

1 Introduction

Openness has long been a guiding principle for liberal democracies, where recognition of the epistemic significance of transparent, free and inclusive inquiry is a source of both political and scientific legitimacy. Just as politicians owe their credibility and influence to their perceived accountability vis-à-vis the electorate, scientists owe their credibility and influence to the perceived effectiveness and breadth of the scrutiny applied to their research. Openness is often viewed as a necessary complement to accountability and public scrutiny. As argued by philosophers ranging from Karl Popper to Jürgen Habermas, Helen Longino and Philip Kitcher, what distinguishes a dictator from an elected leader – or a scientist from a crook – is the extent to which their decision-making processes are visible, intelligible and receptive to critique.

The Open Science (OS) movement, with its emphasis on ensuring that research outputs, components and methods are widely disseminated, scrutinized and reused for the good of science and society, is but the latest chapter in the historical co-evolution of political and scientific accountability. In this sense, the movement is neither novel nor surprising, and maintains a strong continuity with values long viewed as definitive of scientific research – such as the critical questioning of dogmas, the search for reliable evidence, the privileging of rational reasoning and the emphasis on public scrutiny and debate. At the same time, OS has gathered momentum over the last three decades as a response to the broad transformations brought about by the digitalization, globalization and commodification of research. As new technologies and an ever-growing workforce massively increase the volume and velocity of discoveries, questions around what constitutes effective communication become more urgent, with scientific institutions struggling to adapt their practices to the collaborative exigencies of the contemporary world. Insofar as it strives to respond to these developments, OS is all about novelty: it is explicitly geared towards transforming the research system as currently construed, thus potentially revolutionizing the ways in which the scientific process is construed, performed and assessed.

A key component of this transformation is a renewed attention to the multiplicity and diversity of outputs produced over the course of scientific inquiry. Open Science is widely portrayed as an opportunity to redesign research practices, evaluation and governance to better highlight and utilize such outputs, including books and articles but also data, models, software, techniques, instruments, samples and other research constituents whose epistemic value has arguably been underestimated within science communication and credit systems. Hence the blossoming of digital infrastructures to guarantee free and instant access to research papers, data and models ('Open Access', 'Open Data', 'Open Methods');

standardized note-taking tools, such as digital lab books, to help document and eventually replicate research procedures ('Open Notebooks'); reviewing systems that, rather than looking for original contributions to existing knowledge, assess the robustness and validity of research outputs, thus fostering publication of all high-quality results without necessarily making assumptions around what may be especially significant and for whom ('Open Peer Review'); and collaborative venues to foster the exchange of insights and materials across national, disciplinary, professional and cultural borders – particularly through forms of public engagement that bring insights from non-scientists into research ('Citizen/Community Science'). Public and private institutions around the world have set up strategies to support OS initiatives, ranging from national roadmaps to international treaties, online publishing platforms, updated checks on research quality and revised metrics for scholarly excellence. Politicians have also embraced OS with renewed vigour, presenting it as an effective mechanism to transform basic research into 'scientific capital' for future innovation,¹ and thereby reasserting the deep link between the political and scientific roles of openness. From corporate boardrooms to university management and political positioning, debate over the significance of OS and its implementation has risen to the top of the agenda.

This Element presents a philosophically informed reading of the epistemic role of OS within contemporary research: how OS policies and practices affect research methods and outputs, what this means for the nature and structure of scientific inquiry, and how the very idea of openness can and should be understood in relation to the pursuit of knowledge about the world. This is not meant as a purely descriptive take on current OS practices, though long-term engagement with those practices, as briefly discussed below, strongly inform my views. Rather, this Element presents a normative interpretation of the history, motivations and potential of OS, focusing on broad trends characterizing its current implementation. My aim is to provide a constructively critical reading of the commitment to transparency and sharing often made within the OS movement, which has in my view become an obstacle to the movement's efforts to promote reliable and responsible research. I argue that one step towards addressing this concern is the adoption of a different philosophical standpoint, one where openness is conceptualized not as primarily about sharing resources but rather as primarily fostering meaningful communication between the humans involved in research. Making this broad argument requires me, unavoidably, to provide a general characterization of the OS movement that does little justice to its complexity and multiplicity. Let me thus state this

¹ A long-standing twentieth-century agenda in science policy, as pursued by Vannevar Bush in the wake of World War II.

upfront: this Element does not mean to capture the vast and diverse landscape of OS initiatives in any comprehensive way, and there are many realities within OS that do in fact abide by the understanding of openness as connection which I am partial to. Nevertheless, my analysis captures discourse and commitments that are frequently found especially in large-scale OS initiatives and policies, which in my view deserve critical discussion. Hence this Element builds on empirical research around the history and current functioning of OS, yet provides an interpretation of such materials that is explicitly grounded in a normative perspective.

This approach is reflected – and inspired by – an understanding of ethics as integral to epistemology in the tradition of standpoint theory and strong objectivity (Harding 1995), whereby one’s perspective on a subject is always a ‘view from somewhere’ coloured by one’s background and goals. My overall interest in this Element is to support the future development of OS by providing a philosophical framework for what openness could and should mean for research aimed at sustaining life on this planet. I am specifically interested in the use of OS to pursue the public good, including to enrich existing understandings of what forms such ‘good’ may take depending on publics and contexts.² In keeping with this overall philosophical stance, I shall consistently intertwine epistemic and ethical considerations as grounding for my analysis of research practices. As I shall illustrate, ethical concerns around the discriminatory and exclusionary implications of some OS practices are impossible to disentangle from epistemic concerns around the reliability and robustness of research produced through those practices. The methodological soundness of procedures of sampling, representation, modelling, communication and interpretation depends on both technical features and social context.³

Historically, my starting point is two complementary observations. First is the radical significance of pursuing openness in research at the time of writing, when the hopes raised in the 1980s by the rise of the World Wide Web and related communication technologies are giving way to disillusionment at the widespread deployment of digital tools to curtail, obfuscate or misdirect the free circulation and critical scrutiny of ideas. Despite the illustrious history of openness as the cornerstone of liberal thinking, the 2020s are not a time for naïve calls for ‘openness for its own sake’, whatever that may mean. As the Internet becomes a playground for corporate monopoly and fake news threatens to overwhelm attempts at earnest debate, the dangers and misuses of the idea of free information have become apparent for all to see. This has severe

² This stance builds upon like-minded views of Longino (1990), Kitcher (2001), Wylie (2003), Rouse (1987, 2015), Potochnik (2017), Cartwright et al. (2022) and Chang (2022), among others.

³ Beaulieu and Leonelli (2021) and Thompson (2022).

implications for the way in which openness is conceptualized and enacted in relation to scientific research.

The second observation is that, despite the good intentions and the vast efforts committed to their actualization, OS initiatives are fraught with difficulties and are sometimes met with resistance by the very research communities that they are meant to serve. This observation is corroborated by a growing body of international scholarship centred on OS implementation, including extensive qualitative research that I carried out over the last decade, in collaboration with colleagues across the natural and social sciences, to investigate how researchers across countries and domains perceive OS and its implications for their work. We found that in contexts where researchers receive relevant support and training, OS can increase the quality and inclusivity of scientific debate. However, the vast majority of researchers work in disciplines and institutions that are not internationally visible, well-funded and/or attuned to rewarding OS efforts. This makes it difficult for them to use OS infrastructures to support their work, since the design of those infrastructures reflects the interests, assumptions, priorities, skills and technological resources of their developers – who are often English-speaking scientists based in rich institutions where such work can be supported.⁴ I have complemented such work with research documenting the history of ideas of openness and collaboration across the sciences, as well as personal involvement in large-scale efforts by various research and policy organizations to identify conditions under which OS could be actualized.⁵ Through such experiences I witnessed considerable disagreement over what OS involves and what roles openness and transparency play in knowledge production and use.⁶ It is from consideration of the roots and implications of

⁴ Leonelli (2016), Levin et al. (2016), Bezuidenhout et al. (2017), Chen et al. (2019), Leonelli (2022a), Ross-Hellauer et al. (2022). Another prominent source of worry among researchers is the exploitation of OS by commercial entities (part of broader trends towards digital feudalism: Jensen 2020) and organizations interested in distorting scientific results for political reasons (e.g. debates over climate change: Lewandowsky and Bishop 2016, Nerlich et al. 2018).

⁵ My forays into science policy stemmed from research conducted since 2007 on the epistemology of big data, which highlighted the significance of novel ways to mobilize and reuse data towards transforming science. Requests to report on such research led to participation in numerous debates around Open Data, Open Access and OS infrastructure; and roles as researchers' representative or expert advisor for the Global Young Academy, the European Commission, Plan S and the International Council of Science, among others. The resulting reports are available on the Open Science Studies website (www.opensciencestudies.eu); see also Burgelman (2021), Miedema (2021) and Owen et al. (2021) for insider reflections on academic involvement in these policy debates.

⁶ While largely built on the study of scientific practices in biology and biomedicine, my analysis is meant to also embrace the social sciences and humanities, whose perspectives I have learnt about through interaction with social scientists and colleagues in philosophy, history and literature studies, and through advisory roles in research organizations overseeing social science and humanities portfolios. Given this ample remit, throughout the text I use the term science in the

such frictions, rather than from the polished statements associated with the political call to ‘open up science’, that my analysis departs.

A crucial problem is lack of clarity over how OS, with its emphasis on multiplying research avenues, outputs and participants, relates to the existing diversity in epistemic practices utilized by different research communities around the globe – and, in turn, to the varying socio-political settings in which research takes place. It is widely recognized that operating in an OS landscape requires effective communication, which in turn demands some level of consensus around common procedures, standards, principles and metrics. In other words, making decisions around how to open science unavoidably involves deciding what may and may not count as ‘good’ science;⁷ and insofar as OS infrastructures can function as sources of reliable knowledge, they can also act as tools to identify and police questionable research practices. In response to these requirements, many of the more institutionalized OS initiatives tend to privilege a homogenous, universally applicable understanding of the scientific method over a pluralistic and situated one. It is much easier to set up OS guidelines when assuming that science consists of a coherent body of knowledge and procedures that can and should conform to common norms – an assumption that flies in the face of the rampant plurality of research approaches used across domains, locations and contexts, and the significance of such plurality in delivering a robust, comprehensive and reliable understanding of the world.⁸

As yet, there is little systematic understanding of how openness relates to the standards and criteria of best practice developed and performed by researchers around the world to suit their specific goals and working conditions. In what follows, I argue that in the absence of such understanding, the high level of standardization and precise validation practices demanded by some OS initiatives threatens to blindly privilege specific ways of knowing, thus potentially disrupting sophisticated methodologies, inadvertently dismissing well-established research traditions, and exacerbating the already large epistemic and social divides separating research domains and locations. As denounced by a number of critics in science and science studies, there is a substantive risk of

continental sense of *Wissenschaft*, comprising humanities as well as the social and natural sciences.

⁷ This is also why it is impossible to keep a rigid distinction between discussions of OS and discussions of science as a whole: in this Element, the focus on OS often and unavoidably expands to embrace broader debates around what research looks like in the twenty-first century, and what this means for future science practice and policy.

⁸ There is an enormous body of scholarship on scientific pluralism, which I cannot hope to comprehensively review in this Element. I focus on salient aspects, predominantly extracted from the philosophy of science, in Section 4.

some OS policies – despite their good intentions and progressive slant – acting as a reactionary force which reinforces conservatism, discrimination, commodification and inequality in research, thus ultimately closing down opportunities for inquiry in a disastrous reversal of what they set out to achieve. I maintain that it is possible to rescue OS from such a fate by highlighting OS initiatives grounded on a deep understanding of local knowledges and their social context, and that an important step in that direction is to articulate which understanding of scientific practice – in other words, which *philosophy of science* – best underpins the goals set by the OS movement. This is what this Element aspires to contribute, starting from an analysis of the roots, motivations and implications of interpreting openness as anchored on the sharing of research components, and then arguing for an alternative view centred on the reticular and distributed development of research processes, as already exemplified by many grassroots OS projects which consistently engage with the interests, preferences and methods underpinning specific ways of knowing.

The argument is set out in four sections (Sections 2–5). Section 2 reviews some *key features of the contemporary OS movement*, focusing on systemic problems plaguing the global research landscape – and particularly existing constraints on research communication, collaboration and publishing – and OS attempts to address such problems through an expansion of what counts as research output and the provision of incentives to share such outputs as widely as possible. I argue that underpinning many such initiatives is a vision of openness as the *freedom to share* resources and insights at various stages of the research process, whereby the adoption of incentives towards making results more transparent is expected to increase the reproducibility and accessibility of research, leading to more inclusive, engaged and reliable forms of inquiry. In principle, this vision of OS seems unassailable, an effective reaction to a scientific system that has become increasingly opaque, exclusive and commodified. The question that concerns me, however, is how this vision plays out within actual research settings.

Section 3 confronts this question by shifting the analytic focus from the theory to *the practice of OS within everyday scientific work*. I briefly examine four examples of OS implementation, including: (1) the effort to share biological data on the SARS-CoV-2 virus responsible for the coronavirus pandemic, which has been widely hailed as a demonstration of the effectiveness of OS in fostering discovery under emergency conditions; (2) current challenges to the evaluation of quality standards for data, models and software, and the extent to which such evaluation depends on tacit assumptions about which technologies may enhance or even guarantee data validity; (3) the development of global infrastructures to link locally sourced data about crops and their environments,

which is critical to research on food security and planetary health, yet is conditioned by pre-existing inequities between data producers and users; and (4) the use of specific interpretations of the notion of reproducibility as a criterion for what may constitute reliable research methods. These examples illustrate, on the one hand, how the tremendous diversity in goals, values, targets, background knowledge and material settings within contemporary science results in different expectations around best practice; and, on the other hand, how such diversity can be squashed by demands for fast and smooth sharing of scientific resources, which can damage scientific advancement while also failing to address the systemic problems discussed in Section 2.

Having explored one interpretation of openness and found it wanting in research practice, the next step is to explore alternative interpretations of openness that may take better account of scientific diversity and the empirical insights garnered from studies of how researchers conduct, communicate and discuss their work. To this aim, Section 4 builds on philosophical literature on scientific pluralism to *identify four central characteristics of systems of research practice*, which in my view need to be acknowledged and supported by OS initiatives: (1) specificity to local conditions; (2) entrenchment within research repertoires; (3) permeability to newcomers; and (4) demarcation strategies. From this analysis I conclude that it is impossible to foster or even evaluate the quality of scientific procedures and outputs without considering how research conditions change across locations, who is included and excluded from specific ways of conducting research, and with what implications for the structure of inquiry and the knowledge being produced. I end by discussing the interrelations between *epistemic diversity* and *epistemic injustice*, arguing that both play a crucial role in the development of good science, and need to be placed at the centre of OS initiatives.

The analysis of OS practices presented in Sections 3 and 4 allows me, in Section 5, to expand my critique and sketch an alternative vision that better underpins the quest for reliable and responsible research practices. This requires digging further into the epistemic foundations of the idea of openness as sharing. I argue that this view is entangled with an *object-oriented framing of the epistemology of science* as a matter of control over resources, where questions around which forms of expertise are brought to bear on the research process remain secondary to the production of tangible outputs and the development of standard procedures and agreements over how to trade such outputs and thereby accrue their value. Within such framing, science is construed as consisting in the accumulation of facts, methods and insights, whose free circulation, scaffolded by technologically sophisticated infrastructures, suffices to guarantee research progress as well as the opportunity for

different parts of society to deploy those resources towards addressing urgent challenges. I contend that this view of research is misleading and unrealistic, and that related understandings of openness are unlikely to deliver the epistemic benefits associated with the OS movement in the long term. This is not because the technologically mediated sharing of resources is not relevant to scientific development, but rather because sharing does not constitute a necessary starting point nor a sufficient condition for conducting reliable and responsible OS. As an alternative, I propose a conception of *openness as judicious connection*, which is grounded in a *process-oriented epistemology of science* that recognizes the situated, embodied and goal-directed nature of communication and collaboration among researchers. This understanding of openness emphasizes the dynamics of science as a human enterprise that brings different ways of acting and understanding the world in relation with each other, and thus fosters many different forms of output selection, organization and interpretation. Under this interpretation, Open Access is not achieved solely by making access to publications free of charge, but rather by fostering publication on the basis of fair assessment of its quality and irrespectively of authors' ability to pay for processing charges; Open Methods is not a matter of recording and sharing every detail of a research procedure, but rather a reflection on which research components and techniques are most salient to the outcomes, and should thus be accessible and reproducible; Citizen Science does not involve offloading labour-intensive parts of data collection to participants without involving them into the research process, but rather building relationships with non-professional publics who bring relevant insight; and Open Data does not mean the sheer accumulation of research data on digital platforms, but rather the recognition that not all data can or should be made available, and choices need to be made and justified around which data are being shared, and how data infrastructures may support the creative exploration of such data.

This framing of OS takes epistemic diversity and justice as guiding principles for producing reliable knowledge. Open Science initiatives need to question explicitly and regularly what is considered a scientific contribution, for which purposes and by whom. This means recognizing that effective sharing is built on well-justified, contextualized discrimination and judgement over the value and goals of research and its components, rather than absence of judgement, disregard for the specificity of research conditions and related attempts to 'make everything available'. Scientific discovery is thus positioned as a social and situated endeavour, thereby underscoring the links between OS, existing understandings of good practice, and specific conceptions of what an Open Society may look like.