# What should we do with neuroimaging analytical flexibility?

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## Overview

In recent years, a number of publications have shown that analytical flexibility leads to an important variation of scientific results, probably contributing to lack of reproducibility of published works. In genetics after the turn of the century, there was crisis when countless genome-wide association studies (GWAS) failed to replicate, and a national initiative led to recommendations that are credited with greatly improving reproducibility in that discipline (NCI-NHGRI Working group on replication, Nature, 2007, Marigorta 2018). Neuroimaging is still transitioning to a more replicable future, with progress on several fronts, e.g. the median neuroimaging study sample size continues to grow and pipeline containerization technologies are more prevalent. However, contrary to GWAS, neuroimaging seems to have much stronger analytical flexibility issues (cf Carp 2012, Botvinik-Nezer 2020, Bowring 2021, Bhagwat 2021, Descoteaux 2021) and it is unclear what should be done about it. What lessons from genetics can still be put to use in neuroimaging? How severe is the flexibility in neuroimaging and should it be strictly avoided or managed, providing a 'multiverse' of analytic results? Is this even computationally feasible and is this sustainable? How can a multiverse of results be probed and summarised? Should reviewers and editors ask for a series of analyses to show that results are robust?

**Lecture 1:** *Introduction to analytical flexibility, reproducibility and links to meta analyses*
**Angela Laird** Presenter

In this talk, we will introduce the current issues in reproducible neuroimaging, the notion of analytical flexibility and consider how this can impact results robustness obtained with meta-analyses

**Lecture 2:** *Reviewing neuroimaging flexibility: components and records of provenance*
**Camille Maumet** Presenter

This talk will discuss the different components of analytical flexibility in neuroimaging research and how they impact the reproducibility of scientific findings. We will discuss how this flexibility can impede the re-usability of brain imaging datasets if not recorded and disclosed publicly.

**Lecture 3:** *Statistical approaches to multiverse analyses*
**Thomas Nichols** Presenter

In this talk, we will review the statistical challenges of multiverse analyses, the possible strategies to analyse these new type of data and how results would be interpreted.

**Lecture 4:** *Impact of analytical flexibility on reviewers and editors - what should be requested of an article before publishing?*
**Jean-Baptiste Poline** Presenter

Currently, most neuroimaging articles are published with results obtained with one pipeline. As pipeline flexibility yields variable results, should reviewers ask for complementary analyses to establish robustness of results with pipeline? Will new norms of publication and peer review need to be established to consider analytical flexibility?