

## 32.5: Doing Reproducible Research

In the years since the reproducibility crisis arose, there has been a robust movement to develop tools to help protect the reproducibility of scientific research.

### 32.5.1 Pre-registration

One of the ideas that has gained the greatest traction is *pre-registration*, in which one submits a detailed description of a study (including all data analyses) to a trusted repository (such as the [Open Science Framework](#) or [AsPredicted.org](#)). By specifying one's plans in detail prior to analyzing the data, pre-registration provides greater faith that the analyses do not suffer from p-hacking or other questionable research practices.

The effects of pre-registration have been seen in clinical trials in medicine. In 2000, the National Heart, Lung, and Blood Institute (NHLBI) began requiring all clinical trials to be pre-registered using the system at [ClinicalTrials.gov](#). This provides a natural experiment to observe the effects of study pre-registration. When Kaplan and Irvin (2015) examined clinical trial outcomes over time, they found that the number of positive outcomes in clinical trials was reduced after 2000 compared to before. While there are many possible causes, it seems likely that prior to study registration researchers were able to change their methods in order to find a positive result, which became more difficult after registration was required.

### 32.5.2 Reproducible practices

The paper by Simmons, Nelson, and Simonsohn (2011) laid out a set of suggested practices for making research more reproducible, all of which should become standard for researchers:

- *Authors must decide the rule for terminating data collection before data collection begins and report this rule in the article.*
- *Authors must collect at least 20 observations per cell or else provide a compelling cost-of-data-collection justification.*
- *Authors must list all variables collected in a study.*
- *Authors must report all experimental conditions, including failed manipulations.*
- *If observations are eliminated, authors must also report what the statistical results are if those observations are included.*
- *If an analysis includes a covariate, authors must report the statistical results of the analysis without the covariate.*

### 32.5.3 Replication

One of the hallmarks of science is the idea of *replication* – that is, other researchers should be able to perform the same study and obtain the same result. Unfortunately, as we saw in the outcome of the Replication Project discussed earlier, many findings are not replicable. The best way to ensure replicability of one's research is to first replicate it on your own; for some studies this just won't be possible, but whenever it is possible one should make sure that one's finding holds up in a new sample. That new sample should be sufficiently powered to find the effect size of interest; in many cases, this will actually require a larger sample than the original.

It's important to keep a couple of things in mind with regard to replication. First, the fact that a replication attempt fails does not necessarily mean that the original finding was false; remember that with the standard level of 80% power, there is still a one in five chance that the result will be nonsignificant, even if there is a true effect. For this reason, we generally want to see multiple replications of any important finding before we decide whether or not to believe it. Unfortunately, many fields including psychology have failed to follow this advice in the past, leading to "textbook" findings that turn out to be likely false. With regard to Daryl Bem's studies of ESP, a large replication attempt involving 7 studies failed to replicate his findings (Galak et al. 2012).

Second, remember that the p-value doesn't provide us with a measure of the likelihood of a finding to replicate. As we discussed previously, the p-value is a statement about the likelihood of one's data under a specific null hypothesis; it doesn't tell us anything about the probability that the finding is actually true (as we learned in the chapter on Bayesian analysis). In order to know the likelihood of replication we need to know the probability that the finding is true, which we generally don't know.

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