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SMALL SCIENCE: PERSPECTIVES ON CONTEMPORARY SMALL-SCALE RESEARCH

Small Science, Little Fraud? Scale and Misconduct in Contemporary Science

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Abstract: Given that issues of scale and size are commonly used in characterizations of small science, this paper explores their possible relationship with the prevalence of scientific misconduct. The study is based on a detailed review of recent empirical work addressing, both directly and indirectly, different aspects of scale in relation to questionable scientific practices. First, we discuss some problems in conceptualising scientific misconduct. Second, we examine the historical evolution of scientific misconduct, from traditional "epistemological" manipulation to contemporary "post-production" cheating and link it to deeper structural changes in science. Third, we review papers that have examined associations between the size of research groups and projects and other issues of scale, and the risk of misconduct. We conclude that there is substantial evidence that small-scale science affords valuable protection against threats to the values traditionally associated with scientific integrity and research ethics.

Keywords: scientific misconduct; fraud; small science; scale; research climate

Introduction

As early sociologists like Durkheim claimed, the study of deviance and deviant behaviour in any social institution—including society as a whole—is a useful way of understanding its norms, workings and key processes. According to Durkheim and later functionalist sociologists such as Robert Merton, deviance is a necessary part of any functioning society. It serves to clarify explicit and implicit norms, increase conformity and strengthen social bonds through reactions or punishments against deviance. Robert Merton's work on the ethos of science and its institutional imperative was in fact built on this view of deviance.[1]

While the precise status of Mertonian norms remains controversial and has been questioned by many authors,[2] certain practices and behaviours in science are often considered inappropriate or unethical. Most of them never leave the realm of academia or scientific communities. However, from time to time, there are cases that make the news and even become major public scandals.

Scholarly and public attention to scientific misconduct began to develop with some impetus in the 1980s. Two science journalists, William Broad and Nicholas Wade, published the book *Betrayers of the Truth: Fraud and Deceit in the Halls of Science* in 1982,[3] and in 1986 Alexander Kohn,[4] a distinguished biologist, published *False Prophets. Fraud and Error in Science and Medicine*.[5] These two books, together with other similar works, helped to make scientific misconduct a subject of discussion, concern and analysis.

The study of scientific misconduct has proven interesting for different reasons. Firstly, it helps to reveal the inner workings of science, bringing to the surface tacit or unspoken norms, rules or practices that are considered appropriate, good or fair, often going beyond the general guidelines of the so-called scientific method. Secondly, analyses and discourses on misconduct tend to depict slightly different or even contentious views of science itself.

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[1] Robert K. Merton, "The Normative Structure of Science," in *The Sociology of Science: Theoretical and Empirical Investigations*, ed. Robert .K. Merton, 267–278 (Chicago: University of Chicago Press, 1973 [1942]).

[2] S.B. Barnes and R.G. Dolby, "The Scientific Ethos: A Deviant Viewpoint," *European Journal of Sociology/Archives Européennes de Sociologie* 11, no 1 (1970): 3-25; Bruce Macfarlane, "The Decay of Merton's Scientific Norms and the New Academic Ethos," *Oxford Review of Education* 50, no.4 (2024): 468–83.

[3] William Broad and Nicholas Wade, *Betrayers of the Truth: Fraud and Deceit in the Halls of Science* (New York: Simon and Schuster, 1982).

[4] Kohn went on to co-found the scientific humour magazine *Annals of Improbable Research*, which since 1991 has organised the annual satirical Ig Nobel Prize for discoveries "that cannot, or should not, be reproduced."

[5] Alexander Kohn, *False Prophets. Fraud and Error in Science and Medicine* (Oxford: Basil Blackwell, 1986).

For example, the two books mentioned above took very different stands on the matter. While Kohn regarded scientific misconduct as just another instance of social misbehaviour and then naturalised it as a "normal"—though execrable—phenomenon that could be found in any social practice (from politics to sport), Broad and Wade took it as evidence that real science bears "little resemblance to its conventional portrait."[6] In the parlance of that time (the 1980s), they claimed that "non-rational" factors such as rhetoric, prejudice and greed also operate in science. While Kohn used misconduct to reinforce the standard view of science, Broad and Wade took it as proof that the standard view was largely inaccurate.

The aim of this paper is to foster dialogue between contemporary studies of scientific misconduct and historical and sociological discussions on structural features of present science, particularly those relevant for the small/big science distinction. We will try to do this by tackling a rather simple question: can issues of scale in scientific practice be associated with the likelihood of misconduct? In other words, is big science more prone to misconduct? Or is it the other way round? Is small science a safer harbour?

Though size and scale are not the only features of small/big science characterizations and they have even been problematized and nuanced by some authors,[7] matters of size and scale—for research groups, teams, laboratories, funding, and equipment—remain a key element in most approaches.[8] In this exploratory paper, we first discuss some of the key features of what appears to be an emerging new style of scientific misconduct, before attempting to link them to structural changes in the organisation, funding and assessment of science. Second, we consider how different aspects of scale and size can be associated with these new questionable practices. Scale has not been a main concern in the different strands of literature on scientific misconduct, but we will nonetheless rely on the few empirical studies that have directly tackled the issue, which focus mainly on team size and multi-authored papers, and on other works that have somewhat indirectly addressed it, as we expand the argument to other scale-related aspects: from large formal systems for evaluating science using metrics and big data, to the increasing agency of groups of scientists, networks, companies and entire institutions in fraudulent behaviour. Finally, we review the existing empirical literature on the relationship between the size of research teams or large collaborations on the one hand, and higher risk of misconduct or lower levels of research integrity on the other.

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[6] Broad and Wade, *Betrayers of the Truth*, 8.

[7] Catherine Westfall, "Rethinking Big Science: Modest, Mezzo, Grand Science and the Development of the Bevalac, 1971–1993," *Isis* 94, no. 1 (March 2003): 30-56; Catherine Westfall and Robert Crease, "The New Big Science," *Physics Today* 69, no. 5 (May 2016): 30-36.

[8] Xavier Roqué and Gemma Cirac, "Why Small Science," this issue.

An Elusive Matter

Defining scientific misconduct is no easy task. The usual characterisation of fraud as *fabrication, falsification and plagiarism* (FFP) may seem rather straightforward at first and is certainly the most standardised way of understanding the concept today. However, it is not always clear whether specific practices can be labelled in these terms. Let's take plagiarism, for instance. One recognised form is self-plagiarism, or as it is often euphemistically called, *text-recycling*: the practice of reusing one's own previously published texts for a new one, ranging from single phrases or sentences to whole paragraphs or even paper sections. Neither scholars who study the phenomenon nor scientists themselves agree on what levels of text-recycling are acceptable and what levels are inappropriate. Nevertheless, text-recycling is on the rise, with estimates suggesting that the current rate of occurrence (over 6% of all articles) is substantial and worrying.[9] Indeed, it seems to be one of the most widespread forms of scientific misconduct today.

What is considered unacceptable behaviour also varies across disciplines, posing an additional problem. Even particular forms of misconduct, like text-recycling, for instance, appear more admissible in some fields than in others. In economics, for example, the tolerance threshold for it seems lower than in history.[10] It is sometimes argued that in the humanities, wording is the essence of originality, so text-recycling should be especially avoided. In any case, it is worth noting that most discourses on misconduct—from scholarly analysis to scientists' statements or ethical codes—share an underlying vision of science as a single, unified entity in which differences between fields, at least regarding standards of misconduct, are usually minimised.

History is the final challenge in characterising scientific misconduct. Not only have conceptions of misconduct changed throughout the history of science but so have the ways in which it is handled and the levels of concern it raises. In a study of the evolution of the guidelines for ethical scientific conduct in the U.S. since the 60s, Montgomery and Oliver show a shift from an initial reliance on implicit norms and self-governance by the scientific community to a system of explicit, codified guidelines.[11] Though public funding agencies expected researchers to follow unwritten rules of conduct, this system was challenged by public scandals and growing awareness of research fraud in the late 1960s and early 1970s, thereby eroding the implicit trust in self-regulation. This triggered a major transformation

[9] Serge Horbach and Willem Halffman, "The Extent and Causes of Academic Text Recycling or 'Self-plagiarism'," *Research Policy* 48, no. 2 (2019): 492-502.
[10] Horbarch and Halffman, "The Extent and Causes," 496.
[11] Kathleen Montgomery and Amalya L. Oliver, "Shifts in Guidelines for Ethical Scientific Conduct: How Public and Private Organizations Create and Change Norms of Research Integrity," *Social Studies of Science* 39, no. 1 (2009): 137-155.

(1975-1990), where public agencies introduced explicit behavioural proscriptions backed by strong administrative oversight. More recently, since the early 1990s, the increasing involvement of private funding and the rise of public-private partnerships have driven a further shift toward articulating explicit, yet voluntary prescriptive norms. These newer guidelines move beyond simple prohibitions to emphasize affirmative duties and best practices for integrity, demonstrating a co-evolutionary process where the norms of ethical conduct are continually restructured in response to changes in the powerful actors and institutional logics involved in scientific research.

A look at the different terms that have been used to describe this phenomenon over the past few decades is highly indicative of the subtle changes we have gone through: scientific fraud, scientific misconduct, questionable research practices, unethical behaviour; and their antonyms: research integrity or responsible research, for instance. The term "fraud," which was very common in the 1980s and 1990s, is now largely absent from formal texts (research papers, ethical codes or institutional statements), whereas "research misconduct," "questionable research practices" and "research integrity" are on the rise. Currently, the most common approach, and the one we will use here, is to reserve fraud for the FFP triad, questionable research practices (QRPs) for other types of misbehaviour (particularly those we will discuss below), and scientific misconduct as the general term encompassing all of them. But more importantly, beyond the evolution of terms or descriptions, the very nature of scientific misconduct seems to have changed over the past two decades, as discussed below.

Another major issue regarding scientific misconduct is how important or serious it is. There are two basic positions on the matter that resemble the respective views expressed in the two books mentioned above. On the one hand, there are those who minimise its occurrence and impact. Misconduct happens in all human endeavours, so it is only natural to find it also in science. Moreover, the rate of scientific misconduct is quite low and involves only a small minority of scientists. It has little impact on the overall scientific venture and there is no reason to be alarmed.

On the other hand, there are those who argue that it must be dealt with, prevented and sometimes punished, even if it is a small issue in quantitative terms. Advocates of this position believe that science should not be so readily equated with other social practices because it has more "ethical" commitments at its core. "Science is built on honesty" and all scientists work on the assumption that their colleagues are not out to fool them.[12] Although the incidence of misconduct may be low, the damage to the production of reliable knowledge

[12] Kohn, *False Prophets*, 15.

can be significant and long-lasting. Fraudulent scientists are like "rotten apples" and should be removed from the basket before contagion spreads.

This second view is usually accompanied by a call for action. Several institutional mechanisms are often proposed, and in some cases eventually implemented, to deal with scientific fraud. Over the past few decades, many ethical codes have been devised by various scientific societies, universities and other scientific institutions, and many ethics committees have been established, some of which also deal with integrity issues. Journals have also introduced new guidelines to prevent different forms of misconduct in their publications. Finally, some funding agencies have set up their own devices. The US Office for Research Integrity is a notorious example of government involvement in the fight against scientific misconduct, in this case in the field of biomedical research.

The second perspective has evolved into what is now a relatively widespread approach, and the one we take here. Misconduct is increasingly viewed as a serious and concerning phenomenon with deep detrimental effects on science itself and its public image—a particularly critical issue in the era of denialism. But instead of taking an individualistic perspective—through the "rotten apples" angle—it is often linked to institutional and structural developments within and around science.[13]

Misconduct is Not What it Used to Be

Is scientific misconduct on the rise? This is a difficult question to answer. In addition to the elusive matter of accurately characterising the phenomenon, it is inherently difficult to measure for longitudinal comparisons. Without much thought, the rise of institutional devices to deal with research integrity could be taken as an indicator of its increasing incidence. However, it could also mean that the level of sensitivity or concern among stakeholders has risen for other reasons.

One usual way to tackle the measurement challenge is to look at journal retractions, since they can be tracked with a high degree of accuracy (largely thanks to the extraordinary work of the *Retraction Watch* blog).[14] Though many retractions are the result of unintentional mistakes or careless editing or writing, we do know that most of them—more than two-thirds—can be associated with some form of misconduct.[15] Furthermore, since journals are usually very reluctant to retract papers—it is not good for their reputation or business and

[13] Lex Bouter, "Why Research Integrity Matters and How it Can Be Improved," *Accountability in Research* 31, no. 8 (2024): 1277-1286.
[14] https://retractionwatch.com/
[15] Ferric C. Fang, R. Grant Steen and Arturo Casadevall, "Misconduct Accounts for the Majority

the process often takes years—, the total number of retractions may represent a very small proportion of the actual number of papers with serious problems.[16]

The number of retractions has increased dramatically over the past two decades. According to the Retraction Watch database, scientific journals retracted a total of 119 papers in 2002, compared to over 4,600 in 2022 and more than 10,000 in 2023. This astonishing exponential rise far exceeds the overall growth of published papers: the ratio between both figures has tripled in the last decade.[17]

Another valuable source of evidence stems from surveys of scientists regarding their own, and their colleagues', involvement in misconduct. The most recent and comprehensive meta-analysis[18]—which synthesized 43 studies across 18 countries, encompassing 23,228 participating researchers—revealed that 2.9% personally admitted to falsifying, manipulating, or plagiarizing work, and 12.5% admitted to committing questionable research practices. With respect to knowledge of their colleagues' behaviour, the figures rose to 15.5% for outright fraud and 39.7% for other questionable practices. A recent study focused on scientists who had received a research grant from the U.S. National Science Foundation (NSF) showed highly similar results.[19]

Given the notable consistency in these studies' findings, we can conclude that the current prevalence of misconduct in science, in all its varieties, is substantial and alarming. The available evidence discredits the traditional view that scientific misconduct is a limited or anecdotal phenomenon. Indeed, scientific misconduct appears to have become widespread and involves a significant number of researchers.[20] In addition, the nature of misconduct itself seems to be changing.

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of Retracted Scientific Publications," *Proceedings of the National Academy of Sciences* 109, no. 42 (2012): 17028-17033; Fabián Freijedo-Farinas et al., "Biomedical Retractions Due to Misconduct in Europe: Characterization and Trends in the Last 20 Years," *Scientometrics* 129, no. 5 (2024): 2867-2882.

[16] Ivan Oransky and Adam Marcus, "Science Corrects Itself, Right? A Scandal at Stanford Says It Doesn't," *Scientific American*, August 1(2023). Accessed December 2, 2025. https://www.scientificamerican.com/article/science-corrects-itself-right-a-scandal-at-stanford-says-it-doesnt/

[17] Richard Van Noorden, "More than 10,000 Research Papers were Retracted in 2023—A New Record," *Nature* 624, no. 7992 (2023): 479-481.

[18] Yue Xie, Kai Wang and Yan Kong, "Prevalence of Research Misconduct and Questionable Research Practices: A Systematic Review and Meta-analysis," *Science and Engineering Ethics* 27, no. 4 (2021): 41.

[19] Siddhartha Roy and Marc A. Edwards, "NSF Fellows' Perceptions About Incentives, Research Misconduct, and Scientific Integrity in STEM Academia," *Scientific Reports* 13, no. 1 (2023): 5701.

[20] Felicitas Hesselmann and Martin Reinhart, "Cycles of Invisibility: The Limits of Transparency in Dealing With Scientific Misconduct," *Social Studies of Science* 51, no. 3 (2021): 414-438.

In a recent volume edited by Mario Biagioli and Alexandra Lippman,[21] the authors claim that a whole new style of misconduct and questionable practices has emerged over the past two decades. They acknowledge the persistence of traditional scientific fraud (FFP), which is usually associated with the famous motto "publish or perish." However, they note that the new style is gaining momentum and is linked to a slightly different imperative: "impact or perish."

Whereas traditional misconduct is mostly about manipulating the content of publications (data, images, experimental results, etc.), contemporary misconduct is mostly about artificially altering some of the processes *around* publications: citation counts, journal impact factors, h-indexes, and other metrics that are so heavily used in many current institutional research assessment systems. Because these systems largely rely on publication metadata rather than actual content—meaning that reading them is no longer necessary—misconduct practices have evolved to accommodate them. They are more "bureaucratic crimes than epistemic crimes."[22] The old way can be described as *fraud in production* (manipulation of the content to be produced, i.e. knowledge and information), while the new way can be described as *post-production cheating* (manipulation of how the paper is accounted for or assessed).

The new quantitative, metrics-based paradigm of research assessment not only stimulates these new forms of misconduct but also creates the conditions for them. Citation cartels and farms, fake peer reviews, paper mills, fake authors, and other such forms—usually encompassed under the category of questionable research practices—are flourishing and becoming increasingly sophisticated and difficult to detect. The pressure to "have impact" is so strong and pervasive that scientists are expected to convince funders and administrators that their proposed research will have a significant impact even before it is carried out. This has profound consequences for scientific research in most fields, beyond the proliferation of questionable practices. In a remarkable turn, impact is no longer considered an outcome of research; instead, as Michael Power sharply puts it, "it is now research, or a certain style of research, that is becoming the product of an apparatus that targets impact."[23]

This new style of misconduct, consisting mainly in "gaming the metrics," has therefore been causally linked to current research assessment practices that promote productivity and quantity of outputs at the expense of quality. However, other more basic structural factors have also been suggested. The present organization of science has often been

[21] Mario Biagioli and Alexandra Lippman, eds., *Gaming the Metrics: Misconduct and Manipulation in Academic Research* (Cambridge MA: MIT Press, 2020).

[22] Biagioli and Lippman, *Gaming the Metrics*, 4.

[23] Michael Power, "Playing and Being Played by the Research Impact Game," in *Gaming the Metrics*, eds. Mario Biagioli and Alexandra Lippman, 57-66, (Cambridge MA: MIT Press, 2020).

conceptualised as the neoliberal turn in technoscience,[24] academic capitalism,[25] the era of science privatisation/commercialisation[26] or a new regime of knowledge production.[27] For most of these approaches,[28] the productivist turn in research assessment is a specific instance of the introduction of market-like mechanisms within science, in order to foster competition and enable the commodification of scientific knowledge—increasingly taken as a financial asset. Therefore, hyper-competition has evolved into an important driver for scientific activity and has deeply transformed the working of most academic institutions.[29] In fact, empirical studies on hyper-competition, as we will see in more detail below, have shown its positive association with questionable behaviour.[30]

Another related structural feature of present science that might lay behind many cases of misconduct, particularly those usually typified in retractions as "failure to report conflicts of interest," is the strengthening of ties with industry and finance. A well-known global trend in research funding over the past four decades has been the steadily decreasing rate of public financial support and the increasing role of the private sector—Mirowski[31] has extensively documented and discussed this tendency for the US case. According to the OECD,[32] in major economic blocks like the United States, China, Japan, and the European Union, the business sector is the primary source of R&D funding, often accounting for 65% to nearly 80% of total Gross Domestic Expenditure on R&D. These activities are mainly carried out either by companies or by universities through contracted research or private-public partnerships. Many conflicts of interest, particularly in biomedical research which is now the most important area of science in terms of output and funding, come from monetary connections between public researchers and private funders. In fields such as pharmacology, it is almost impossible to find researchers without financial ties to private

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[24] Luigi Pellizzoni and Marja Ylönen, eds., *Neoliberalism and Technoscience: Critical Assessments* (London: Routledge, 2012).

[25] Sheila Slaughter and Larry Leslie, *Academic Capitalism: Politics, Policies, and the Entrepreneurial University* (Baltimore: Johns Hopkins University Press, 1997).

[26] Philip Mirowski, *Science-mart: Privatizing American Science* (Cambridge: Harvard University Press, 2011).

[27] Dominique Pestre, *A Contre-science: Politiques et Savoirs des Sociétés Contemporaines* (Paris: Seuil, 2013).

[28] There has been some controversy over them among historians and STS scholars; see, for instance, the exchange between Helga Nowotny and Dominique Pestre in *Science, Technology and Society* 5, no. 2 (March 2000).

[29] Willem Halffman and Hans Radder, "The Academic Manifesto: From an Occupied to A Public University," *Minerva* 53, no. 2 (2015): 165-187.

[30] Elise Smith et al., "Misconduct and Misbehavior Related to Authorship Disagreements in Collaborative Science," *Science and Engineering Ethics* 26, no. 4 (2020): 1967-1993.

[31] Mirowski, *Science-mart*.

[32] OECD, "Main Science and Technology Indicators," Directorate for Science, Technology, and Innovation, data base, September (2025).

corporations. Just as an illustration, in 2002 the prestigious *New England Journal of Medicine* retracted a ban that prevented authors of review papers from having any financial links to the pharmaceutical companies whose drugs were being assessed. The journal cited the unavailability of supposedly unbiased specialists as the reason for this embarrassing policy reversal.[33]

Scale and Misconduct

Big science is often described as implying large projects (involving many researchers) and large amounts of funding. There is empirical evidence that large-scale, multidisciplinary projects requiring extensive resources (from people to infrastructures) are no longer isolated spots in a great sea of—relatively—small science; on the contrary, they are becoming increasingly common in many areas of science and engineering.[34]

Nevertheless, projects and teams, important as they seem, are not the only aspects of science that have become substantially bigger in recent decades. We have already mentioned the new quantitative research assessment system, which is generally based on big data from large databases, usually owned by a few private companies. This new system can produce assessments on a larger scale and at a faster pace, but at a lower cost, than the traditional peer review process. As one might expect, its standards of quality and accuracy are much lower, to say the least.[35]

Academic publishing has also suffered from sharp inflationary growth in some of its dimensions. The total amount of papers published has exhibited exponential growth, increasing by 59% in the decade from 2012–2022.[36] Until a few years ago the whole sector was dominated by five major publishing houses (Elsevier, Black & Wiley, Taylor & Francis, Springer Nature and SAGE), which controlled more than 50% of the market. In line with the privatisation turn mentioned above, these for-profit commercial publishers began in the 1960s and 1970s to acquire top-tier journals previously owned by scientific or academic not-for-profit societies.[37] These publishers are among the most lucrative companies in the

[33] Jeffrey M. Drazen and Gregory D. Curfman, "Financial Associations of Authors," *New England Journal of Medicine* 346, no. 24 (2002): 1901-1902.

[34] Alexander M. Petersen, Ioannis Pavlidis and Ioanna Semendeferi, "A Quantitative Perspective on Ethics in Large Team Science," *Science and Engineering Ethics* 20, no. 4 (2014): 923-945.

[35] Diana Hicks et al., "Bibliometrics: the Leiden Manifesto for Research Metrics," *Nature* 520, no. 7548 (2015): 429-431.

[36] National Science Board, NSF, "Publications Output: U.S. Trends and International Comparisons," Science and Engineering Indicators (2024). NSB-2023-33. Alexandria, VA. Accessed December 2, 2025. https://ncses.nsf.gov/pubs/nsb202333/.

[37] For a detailed historical account of the evolution of academic publishing see Aileen Fyfe et al., *A*

world: their global revenues are similar to those of the film and music industries, while their profit margins surpass those of Apple and Amazon.[38]

But in the last decade, a few new publishers have emerged with a new operating model. They have occasionally been grouped into the predatory category, though their journals do not fully satisfy all standard criteria and exhibit significant differences in key areas such as peer review, editorial oversight, and indexing. They are usually termed *questionable* or *grey* publishers and share characteristics with both legitimate and predatory models. Publishers like Frontiers and MDPI are frequently included in the category. All their journals are open access—they emphatically present themselves as champions of open science—, and their business model relies primarily on charging authors APCs (article processing charges). Compared to plain predatory publishers they are much larger companies and publish far more papers; in 2024 MDPI journals published 285,000 papers, which now makes it the fourth most important scientific publisher by volume. And, while authors in predatory journals come mainly from the Global South, those publishing in questionable journals are predominantly from China, US, and the EU—in this case mostly from central, east and southern countries.[39]

From the point of view of scientific misconduct, these publishers have often been linked to different forms of questionable practices, including their remarkably short review cycles—often featuring brief, vague, or generic feedback—; the enormous volume of publications, largely through special issues—just a single MDPI journal (*Int. J. Environ. Res. Public Health*, delisted from the Web of Science in 2023) published more than 17,000 papers in one year—; a low barrier to entry for editorial board members; a high rate of self-referencing; and their complex and aggressive system of discounts and author incentives.[40] Concerns and controversies over these journals have arisen in the last years among many scientists and analysts. An interesting example for readers of this journal took place among STS and meta-research scholars involved in a special issue for a Frontiers journal.[41] In countries like Spain, hundreds, maybe thousands of scholars have achieved tenure or professorships

History of Scientific Journals (London: UCL Press, 2022).

38 Martin Hagve, "The Money Behind Academic Publishing," *Tidsskrift for Den norske legeforening* 140, 17 August (2020).

39 Peter Sasvári and Anna Urbanovics, "The Current Situation of MDPI Publications? Findings from the EU-27 Member States," in Proceedings of the Central and Eastern European *eDem and eGov Days*, 191-197 (New York: ACM, 2023).

40 M. Ángeles Oviedo-García, "Journal Citation Reports and The Definition of a Predatory Journal: The Case of the Multidisciplinary Digital Publishing Institute (MDPI)," *Research Evaluation* 30, no. 3 (2021): 405-419a.

41 Serge Horbach, Michael Ochsner and Wolfgang Kaltenbrunner, "Reflections on Guest Editing a Frontiers Journal," *Leiden Madtrics Blog,* October 31, 2022. Accessed December 2, 2025. https://www.leidenmadtrics.nl/articles/reflections-on-guest-editing-a-frontiers-journal

thanks to these publications. They are sometimes ironically called "MDPI professors." This has created a comparative grievance with scholars who have not resorted to these "easy" venues.[42]

These new developments show different ways in which matters of size and scale in science are connected to scientific misconduct. First, publication in questionable journals is clearly associated with some forms of misconduct such as hyper-prolific authors—those publishing more than one paper per week—a striking new phenomenon in science.[43] Secondly, some of the new instances of misconduct involve whole organizations or institutions—from large publishers to paper mills—and are no longer perpetrated by individual scientists but instead involve groups and networks of scientists. Another example of this are citation cartels: groups of authors who quote each other excessively or disproportionately more than other scientists working on the same subject. Citation cartels (or citation rings, as they are also called) have proliferated and sometimes become more sophisticated and efficient when they manage to enlist journal editors.[44] Finally, ghost authorship—more prominent in biomedical research—is another common post-production questionable practice that requires institutional support, mainly from pharmaceutical companies, and there is evidence that it is also on the rise.[45]

Overall, it seems that misconduct is becoming collaborative and even institutional. Although individual and small-scale fraud is likely to remain as common as before, collaborative endeavours involving coordinated action by groups of scientists seem to be the trending pattern now. Thus, the collaborative turn in scientific research that took place throughout the 20th century has now expanded to scientific misconduct.

The Links Between Large Teams and Misconduct

Are larger research teams more prone to misconduct? In principle, one might expect that research carried out by groups of scientists would be less inclined to questionable practices or outright fraud than research carried out by individual authors, simply because the colleagues involved are likely to exert some degree of social control. A study of

[42] Emilio Delgado López-Cózar and Alberto Martín-Martín, "Detectando Patrones Anómalos de Publicación Científica en España (I): Las Evidencias Empíricas," *Anales de Química de La RSEQ* 119 no. 2 (2023): 71-86.
[43] Edré Moreira et al., "The Rise of Hyperprolific Authors in Computer Science: Characterization and Implications," *Scientometrics* 128 no. 5 (2023): 2945-2974.
[44] Biagioli and Lippman, *Gaming the Metrics*, 11.
[45] Sergio Sismondo, *Ghost-managed Medicine: Big Pharma's Invisible Hands* (Manchester: Mattering Press, 2018).

retractions provides some evidence in this direction: according to Rathmann and Rauhut,[46] larger groups of scientists demonstrate a lower likelihood of retraction than their smaller counterparts. However, a deeper and more extensive analysis has shown some correlation between misconduct (also in terms of retractions) and larger groups. Specifically, papers with more than three authors have a higher retraction rate than those by one or two authors. In addition, authors involved in large collaborations tend to accumulate more retractions. [47]

When indexes other than retractions are considered—for instance, the so-called positive results bias—larger collaborations in science appear to run a higher risk of misconduct.[48] This is particularly evident in multidisciplinary and international projects, where both the epistemic and cultural distance between authors often hinders mutual scrutiny and criticism. As a result, larger collaborations have a higher rate of positive results and more retractions.

This last point raises the question of what other aspects of large research collaborations may contribute to the prevalence of misconduct. Several scholars have suggested that the *allocation of credit* is a recurrent source of problems in large collaborations. The likelihood of unfair reward seems to increase with team size: the more researchers involved, the harder it is to allocate *ex post facto* credit and responsibilities.[49] In this context, the inclusion or exclusion of individual researchers from co-author lists—often, as a matter of hierarchy—is usually a matter of disagreement. The same applies to the disentanglement of conflicts of interest when many researchers are involved in a single publication.

Another particular concern in large team research is the *weakening of the mentor-mentee relationship*. A higher ratio of mentees (such as PhD candidates) to a supervisor diminishes the amount of time available for each student. This is known to reduce the development of strategies to avoid misconduct or questionable practices, which in turn can have a profound impact on the transmission of values across generations of scientists. Petersen et al. generalise this idea to a decrease in "the ability of any given team member to monitor all aspects of the team's operation" as the number of participants grows.[50]

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[46] Justus M.K. Rathmann and Heiko Rauhut, "Teams Prevent Misconduct: A Study of Retracted Articles From the Web of Science," *17th International conference on Scientometrics & Infometrics ISSI 2019,* 1032-1037 (Rome: Editioni Efesto, 2019).

[47] Kiran Sharma, "Team Size and Retracted Citations Reveal the Patterns of Retractions from 1981 to 2020," *Scientometrics* 126, no. 10 (2021): 8363-8374.

[48] Daniele Fanelli, "Pressures to Publish: What Effects Do We See?," in *Gaming the Metrics: Misconduct and Manipulation in Academic Research*, eds. Mario Biagioli and Alexandra Lippman, 111-122 (Cambridge: MIT Press, 2020).

[49] Petersen et al., "A Quantitative Perspective," 931.

[50] Ibid.

The mentor-student relationship takes us beyond the metrics of publications, citations and author lists and into a more abstract and subtle realm: the work environment in scientific institutions. In a recent study on the determinants of scientists' perceptions of misconduct,[51] the authors conclude that what they call the "research climate" is the most important and influential. The research climate includes aspects such as adherence to ethical norms, fairness of supervision/mentoring or quality of resources. Other studies in this line have shown that when scientists believe they are treated fairly, they are less likely to engage in misconduct.[52]

One of the critical aspects of the research climate in most scientific institutions today is a strong competition imperative. Advocates claim that science has always been steeped in competition. They are right: historical examples of notorious scientists competing for discovery, attribution, prestige, glory or money abound. However, competition is now much more intense than ever before because it is incentivized with unprecedented strength by different institutions (including scientific ones) and enforced by new tools (from research assessment metrics to all kinds of rankings). This is why many authors prefer to use the term *hyper-competition* to describe some of these current phenomena.

The link between hyper-competition and scientific misconduct has become a serious concern for many scholars. Empirical studies have found a positive relationship between the degree of perceived competition in research environments and the "likelihood that departmental members will observe misconduct among their colleagues."[53] Strong competition is correlated with higher exposure to misconduct, fear of retaliation for whistleblowing and other sources of conflict and is negatively associated with adherence to regulatory and ethical codes and sense of community. In addition, the ubiquitous introduction of science policies for achieving excellence exacerbates the hyper-competitive imperative and some of its adverse effects: "a decline in free and open sharing of information and methods, sabotage of others' ability to use one's work, interference with peer-review processes, deformation of relationships, and careless or questionable research conduct."[54] It could be argued that Robert Merton's famous Matthew effect is now financially strengthened, as many scientists compete for scarce rewards and resources in a system that disproportionately favours those with marginally greater achievement. Finally, some authors have also explored the negative

[51] Tamarinde Haven et al., "Explaining Variance in Perceived Research Misbehavior: Results From a Survey Among Academic Researchers in Amsterdam," *Research Integrity and Peer Review* 6, no. 1 (2021): 1-8.

[52] Madelijne Gorsira et al., "Corruption in Organizations: Ethical Climate and Individual Motives," *Administrative Sciences* 8, no. 1 (2018): 4.

[53] Melissa S. Anderson et al., "The Perverse Effects of Competition on Scientists' Work And Relationships," *Science and Engineering Ethics* 13, no 4 (2007): 437-461, on 439.

[54] Anderson et. al., "The Perverse Effects," 443.

epistemic effects of hyper-competition—on the kind of research problems addressed and their relationship with societal values and concerns.[55]

Conclusion

The historical evolution of scientific misconduct, moving from traditional data manipulation to contemporary "post-production" cheating, is a clear reflection of dramatic structural changes in how science is now organized and assessed. The new style is linked to the impact imperative and involves artificially altering the processes around publications, such as juggling citation counts, journal impact factors, and other metrics heavily used in research assessment systems. Many of these practices suggest misconduct is becoming increasingly collaborative and even institutionally based.

We traced the causes and incentives for this new style of misconduct to deeper structural features of contemporary science. The introduction of market-like mechanisms—such as metrics and rankings—has strengthened what some authors term as hyper-competition, which some empirical studies have strongly associated with questionable behaviour. This intense environment erodes adherence to ethical codes, diminishes the sense of community, and might ultimately affect the shaping and selection of research topics. Moreover, beyond assessment systems, the increasing involvement of private interests and funding in scientific research is another source of frequent misconduct.

Our central question explored whether issues of scale can be associated with the likelihood of misconduct, and thus whether small science might be more immune to it. Based on a review of the empirical work available, our tentative conclusion is that large scale schemes—in research teams, collaboration, research assessment and even the publishing environment—seem to show a higher incidence of misconduct and questionable research practices. The problematic allocation of credit and responsibility in large teams, the weakening of supervisory and mentoring roles (which hinders the transmission of ethical values), and the shrinking of community ties are some of the possible causal mechanisms for this link. All of them end up damaging the research climate of specific research sites, which is the most influential factor in determining scientists' engagement in misconduct.

This suggests the converse: where these characteristics are absent, as is often the case in small science endeavours, misconduct is less likely to occur. Naturally, we do not intend

[55] Stephanie Meirmans, "How Competition For Funding Impacts Scientific Practice: Building Pre-Fab Houses But No Cathedrals," *Science and Engineering Ethics* 30, no. 1 (2024), 6; Maximilian Fochler, Ulrike Felt and Ruth Müller, "Unsustainable Growth, Hyper-Competition, and Worth In Life Science Research: Narrowing Evaluative Repertoires in Doctoral And Postdoctoral Scientists' Work And Lives," *Minerva* 54 no. 2 (2016): 175-200.

to establish a simple link between small science and a kind of guaranteed immunity from scientific misconduct. However, just as different characterizations of small science have pointed to its strong relationship with certain social values—frugality, flexibility, diversity, or sustainability—we understand that some aspects of small-scale science also afford valuable protection against threats to the values traditionally associated with scientific integrity and research ethics.

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Competing Interests

The author has declared that no competing interests exist.