Bias propagation in Bayesian meta-analysis: A simulation study

Executive Summary

The study explores the resilience of Bayesian meta-analysis against various forms of bias, specifically prior selection, and compares the impact of this bias to the widely recognised phenomenon of p-hacking in frequentist statistics. I aimed to empirically evaluate the robustness of Bayesian hypothesis testing under different prior distributions and true effect sizes by using simulated datasets and assessing the extent to which prior selection influenced the outcomes of statistical analyses both frequentist and Bayesian.

The core of the investigation involved the computational simulation of 50 studies (Figure 1), each with a placebo and control group, with varying differences in means $\Delta\mu$ to represent different effect sizes. Bayes' factors were then calculated under five distinct prior distributions for each $\Delta\mu$ group.

The findings indicate a nuanced relationship between prior selection and the resulting Bayes' factors. Contrary to initial expectations, the selection of biased (narrower) priors did not significantly skew the results towards either hypothesis, suggesting an inherent resilience of the Bayesian approach to the manipulations akin to *p*-hacking. This was particularly evident for larger effect sizes, where Bayesian methods consistently favored the alternative hypothesis, aligning with the true simulated effects.

However, for smaller effect sizes, the influence of prior selection became more pronounced, albeit not to the extent anticipated. The study further juxtaposed these Bayesian outcomes against traditional frequentist tests, revealing a comparable inability of both methodologies to detect very small effect sizes, underscoring a common limitation across statistical paradigms.

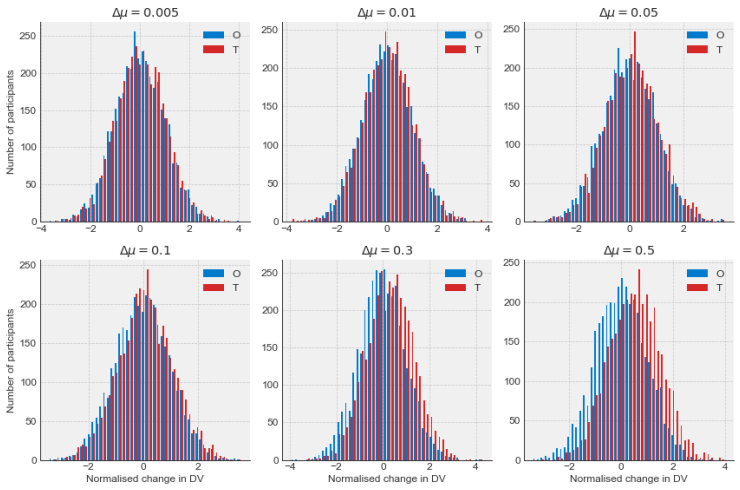

Figure 1

Aggregated data from the simulated studies

The implications of these findings are multifaceted. Firstly, they bolster the argument for the potential of Bayesian methods as a solid defense against statistical manipulation. Secondly, they highlight the importance of considering effect sizes and sample sizes in the design and interpretation of both Bayesian and frequentist analyses. Lastly, the study underscores the need for further empirical investigations into the effects of other elements of Bayesian analysis (such as likelihood selection) on bias propagation.