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Wagenmakers, E.-J.; Dutilh, G.

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Preregistration: Why, What, Where?

Why preregistration? With preregistration, researchers stipulate their hypothesis and analysis plan in advance of data collection, tying their hands and letting the empirical chips fall where they may (Pierce, 1883). The theoretical advantage of preregistration is that it sharpens the distinction between two complementary but separate stages of scientific inquiry: the stage of generating hypotheses (i.e., exploratory research) and the stage of testing hypotheses (i.e., confirmatory research). By respecting this distinction, researchers inoculate themselves against the pervasive effects of hindsight bias and confirmation bias (e.g., Nuzzo, 2015). Preregistration does not prevent researchers from conducting and presenting exploratory analyses, but it does prevent them from unwittingly presenting an exploratory finding as if it had been confirmatory.

What should be preregistered? A useful preregistration document outlines the intended analysis plan in as much detail as possible. For instance, it is not enough to state "We will investigate the impact of playing violent video games on aggression" – this statement preregisters the hypothesis, but leaves the analysis plan vague. In order to appreciate the level of detail that is required, consider the questions that are asked on AsPredicted (<http://aspredicted.org/>), a website that facilitates user-friendly preregistration:

- 1) What's the main question being asked or hypothesis being tested in this study?
- 2) Describe the key dependent variable(s) specifying how they will be measured.
- 3) How many and which conditions will participants be assigned to?
- 4) Specify exactly which analyses you will conduct to examine the main question / hypothesis.
- 5) Any secondary analyses?
- 6) How many observations will be collected or what will determine sample size? No need to justify decision, but be precise about exactly how the number will be determined.
- 7) Anything else you would like to pre-register? (e.g., data exclusions, variables collected for exploratory purposes, unusual analyses planned?)
- 8) Have any data been collected for this study already?"

To obtain a feel for what aspects of an analysis plan need to be preregistered, you can also view online preregistration documents for published experiments. The rule of thumb is "when in doubt, preregister". After all, the goal of preregistration is to eliminate any wiggle room in the data analysis stage, and this requires that the exact analysis plan is specified beforehand. The ideal scenario is where the specifications in the preregistration document have been translated to a concrete syntax for data analysis; this syntax can be illustrated and tested on fake data. After the real data have been collected, the only action required to obtain your preregistered results is to replace the fake data with the real data.

Where to preregister the analysis plan? There are many options. In order to be compelling, the preregistration document needs to be stored publicly, so that you are not tempted to alter particular aspects after the fact. Here are some of the options:

1. Publish the preregistration document on a personal website.
This is what was done in Wagenmakers et al. (2012), in a bygone era for preregistration in psychology. The disadvantage of using personal websites are twofold: first, the preregistration document is easy to tinker with; second, the links may stop working. In fact, the link to the preregistration document reported in Wagenmakers et al. (2012) has stopped working – the document is still on the website, but finding it requires a search.
2. Publish the preregistration document on a mailing list.
The benefit of this kind of preregistration is that it is very public: everybody on the mailing list will know what you are attempting to demonstrate. If the experiment does not pan out as you had hoped, you may feel pressure to report the results regardless, reducing the effects of publication bias. The drawback is that everybody on the mailing list knows about your plans, which some researchers are uncomfortable with (for instance because they perceive a threat of being scooped). Another drawback is that the members of the mailing list may not be interested in your preregistration plans and consider themselves spammed.
3. Present the preregistration document to your Institutional Review Board as part of the approval process for particular experiments.
This option is natural, and at the Psychology Department at the University of Amsterdam the IRB approval process now requires that researchers stipulate whether their proposed experiments are exploratory or confirmatory; for the latter, a preregistration document is required. In order for this option to suffice on its own, there has to be a way to make the preregistration document publicly available using a permanent link. For now, it may be easiest to take the IRB preregistration document and simply post it on the OSF. In the future, it will be possible to create a link to your preregistration document directly via the ethical committee website, with the option to reveal it to the world or not, or at a later stage (after publication). The TOP is currently working on implementing these new features.
4. Post the preregistration document on the Open Science Framework.
The OSF provides specific facilities for preregistration. The "Registrations" tab presents a series of options that allow a project to be frozen, embargoed, and made publicly accessible. Preregistration itself is not public and therefore there is little pressure to publish or share the results regardless of the outcome.
5. Post the preregistration document on AsPredicted.
One advantage of AsPredicted over the OSF is that AsPredicted provides a series of questions that provide structure to the preregistration document, making preregistration easy and fast.
6. Engage in a Registered Report.
Promoted by Chris Chambers, the Registered Report (RR) format attempts to fight both significance seeking and publication bias. For a RR, authors initially submit for publication their introduction and method section together with a detailed data analysis plan. After review and successful revision the authors obtain "In Principle Acceptance",

which ensures that the eventual publication of the paper does not depend on the critical outcome (but it does depend on the data being of sufficiently high quality, where "quality" is unambiguously defined up front). A list of journals that have started to offer the RR format is available at <https://osf.io/8mpji/>. This list includes the Registered Replication Reports (RRR) at *Perspectives on Psychological Science*. The RRR format "consist of multi-lab, high-quality replications of important experiments in psychological science along with comments by the authors of the original studies." (<http://www.psychologicalscience.org/index.php/replication>).

To conclude: preregistration is beneficial and mechanically straightforward. The main difficulty with preregistration is that it forces the researcher to think carefully about the statistical analysis before the data have been collected. A blessing in disguise, this burden is bound to result in experiments that are better designed and less prone to confirmation bias and hindsight bias.

Annotated Online Materials on Preregistration

1. Gormally, C., & Nuzzo, R. (2015). Eureka! Whoops...not so much. Self-deception in science & what we can do about it.
<https://caragormally.wordpress.com/portfolio/eureka/>
A compelling comic about preregistration.
2. Nuzzo, R (2015). Fooling ourselves. *Nature*, 526, 182-185.
<http://www.nature.com/news/how-scientists-fool-themselves-and-how-they-can-stop-1.18517> A summary of how scientists fool themselves and how they can stop. The figure that lists "cognitive fallacies" and "debiasing techniques" is particularly instructive.
3. Hardwicke, T. (2016) A preregistration primer.
<https://osf.io/8uz2g/>. What the title says.
4. Wagenmakers, E.-J. (2015). A perfect storm: The record of a revolution. In-Mind Magazine: <http://www.in-mind.org/article/a-perfect-storm-the-record-of-a-revolution>.
A discussion of preregistration as a cure for the recent crisis of confidence in psychology.
5. Neuroskeptic, <http://blogs.discovermagazine.com/neuroskeptic>.
Neuroskeptic was one of the first researcher-bloggers who advocated preregistration as an effective tool against hindsight bias and significance seeking. Search for "preregistration" on the blog and you will find a number of relevant entries.
6. The Center for Open Science, <https://cos.io/prereg/>. This page is dedicated to the \$1,000,000
preregistration challenge and also features an instructional video.
7. A trio of Chris Chambers; first, his Open Letter to *Cortex*
(<http://neurochambers.blogspot.co.uk/2012/10/changing-culture->

[ofscientific.html](#)); second, the Open Letter to the Guardian (<http://www.theguardian.com/science/blog/2013/jun/05/trust-in-science-study-pre-registration>); finally, the OSF page on the Registered Report format (<https://osf.io/8mpji/wiki/home/>).

8. Leif Nelson, <http://datacolada.org/2014/01/07/12-preregistration-not-just-for-the-empiro-zealots/> This post describes one of the main reasons for preregistration: "I want people to be amazed."
9. COMPare, <http://compare-trials.org/>
A team of researchers from the University of Oxford set out to track "outcome switching" in clinical trials. This work is possible only because clinical trials have mandatory preregistration.

Annotated Reading List on Preregistration

1. Chambers, C. D. (2013). Registered Reports: A new publishing initiative at *Cortex*. *Cortex*, 49, 609-610.
Introduces the "Registered Report" format described above.
2. Chambers, C. D. (in press). The seven deadly sins of psychology: A manifesto for Open Science. Princeton University Press.
Set to appear in 2017, this compelling book promotes preregistration as one of the most reliable methods against motivated reasoning and hindsight bias. Highly recommended.
3. De Groot, A. D. (1956/2014). The meaning of "significance" for different types of research. Translated and annotated by Eric-Jan Wagenmakers, Denny Borsboom, Josine Verhagen, Rogier Kievit, Marjan Bakker, Angelique Cramer, Dora Matzke, Don Mellenbergh, and Han L. J. van der Maas. *Acta Psychologica*, 148, 188-194.
Originally published in Dutch, De Groot highlights why it is essential to discriminate hypothesis-generating research ("let us see what we can find") from hypothesis-testing research, arguing that the former presents a multiple-comparisons problem with the number of comparisons unknown. One of De Groot's conclusions: "One 'is allowed' to apply statistical tests in exploratory research, just as long as one realizes that they do not have evidential impact".
4. Feynman, R. P. (1974). Cargo cult science. *Engineering and Science*, 37, 10-13.
Transcript of a famous commencement address. Points out the importance of scientific integrity and warns against the danger of researchers fooling themselves. In 1878 and 1883, the same points were made by C.S. Peirce.
5. Feynman, R. P. (1998). *The meaning of it all: Thoughts of a citizen-scientist*. Reading, MA: Perseus Books.
On pp. 80-81, argues that researchers cannot find their hypothesis in the data. Gigerenzer later termed this "Feynman's conjecture", that is, "To report a significant result and reject the null in favor of an alternative hypothesis is

meaningless unless the alternative hypothesis has been stated before the data was obtained." (Gigerenzer, 2004, p. 602).

6. Gelman, A., & Loken, E. (2014). The statistical crisis in science. *American Scientist*, 102, 460-465. Suggests that researchers fool themselves with data-dependent analysis methods ("the garden of forking paths").
7. Gigerenzer, G. (2004). Mindless statistics. *The Journal of Socio-Economics*, 33, 587-606.
On page 602-203, this inspiring paper discusses "Feynman's conjecture" (a historically more apt term would be "Peirce's conjecture").
8. Goldacre, B. (2009). *Bad science*. London: Fourth Estate.
Highlights the problems of biased data analysis and advocates preregistration as a simple and effective cure (pp. 220-221).
9. Lindsay, D. S. (2015). Replication in psychological science. *Psychological Science*, 26, 1827-1832. Editorial that promotes preregistration.
10. Menke, C. (2009). *Zum methodologischen Wert von Vorhersagen* [On the methodological value of predictions]. PhD thesis, Paderborn.
In German, chapter 6 provides an interesting discussion on the pros and cons of Peirce's "predesignation" of hypotheses and analysis plans.
11. Moore, D. A. (in press). Pre-register if you want to. *American Psychologist*.
Argues that preregistration is an easy way for researchers to lay claim to their predictions.
12. Peirce, C. S. (1883). A theory of probable inference. In C. S. Peirce (Ed.), *Studies in logic*, pp. 126-181. Boston: Little & Brown.
One of the earliest pleas for "predesignation" in order to prevent researchers from fooling themselves. Includes detailed examples.
13. Simmons, J. P., Nelson, L. D., & Simonsohn, U. (2011). False-positive psychology: Undisclosed flexibility in data collection and analysis allows presenting anything as significant. *Psychological Science*, 22, 1359-1366.
Modern classic that provides a concrete example of how post-hoc methods of significance seeking can distort statistical conclusions.
14. Wagenmakers, E.-J., Wetzels, R., Borsboom, D., van der Maas, H. L. J., & Kievit, R. A. (2012). An agenda for purely confirmatory research. *Perspectives on Psychological Science*, 7, 627-633. Clearly the best work on the list, this article reiterates arguments from Peirce and De Groot (without citing either). It also contains a short discussion of the Texas sharp shooter (without acknowledging that the basic idea arguably goes back to Cicero).

Authors: Eric-Jan Wagenmakers & Gilles Dutilh (2016). Column for the Psychology Research Institute at the University of Amsterdam, <https://osf.io/jn3zt/>.