The fMRI preregistration template

**The evolution of the template:**

| **2018**  **(original)**  Jessica Flannery | Adopted the text from the OSF preregistration challenge template to include the details important for fMRI psychology design. The OSF template was retained in some areas and edited in other areas to incorporate both prior published templates and guidelines regarding fMRI (Nichols et al., 2016; Poldrack et al., 2008; van’t Veer & Giner-Sorolla, 2016). Find the current version here: <https://osf.io/6juft/> |
| --- | --- |
| **Nov 2019**  MPI-CBS  hackathon | Discussed the structure and rearranged the sections of the preregistration so that they matched the [OSF preregistration template](https://docs.google.com/document/d/1DaNmJEtBy04bq1l5OxS4JAscdZEkUGATURWwnBKLYxk/edit?pli=1) (Study Information, Design Plan, Sampling Plan, Variables, Analysis Plan, Other). Agreed it would be best to first focus on task/resting state fMRI studies with this template (e.g. exclude sMRI and DWI for the moment). |
| **June 2020**  MPI-CBS  hackathon | Worked on details of the experimental design (regarding neuropsychological testing and design/implementation of the behavioral task). Swapped the order of Design and Sampling Plan from the original OSF template. Restructured the Acquisition and Preprocessing section to improve the usability regarding the details of MRI sequences and preprocessing settings. |
| **Aug 2020**  MPI-CBS  hackathon | Sandra, Emiliano, Peer, Abdalla, Remy, Frauke, Lina, and Eleni went through the document until analyses section, discussed and made comments on sections that need further improvement. Decided that the template should focus on a “basic” design with anatomical sequences + task-based fMRI + additional behavioral/questionnaires. Encourage the preregistration of other modalities and experiments but don’t want to give more detail about these to keep the document as comprehensive as possible. Decided to make the template detailed to nudge people into considering certain topics (e.g. power analysis). |
| **Mar 2021**  MPI-CBS  hackathon | Lina, Frauke, Hannah, Jessica, Maurizio, Lieneke, Arsene went through the template and identified open (and new) discussion points. A major point was to provide a concise or detailed preregistration template. In the current version many parameters and decisions cannot or are usually not altered after having acquired the data (e.g. sequence parameters, design plan), and are thus usually not subject to researchers’ degrees of freedom. Therefore it was decided to make these less prominent in the template, and put more emphasis on hypothesis formulation, preprocessing and analysis plan. To not scare people away, essential/optional tags should be added, and examples provided instead of exhaustive lists of possible parameters. It was also decided to shorten the power analysis part not to make the document too educational. Finally, a schedule was agreed on, see below. |

**Discussion points**

* detailed vs. concise description of elements, or support both?
  + template might be too overwhelming if detailed -> rather break down by using mandatory/optional, maybe have “defaults” of programs in supplements/methods part to make sure they are reported
  + lots of details about things that you cannot change after you have conducted your experiment (fmri sequence), most people preregister after they have acquired their task
  + move acquisition parameters and other parts which are important for manuscript but not for preregistration to appendix
* mark recommended and essential labels (e.g., relating to the choice of going with a detailed vs. concise description)
* other modalities (to be added after publishing the fMRI specific template)
* incorporate fmriprep’s defaults
* align structure with structure of a manuscript: decision: keep current order (OSF template) and move into a more concise version
* use tables as list of check boxes when writing methods section
* power analysis: unknown effect sizes and practical limitations in fMRI studies rather than a-priori power analysis which are rarely done. Exploratory vs. confirmatory analyses,

# Table of contents

[**Usage Notes to the template**](#_8kgp0t6k31w4) **1**

[**Study Information**](#_774mkwbtq21o) **1**

[Working title\*](#_2et92p0) 1

[Authors\*](#_tyjcwt) 1

[Description](#_3dy6vkm) 1

[Hypotheses\*](#_1t3h5sf) 1

[**Design Plan**](#_4d34og8) **2**

[Study Type\*](#_xzqz60g3j4ua) 2

[Study Design\*](#_5zd8fnkg6zv8) 2

[Experimental design\*](#_v9mw24180q5p) 3

[Blinding\*](#_cuoqiwcte3v0) 4

[Randomization\*](#_ottb9b33tnk4) 4

[**Sampling Plan**](#_kol1ukav7278) **5**

[Details of Larger Project\*](#_irrudfz3thyl) 5

[Existing data\*](#_l9nw9vlx35ds) 5

[Data collection\*](#_9l95jwen0ne5) 6

[Sample Size\*](#_e2a5en99wm9z) 7

[**Variables**](#_8tgndtg94z1l) **8**

[Manipulated variables](#_44sinio) 8

[Measured variables\*](#_omxd3x3jr2d7) 8

[**Analysis Plan**](#_3j2qqm3) **12**

[Statistical modeling\*](#_1y810tw) 12

[Follow-up Analyses](#_d7wttu1v8sy7) 16

[Exploratory Analyses](#_15xeyed026qw) 16

[**Appendices**](#_5ge4d96nd9j) **1**

[Appendix 1: Examples of fMRI study pre-registrations](#_u1pp9xrkm7be) 1

[Appendix 2: fMRI data acquisition checklists](#_yfwkl8r9654m) 2

[Appendix 3: Additional fMRI analyses](#_1ksv4uv) 5

# Usage Notes to the template

*The goal of this template is to provide sufficient information in preregistration of fMRI studies to increase reproducibility.*

*A \* indicates you should fill out this section, all other sections are optional.*

*You can use the tables to fill in your design specifications, or use them as checklists of information you include in the text for in attached files (e.g., json file of scan parameters). If a certain table/section does not apply, just state “NA.” Tip: Using it as a checklist will allow you to write these sections as they will appear in your future paper.*

# Study Information

## Working title\*

A specific and informative description of your planned study. It doesn’t have to be the same title that you use for later publication.

## Authors\*

This can but does not need to include authorship order and/or contributions planned for later publication.

## Description

Give a brief introduction with some background, purpose or aims of the study, or broad research question to help to ensure your hypotheses are properly informed. The recommended length is that of an abstract. One may also consider to write this section as a concise introduction for the planned publication.

## Hypotheses\*

List each hypothesis you want to test as part of this study. Each hypothesis should be specific, concise and testable. The table below can be used as a checklist.

Be as specific as possible about your regions of interest (ROI) and definitions of other relevant variables mentioned here. How to define your ROIs or operationalize these relevant variables should be detailed in the section **Variables** and **Analysis Plan**.

| \_\_ | Is the hypothesis directional or non-directional? |
| --- | --- |
| \_\_or NA | If directional, state the directional relationship between your (manipulated or measured) variables. |
| \_\_or NA | For interaction effects, describe the expected shape of the interactions. |
| \_\_or NA | If you are manipulating a variable, formulate predictions for successful manipulation checks: What variables will you use to check whether your manipulation worked? If not, explain why no manipulation check is included. |
| \_\_or NA | A figure or table with expected results, e.g., to describe complex interactions. |
| \_\_or NA | If multiple alternative predictions can be made for the same IV-DV combination, describe what outcome would be predicted by which theory. |

*Adapted from van’t Veer & Giner-Sorolla, 2016*

# Design Plan

*Describe the overall design of your study. This research plan is designed to register a single study, so if you have multiple experimental designs that you wish to preregister, please complete separate preregistrations for each of them.*

## Study Type\*

| \_\_ | Experiment (incl. a manipulation or treatment to which participants are randomly assigned) |
| --- | --- |
| \_\_ | Observational study (data collected from subjects without having been randomly assigned to a treatment) |
| \_\_ | Other: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |

## Study Design\*

Describe your **study design**. Is it a between-subjects (unpaired), within-subjects (paired), or mixed design? If applicable, specify manipulation(s), groups tested, and repeated measurements. For typical types of study designs, see Appendix 2.

| **Experiment / Intervention study**: involves a manipulation of exposure on the subject level | |
| --- | --- |
| \_\_ or NA | Are effects of an intervention tested in one population by allocating participants randomly to the experimental or control group and testing pre and post intervention? (randomized controlled study) |
| \_\_or NA | Are participants allocated to only one group or re-allocated to the other group after a wash-out period? (crossover study) |
| \_\_or NA | Are intervention effects tested in different populations? (e.g., patients vs. controls) |
| **Observational study**: only measures exposures and outcomes, no manipulation of the exposure | |
| \_\_or NA | case-control study (e.g. patients vs. healthy controls) |
| \_\_or NA | classical fMRI study (e.g. healthy participants performing the same task) |
| \_\_or NA | cross-sectional study (e.g. differences in fMRI activity predict between-person differences in a trait) |
| \_\_or NA | cohort study/longitudinal study (e.g. fMRI or change in fMRI predict within-person change in a trait) |

## Experimental design\*

Describe the experimental design of the task(s) performed in the scanner. You can fill in the table for each task or write a paragraph below as you would for your publication and use the table as a checklist. Consider sharing the code and link to it here.

| **Design specification** | | |  |
| --- | --- | --- | --- |
| \_\_ | Design type (task, rest; event-related, block, mixed design, naturalistic) | |  |
| \_\_ | Instructions to subjects (what were they asked to do?) | |  |
| \_\_ | State whether or not participants practiced the task, and if so, describe the practice. | |  |
| \_\_ | Conditions & Stimuli (as detailed as possible, pictures encouraged) | |  |
| \_\_ | Number of runs, blocks, trials or experimental units per session and/or subject | |  |
| \_\_ | Timing and Duration (length of each trial and interval between trials, jitter) | |  |
| \_\_or NA | Was the design optimized for efficiency? If so, how? | |  |
| \_\_or NA | Randomization/pseudo-randomized/counterbalancing (why/why not done & how) | |  |
| \_\_ | Length of experiment (length of full scan and each run) | |  |
| \_\_or NA | Run order (of tasks within scanner) | |  |
| \_\_ | Presentation software & response collection (software and hardware, name, version, operating system; code if possible) | |  |
| **Piloting** | | |  |
| \_\_or NA | Did you validate your stimuli? (If yes, describe study & results) | |  |
| \_\_or NA | Did you pilot your study design? (If yes, describe study and results) | |  |

*Note: this question has a variety of possible answers. The key is for a researcher to be as detailed as is necessary given the specifics of their design. Be careful to determine if every parameter has been specified in the description of the study design. There may be some overlap between this section and the following section. That is OK, as long as sufficient detail is given in one of the areas to provide all of the requested information.*

## Blinding\*

Blinding describes who is aware of the experimental manipulations within a study.

| \_\_or NA | No blinding is involved in this study. |
| --- | --- |
| \_\_or NA | For studies that involve human subjects, they will not know the treatment group to which they have been assigned. |
| \_\_or NA | Personnel who interact directly with the study subjects (either human or non-human subjects) will not be aware of the assigned treatments. (Commonly known as “double blind”) |
| \_\_or NA | Personnel who analyze the data collected from the study are not aware of the treatment applied to any given group. |
| \_\_or NA | Additional blinding in this study:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |

## Randomization\*

Is there any form of randomization of your participants and/or staff? If so, detail the type of randomization (e.g., simple randomization, block randomization, stratified randomization, minimization) and the mechanism used to implement the random allocation sequence (e.g., a certain software). Note that the randomization applied in the experimental design of your task can be described in the section **Study Design** above.

# Sampling Plan

*Describe how you plan to collect samples, as well as the number of samples you plan to collect and your rationale for this decision. Please keep in mind that the data described in this section should be the actual data used for analysis, so if you are using a subset of a larger dataset, please describe the subset that will actually be used in your study.*

## Details of Larger Project\*

Is your preregistration part of a larger project?

* + No
  + Yes  
    If yes, provide a brief description of the larger study or, if applicable, link to the OSF project page, a related preregistration, a poster, etc. You may also include a figure detailing the protocol of the project. Note, this is meant to provide context for the larger scope of the project.

## Existing data\*

Preregistration is designed to emphasize the distinction between confirmatory tests, specified prior to seeing the data, and exploratory analyses conducted without specific hypothesis or after observing the data. Therefore, creating a research plan in which existing data will be used presents unique challenges. For research that uses existing datasets (e.g. Human Connectome Project, UK biobank, etc.), we also refer to the OSF preregistration template for secondary data analysis, which was designed specifically for this type of analytical research (<https://osf.io/x4gzt/>). Please select the description that best describes your situation:

* + Registration prior to creation of data
  + Registration prior to accessing the data
  + Registration prior to any human observation of the data
  + Registration prior to analysis of the data
  + Registration following analysis of the data

Explanation of Existing Data

If you indicate that you will be using some data that already exists in this study, please describe your prior knowledge of any patterns or summary statistics in the data. This may include an explanation of how access to the data has been limited, who has observed the data, and if/what is already known about the sample you investigate (e.g., links to prior papers, osf project page, prior posters or talks, or descriptions). The purpose of this question is to assure that the line between confirmatory and exploratory analysis is clear.

## Data collection\*

Is this preregistration done before data collection?

* + No  
    There is no need to describe the data collection in complete detail in your preregistration. Nonetheless, it is strongly recommended to include information on your sample (see checklist below), behavioral and fMRI data acquisition (**Appendix 2**) in a short paragraph as it would appear in the Methods section of a publication. Especially mention details important for your choices in **Variables** and **Analysis Plan** (e.g. temporal/spatial resolution of fMRI which may motivate certain preprocessing or analysis procedures).
  + Yes  
    Describe all steps of data collection including your sample description (see checklist below). Make sure to detail procedures of all relevant behavioral and fMRI data acquisition steps. Other measurements relevant to address your hypotheses or that are included for different purposes (e.g., characterizing groups, sensitivity analysis, exploratory analysis) may also be detailed here. For the task-based fMRI measurements you can use the table in **Appendix 2** as a checklist of topics to cover in this description.

*Note: There may be some overlap between this and other sections. Again, that is OK, as long as sufficient detail is given in one of the areas to provide all of the requested information.*

| Sample description | |
| --- | --- |
| \_\_ | Population | |
| \_\_ | Recruitment efforts | |
| \_\_ | Inclusion criteria | |
| \_\_ | Exclusion criteria | |
| \_\_ | Reimbursement for participation | |
| \_\_ | Information on ethics approval and informed consent | |
| \_\_ | Number of participants tested and analyzed | |
| \_\_ | Age | |
| \_\_ | Sex / Gender | |
| \_\_ | Handedness | |
| \_\_or NA | Clinical criteria | |
| \_\_or NA | Matching strategy | |
| \_\_or NA | Other relevant participant or group characteristics for your study | |
| \_\_ | Study timeline including all measures | |

Other Measures

Please specify all additional measures you plan to investigate, for example:

* **Experimental tasks outside the scanner:** For each additional behavioral task, give a short description and specify the design and task. You may use the table for the design of scanner tasks in the section **Design Plan** as a checklist.
* **Questionnaires and standardized assessments:** For each questionnaire and standardized assessment, mention the name and version.
* **Additional neuroimaging measures:** Give a description and brief purpose statement of any other imaging modalities that will be included in your study (e.g., EEG, Neuromodulation (TMS, tDCS, …)).
* **Physiological recordings:** Give a description and brief purpose statement of any physiological data that will be collected from the participants before/during/after fMRI (e.g. eye-tracking, pulse, electrocardiography, plethysmography (pulse oximetry), respiration, blood pressure, blood samples, skin conductance (SCR), electromyography, etc.). For each measure, mention the device.

*Note that parts of this section may be covered in the Design Plan section instead.*

## Sample Size\*

State your target sample size and, if applicable, your stopping rule. Justify your choices.

Justification of sample size or stopping rule:

| \_\_or NA | Power Analysis for fMRI or behavioral analysis. Please provide all details on your calculation. (strongly recommended, no standard procedures for fMRI power analysis but see <https://brainpower.readthedocs.io/en/latest/index.html> for available tools) |
| --- | --- |
| \_\_or NA | Time constraints (e.g., will recruit for one year or until X date) |
| \_\_or NA | Money constraints (e.g., monetary support will support up to X subjects) |
| \_\_or NA | Personnel constraints (e.g., will recruit for time period in which personnel support is available) |
| \_\_ | Other: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |

If possible, include contingencies for if your target sample size is not met. E.g., how will hypotheses be adopted to better powered question?

# Variables

*In this section you can describe all variables (both manipulated and measured variables) that will later be used in your analysis plan. In your analysis plan, you will have the opportunity to describe how each variable will be used. If you have variables which you are measuring for exploratory analyses, you are not required to list them, though you are permitted to do so.*

## Manipulated variables

Describe all variables you plan to manipulate and the levels or treatment arms of each variable. This is not applicable to an observational study.

## Measured variables\*

Behavioral data

Describe each variable that you will measure and indicate the corresponding confirmatory hypothesis. You can use the checklist below.

| **Measured variables** | |
| --- | --- |
| \_\_ | **Outcome** measures/dependent variables (specify whether confirmatory or exploratory outcome, how variable was measured, scale/range of measure, which subscale/component of measure you will use). |
| \_\_ | **Predictor** measures/independent variables (specific measure, scale/range of measure, which subscale/component of measure you will use). |
| \_\_or NA | **Covariate** measures (specific measure, scale/range of measure, which subscale/component of measure you will use). |
| **Quality control** | |
| \_\_ | Any outcome-neutral criteria that must be met for successful testing of the stated hypotheses. Such quality checks might include the absence of floor or ceiling effects in data distributions, positive controls, or other quality checks that are orthogonal to the experimental hypotheses. |
| \_\_or NA | How will you determine which subjects, data points or measures (if any) to **exclude** from your analyses? If possible, specify objective exclusion criteria (due to technical errors, slow reactions, instructions not understood, accuracy below a certain threshold, or for any other reasons). |
| \_\_or NA | How will you deal with incomplete or missing data (e.g., missing timepoints or missing/incomplete data within or between runs; what percent missing will be included)? Under what conditions would data be replaced and how? |
| \_\_or NA | If possible, define contingency plans how to proceed in such cases, (e.g., plans if x% of behavioral data is missing; if the X questionnaire is missing for more than 10% of participants we will not use it or if X does not show variability in response (either ceiling or floor effects) in which we cannot look at behavioral pattern of interest, we will not use that questionnaire and use Y questionnaire instead). |
| **Transformations** | |
| \_\_or NA | If you plan on transforming, centering, recoding the data, or will require a coding scheme for categorical variables, please describe that process.  Include contingency plans for transformation: (e.g., transformations that will occur if data are skewed or for model convergence/multicollinearity) |
| **Code** |  |
| \_\_or NA | Link to shared code for scoring behavioral data. |

fMRI data

Describe what variable will be measured (e.g., BOLD response) and detail all preprocessing steps. You can fill in the table or write paragraph below as you would for paper and use the table as checklist of topics covered.

For each piece of software used, give the version number. Also indicate which platform you ran the software on.

| **Quality control** | | **software, version** |
| --- | --- | --- |
| \_\_or NA | incidental findings (Protocol for review of any incidental findings, and how they are handled in particular with respect to possible exclusion of a subject’s data.) |  |
| \_\_ | motion monitoring (For functional acquisitions, any visual or qualitative checks for severe motion; likewise, for structural images, checks on motion or general image quality.) Including prospective quantitative motion monitoring and/or correction? |  |
| \_\_ | How will you determine which data points or samples (if any) to exclude from your analyses? How will outliers be defined and handled?  If possible, specify objective exclusion criteria, e.g.   * a participant has X percentage of volumes with motion or exceeds pre-defined motion threshold? * general artifacts qualitatively or quantitatively defined (multi band stripes, respiration-related … ) * registration fails because of atrophy, brain lesion … |  |
| \_\_or NA | How will you deal with incomplete or missing data (e.g., missing timepoints or missing/incomplete data within or between runs; what percent missing will be included)? Under what conditions would data be replaced? |  |
| \_\_or NA | Other quantitative quality control metrics (signal-to-noise ratio, contrast-to-noise ratio, motion parameters, outliers, etc)? How will these be assessed (e.g. which software, version, etc)? Will any of these metrics factor into the decision to exclude subjects? If so, how? |  |
| **Anatomical preprocessing** (e.g. which steps are taken before coregistration of anatomical & functional) | | |
| \_\_or NA | Intensity non-uniformity correction |  |
| \_\_or NA | brain extraction |  |
| \_\_or NA | tissue segmentation |  |
| **Functional preprocessing** | | |
| \_\_or NA | Remove first volumes to reach steady-state (during acquisition or preprocessing)? How many volumes were discarded? |  |
| \_\_or NA | **Distortion correction** (fieldmap, ap-pa acquisitions) |  |
| \_\_or NA | **Intensity normalization** |  |
| \_\_or NA | **Slice timing correction** (specify reference slice, e.g., first slice, and interpolation, e.g., Fourier phase shift interpolation) |  |
| \_\_or NA | **Primary motion correction (realignment)** (reference scan for realignment, image similarity metric, type of interpolation used, degrees-of-freedom and optimization method) |  |
| \_\_or NA | **Intrasubject registration (e.g. anatomical to functional)** |  |
| \_\_or NA | Directionality (e.g. anatomical to functional, functional session 1 to functional session 2, etc) |  |
| \_\_or NA | Transformation model (linear or nonlinear) |  |
| \_\_or NA | Degrees of freedom |  |
| \_\_or NA | Interpolation method |  |
| \_\_or NA | Image similarity metric |  |
| \_\_or NA | **Intersubject registration (e.g. anatomical/functional to template)** |  |
| \_\_or NA | Brain image template space, name, modality and resolution (e.g., MNI Avg152, T1 2 × 2 × 2 mm; customized sample template) |  |
| \_\_or NA | Directionality (e.g. anatomical to functional, functional session 1 to functional session 2, etc) |  |
| \_\_or NA | Transformation model (linear or nonlinear) |  |
| \_\_or NA | Degrees of freedom |  |
| \_\_or NA | Interpolation method |  |
| \_\_or NA | Image similarity metric |  |
| \_\_or NA | **Smoothing**  Size and type of smoothing kernel (provide justification for size; e.g., for a group study, “12 mm FHWM Gaussian smoothing applied to ameliorate differences in intersubject localization”; for single subject fMRI “6 mm FWHM Gaussian smoothing used to reduce noise”) |  |
| \_\_or NA | **Temporal filtering** (type of filter, frequency band) |  |
| **Flowchart** | | |
| \_\_or NA | A flowchart can be attached that depicts the order of the preprocessing steps for each acquisition type (anatomical and functional). |  |
| **Code** |  |  |
| \_\_or NA | Link to shared code for preprocessing data |  |

# Analysis Plan

*In this section, you describe all confirmatory analyses you plan to conduct. Be as specific as possible (e.g. assign each hypothesis to be tested to the corresponding model in this section; specify the usage of covariates in sensitivity analyses and the selection of regions of interest). If you plan to include additional fMRI analyses techniques, check Appendix 3 for checklists.*

## Statistical modeling\*

Behavioral analysis

Specify all analyses to test your hypotheses. Remember that all confirmatory analyses specified below must be reported in the final article, and any additional analyses must be noted as exploratory or hypothesis generating. For each hypothesis, include the following information:

| \_\_ | Statistical model (e.g., ANOVA, multiple regression, etc.) and its specification (that includes each variable that will be included as predictor/factor (incl. its levels), outcome, or covariate). |
| --- | --- |
| \_\_or NA | Specify any interactions that will be tested |
| \_\_ | Name assumptions that need to be met and how they will be tested |
| \_\_ | Include a contingency plan in case assumptions are not met |
| \_\_ | Include software and packages used for each test |
| \_\_ | What criteria will you use to make inferences? Please describe the information you’ll use (e.g. p-values, Bayes factors, specific model fit indices), as well as cut-off criterion, where appropriate. |
| \_\_ | Note whether you will adjust for multiple comparisons and how (e.g. correction procedure, number of tests included …)or explain why not. |

fMRI analysis

Specify all analyses to test each hypothesis. Please include the type of model and the specification of the model (this includes each variable that will be included as predictors, outcomes, or covariates). Also specify any interactions that will be tested. Remember that all confirmatory analyses specified below must be reported in the final article, and any additional analyses must be noted as exploratory or hypothesis generating.

Specify whether you plan to perform whole-brain or ROI-analysis. In case of ROI, be specific (e.g. defined based on anatomical definition, prior study cluster, Neurosynth definition, Parcellation definition). List regressors of interest at the neural level and corresponding confirmatory hypothesis. If applicable, describe covariate measures.

For necessary details regarding functional connectivity and decoding analysis, please see **Appendix 4**.

| **Individual (first) level modeling** | |  |
| --- | --- | --- |
| \_\_ | Event­-related predictors (modeled duration (or zero), whether parametric modulation is used) |  |
| \_\_ | Block Design predictors (note whether or not baseline will be explicitly modeled) |  |
| \_\_or NA | Include design matrix and efficiency/collinearity measure (recommended) |  |
| \_\_ | HRF basis (e.g. canonical only, canonical with temporal derivative, or with temporal and dispersion derivative, Finite Impulse Response model) |  |
| \_\_ | Movement regressors; specify if squares and/or temporal derivative used. |  |
| \_\_ | Any other nuisance regressors, and whether they were entered as interactions (e.g. with a task effect in 1st level fMRI, or with group effect). |  |
| \_\_ | Any orthogonalization of regressors or parametric modulators, and set of other regressors used to orthogonalize against. |  |
| \_\_ | Contrast construction (Exactly what terms are subtracted from what? Define these in terms of task or stimulus conditions instead of underlying psychological concepts. |  |
| \_\_ | Model settings   * For *mass-­univariate first level fMRI,* these include drift regressors (e.g. DCT basis in SPM, with specified cut­off) and autocorrelation model (e.g., global approximate AR(1) in SPM; locally recularized autocorrelation function in FSL). Check your imaging toolbox to see default settings. |  |
| **Group (second)-level modeling** | |  |
| \_\_ | State and justify statistical model and estimation method, inference type (mixed/random effects or fixed), e.g., “Mixed effects inference with one sample t-test on summary statistic” (SPM2/SPM5), e.g., “Mixed effects inference with Bayesian 2-level model with fast approximation to posterior probability of activation.” (FSL). |  |
| \_\_or NA | If more than 2-levels, describe the levels and assumptions of the model (e.g., are variances assumed equal between groups) |  |
| \_\_or NA | If multiple measurements per subject, list method to account for within subject correlation, exact assumptions made about correlation/variance, e.g., SPM: “Within-subject correlation estimated at F-significant voxels (P <0.001), then used globally over whole brain”; or, if variances for each measure are allowed to vary, “Within-subject correlation and relative variance estimated…” |  |
| \_\_or NA | For group model with repeated measures, specify how condition effects are modeled (e.g. as factors, or as linear trends), and whether subject effects are modeled (i.e. as regressors, as opposed to with a covariance structure). |  |
| \_\_or NA | For group effects: clearly state whether or not covariates are split by group (i.e. fit as a group-by-­covariate interaction). |  |
| \_\_ | Model type (e.g., Mass Univariate, Multivariate (e.g. ICA on whole brain data), Local Multivariate (e.g. “searchlight”), Representational Similarity Analysis, psychophysiological interaction (PPI)) |  |
| \_\_ | Model settings   * For *mass-­univariate group level fMRI* these include fixed effects (all subjects’ data in one model), or random or mixed ­effects model (implemented with (1) Ordinary least squares (OLS, aka unweighted summary statistics approach; SPM default, FSL FEAT’s “Simple OLS”), (2) weighted least squares (i.e. FSL FEAT’s “FLAME 1”) using voxel­wise estimate of between subject variance, or (3) Global weighted least squares (i.e. SPM’s MFX)). * With *any group (multi­subject) model*, indicate any specific variance structure, e.g. Unequal variance between groups (and if globally pooled, as in SPM), or if repeated measures, the specific covariance structure assumed (e.g. compound symmetric, or arbitrary; if globally pooled). * For *local­ multivariate report,* indicate the number of voxels in the local model, and the Local model used (e.g. Canonical Correlation Analysis) with any constraints (e.g. positive weights only). |  |
| **ROI analysis** | |  |
| \_\_or NA | Will you limit your analysis to a specific ROI? (e.g. unilateral, cerebellum) |  |
| \_\_or NA | How will you define your ROI (e.g., functional, anatomical, meta-analysis, parcel localizer)? |  |
| \_\_or NA | Justify definition of ROI and analysis conducted with it: (e.g., if your ROI is defined based on the cluster; how will you ensure your ROI analyses are not circular?) | |
| \_\_or NA | How was signal extracted within ROI?(e.g., average parameter estimates, FIR deconvolution?) | |
| \_\_or NA | If percent signal change reported, how was scaling factor determined  (e.g., height of block regressor or height of isolated event regressor)? | |
| **Inference on statistic image (thresholding)** | |  |
| \_\_ | Whole brain or a specific search region? Specify type of search region analysis, and the volume in voxels or mm3) |  |
| \_\_or NA | If not whole brain, state how the region will be determined; method for constructing region should be independent of present statistic image:   * Carefully describe any small volume (SV) correction used for each contrast. * If the SV correction mask will be defined anatomically, provide named anatomical regions from a publicly available ROI atlas and, if probability-based, state selected threshold.   ● If the SV correction mask will be functionally defined, clearly describe the functional task and identify any risk of circularity.   * All SV corrections should be fully described in the methods section, not just mentioned in passing in the results. |  |
| \_\_ | Statistical type, e.g., voxel-wise (aka peak­wise in SPM) or cluster-wise (cluster size, cluster mass, threshold­free Cluster Enhancement (TFCE)). |  |
| \_\_or NA | Statistical threshold used to infer significance (e.g. p < 0.05) |  |
| \_\_or NA | If cluster-wise (cluster size or mass) significance, state cluster-defining threshold (e.g., P = 0.001). |  |
| \_\_or NA | For all cluster­wise methods, report neighborhood size used to form clusters (e.g. 6, 18 or 26). |  |
| \_\_or NA | For TFCE, report use of non­default TFCE parameters. |  |
| \_\_ | P value computation. Report if anything but standard parametric inference used to obtain (uncorrected) P­-values. If nonparametric method was used, report method (e.g. permutation or bootstrap) and number of permutations/samples used. |  |
| \_\_ | Multiple test correction. For mass­univariate, specify the type of correction and how it is obtained, e.g., Familywise Error (Random Field Theory (typical), Permutation, Monte Carlo, Bonferroni), False Discovery Rate (Benjamini & Hochberg FDR (typical), Positive FDR, Local FDR, Cluster­level FDR), or none/uncorrected. |  |
| \_\_or NA | If permutation or Monte Carlo, report the number of permutations/samples. |  |
| \_\_or NA | If Monte Carlo, note brain mask and smoothness used, and how smoothness was estimated. |  |
| \_\_or NA | If FWE found by random field theory, list smoothness in mm FWHM and the RESEL count. |  |
| \_\_or NA | If FWE found by simulation (e.g., AFNI AlphaSim), provide details of parameters for simulation. |  |
| \_\_or NA | If not a standard method, specify the method for finding significance (e.g., “Custom in-lab software was used to construct statistic maps and thresholded at FDR< 0.05 (Benjamini and Hochberg, 1995)” |  |
| \_\_or NA | False negative discussion: Any discussion of failure to reject the null hypothesis (e.g., lack of activation in a particular region) should be accompanied by SNR or effect size of the actually observed effect (allows reader to infer power to estimate an effect) |  |

*Recommendations of fMRI details come from Nichols et al., 2016; Poldrack et al., 2008.*

*For extended checklist guidelines for this section following data analysis, see OHBM COBIDAS report Nichols et al., 2016.*

## Follow-up Analyses

If not specified previously, will you be conducting any confirmatory analyses to follow up on effects in your statistical model, such as subgroup analyses, pairwise or complex contrasts, or follow-up tests from interactions? Remember that any analyses not specified in this research plan must be noted as exploratory.

## Exploratory Analyses

If you plan to explore your data set to look for unexpected differences or relationships, you may describe those tests here. An exploratory test is any test where a prediction is not made up front, or there are multiple possible tests that you are going to use. A statistically significant finding in an exploratory test is a great way to form a new confirmatory hypothesis, which could be registered at a later time.

# Appendices

## Appendix 1: Examples of fMRI study pre-registrations

* Pre data collection preregistration following a structure similar to the present template with extensive detail: <https://osf.io/2zhve>
* Pre data collection preregistration with extensive detail in flow-text: <https://osf.io/7q68p/>
* studies with standard preprocessing approaches (SPM, fMRIprep): <https://osf.io/5mx3w>; <https://osf.io/hndbq> [previously collected data]
* concise preregistration of functional connectivity analyses of existing data: <https://osf.io/utqq2>
* methods analysis on publicly available datasets: <https://osf.io/2jxdk/>
* Example of a multi-study pre-registration: <https://osf.io/wzd8a>

## 

## Appendix 2: fMRI data acquisition checklists

*If your study includes multiple different scanners, or if multiple different sequences of the same category are used (e.g. multiple functional MRI sequences), please fill out a separate table for each scanner and sequence.*

**Participant preparation**

| Test scanning (Report type of (mock) scanner and protocol; i.e. duration, types of simulated scans, experiments). | \_\_or NA |
| --- | --- |
| Special equipment to reduce/monitor head motion (head cases, prospective motion tracking …) | \_\_or NA |
| Specific accommodations (e.g., pediatric, parent present, asleep) | \_\_or NA |
| Experimental personnel (number of planned personnel to interact with participants) | \_\_or NA |

***MRI system***

| Manufacturer | \_\_ |
| --- | --- |
| Model name | \_\_ |
| Software version | \_\_ |
| Field strength (in Tesla) | \_\_ |
| Transmission coil | \_\_ |
| Receiving head coil | \_\_ |

***MRI acquisition***

*If this is a study using multiple different scanners, or if multiple different sequences of the same category are used (e.g. multiple functional MRI sequences), please fill out a separate table for each scanner and sequence.*

| **For all acquisitions:** | Pulse sequence (gradient/spin echo etc.) | \_\_ |
| --- | --- | --- |
| Readout (EPI, spiral, 3D, partial Fourier, etc.) | \_\_ |
| Echo time (TE) | \_\_ |
| Repetition time (TR)   * For multi­shot acquisitions, additionally the time per volume. | \_\_ |
| Flip angle (FA) | \_\_ |
| Acquisition time (duration of acquisition) | \_\_ |
| Field of view (FOV) | \_\_ |
| FOV position?   * Full or partial brain coverage? * Guided by anatomical landmarks? * Guided by built-in scanner functions (e.g. AUTO ALIGN)? | \_\_ |
| Voxel size (in-plane) | \_\_ |
| Slice thickness | \_\_ |
| Slice gap | \_\_ |
| Slice selection direction (axial, sagittal, coronal, oblique) | \_\_ |
| Slice angulation | \_\_ |
| Slice acquisition order (ascending, descending, interleaved) | \_\_ |
| Parallel imaging method (GRAPPA, PAT …) | \_ or NA |
| Scanner-side preprocessing (e.g., Including: Fat saturation, Reconstruction matrix size differing from acquisition matrix size; Prospective-motion correction (including details of any optical tracking, and how motion parameters are used); Signal inhomogeneity correction; Distortion-correction.) | \_ or NA |
|  | Phase encoding direction | \_\_ |
| **Functional MRI /**  **or "dynamic (4D) MRI e.g. functional, perfusion MRI"** | Number of volumes | \_\_ |
| Single or multi-echo? | \_\_ |
| Simultaneous multislice acquisition & parameters (e.g. multiband) | \_ or NA |
| T1 stabilization (discarded “dummy” scans *by scanner*) | \_ or NA |
| Sparse sampling delay (delay in TR) if used. |  |
| **T1-weighted imaging** | Fat suppression | \_ or NA |
| **Other anatomical imaging (T2)** |  | \_ or NA |
| **Inversion recovery sequences** | Inversion time (TI) | \_ or NA |
| **Additional imaging**  **for distortion**  **correction** | B0 field maps   * echo difference between acquisitions | \_ or NA |
| ap-pa acquisitions (reverse phase)   * state if parameters differ from functional acquisition | \_ or NA |
| **Physiological measures** | Description (acquisition method, hardware) and brief purpose of any physiological data that will be collected from the participants before/during/after fMRI (e.g. eye-tracking, pulse, electrocardiography, plethysmography (pulse oximetry), respiration, blood pressure, blood samples, skin conductance (SCR), electromyography, etc.). | \_ or NA |
| **Other imaging modalities** | Give a description and brief purpose statement of any other imaging modalities that will be included in your study (e.g., EEG, Neuromodulation (TMS, tDCS, …)). |  |

## Appendix 3: Additional fMRI analyses

| **Functional connectivity** | |
| --- | --- |
| *Confound adjustment & filtering Report:* | |
| \_\_or NA | Method for detecting movement artifacts, movement-related variation, and remediation (e.g. ‘scrubbing’, ‘despiking’, etc) |
| \_\_or NA | Use of global signal regression, exact type of global signal used and how it was computed |
| \_\_or NA | Whether a high or lowpass temporal filtering is applied to data, and at which point in the analysis pipeline. Note, any temporal regression model using filtered data should have its regressors likewise filtered |
| *Multivariate method: Independent Component Analysis Report:* | |
| \_\_or NA | Algorithm to estimate components |
| \_\_or NA | Number of components (if fixed), or algorithm for estimating number of components |
| \_\_or NA | If used, method to synthesize multiple runs |
| \_\_or NA | Sorting method of IC’s, if any |
| \_\_or NA | Detailed description of how components were chosen for further analysis |
| \_\_or NA | Dependent variable definition |
| *For seed-based analyses report:* | |
| \_\_or NA | Definition of the seed region(s) |
| \_\_or NA | Rationale for choosing these regions |
| *For region-based analyses report:* | |
| \_\_or NA | Number of ROIs |
| \_\_or NA | How the ROI’s are defined (e.g. citable anatomical atlas; auxiliary fMRI experiments); note if ROIs overlap |
| \_\_or NA | Assignment of signals to regions (i.e. how a time series is obtained from each region, e.g. averaging or first singular vector) |
| \_\_or NA | Note if considering only bilateral (L+R) merged regions |
| \_\_or NA | Note if considering only interhemispheric homotopic connectivity |
| *Functional connectivity measure/model Report:* | |
| \_\_or NA | Measure of dependence used, e.g. Pearson’s (full) correlation, partial correlation, mutual information, etc; also specify: |
| \_\_or NA | Use of Fisher’s Z-transform (Yes/No) and, if standardised, effective N is used to compute standard error (to account for any filtering operations on the data) |
| \_\_or NA | Estimator used for partial correlation |
| \_\_or NA | Estimator used for mutual information |
| \_\_or NA | Regression model used to remove confounding effects (Pearson or partial correlation) |
| *Effectivity connectivity Report:* | |
| \_\_or NA | Model |
| \_\_or NA | Algorithm used to fit model |
| \_\_or NA | If per subject model, method used to generalize inferences to population. Itemize models considered, and method used for model comparison |
| *Graph analysis* | |
| \_\_or NA | Report the ‘dependent variable’ and ‘functional connectivity measure’ used (see above). Specify either:   * Weighted graph analysis or * Binarized graph analysis is used, clarifying the method used for thresholding (e.g. a 10% density threshold, or a statistically defined threshold); consider the sensitivity of your findings to the particular choice of threshold used |
| \_\_or NA | Itemise the graph summaries used (e.g. clustering coefficient, efficiency, etc), whether these are global or per¬node/per¬edge summaries. In particular with fMRI or EEG, clarify if measures applied to individual subject networks or group networks |
| **Decoding analysis** | |
| \_\_or NA | Algorithm choice(s) |
| \_\_or NA | Hyperparameter optimization |
| \_\_or NA | Cross-validation regimen [including whether stratification is applied] |
| \_\_or NA | Hold-out samples |