MRC Cognition and Brain Sciences Unit

UNIVERSITY OF CAMBRIDGE

fMRI analysis

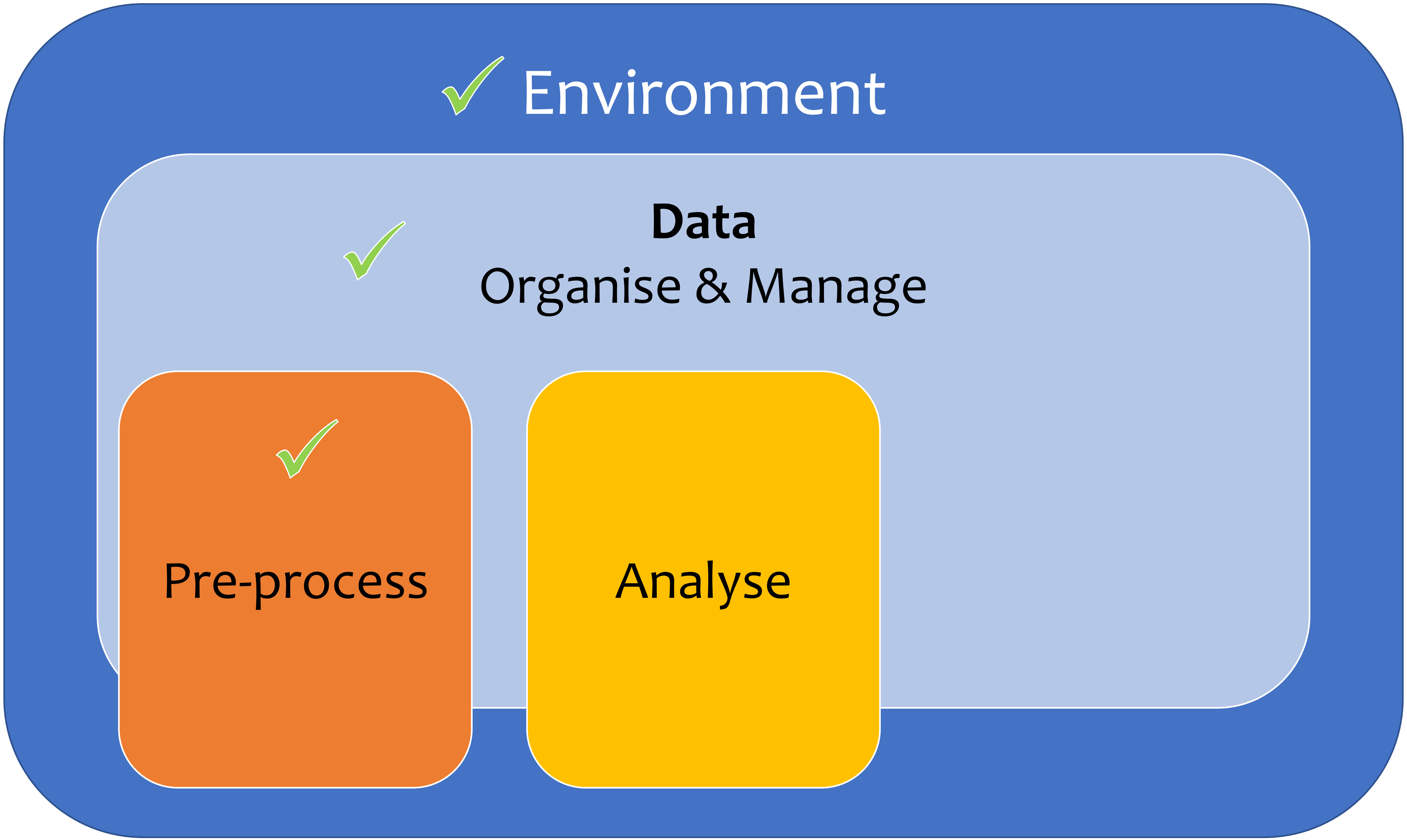
GitHub https://github.com/dcdace/fMRI-COGNESTIC-23

Dace Apšvalka

[Datza]

http://www.dcdace.net

COGNESTIC, 2023


Environment
Data
Organise & Manage
Pre-process
Analyse

BOLD signal = X * b + errors

BOLD signal	=	X * b	+ errors
		explained variation	unexplained variation
		task-related activity changes	noise (other changes)

- **What we know?**
  - BOLD signal: we collect this from the brain (functional data)
  - X: the design matrix (each column is a predictor that we build ourselves)
- **What we want to find?**
  - b: vector of beta-weights (one weight for predictor in X) that give the best approximation of the BOLD signal
- **How we find it?**
  - By minimising the sum of squared errors. In practice, the **GLM has a formula, which guarantees to find these beta-weights**

1. **Extract the signal time-series** from a given voxel

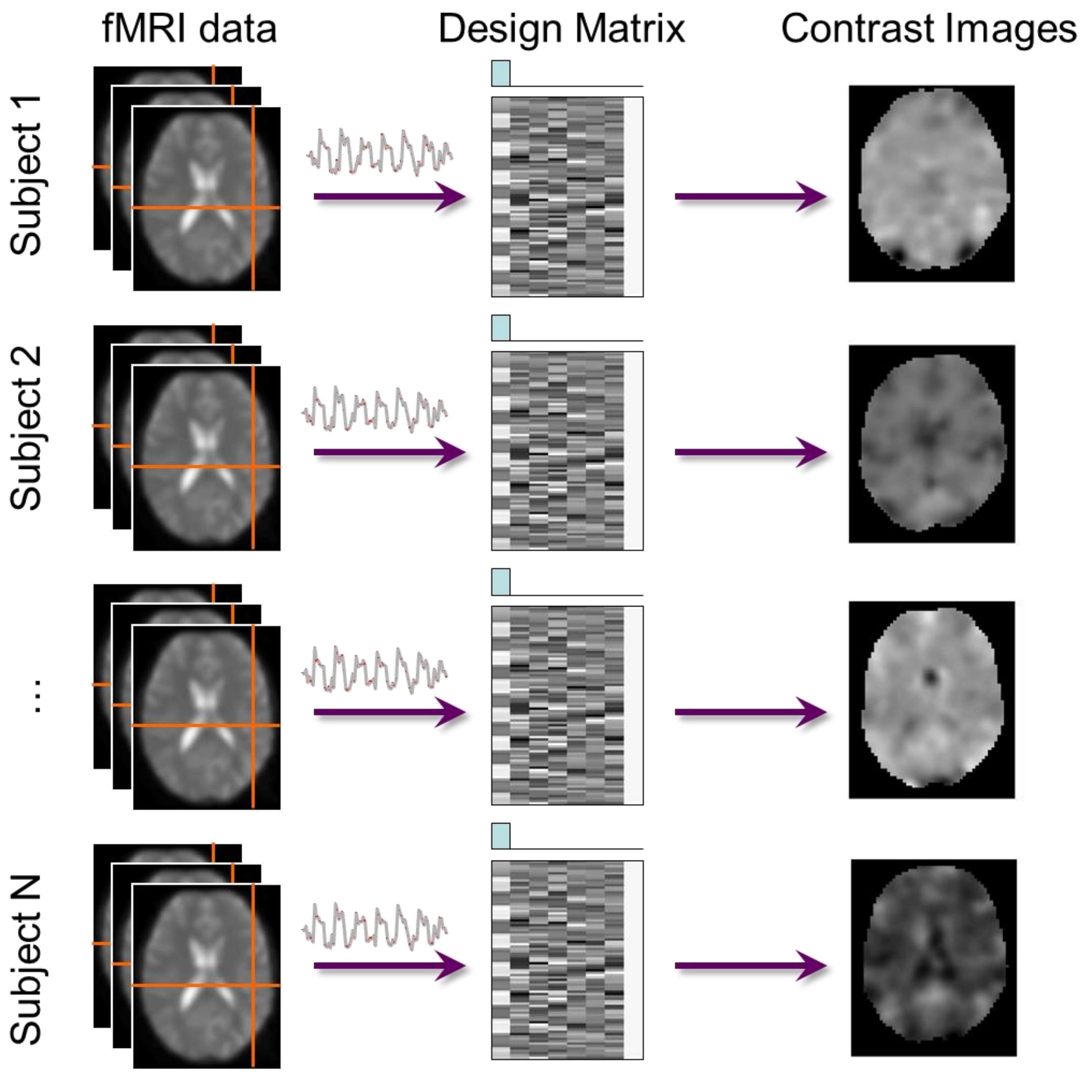
2. **Run GLM** (the signal and the design matrix are the inputs) to **find beta-weights** that best approximate the true signal

3. Define your **contrast** and test it

4. Repeat for **all voxels**
   - Produces an image file with contrast values for each voxel: **contrast-maps**

First-level analysis

- Run the GLM for each subject



First-level analysis

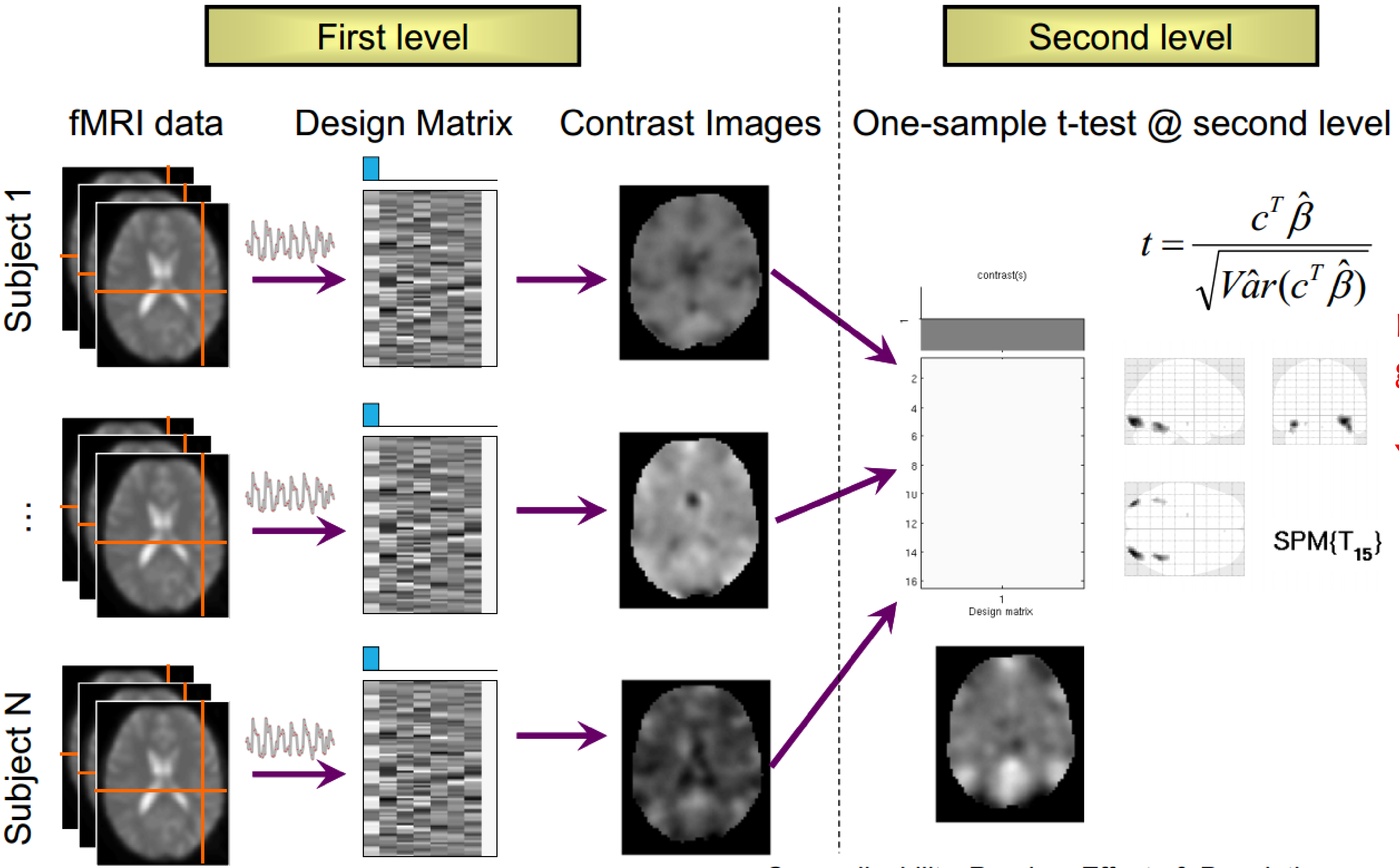
Let’s see the nb05_Subject-Level-Analysis.ipynb notebook

Group level (2nd level) analysis is across subjects

- Which voxels are showing significant activation differences between our conditions consistently **within a group**
  - Average contrast effect across the sample (e.g., one-sample t-test)

- Importantly, all subject brains need to be in a common space, e.g. MNI, to perform voxel-wise group analyses

Summary statistics, Random effects approach



$$t = \frac{c^T \hat{\beta}}{\sqrt{\hat{Var}(c^T \hat{\beta})}}$$

It is still a GLM model, and we get group level beta estimates!

$Y_{group} = X_{group}\,\beta_{group} + \varepsilon_{group}$

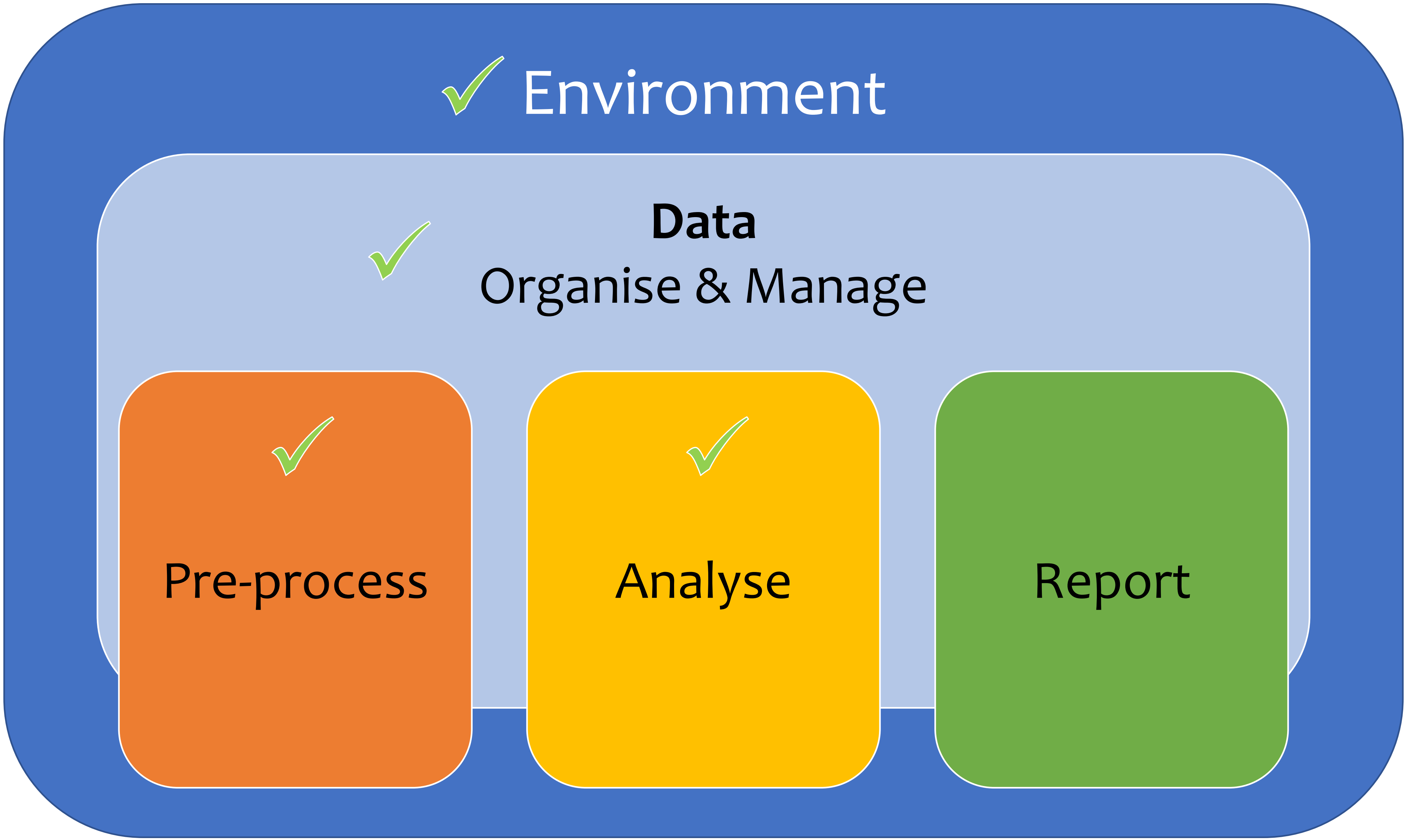
Generalisability, Random Effects & Population Inference. Holmes & Friston, NeuroImage,1998.

Stats tests at the 2nd level

- Condense where possible
  - If a factor can be collapsed through a contrast at the 1st level, do so and use the simplest possible 2nd level model
  - T-tests at the 2nd level are preferred
    - Avoids need to estimate non-sphericity to account for within-subject correlations across repeated measures
    - Generally more accurate estimation of error

- However, if more than 2 factors or levels exist, a single t-contrast cannot capture the main effects and interactions
  - 2nd level ANOVA will be necessary

Let’s see the nb06_Group-Level-Analysis.ipynb notebook

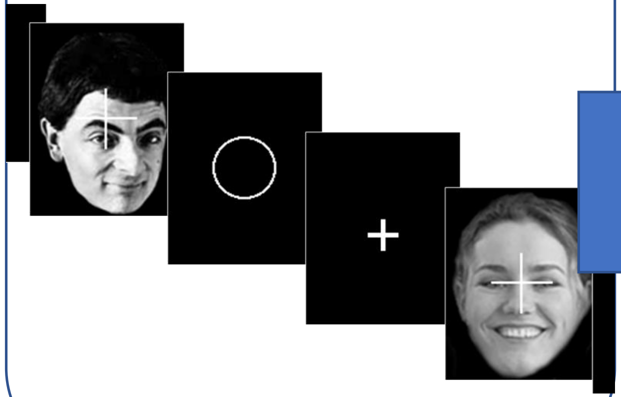

Environment
Data
Organise & Manage
Pre-process
Analyse
Report

Sharing & Reporting

- Share your **code** and notebooks on GitHub
- Make it **citable** with Zendono
  - https://docs.github.com/en/repositories/archiving-a-github-repository/referencing-and-citing-content
- If you have consent from participants, share the **BIDS data** on OpenNeuro
- Add your **contrast maps** to NeuroVault

Famous vs **Unfamiliar**
faces are processed
differently in the brain

Design an experiment

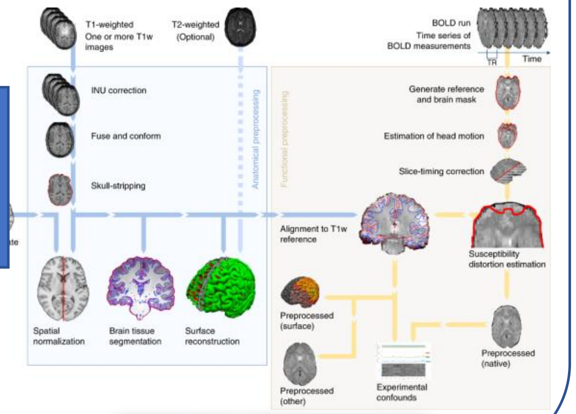


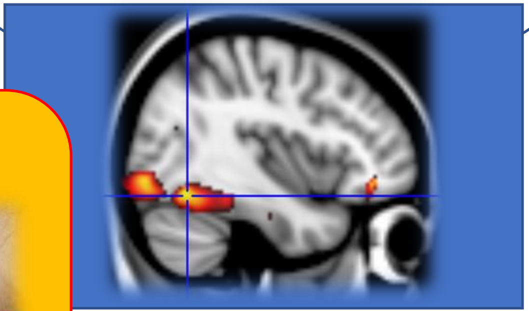
Stimuli
Timing

Collect the MRI data

Anatomical image
Functional images
Event details

Pre-process & Analyse





The final push