

How study pre-registration can benefit neuroscience

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REVIEW

Only Human: Scientists, Systems, and Suspect Statistics

A review of: Improving Scientific Practice: Dealing With The Human Factors, University of Amsterdam, Amsterdam, September 11, 2014

Tom E. Hardwicke*, Leila Jameel*, Matthew Jones*, Eryk J. Walczak* and Lucia Magis-Weinberg*

It is becoming increasingly clear that science has sailed into troubled waters. Recent revelations about cases of serious research fraud and widespread 'questionable research practices' have initiated a period of critical self-reflection in the scientific community and there is growing concern that several common research practices fall far short of the principles of robust scientific inquiry. At a recent symposium, 'Improving Scientific Practice: Dealing with the Human Factors' held at The University of Amsterdam, the notion of the objective, infallible, and dispassionate scientist was firmly challenged. The symposium was guided by the acknowledgement that scientists are only human, and thus subject to the desires, needs, biases, and limitations inherent to the human condition. In this article, five post-graduate students from University College London describe the issues addressed at the symposium and evaluate proposed solutions to the scientific integrity crisis.

Talk Overview

- Problems with everyday research practices in psychology and cognitive neuroscience
- How study pre-registration can help, including details of the Registered Reports format and examples
- Response to FAQs and criticisms

QUESTIONS

In the interests of doing good science, which part of a research study should be beyond your control?

The results

In the interests of advancing your career, which part of a research study is most important for publishing in 'top journals'?

The results

Could this be why aliens fly right by?

Science has an incentive problem

What's best for science

Transparent and high quality research, regardless of outcome

What's best for scientists

Producing a lot of "good results"

What is a “good result”?

“novel”

“striking”

“clear”

“...found a significant effect”

“worked”

“results show convincingly...”

“major advance”

“definitive”

“beautiful”

“breakthrough”

“high impact”

What happens when researchers are pressured to get “good results”?



Publication bias – *suppression of negative or complex findings*

Significance chasing – *“p-hacking”, selective reporting*

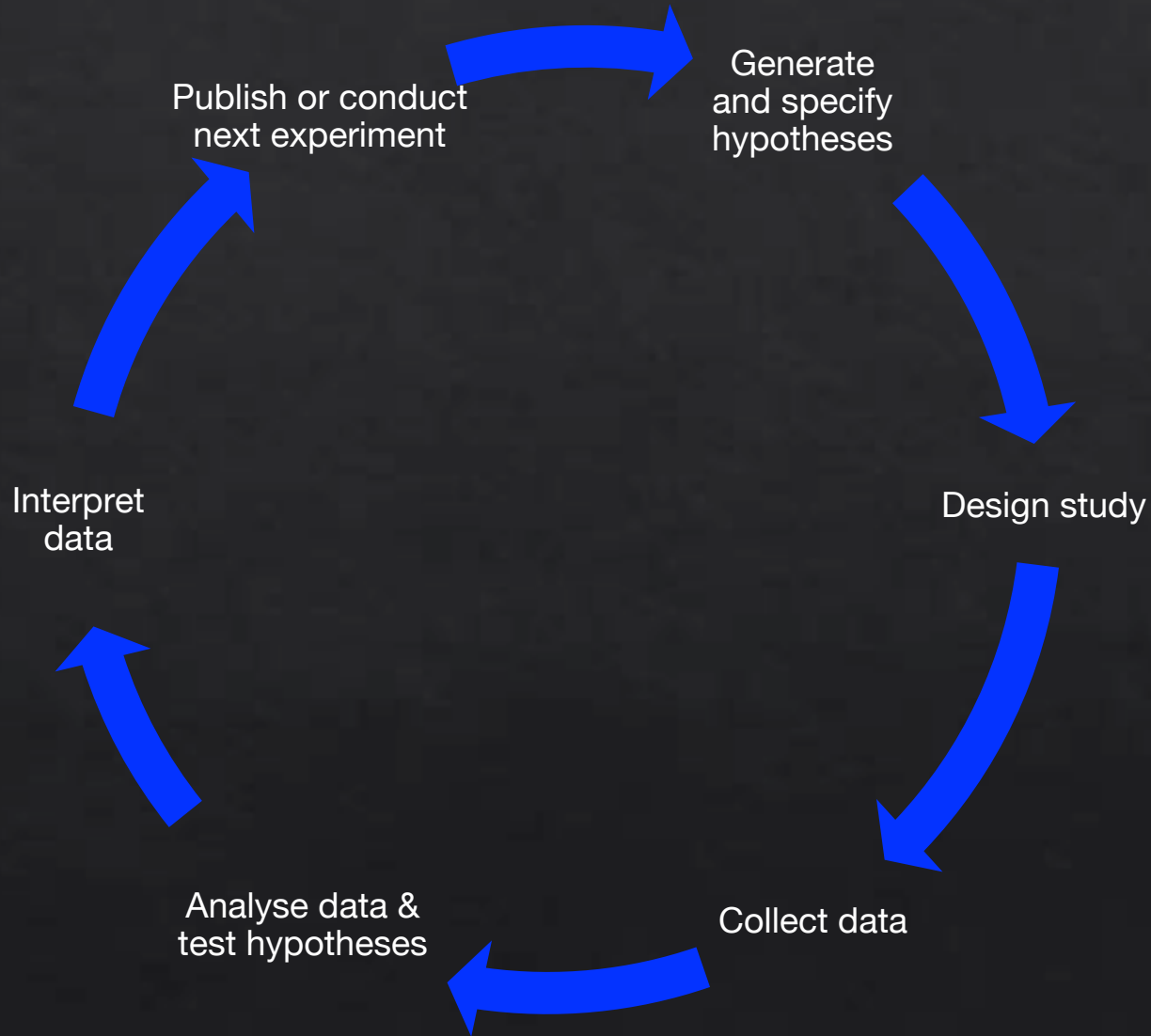
HARKing – *hypothesizing after results are known*

Lack of data sharing – *no time, too hard, no incentive*

Low statistical power – *quantity of papers over quality*

Lack of replication – *seen as boring, lacking in intellectual prowess*

Hypothetico-deductive scientific method



~92% positive
Fanelli (2010)

Publication bias

Lack of data sharing

~70% failure
Wicherts et al (2006)

Lack of replication

In psychology: 1
of 100 papers
Makel et al (2012)

Low statistical power

~50% chance to detect medium effects
Cohen (1962); Sedlmeier and Gigerenzer (1989); Bezeau and Graves (2001)

~50-100% prevalence
John et al (2012)

Analyse data & test hypotheses

Interpret data

HARKing

~50-90% prevalence
John et al (2012)
Kerr (1998)

Significance chasing

Why is this happening?

Because we place too much importance on the **results** of experiments and not enough on the **processes** that produce them

Results make science exciting but judging the quality of science (and scientists) according to the results condemns us to being a “soft” science

Can we fix this? Yes

Philosophy:

What gives hypothesis-testing its scientific value is:

- the QUESTION it asks
- the QUALITY of the method it uses
- not the RESULT it produces

If we accept this philosophy then editorial decisions at journals should be *blind* to results

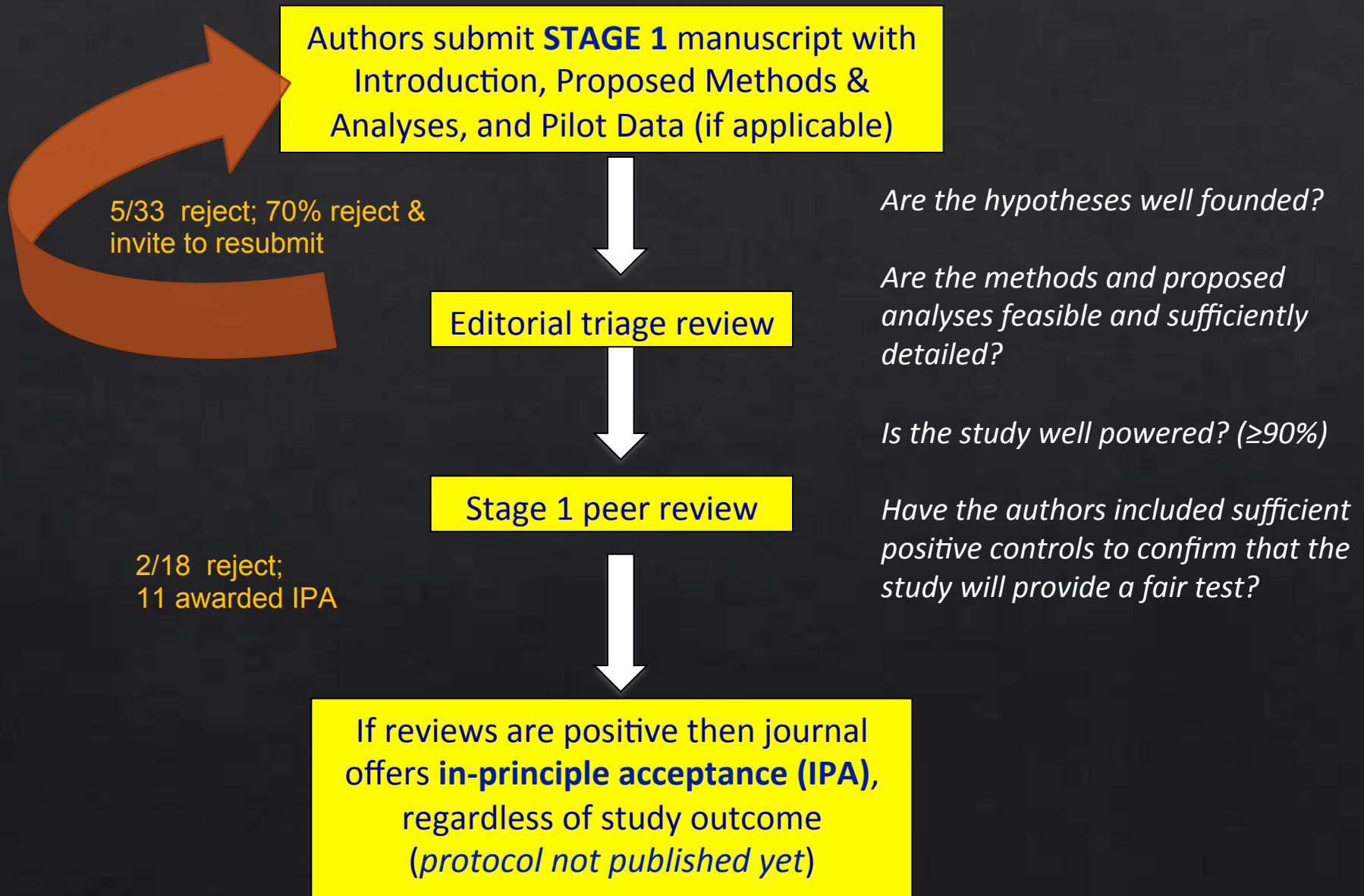
Registered Reports



Four central aspects of the Registered Reports model:

- Researchers decide hypotheses, experimental procedures, and main analyses *before* data collection
- Part of the peer review process takes place before experiments are conducted
- Passing this stage of review virtually guarantees publication
- Original studies and high-value replications are welcome

How it works



How it works

Authors do the research



- Authors resubmit completed **STAGE 2** manuscript:
- **Introduction** and **Methods** (virtually unchanged)
 - **Results (new)**: Registered confirmatory analyses + unregistered exploratory analyses
 - **Discussion (new)**
 - **Data deposited in a public archive**



Stage 2 peer review

Did the authors follow the approved protocol?

Did positive controls succeed?

Are the conclusions justified by the data?



6 published

Manuscript published!

None of these things matter

A red circle with a diagonal slash through it, indicating prohibition or negation.

**WHETHER
HYPOTHESIS
SUPPORTED**

A red circle with a diagonal slash through it, indicating prohibition or negation.

**WHETHER
 $p < .05$**

A red circle with a diagonal slash through it, indicating prohibition or negation.

**WHETHER
RESULTS
ARE NOVEL**

A red circle with a diagonal slash through it, indicating prohibition or negation.

**WHETHER
RESULTS
HAVE
“IMPACT”**

What does matter



THE
HYPOTHESES
ARE CLEAR

THE STUDY
IS POWERED

THE
METHOD IS
SOUND

THE
QUALITY OF
THE DATA IS
GOOD

Two examples of published register reports



ELSEVIER

Available online at www.sciencedirect.com

ScienceDirect

Journal homepage: www.elsevier.com/locate/cortex

Registered report

The effects of AMPA blockade on the spectral profile of human early visual cortex recordings studied with non-invasive MEG

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Perampanel

ABSTRACT

The generation of gamma-band (>30 Hz) cortical activity is thought to depend on the reciprocal connections of excitatory glutamatergic principal cells with inhibitory GABAergic interneurons. Both *in vitro* and *in vivo* animal studies have shown that blockade of glutamatergic α -amino-3-hydroxy-5-methyl-4-isoxazolepropionic acid (AMPA) receptors reduces the amplitude of gamma-band activity. In this registered report, we hypothesised that similar effects would be observed in humans following administration of perampanel, a first in class AMPA antagonist, used in the treatment of epilepsy. In a single-blind placebo-controlled crossover study, 20 healthy male participants completed two study days. On one day participants were given a 6 mg dose of perampanel and on the other an inactive placebo. magnetoencephalography (MEG) recordings of brain activity were taken before and two hours after drug administration, with activity in the visual cortex probed using a stimulation protocol known to induce gamma-band activity in the primary visual cortex. As hypothesised, our results indicated a decrease in gamma-band amplitudes following perampanel administration. The decreases in gamma-band amplitudes observed were temporally restricted to the early time-period of stimulus presentation (up to 400 msec) with no significant effects observed on early evoked responses or alpha rhythms. This suggests that the early time-window of induced visual gamma-band activity, thought to reflect input to the visual cortex from the lateral geniculate nucleus, is most sensitive to AMPA blocking drugs.

What we learned?

- ◆ It was a “high risk & costly” study involving drug intervention and MEG
- ◆ The theoretical question was straight forward:
 - ◆ Are gamma bands oscillation associated with glutamatergic principal cells
- ◆ Issues: how much drug to give? What should be the outcome neutral criteria?
- ◆ Reviewer was not happy with the results (suggesting non registered analyses)



ELSEVIER

Available online at www.sciencedirect.com

ScienceDirect

Journal homepage: www.elsevier.com/locate/cortex

Registered report

Role of features and categories in the organization of object knowledge: Evidence from adaptation fMRI

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Keywords:

Taxonomic category

Thematic category

Features

The organization of object knowledge

ABSTRACT

There are two general views regarding the organization of object knowledge. The feature-based view assumes that object knowledge is grounded in a widely distributed neural network in terms of sensory/function features (e.g., Warrington & Shallice, 1984), while the category-based view assumes in addition that object knowledge is organized by taxonomic and thematic categories (e.g., Schwartz et al., 2011). Using a functional magnetic resonance imaging (fMRI) adaptation paradigm, we compared predictions from the feature- and category-based views by examining the neural substrates recruited as subjects read word pairs that were identical, taxonomically related, thematically related or unrelated while controlling for the function features involved across the two categories. We improved upon previous study designs and employed an fMRI adaptation task, obtaining results overall consistent with both the category-based and feature-based views. Consistent with the category-based view, we observed for both hypothesized regions of interest (ROI) and exploratory (whole-brain analyses) reduced activity in the left anterior temporal lobe (ATL) for taxonomically related versus unrelated word pairs, and for the exploratory analysis only, reduced activity in the right ATL. In addition, the exploratory analyses revealed reduced activity in the left temporo-parietal junction (TPJ) for thematically related versus unrelated word pairs. Consistent with the feature-based view, we found in the exploratory analyses that activity reduced in the bilateral precentral gyri (i.e., function regions) including part of premotor cortex as the function relatedness ratings increased. However, we did not find a relationship between adaptation effects in the bilateral ATLs and left TPJ and corresponding ratings of taxonomic/thematic relationships suggesting that the adaptation effects may potentially not reflect aspects of taxonomy that have been traditionally assumed. Together, our findings indicate that both feature and category information are important for the organization of object knowledge although the exact nature of those organization principles is an important question for future research.

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What we learned?

- ◆ The theoretical question was complex:
 - ◆ Feature vs. category based organization within two regions of interest anterior temporal, temporal-parietal junction
- ◆ Issues: how to define region of interest
- ◆ How specific the hypothesis need to be
- ◆ What would be a neutral-outcome to assess data quality
- ◆ Not ignoring null results
- ◆ How to report results from whole brain analysis

FAQ

1. “Is Registered Reports suitable for all sciences?”

- Applicable to any area engaged in deductive, hypothesis-driven research where one or more of the following problems apply:
 - **Publication bias**
 - **Significance chasing**
 - **HARKing – “hypothesizing after results are known”**
 - **Low statistical power**
 - **Lack of direct replication**
 - **Lack of data sharing**

2. “What’s to stop researchers from ‘pre-registering’ a study that they have already conducted?”

- Time-stamped raw data files must be submitted at Stage 2 with basic lab log and certification from all authors that data was collected after provisional acceptance
- Submitting a completed study at Stage 1 would therefore be fraud
- Strategy would backfire anyway when reviewers ask for protocol amendments
- *Registered Reports aren’t designed to prevent fraud but to incentivize good practice*

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3. “What’s to stop Registered Reports from becoming a dumping ground for inconclusive null results?”

- *a priori* power requirements ($\geq 90\%$) increase reproducibility of all findings
- Bayesian methods welcomed ($B < 0.33$ or $B > 3$ for substantial evidence). A specialist Bayes editor has been appointed at *Cortex* (Zoltan Dienes)

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4. “Won’t this limit the reporting of serendipitous findings?”

- There are **no restrictions** on the reporting of unregistered exploratory analyses.
- Confirmatory and exploratory analyses will simply be labeled correctly

5. “This is too much work for authors. We usually don’t decide how to analyse our data until after we’ve looked at it”

- It’s a similar amount of work, just done at a different time – and provisional acceptance virtually guarantees a publication, without the pressure to obtain “good results”

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- RR does requires in depth review of prospective methods and theoretical grounding.

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7. “Reviewers could steal my ideas at the pre-registration stage and scoop me”

- Only a handful of people know about each Stage 1 submission
- Once protocol is accepted, the journal can’t reject your paper because something similar was published (novelty is irrelevant)
- Manuscript received date on published RR will be the date of Stage 1 submission
- How different from grant applications, conference presentations, seminars?

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- No, but it gives peace of mind to authors that their papers won't be rejected because of negative findings, perceived novelty / importance of outcomes. No file drawer

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10. “I have no idea of what effect size to expect in my experiment, so how can I do a power analysis as part of Stage 1?”

- Usually there is at least some literature. But even if not, a minimal effect size of theoretical interest can be specified
- If minimal effect size is uncertain, options are an orthodox statistical approach with corrected peeking (Strube et al., 2006, *Beh Res Meth*, 38, 24-27) or Bayesian methods to specify distribution of possible effect sizes
- Pilot results to establish effect size are welcomed in Stage 1 submissions

11. “Sometimes a design is sound, but the data is garbage because researchers run the experiment poorly. How will you distinguish negative findings / weird results due to poor practice from those that are genuine?”

- Authors must include outcome-neutral conditions for ensuring that the experiments are capable of testing the stated hypotheses (e.g. positive controls, manipulation checks)

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13. “What happens if we need to change something about our experimental procedures after they are provisionally accepted?”

- Minor changes (e.g. replacing equipment) can be footnoted in Stage 2 manuscript as protocol deviations
- Major changes (e.g. changing exclusion criteria) require withdrawal and resubmission
- Editorial team decides whether deviation is sufficiently minor to continue

14. “Some of my analyses will depend on the results, so how can I pre-register each step in detail?” (e.g. outlier exclusion, ROI selection)

- Pre-registration doesn't require each decision to be specified, only the decision *tree*
- Authors can pre-register the contingencies / rules for future decisions

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16. “Pre-registration will denigrate exploratory research”

- No, what denigrates exploratory research is HARKing: presenting exploration as confirmation (shoehorning Kuhn into Popper)
- Exploratory analyses are welcome to be reported, but under an explicit heading.
- Exploratory research is simply not valued in its native form, so lets start doing so!

17. “How will Registered Reports incentivize replication studies?”

- Conspiracy of circumstances tells us not to bother doing direct (exact) replications
 - Method sections are often too vague to allow precise replication
 - Chronic lack of power in novel research means that replications often require very large sample sizes
 - Attempting to exactly repeat a previous experiment can be seen (in psychology) as an act of aggression (cf. physics)
 - Most psych/neuro journals want novelty and see replications as (usually) unpublishable
- RRs: have proposed replication experiment reviewed and provisionally accepted *before* you invest substantial resources into doing it; potentially involve original authors in peer review of the protocol

Registered Reports information hub on the Open Science Framework

The screenshot shows the Open Science Framework (OSF) Registered Reports Wiki page. The top navigation bar includes the OSF logo, 'Explore', and 'Help' links. Below this, a secondary navigation bar highlights 'Registered Reports' with sub-links for 'Wiki', 'Statistics', 'Registrations', and 'Forks'. The main content area is titled 'Home' and features a 'Project Wiki Pages' sidebar on the left. This sidebar lists various pages, including 'Details and Workflow', 'Journal Companion', 'Resources for Editors', and a series of 'FAQ' pages covering topics like 'Novelty of Format', 'Philosophy of Science', 'Design and Analysis', 'Timescale', 'Scientific Creativity and Exploration', 'Career Incentives', 'Scientific Quality', 'Workload and Bureaucracy', 'Strategies to Game the System', and 'For Journal Editors'. The main content area, titled 'View', contains a paragraph explaining the importance of Registered Reports, a quote from Daniel Simons and Chris Chambers about the initiative's impact, and a section titled 'Journals that have adopted Registered Reports' which lists journals like 'Attention, Perception, and Psychophysics' and 'Cognition and Emotion'. A URL is overlaid on the bottom right of the screenshot.

Open Science Framework Explore Help

Registered Reports Wiki Statistics Registrations Forks

Home

Project Wiki Pages

- Home
- 1. Details and Workflow
- 2. Journal Companion
- 3. Resources for Editors
- 4. Frequently Asked Questions
- FAQ 1: Novelty of Format
- FAQ 2: Philosophy of Science
- FAQ 3: Design and Analysis
- FAQ 4: Timescale
- FAQ 5: Scientific Creativity and Exploration
- FAQ 6: Career Incentives
- FAQ 7: Scientific Quality
- FAQ 8: Workload and Bureaucracy
- FAQ 9: Strategies to Game the System
- FAQ 10: For Journal Editors

View

Registered Reports emphasize the importance of the research question and the quality of methodology by conducting the peer review prior to data collection and analysis. Accepted papers then are virtually guaranteed publication in the journal if the authors follow through with the registered methodology.

"Registered Reports eliminates the bias against negative results in publishing because the results are not known at the time of review" said Daniel Simons, Professor at University of Illinois, Urbana-Champaign and co-Editor of Registered Replication Reports at Perspectives on Psychological Science. Chris Chambers, Professor at Cardiff University, section editor at Cortex and AIMS Neuroscience, and chair of the Registered Reports Committee supported by the Center for Open Science (COS) adds, "Because the study is accepted in advance, the incentives for authors change from producing the most beautiful story to producing the most accurate one."

Two articles provide an introduction to the Registered Reports concept: one is an introduction to a special issue of 15 Registered Reports in Social Psychology (Frost & Lavenex, 2014), the other is an introduction to Registered Reports for AIMS Neuroscience including answers to 25 common questions about Registered Reports (Chambers, Feredoes, Muthukumaraswamy, & Eickholt, 2014). Chris Chambers provides an update on how the Registered Reports initiative is making an impact in this article in Editors' Update.

Below is the list of journals currently offering Registered Reports or similar formats. This list will be updated regularly as new journals join the initiative. See also our table that compares the specific features of Registered Reports at different outlets.

Journals that have adopted Registered Reports

Not all journals adopt identical procedures for Registered Reports. To be considered for this list, the journal policy for registered reports must include at least these features: (a) peer review occurs prior to observing the outcomes of the research, and (b) manuscripts that survive pre-study peer review receive an in-principle acceptance that will not be revoked based on the outcomes, but only on failings of quality assurance, following through on the registered protocol, or unresolvable problems in reporting clarity or style.

AIMS Neuroscience (Editorial)

Attention, Perception, and Psychophysics

Cognition and Emotion

Comprehensive Results in Social Psychology

Cortex (Editorial)

Drug and Alcohol Dependence (Editorial)

Experimental Neuroscience (Editorial)

<https://osf.io/8mpji/wiki/home/>

Google “registered reports” – top hit

Thank you for listening

