Open Science and Reproducibility of Science: Essential Foundations for Research Integrity

Course: **Research Ethics and Academic Integrity**

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1. Introduction

Science is about the systematic pursuit of knowledge that is dependable and can be checked or tested by others (Popper, 2005). An important feature of science is that it is an ongoing process, involving uncertainty, revision and continuous inquiry (Popper, 2005). Reproducibility and replication are one of the key mechanisms for establishing reliability of science (Rooney et al., 2016). Yet, in recent decades, the scientific community has confronted a profound challenge: a widespread reproducibility and replication crisis (Ioannidis, 2018). Reproducibility is concerned with data transparency, code availability, documentation and computational integrity and the question here is whether one study finding's can be obtained by an independent researcher given the same data and methods (Goodman et al., 2016). Replication on the other hand is concerned with external validity, robustness and whether phenomenon is real and the question is whether the same finding can be obtained given new data (Sileshi, 2023). With this crisis, many published findings fail to hold up under independent scrutiny. This crisis has raised significant concerns regarding the robustness, transparency and credibility of scientific findings across disciplines. The crisis is not just technical, but deeply ethical (Resnik & Shamoo, 2017), raising questions on research integrity, public trust in science, and the responsible use of resources.

One of the responses to reproducibility and replication crisis is Open Science, which covers research practices that promote transparency, accessibility, collaboration, and sharing of research outputs. By aligning research processes with principles of openness, open science seeks to enhance reproducibility while fulfilling ethical obligations under frameworks such as respect for autonomy, beneficence, justice, and non-maleficence (European Commission, 2010).

This essay explores the relationship between open science and reproducibility using the lens of research ethics and academic integrity. The main argument is that researchers have a moral

obligation to adopt Open Science practices, as this is essential for upholding the pursuit of truth, preventing misleading and harmful claims and ensuring that science serves society. It explores key definitions, nature of the crisis, challenges and potential solutions.

2. Definition of terms open science and reproducibility

Open science refers to a set of principles and practices that make scientific research more accessible, transparent, reproducible and collaborative. These include open access publishing, open data, open methods/code, open peer review and citizen science. International frameworks, such as UNESCO's Recommendation on Open Science, emphasise the importance of transparency, scrutiny, critique and reproducibility to reinforce rigour and societal impact (UNESCO, 2023). Central to Open Science are the FAIR principles (Findable, Accessible, Interoperable, Reusable) for data management and stewardship. FAIR principles aim to maximize data usage through rich metadata, persistent identifiers, standardized protocols and clear licensing, which enable both human and machine discovery, access, integration, and effective reuse (Wilkinson et al., 2016).

Reproducibility is defined as obtaining consistent results when repeating a study using the same or similar methods and data. Although it is sometimes used interchangeably with reproducibility, **replicability** refers to research where results can be duplicated using the same procedures, but with new data (Goodman et al., 2016).

Good science according to (Parsons & Wright, 2015) is characterized as rigorous, hypothesis-driven and transparent about limitations, as well as open to revision, as opposed to bad science which is based on flawed design, over-extrapolation and deliberate distortion for personal gain. Good science inherently supports reproducibility through openness.

Research integrity refers to adherence to research ethics (the principles, norms and regulations that govern how scientific research is conducted). Researchers are expected to observe principles of honesty, reliability, respect and accountability in conducting their research and not to falsify data and results, plagiarize or compromise methodological rigour (European Commission, 2010).

Open science refers to knowledge that is transparent and accessible, and which is shared and developed through collaborative networks (Vicente-Saez & Martinez-Fuentes, 2018).

3. The Causes and Scope of the Reproducibility Crisis

When reproducibility is not possible, a serious problem arises because this erodes science's credibility. The problem of lack of reproducibility is widespread across all scientific fields

including psychology, economics, management, finance, neuroscience, marketing, international business, leadership, and innovation research, education, medicine and sports and exercise science (Balafoutas et al., 2025). The replication crisis has been heavily debated in psychology, biomedicine, and economics, but it remains largely unappreciated and underreported in the agricultural sciences (Sileshi, 2023). Consequently, non-reproducible research in agriculture wastes finite funding resources, impedes scientific progress (e.g. climate adaptation strategies) and ultimately erodes public and policymaker trust in agricultural innovations.

The systemic challenges of the replication crisis are illustrated by previous studies, such as by (Camerer et al., 2016). The researchers attempted to replicate 18 laboratory experiments published in top-tier economics journals using high-powered, preregistered protocols and found that only 61% of the studies produced statistically significant effects in the original direction. Furthermore, even among the successful replications, the observed effect sizes shrank to an average of just 66% of their originally reported magnitudes. Interestingly, the study used prediction markets to gauge the beliefs of peers, revealing that economists could accurately predict which findings were robust and which were fragile simply by reviewing the methodology. Although experimental economics performed better than other disciplines, likely due to established disciplinary norms such as strict prohibitions against deceiving subjects and standard protocols for sharing materials, the findings emphasise that even the highest tiers of published social science are vulnerable to inflated effect sizes and un-replicable results.
Systemic factors have been cited as the cause of the ongoing reproducibility crisis. These include low statistical power, flexible analytical choices ('p-hacking'), publication bias favouring positive results and conflicts of interest (Ioannidis, 2018). While these questionable research practices undermine integrity, they do not necessarily constitute outright fraud. Institutional pressures, such as publish or perish culture, hyper-competition for funding, and metrics prioritizing quantity of publications over quality exacerbate the issue. Scientists bear a societal duty to produce reliable knowledge and combat misinformation. Non-reproducibility failures are a demonstration of ethical lapses and raise suspicions of data fabrication or manipulation, violating principles of honesty, transparency, and accountability central to research integrity.

Open Science as a Response From a virtue ethics perspective, Open Science cultivates habits of intellectual humility (acknowledging limitations), openness to scrutiny, and communal responsibility. It aligns with the duty to share knowledge as a public good and consequentialist

goals of maximizing societal benefit while minimizing harm (e.g., preventing policy based on irreproducible findings) (European Commission, 2010). The European Commission's ethics resources underscore informed consent, risk-benefit analysis, and justice in research, which are principles extended by Open Science to data subjects and future users. Withholding data or methods can constitute a form of injustice, denying colleagues and society the ability to verify or build upon work. In addition, selective reporting or non-disclosure of conflicts erodes public trust. Open practices, such as preregistration of studies, raw data and methods sharing and open access publishing act as safeguards against bias, promoting the self-correcting nature of science.

4. Challenges and Criticisms

Despite its benefits, Open Science faces obstacles. These include technical barriers such as data volume and standardisation, privacy and security concerns, especially in sensitive fields and resource disparities (low- and middle-income researchers may struggle with costs). An over-emphasis on openness can conflict with dual-use risks or proprietary interests (Khalil et al., 2022). Incentive structures remain misaligned, with career advancement often favouring novel, positive findings over replications or negative results. Critics question whether Open Science fully resolves the crisis or merely shifts problems (e.g. the flood of data without proper curation) (Klebel et al., 2025).

5. Pathways Forward

Although there is some deliberate action aimed at correcting the way research is conducted, e.g. through funding to support reproducibility and undertaking to publish all trial data, more can still be done. Teaching researchers on sound statistics (Wasserstein et al., 2019), remunerating researchers on quality rather than quantity of output and encouraging a culture where admitting mistakes is seen as a strength, not a failure and that knowledge is additive and results can be revised given new data and findings could help relieve the pressure to publish more over quality (Ioannidis, 2014).

Mitigating the 'natural selection of bad science' requires a structural shift in how scientific value is measured and rewarded. Modern Open Science frameworks and empirical critiques (e.g. (Balafoutas et al., 2025); (CEGA, 2019)) suggest that universities, funding bodies and journals should move away from purely quantitative metrics, such as raw publication volume and journal impact factors, and explicitly reward procedural rigour and analytical transparency instead. Specifically, academic institutions should restructure their hiring, promotion and tenure criteria so that they value the public sharing of fully documented, computationally reproducible code

and raw datasets, and treat high-powered replication studies as vital scholarly contributions. Furthermore, journals should adopt alternative publication models such as Registered Reports (CEGA, 2019), which evaluate and accept research protocols based on design merit before data collection begins. This would structurally eliminate publication bias and the incentive to engage in questionable research practices such as p-hacking. By embedding these transparent practices directly into institutional workflows, the scientific ecosystem can ensure that policies are grounded in trustworthy, replicable data.

6. Conclusion

Open science and reproducibility are not peripheral technical fixes; they form the ethical foundation of trustworthy scientific research. By embracing transparency systematically, researchers can combat systemic biases, fulfil their professional integrity obligations, and rebuild the public and academic trust that has been eroded by the reproducibility crisis. As (Parsons & Wright, 2015) caution, good science must inherently be open to scrutiny and revision; anything less compromises its validity and risks rendering it bad, unreliable and ultimately harmful to the communities it serves. For researchers and the wider academic community, navigating this landscape requires a shift in focus away from singular publication metrics and towards a culture of humility, collaboration and methodological accountability. Ultimately, honoring the societal contract of science requires deliberate alignment of institutional incentives, digital infrastructure and research ethics to ensure that open, reproducible practices become the absolute standard rather than the exception.

7. References

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