | paintbrush  |
| 21  | real  | garage   | paintbrush  | 69  | real  | kitchen  | pizza cutter| 117 | image | garage   | paintbrush  |
| 22  | real  | garage   | pliers (long)| 70  | real  | kitchen  | masher      | 118 | image | garage   | pliers (long) |
| 23  | real  | garage   | pliers (long)| 71  | real  | kitchen  | masher      | 119 | image | garage   | pliers (long) |
| 24  | real  | garage   | pliers (long)| 72  | real  | kitchen  | masher      | 120 | image | garage   | pliers (long) |
| 25  | real  | garage   | hammer      | 73  | real  | kitchen  | scissors    | 121 | image | garage   | hammer      |
| 26  | real  | garage   | hammer      | 74  | real  | kitchen  | scissors    | 122 | image | garage   | hammer      |
| 27  | real  | garage   | hammer      | 75  | real  | kitchen  | scissors    | 123 | image | garage   | hammer      |

(continued on next page)
| id | displ | cat     | name  | id | displ | cat     | name  |
|----|-------|---------|-------|----|-------|---------|-------|
| 28 | real  | garage  | pruner| 76 | real  | kitchen | scoop |
| 29 | real  | garage  | pruner| 77 | real  | kitchen | scoop |
| 30 | real  | garage  | putty knife | 78 | real  | kitchen | basting |
| 31 | real  | garage  | putty knife | 79 | real  | kitchen | basting |
| 32 | real  | garage  | putty knife | 80 | real  | kitchen | basting |
| 33 | real  | garage  | putty knife | 81 | real  | kitchen | basting |
| 34 | real  | garage  | screwdriver | 82 | real  | kitchen | spatula |
| 35 | real  | garage  | screwdriver | 83 | real  | kitchen | spatula |
| 36 | real  | garage  | screwdriver | 84 | real  | kitchen | spatula |
| 37 | real  | garage  | trim roller | 85 | real  | kitchen | spoon |
| 38 | real  | garage  | trim roller | 86 | real  | kitchen | spoon |
| 39 | real  | garage  | trim roller | 87 | real  | kitchen | spoon |
| 40 | real  | garage  | utility knife | 88 | real  | kitchen | tongs |
| 41 | real  | garage  | utility knife | 89 | real  | kitchen | tongs |
| 42 | real  | garage  | utility knife | 90 | real  | kitchen | tongs |
| 43 | real  | garage  | wire brush | 91 | real  | kitchen | turner |
| 44 | real  | garage  | wire brush | 92 | real  | kitchen | turner |
| 45 | real  | garage  | wire brush | 93 | real  | kitchen | turner |
| 46 | real  | garage  | wrench | 94 | real  | kitchen | whisk |
| 47 | real  | garage  | wrench | 95 | real  | kitchen | whisk |
| 48 | real  | garage  | wrench | 96 | real  | kitchen | whisk |

Table 1 (continued)
candidate ICs for rejection include: spatial topography localized within or near the eyes; non-dipolar spatial topography, as indicated by residual variance of the equivalent current dipole greater than 15%; power spectral density with a profile that did not follow a 1/f pattern (e.g., with relatively low power at lower frequencies at high broadband power). These criteria are standardized and have been validated by a large community of EEG researchers. Further information, including training resources, are available online at: https://labeling.ucsd.edu/tutorial and in a related journal publication [3]. To prevent excessive data trimming, components that were not unequivocally attributed to any category, including components with mixtures of brain-related and non-brain-related activity, were retained in the data. Moreover, researchers who wish to refine the IC selection are encouraged to do so by using an automated labeling toolbox for EEGLAB that has been recently released [4]. The data in/data/ersp_analyses were preprocessed up to this level. However, additional pre-processing steps were conducted in preparation for the mass univariate ERP analysis [5], which relies on the utilization of the Mass Univariate ERP Toolbox [5], and for other potential ERP analyses. First, EEG was down-sampled to 128Hz, low-pass filtered with a 30Hz cut-off (although non-filtered EEG was also retained and processed further), and epochs were created from −200 ms to 800 ms and baseline corrected in the period from −200 ms to 0 ms, with all times relative to stimulus onset. Non-filtered single-trial EEG was organized in a 4-D matrix (subject, electrode, timepoint, trial) and stored in the file n24_SingleTrialEEG.mat (under/data/erp_analyses). Group averages were calculated separately for low-pass filtered and non-filtered data in each experimental condition, and stored in separate variables in the file GA_24subjects.mat (under/data/erp_analyses). Researchers who are interested in reproducing any ERP analysis described in Ref. [1] should use data files provided in/data/erp_analyses; this includes some format-specific files that are necessary to replicate the mass univariate analysis.

2.2. Event codes

EEG data files contain two types of event codes: (i) a code from 1 to 192 that corresponds to the actual experimental stimulus presented on each trial (i.e. what object was presented, and in what display format), and (ii) a code (239) that marks the end of the stimulus presentation period. Please note that codes from 1 to 192 also mark the moment of the beginning of the stimulus presentation period. Additional event codes were used in this experiment (for example, corresponding to participants’ responses), but they were delivered outside of the time-windows of this epoched dataset, and therefore they are not visible in the EEG dataset. However, these additional codes may be present

Fig. 3. Example of independent component rejection based on expert review. Ten components from one example subject (#24) are shown prior to rejection, but after an expert has performed labeling. Components with a red background have been selected for rejection, while components with a green background will be retained in the dataset.
elsewhere in the data (for example, they have been used within the analysis scripts and are contained in data summary files; see Paragraph 2.3). Therefore, we provided a figure and a table describing all event codes comprehensively (Fig. 2 and Table 1).

2.3. Data summary files

Behavioral data are available within data summary files. These files are named Sub-JXX_DataSummary.mat (where ‘XX’ is replaced by a two-digit subject number from ‘01’ to ‘24’) and are located in/data/data_summary. Data summary files contain on-line effort ratings (variable: experiment_table, column 12; see LoadTableIndexes.m) as well as off-line familiarity and frequency-of-use ratings (variable: experiment_table_Quest, columns 2 and 3, respectively; see LoadTableIndexes.m). In addition, data summary files include the variables EventCodes and Latencies, which contain a trial-by-trial list of all event codes and their corresponding latencies, respectively. Finally, the variable li, also included in data summary files, contains logical indexes for trials of the two experimental conditions (li.Real and li.Image) as well as logical indexes for trials that must be rejected due to EEG artifacts (li.RejectEpochs) and for trials with non-missing behavioral responses (li.trialsToAccept). The function LoadTableIndexes.m is provided as a helper to facilitate column access to the variables within Data Summary mat-files.

2.4. Analysis scripts

Analysis of behavioral data. The methods used for this analysis are described in Ref. [1]. Here, we provide the list of analysis scripts that can be used to reproduce Fig. 1C of [1]. These script are located in/scripts/behavior:

1. RO_EEG_SaveStimScores.m
2. RO_EEG_FiguresBehavior.m

ERSP power analysis. The methods used for this analysis are described in Ref. [1]. Here, we provide the list of analysis scripts that can be used to reproduce the figures presented in Ref. [1].

Analysis of ERSP in central electrode cluster (Fig. 2 in Ref. [1]; scripts located in/scripts/ersp_Ccluster):

1. RO_EEG_SingleTrial_TimeFrequency_Decomposition_Ccluster.m
2. RO_EEG_TFspectra_Ccluster.m
3. RO_EEG_TFgroup_PermTest_Ccluster.m

Analysis of lateralized ERSPs (Figure 4 in Ref. [1]; scripts located in/scripts/ersp_lateralized):

1. RO_EEG_SingleTrial_TimeFrequency_Decomposition_C3.m
2. RO_EEG_SingleTrial_TimeFrequency_Decomposition_C4.m
3. RO_EEG_TFspectra_C3C4.m
4. RO_EEG_TFgroup_PermTest_C3C4.m

Analysis of item-based brain-behavior correlation (Fig. 3 in Ref. [1]; scripts located in/scripts/ersp_corrBehav):

1. RO_EEG_SingleTrial_QuickTF_Ccluster.m
2. RO_EEG_ItemAnalysis_SlidingWindow_Analysis.m
3. RO_EEG_ItemAnalysis_SlidingWindow_Figure.m

ERP analysis. The methods used for this analysis are described in Ref. [1]. Here, we provide the list of analysis scripts and related data files that can be used to reproduce the figures presented in Ref. [1].
Mass univariate analysis of ERPs (Figure 5 in Ref. [1]; scripts located in /scripts/erp_mua):

1. RO_EEG_MassUnivariateAnalysisERP.m
2. RO_EEG_FiguresERP_ROI1.m
3. RO_EEG_FiguresERP_ROI2.m

Analysis of late parietal ERPs (Figure 6 in Ref. [1]; scripts located in /scripts/erp_lpp; please note that this analysis requires to run RO_EEG_MassUnivariateAnalysisERP.m as a pre-requisite):

1. RO_EEG_LPP.m
2. RO_EEG_LPP_ROIanalysis.m

Control analysis. This analysis consists of a replication of previously-described ERSP and ERP analyses when only a subset of trials is used (see Ref. [1] for further details). Because we have already provided scripts to conduct both ERSP and ERP analyses, here we are providing a script that identifies the subset of trials used for the control ERSP and ERP analyses in Ref. [1]. This script, RO_EEG_ControlAnalysis.m, is located in /scripts/control, and its execution produces a .mat file containing the variable trialsToKeep as well as a copy of Fig. 7A in Ref. [1]. The variable trialsToKeep is a 3-D matrix (subject, trial, condition) with logical indexes corresponding to trials that were used for the control analysis (please note: under ‘condition’, the first dimension is ‘real object’ and the second is ‘image’). These logical indexes can be used within the previously-described ERSP and ERP analysis scripts in order to restrict such analyses to the desired subset of trials.

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Transparency document

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.dib.2019.103857.

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[1] F. Marini, K.A. Breeding, J.C. Snow, Distinct visuo-motor brain dynamics for real-world objects versus planar images, Neuroimage (2019), https://doi.org/10.1016/j.neuroimage.2019.02.026.
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