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REVIEWS

Accounting for Complexity

Thinking with Idealisations, Models, and Data

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Abstract

What does it mean to call something complex? This Review essay describes three recent books which take up complex problems and the problem of complexity: philosopher Angela Potochnik's *Idealization and the Aims of Science* (2017); science and technology studies (STS) scholar Nicole Nelson's *Model Behavior: Animal Experiments, Complexity, and the Genetics of Psychiatric Disorders* (2018); and historian of science Bruno Strasser's *Collecting Experiments: Making Big Data Biology* (2019). Taken together, these works lay out a refreshed analytic vocabulary and set of guiding concerns for thinking about what complexity is and does in medical research, and how complexity mediates public participation in science and medicine.

Keywords

Complexity, Model organisms, Epistemology, Big data.

It seems self-evident to say that contemporary medical research is complex. From multifactorial genetics to the intricate and interwoven socio-environmental conditions that shape human health, the term 'complexity' has become a ubiquitous shorthand. But what does it mean to call something complex? Is it a description of the thing itself, or a reflexive comment on our own ability to

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understand it? And is complexity always an obstacle to be overcome, or can it play a productive role?

This Review essay describes three recent books which take up complex problems and the problem of complexity: philosopher Angela Potochnik's *Idealization and the Aims of Science* (2017)*,* STS scholar Nicole Nelson's *Model Behavior: Animal Experiments, Complexity, and the Genetics of Psychiatric Disorders* (2018), and historian of science Bruno Strasser's *Collecting Experiments: Making Big Data Biology* (2019). Taken together, these works lay out a refreshed analytic vocabulary and set of guiding concerns for thinking about what complexity is and does, particularly in the postgenomic era.[1] While Potochnik, Nelson, and Strasser represent a number of distinct—and occasionally conflicting—disciplinary perspectives and methodological approaches, their viewpoints offer a number of inroads for the study of complex phenomena that should be of interest to researchers working across a diverse array of topics in science and medicine. I begin by offering an overview of the arguments presented by each of these books with a view toward what they might offer for studies engaging with 'complex' sciences. I then discuss how these authors suggest that complexity mediates public discourse around science and medicine and conclude by posing a few open questions.

We might start with the question: what work do researchers do in pursuit of understanding a phenomenon that is too complex to capture in full? They can abstract, reduce, ignore elements, or—as Angela Potochnik suggests—idealise them. An accessible text written for a broad audience beyond the formal philosophy of science, Potochnik's (2017) *Idealization* makes the case for practice-oriented accounts of research that do not shy away from the messiness of complexity while also retaining a normative (rather than simply descriptive) stake. Through discussions of a wide range of topics from game theory in natural selection to aggression and behavioural genetics, she examines idealisations, which she characterises as 'assumptions made without regard for whether they are true and often with full knowledge that they are false' (idem, ix), in order to explore what she identifies as science's primary aim: understanding, rather than an absolute 'truth'. As Potochnik argues, idealisations are a necessary product of the inherent complexity of the world: because the natural phenomena being studied are inherently and overwhelmingly multifactorial, idealisations are necessary representational strategies that allow researchers to render complex phenomena manipulable (for Potochnik's exploration of causal complexity in physical sciences, see Chapter Two). Like the rational actors of economic theory or the frictionless planes common to physics, however, idealisations necessarily

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[1] The 'postgenomic' era refers to the time period following the 2000 publication of the Human Genome Project's rough draft to the present day.

represent some causal patterns but come into conflict with others; while they can (and do) extend our understanding, idealisations are not themselves complete accounts of the world. As Potochnik repeats throughout, this state of affairs means that idealisations are 'rampant and unchecked' (idem, 41) in science because they are a necessary element of knowledge production across all fields and are not meant to be corrected in the face of conflicting observation.

The idea that scientific knowledge does not necessarily represent a singular reality is likely uncontroversial to most anthropologists of science and medicine. For instance, analytic vocabularies like that of ontological multiplicity (Mol 2002) are commonplace in some theoretical lineages, while incommensurable worlds (de la Cadena 2015) proliferate in others, pointing in different ways to the necessarily local and often divergent ways in which knowledge is produced. However, a strength of Potochnik's analysis is in drawing out what we might gain from employing a more 'modest pluralism' grounded in a limited realism (2017, 219–20). As she argues, the non-integration of science is a result of different fields with different aims modelling different causal patterns, each of which has the potential to further our understanding without producing a unified account of the world. This means that 'de-idealisation' is not only impossible, but undesirable. Instead, Potochnik's exhortation to 'coordinate unity' (see Chapter Six) helps to explain the collaborative production of science without necessitating talk of levels or the ever-looming reduction of all science to microphysics. Although the contours of some of these debates are firmly rooted in the philosophy of science, Potochnik is able to link these epistemic concerns to how diverse social values shape scientific knowledge—a topic I return to in a moment—while remaining clear that science is not inherently compromised by this sociality.

Potochnik spends significant time describing the importance of the turn to practice-based inquiry in the philosophy of science. However, social scientists may find her account lacking analysis of many of the sorts of practices that take place outside the laboratory and yet make up much of the fabric of knowledge production. For instance, how do researchers make sense of conflicting idealisations in their problem spaces? How do they talk about the idea of complexity itself? These questions open Nicole Nelson's (2018) *Model Behavior*, an STS-grounded ethnography of the mouse models employed in addiction research. Nelson examines how the 'validity'—a category not dissimilar to Potochnik's 'epistemic acceptability'—of particular models is achieved through laboratory and discursive practice. In doing so, she directs our attention to how the validation of heterogeneous experimental models are used to support community understanding rather than for the closure of controversy: as she describes, researchers use mouse models as 'a shortcut into manipulating a larger phenomenon, not a firm fact' (idem, 46). While mice may not exhibit alcohol use disorders or experience anxiety in a way directly comparable to humans, the meaning-making practices common to psychiatric genetics allow for these models to stand in for them. Complexity is not explained away in the process but is instead managed and even made epistemically productive.

Through this story, Nelson develops ‘epistemic scaffolding’ as an analytic metaphor for describing how model validation work is used to support upstream research (see Chapter Three). Epistemic scaffolding relies on multiple (and sometimes overlapping) explanatory strategies to justify why particular models and experimental systems offer traction when dealing with complex phenomena. In contrast to normative accounts of research in which evidence is built into increasingly general propositions about the nature of the world, Nelson details how scaffolding allows for ‘a series of increasingly risky claims about a model’s knowledge production capacities’ (idem, 86). While scaffolds are intended to disappear from completed construction, she describes how epistemic scaffolding often ends up as a ‘permanently provisional’ (idem, 85) set of supports, shaping the epistemic foundation of research programmes through negotiation by adding and subtracting support as necessary to communicate (un)certainty about the strength of particular claims. Here, ‘complexity’ functions as an emic language for the management of apparent conflicts in both research outcomes and scaffolded explanations; while disagreement may remain regarding final interpretation, researchers understand the inherent complexity of behavioural genetics to necessitate provisional and partial explanatory efforts. Through this account, Nelson demonstrates that the validation of models is not simply a matter of pluralistic community formation within a richly complex problem space, but the product of ongoing negotiation both within and *between* particular theoretical camps. Uncertainty—as well as conflicting observations and anomalies (see Chapter Four)—function as community *resources,* not community problems. To return to Potochnik’s description of the epistemic strengths of non-integrated science, Nelson’s work offers a complementary account of how disparate approaches are woven together within the social world of a particular discipline.

As an important caveat to this comparison, model organisms are not the type of scientific models to which Potochnik’s arguments primarily apply. However, the use of model organisms relies on a conceptualisation of an idealised system (or idealised systems in the plural, as is often the case) in order to determine which elements of a complex phenomenon should be replicated in the experimental model. This distinction is a strength of Nelson’s analysis in Chapter Five, as she explores the variety of mechanisms through which ‘binge drinking’ is reproduced as a disease entity in mice. For instance, some researchers rely on an idealised, reductionist imagination of binge drinking in which individuals simply consume too much alcohol—in this instance, mice can receive fixed amounts of ethanol via injection, ensuring standardised blood alcohol concentration in the study population. But what if alcohol use disorder is instead considered as a ‘disease of the will’ (Valverde 1998)? What if what matters is not how much a person (or mouse) drinks, but their relationship to desire and restraint? Mice in this model have to be made to *want* to drink—introducing a variety of challenges and further methodological disputes—and subsequent individual differences in consumption create statistical noise. Both of these sorts of models produce meaningful understandings of (some elements of) a complex system, but openly fail to incorporate the complex structural, social, and personal factors which these researchers know to underpin alcohol use disorders in humans. Here, epistemic scaffolding offers a useful heuristic into the apparent disjunctures between researchers’ theories and practices.

What is particularly of note throughout is Nelson’s care in detailing the stakes of these sorts of methodological disputes: her account makes it clear that these differences do not simply end at the level of ontological incommensurability. Instead, she pushes for a rigorous interrogation of how researchers *rely* on claims about complexity and uncertainty, ‘cultivat[ing] complexity talk’ (2018, 9) to ground their own experimental imaginations and knowledge claims within contested fields. Her interest in the sociality and publication economy of this community adds a welcome complement to Potochnik’s descriptions of relatively settled scientific models—complexity here, for Nelson, is not simply an underlying condition that allows for the coexistence of divergent understandings, but the constitutive element which holds them together.

Potochnik’s and Nelson’s accounts largely focus on complexity in small-scale experimental design and the production of scientific theory, and mostly limit their scope to formal research and researchers. However, contemporary discussions of complexity are often more rooted in ideas about the indexicality of ‘big data’—or, to quote Chris Anderson (2008), that ‘with enough data, the numbers speak for themselves’. In such accounts, scientific theory (and, indeed, scientists themselves) are sometimes figured as irrelevant, since data-driven descriptive work appears ready to overtake the delicate contingency of experimental research and theorisation. While such claims about the epistemic novelty of big data have been roundly rebuffed by critical studies of science and medicine in the last several years (e.g., Leonelli 2014), the idea that a broader category of actors now participates in the production of scientific knowledge through the creation and management of data merits further elaboration. What happens when complexity increasingly seems like something we can represent ‘as is’ with massive amounts of data? And what of the people who produce it?

In *Collecting Experiments*, Bruno Strasser (2019) historicises these debates and demonstrates how data and their labourers have long played critical roles in the life sciences. From blood banks to bacterial type culture libraries (see Chapters Two and One, respectively), protein atlases to sequence databases (Chapters Four and Five), Strasser offers a capacious comparative account of the variety of actors and institutions who have often been left out of stories about the knowledge that scientific collections are used to produce. By centring these players, Strasser contextualises and complicates contemporary claims about the epistemic novelty of big data biology, demonstrating how scalar work has been a pillar of the field for decades—and how it has always relied on the sorts of infrastructural actors today best represented by biomedical databases. As he argues, data-driven and experimental approaches have never been fully separate, but now represent an increasingly hybrid epistemic culture in biology. This convergence has significant implications for not only the kinds of knowledge that are produced, but also the professional cultures and moral economies that make up the life sciences.

One of Strasser's main historiographic interventions is in the relationship between natural history-based modes of comparative research and the 'exemplary' (here referring to the use of model/exemplar systems and idealisations) research common to 20th century experimental biology (see also Strasser and de Chadarevian 2011). While Strasser is the only one of the three authors treated here who does not take up 'complexity' as an analytic, this distinction nevertheless hinges on its conceptualisation and management. Modes of practice based on collecting (such as museum practice and field research) worked to produce 'concentrated versions of the world' (2019, 26) by accumulating collections that are as close as possible to 'complete'. As an epistemic culture, collecting has been organised around capturing natural diversity 'as it is' in order to represent as much natural complexity as possible—a practice often disparaged as 'stamp collecting' and 'butterfly counting' by experimentalists. In contrast, experimental research communities have relied on a very different set of logics about the relationship between models and the complex natural systems they are assumed to represent. Because of this tension, Strasser's account makes it clear that the hybridity of collecting and experimental styles of thought common to the contemporary life sciences was not only *not* inevitable but stabilised only as a result of great and ongoing effort. For anthropologists interested in the use of clinical specimen collections or data repositories, Strasser's work offers critical insight into the history and epistemic proclivities of scientific collecting.

I have up to this point focused on the implications of complexity in scientific research. However, these books also take up the matter of how complexity shapes public discourses surrounding science and medicine, as well as how popular understandings of complexity in turn condition the production of knowledge, both in content and in form. As Potochnik argues in Chapter Seven, complexity not only allows for social values to enter science but necessitates it. Faced with a near-infinite array of causal patterns and possible idealisations, our choices of how to model phenomena embed particular human capacities and concerns within scientific products: as she writes, ‘by influencing which research programs are pursued, individual and shared interests, concerns, and values shape the content of our explanations—not just what we aim to explain but *what in fact explains those things*’ (2017, 200, emphasis mine). For example, examining evolution through an idealisation of game theory versus an idealisation focused on the limits of phenotypic plasticity is a choice predicated on particular social values and scientific goals, which leads to divergent explanations of a particularly complex phenomenon. Importantly, this does not mean that the knowledge inflected by these values is illegitimate or compromised—simply that we would do well to be mindful of how divergent research programmes need to coordinate not only between conflicting idealisations but, further, between the values they instantiate.

While natural complexity may function as a tool for a variety of interests, the rhetoric of complexity is perhaps more limited as a discursive resource. In the last chapter of *Model Behavior*, Nelson describes a series of encounters with her interlocutors, orbiting their frustration with the public’s distrust of psychiatric genetic research. This distrust appeared to them to be linked to a popular belief in deterministic ‘genes-for’ particular conditions, a byproduct of journalistic simplification and a tendency to downplay or edit out researchers’ own appeals to unresolved complexity. Because discussions of complexity often sound like (or rely on) jargon, they appear to deflate the immediacy and importance of research applications and are often cut out of popular accounts for that reason—the communicative and claim-making strategies of journalists and researchers appear to be actively opposed. However, as Nelson argues, these points of discomfort have the potential to direct our analysis to tensions in the production of certainty and point toward where research and science communication might find shared commitments rather than epistemic opposition.

Of these three works, Strasser’s is perhaps the most concerned with popular understandings of complexity, particularly as they relate to the moral economy of big data and the research ecologies that produce it. As he demonstrates, the contemporary open access movement is a direct result of the scale of data demanded for computational research on complex biological systems. These projects necessitated significant shifts in the labour structures of the life sciences, and the unduplicatable amount of resources to produce and maintain these data drove the emergence of early open access data resources like the Encyclopedia of DNA Elements (ENCODE) project and the widely-used sequence database GenBank. These shifts contributed in turn to the proliferation of open access in scientific publishing and other arenas, democratising access to scientific data and, increasingly, lay participation in data analysis (see particularly Chapter Six and Conclusion). In these and similar efforts, the hybridisation of epistemic cultures rooted in collecting and experimentation have driven important trends in the research ecology of the life sciences as well as the types of knowledge life sciences has produced, and have allowed new groups access to epistemic authority. For researchers interested in lay science organisations like genetic rare disease advocacy groups—particularly those that curate and manage large data resources—Strasser's account offers useful insight into how social problematisation shapes scientific knowledge.

Complexity is more than it appears, and it has the potential to open up as much as it obscures. Taken together, these three books push us to look more closely at what complexity is and does, and to be mindful of how we employ it in our own accounts.

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