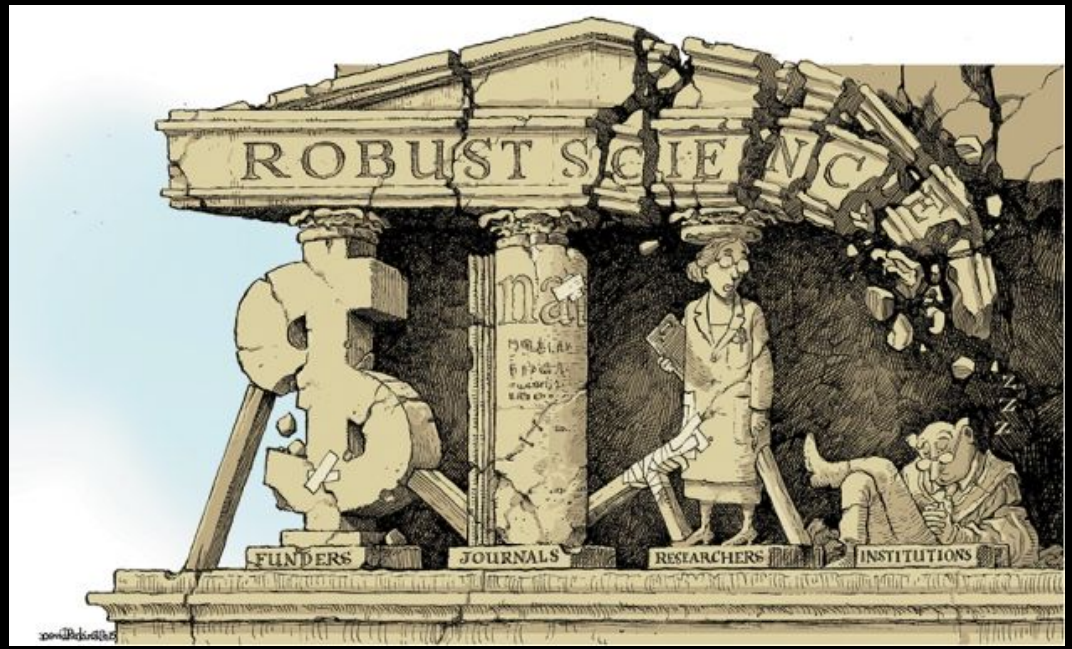
Progress Toward Openness, Transparency, and Reproducibility in Cognitive Neuroscience

Rick O. Gilmorea, Michele T. Diaza,b, Brad A. Wyblea, and Tal Yarkonic

open science so far
and
the problems

Where are we at - the bad

many findings in psychological science may be difficult to reproduce



⟶ of 190 studies examined in 6 large-scale efforts combined, 47% were successfully replicated

https://www.nature.com/articles/d41586-018-07474-y

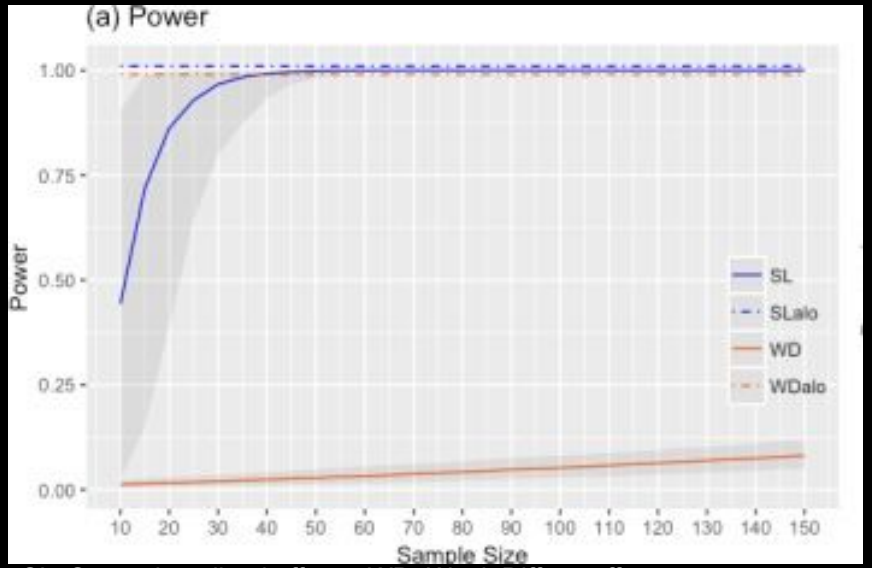
Where are we at - the bad

statistical power in brain imaging studies is low and has not improved

➔ the combination of :

- a large number of dependent variables,
- a relatively small number of observations (subjects),
- and a need to correct for multiple comparisons

can decrease statistical power dramatically



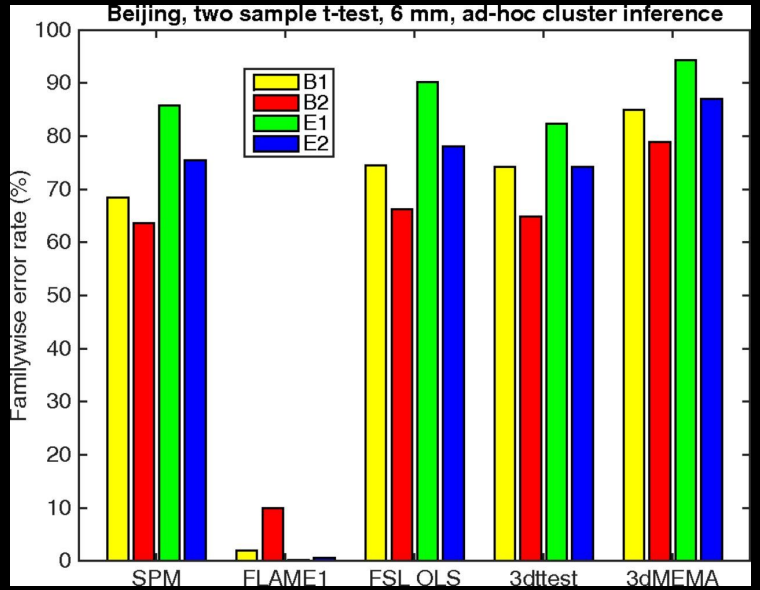
SL: Strong Localized effects, WD: Weak Diffuse effects

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5695788/

Where are we at - the bad

software errors in analysis tools are common and can go undetected for many years

most common software packages for fMRI analysis (SPM, FSL, AFNI) can result in false-positive rates of up to 70%



https://www.pnas.org/content/113/28/7900

Where are we at - the bad

the open sharing of data, code, and materials is rare

Where are we at - the good

- renewed focus on reaffirming reproducibility, transparency, and openness as essential core values in psychological science and related fields
- emergence and rapid growth of data archives, meta-analytic tools, software pipelines, and research groups devoted to improved methodology
- greater clarity about what these values mean in practice (see last week ;))

What even is reproducibility?

What really is reproducibility - Methods reproducibility

different investigators are able to obtain the same results when applying the same tools and analytical procedures used in a study to the same (i.e., original) dataset

What really is reproducibility - Methods reproducibility

main problem:

- how to report the multitude of small individual choices involved in a typical analysis pipelines

Implemented solutions:

- standardised software packages (e.g. EEGLAB or SPM)
- promotion of data and metadata standards for research (e.g The Big EEG Consortium)
- convergence on recommendations on what and how to report parameter-choices
- standard toolboxes for experimental tasks

But:

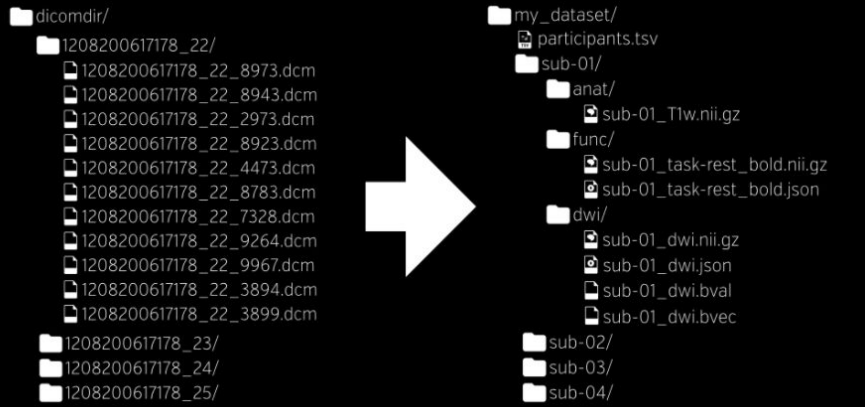
- Not all these developments have become common practice (e.g. not reproducable graphical interfaces are still popular)
- there are untracked differences (e.g. the OS or dependencies)
- individualised task stimuli and designs are not often shared

Initiatives concerning **methods** reproducibility

Data format standardization

- BIDS format for BOLD data
  - Brain Imaging Data Structure
  - separate folders for different raw data types
  - derivates folder

- easier for others to read, re-analyze or use it in a meta-analysis



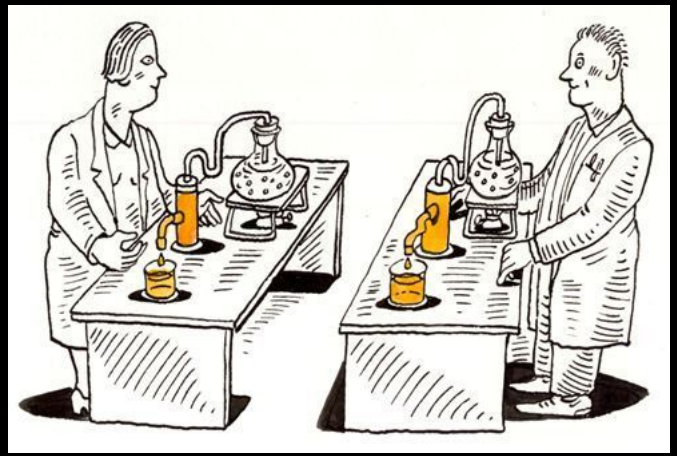
Initiatives concerning **methods** reproducibility

Behavioral method reproducibility

- Recording of videos
  - full communication of methods and a complete transparency
  - issue of privacy
  - could use an “ideal” or “fake” participant for this

What really is reproducibility - Results reproducibility

a new study with new data, collected following the original procedures as closely as possible, yields the same outcomes



What really is reproducibility - Results reproducibility

main problem:

➢ Results reproducibility highly depends on on the comparability of the different equipments and software and **results reproducibility is difficult to quantify**

Implemented solutions:

- highly convergent (imaging) techniques, that are capable of producing convergent results in different labs
- development of generalizable models for multi-site data collection
- systematic measurement and control of how fMRI signals vary across sites (fBIRN)
- Large-scale meta-analyses that show a marked degree of convergence on stable neural correlates for most major psychological processes

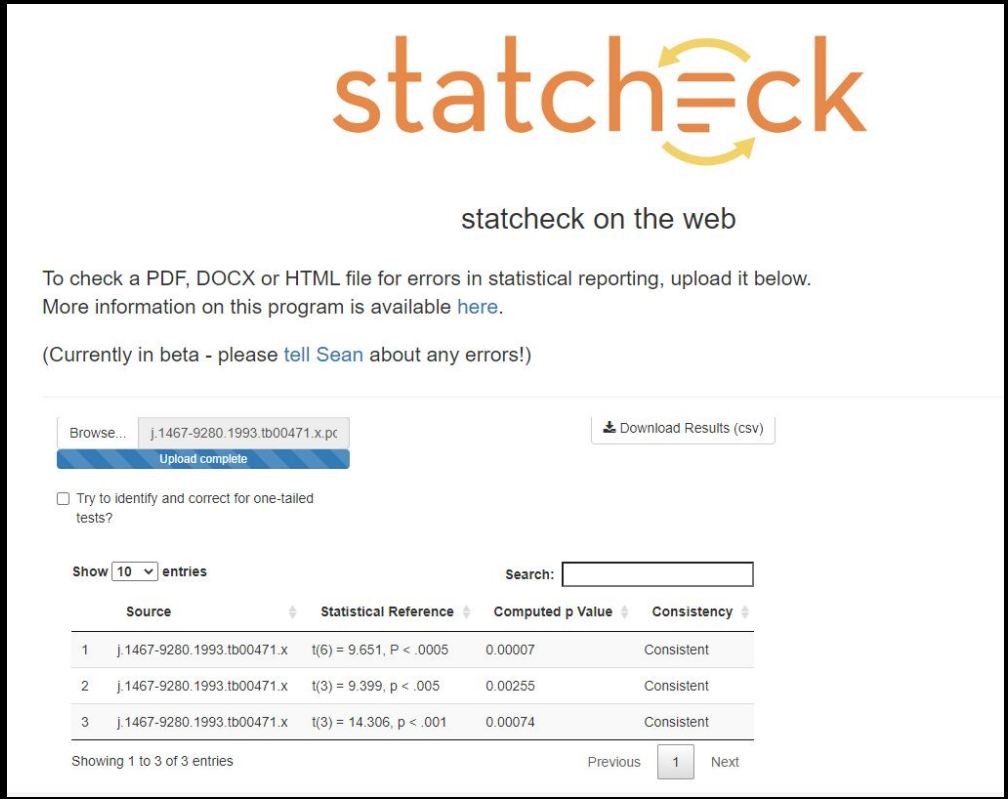
But:

- initiatives promoting neuroimaging data sharing have historically met with limited success
- there is a lack of consensus about what quantitative measures should be used

Initiatives concerning **results** reproducibility

Stats

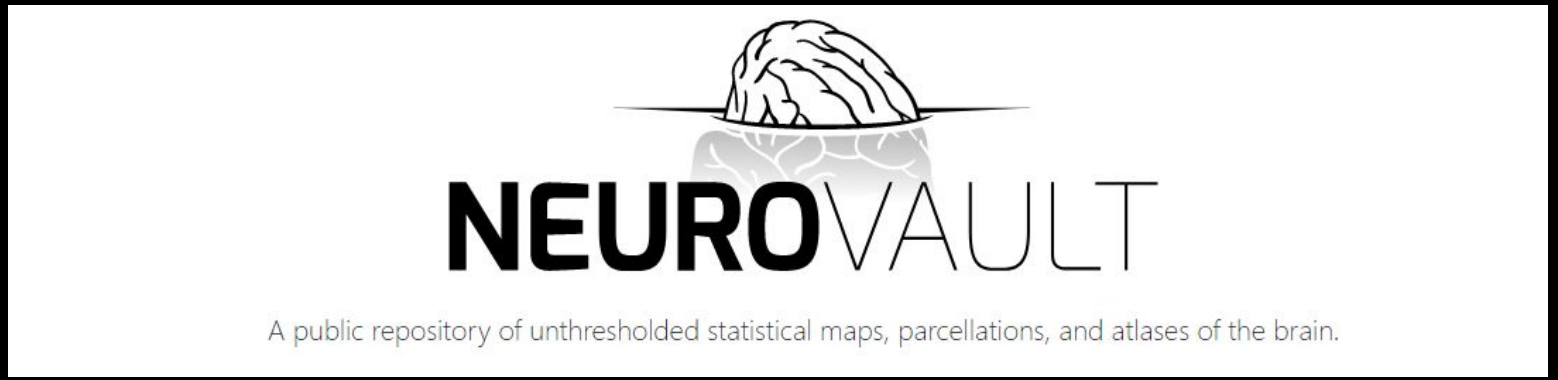
- Statcheck.io
  - makes sure that the stats reported in the paper are correct
  - does not actually redo the stats



Initiatives concerning **results** reproducibility

Neurovault

- Bunch of whole-brain statistical maps
- Let's take a look



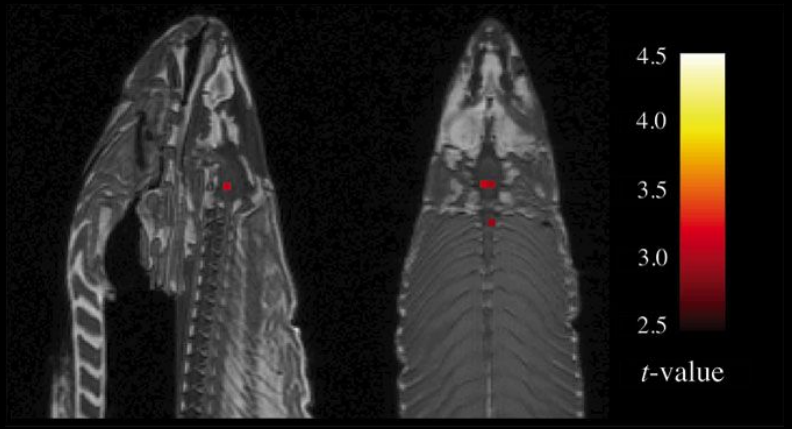
What really is reproducibility - Inferential reproducibility

independent researchers come to similar conclusions about what patterns of data mean, based on their own replication study or a reanalysis of a prior study

What really is reproducibility - Inferential reproducibility

main problems:

- low power in (fMRI) studies often leads to incorrect interpretations
- inflated false positives due to insufficient correction for multiple comparisons
- Researchers can disagree on the interpretation of even sound findings
  - what does the BOLD signal mean?
  - kind of information extracted from multivariate pattern analysis?
  - reverse inference
  - etc….

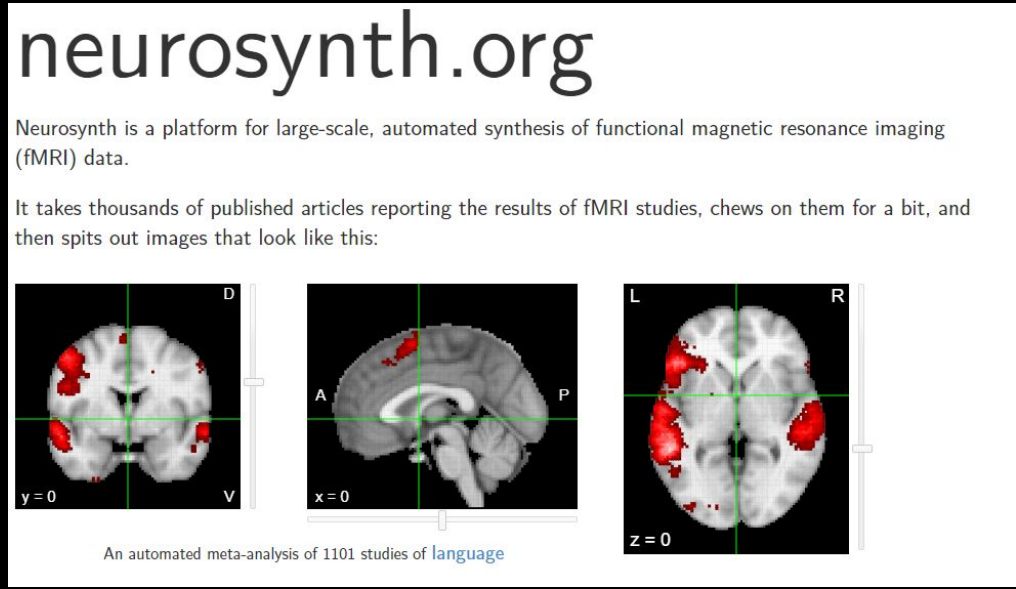


https://www.psychology.mcmaster.ca/bennett/psy710/readings/BennettDeadSalmon.pdf

Initiatives concerning **inferential** reproducibility

Neurosynth

- meta-analyses
- activation coordinates in MNI space and word frequencies text mined from papers on the web
- get ROIs for your dataset
- Let's take a look



Initiatives concerning **inferential** reproducibility

Machine learning

- “new” philosophical way of thinking about explanations of neural data
- prediction of ‘out-of-sample’ dataset
- allows to get at information patterns than are too subtle or complex for standard summary statistics
- still an inferential problem
  - overfitting
  - above-chance decoding = ‘information’ in a region?

Take aways

- authors see (saw back in 2017) a bright tomorrow
- raise issue of who will store and pay for storage of large datasets

- distinction between the types of reproducibilities a bit artificial
- wonderful paper for pointing towards different resources/web-based apps etc.