

**Journal:**

**Title:** Advocating for the credibility revolution

**Richard Ramsey<sup>1,2</sup>**

<sup>1</sup> Wales Institute for Cognitive Neuroscience, School of Psychology, Bangor University, Bangor, Gwynedd, Wales, LL57 2AS, United Kingdom.

<sup>2</sup> Department of Psychology, Macquarie University, Sydney, NSW 2019, Australia.

Correspondence: [r.ramsey@bangor.ac.uk](mailto:r.ramsey@bangor.ac.uk)

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The credibility of psychological science has been questioned recently, due to low levels of reproducibility and the routine use of inadequate research practices (Chambers, 2017; Open Science Collaboration, 2015; Simmons, Nelson, & Simonsohn, 2011). In response, wide-ranging reform to scientific practice has been proposed (e.g., Munafò et al., 2017), which has been dubbed a “credibility revolution” (Vazire, 2018). My aim here is to advocate why and how we should embrace such reform, and discuss the likely implications.

To my mind, the last 5 to 10 years have proved beyond reasonable doubt that common research and publishing practices have unwittingly seduced researchers (including myself) into thinking that high-quality psychological and brain science was unrealistically easy. And now we have hit a correction point. My hope is that even though psychology is a comparatively new science, by turning a weakness into a strength, it may prove instructive for more established scientific disciplines that face similar questions concerning common research practices. Psychology may be in a pivotal position to influence other fields because cognitive biases that harm scientific progress, such as confirmation and hindsight biases (Munafò et al., 2017), pervade all scientific endeavours; they do not only apply to psychology.

This short article is especially suited to anyone who is eager to start embracing reform, but feels overwhelmed by the scale and pace of change. Even though the central message is universal, it is especially aimed at early career researchers who are in the throes of generating and sculpting a research programme. In some cases, I take cues from recently published work, and in other cases I rely on my own experience leading a laboratory through this tumultuous time, as I believe both avenues are instructive. In turn, I outline why and how to embrace the credibility revolution and what the implications are for researchers.

Why?

As poignantly remarked by Richard Feynman, the primary imperative for any scientist is to avoid fooling yourself (Feynman, 1974). From this perspective, the credibility revolution aims to reinforce a defence against innocent self-delusion. The aim of reform is to build research structures that encourage and optimise cumulative science and the advancement of knowledge, a goal which every scientist can support. It wastes resources for researchers

to chase false positives, as well as re-create materials, experimental code and analysis pipelines endlessly around the world. Instead, the global aim of improving the trustworthiness and evidential value of science is better served if everyone shares as much as possible, thereby educating each other on the ways in which to best adopt more transparent and powerful research practices. From a selfish perspective, although there are costs, mainly in terms of time, there are also many benefits in terms of visibility, citations and job opportunities (McKiernan et al., 2016). Finally, on a personal level, it is exciting to be part of such a fast-paced and changing landscape where key pillars of scientific practice, which many of us have taken for granted as we trained and established our careers, are being scrutinised in a new light, and in some cases, dramatically changed.

How?

With so many valuable and eminently sensible suggestions for how to reform (e.g., Chambers, 2017; Munafò et al., 2017), it can be overwhelming to decide where and how to start. However, I encourage members of my own laboratory to not let perfection be the enemy of the good. Small starter steps add value on their own (Klein et al., 2018). Furthermore, behaviour change research has shown that for effective lifestyle changes, concrete plans for individual goals should be made gradually, so that they form consistent and repeatable habits (Dalton & Spiller, 2012; Lally, van Jaarsveld, Potts, & Wardle, 2010). In other words, to foster sustainable changes, it is ill-advised to attempt to change everything at once. In this spirit, out of the many practices one may ultimately want to adopt to embrace open science, I offer a three starting points, which I feel from personal experience represent a good cost-benefit trade-off:

1. *Pre-register* all confirmatory projects (using AsPredicted.org or the open science framework, OSF; <https://osf.io>) and aim towards submitting registered reports ultimately (<https://cos.io/rr/>). Transparently label exploratory projects and analyses as exploratory.

2. *Share* all research materials and data in an ethically appropriate manner, including raw data and analysis pipelines. See R and R Markdown for sharable analysis

pipelines (<https://rmarkdown.rstudio.com/>) and the OSF and Github (<https://github.com/>) for storage solutions.

3. *Preprint* articles prior to journal acceptance, so that they are immediately available and the work can benefit from wider feedback (e.g., PsyArXiv, bioRxiv).

What are the implications? The good, the bad and the beautiful.

The primary implication is that expectations regarding the research process need to change, in terms of timelines, scope and feasibility. Indeed, given the inferences that researchers typically want to make (Fried, 2017), many projects should not make it off the starting line when evaluated through an open science lens. A common refrain in my lab over the past 5 years has been “this is a non-starter”, a realisation my students and I (sometimes painfully) come to when we sit down to consider power, precision and feasibility of sample sizes.

All else being equal, the result will be slower, but better, science (Frith, 2015; Krakauer, 2019). As a community, we will make much more certain progress and use funds more efficiently, which will ultimately lead to the generation of more credible knowledge, which is, after all, the aim of what we are doing. As a trainee researcher or indeed as a laboratory director, it may feel like less distance is being travelled, but this is just a reflection of our own ignorance; we must shoulder the responsibility for acting like science was easier than it is, and implement the required correction (Firestein, 2012). Simply put, we should publish less work of higher quality, and we should change how science and scientists are evaluated so that work that extends knowledge is rewarded and incentivised (Kidwell et al., 2016; Moher et al., 2018; Nosek et al., 2015; Nosek, Spies, & Motyl, 2012).

On a positive note, help is at hand. A rapidly growing community exists to support efforts to be open, in terms of online materials (e.g., reproducibiliTEA, <https://osf.io/3qrj6/>), vibrant blogging and Twitter communities (e.g., <http://daniellakens.blogspot.com/>), an international society (SIPS, <https://improvingpsych.org>), as well as practical guidelines for laboratory policy (Klein et al., 2018), peer review (Davis et al., 2018), analysing data (e.g., <https://pagepiccinini.com/r-course/>), humility when encountering mistakes (Bishop, 2018), and visualising data in beautiful ways (Allen, Poggiali, Whitaker, Marshall, & Kievit, 2019);

Healy, 2019). In addition, there are comprehensive courses available online (e.g., <https://www.coursera.org/learn/statistical-inferences>), complete programmes in higher education (<https://psyteachr.github.io/>) and national networks (e.g., UK reproducibility Network, UKRN, twitter: @ukrepro). Some institutions are also beginning to drive change by embedding open science practice into research policy, including promotion guidelines (e.g., <https://tinyurl.com/yj78deh7>), and a recent editorial at Nature Human Behaviour has highlighted the need for reforming the way PhD students are trained and evaluated (Look beyond publications in assessment of PhDs, 2019). Therefore, you are not alone in having concerns, questions and aspirations regarding reform and there are many resources to help.

As a personal reflection, as somebody leading a team of researchers, I have found the scale of the challenge we face simultaneously daunting and stimulating, which has motivated me as a scientist more than any other single factor in the past 5 years. Further, the sense of solidarity and community spirit to help and bring others along on this open science journey has been refreshing and inspiring.

However, I acknowledge that such a rosy view of reform may not be shared by all (Houtkoop et al., 2018), and especially not early career researchers (ECRs). With such mammoth reform looming large and community expectations for eye-catching findings and publication numbers being slow to update, the threat of a career ending before it begins is ever more tangible (Allen & Mehler, 2019). So, what are ECRs, especially, to do? In my view, ECRs must take ownership and make open science best-practice a clear commitment that is front and centre in their research programme and clearly document this in their CVs (Dougherty, Slevc, & Grand, 2019). By explicitly articulating that not all scientific outputs are created equal, ECRs can maximise the career benefits of open science (McKiernan et al., 2016), whilst making it easier for hiring committees to see just how much added value has been produced and who may be in a position to drive substantial change in future research (Allen & Mehler, 2019).

In sum, I advocate embracing the credibility revolution and open-science best practice piece-by-piece and step-by-step for both principled and practical reasons. Although the costs are non-trivial, mainly in terms of time, I would argue that the benefits easily outweigh the costs (McKiernan et al., 2016). So, jump onboard the credibility revolution, as before long, open and credible science will be the only game in town and we will just call it science.

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