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Repertoires: A post-Kuhnian perspective on scientific change and collaborative research

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ABSTRACT

We propose a framework to describe, analyze, and explain the conditions under which scientific communities organize themselves to do research, particularly within large-scale, multidisciplinary projects. The framework centers on the notion of a research repertoire, which encompasses well-aligned assemblages of the skills, behaviors, and material, social, and epistemic components that a group may use to practice certain kinds of science, and whose enactment affects the methods and results of research. This account provides an alternative to the idea of Kuhnian paradigms for understanding scientific change in the following ways: (1) it does not frame change as primarily generated and shaped by theoretical developments, but rather takes account of administrative, material, technological, and institutional innovations that contribute to change and explicitly questions whether and how such innovations accompany, underpin, and/or undercut theoretical shifts; (2) it thus allows for tracking of the organization, continuity, and coherence in research practices which Kuhn characterized as 'normal science' without relying on the occurrence of paradigmatic shifts and revolutions to be able to identify relevant components; and (3) it requires particular attention be paid to the performative aspects of science, whose study Kuhn pioneered but which he did not extensively conceptualize. We provide a detailed characterization of repertoires and discuss their relationship with communities, disciplines, and other forms of collaborative activities within science, building on an analysis of historical episodes and contemporary developments in the life sciences, as well as cases drawn from social and historical studies of physics, psychology, and medicine.
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1. Introduction

A vast body of scholarship in the history, philosophy, and social studies of science underscores the critical role of collaboration in the development of scientific knowledge (to name just a few examples, see Griesemer & Gerson, 1993; Wray 2001, 2002; Hackett, 2005; Shrum, Chompalov, & Genuth, 2007; Gerson, 2009; Gorman, 2010; Andersen 2010, 2016).[1] Many forms of scientific collaboration have been documented and analyzed, including co-located and dispersed, short and long-term, virtual and in-person, large and small scale, and even voluntary and involuntary (Nersessian, 2006; Felt, 2009; Parker, Vermeulen, & Penders, 2010; MacLeod & Nersessian, 2013). Collaboration often involves individuals with different skills, training, and goals, who are not co-located and who, even when working toward common goals, are subject to diverse institutional,[2] cultural, and financial

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[1] In this paper, we do not consider the extensive philosophical literature on social epistemology or more theoretical literature on collaboration from the philosophy of science in any detail, but focus on that literature most relevant from a philosophy of science in practice point of view (Ankeny et al., 2011). Making a link between formal treatments and our historically-informed account is an important task, but one that lies beyond the scope of this paper.

[2] We are using the term 'institution' as typically utilized in ordinary language and science and technology studies as a generic descriptor to refer to legal, political, commercial, social, or other types of formal and informal organizations or structures including, but not limited to, governmental and state-based bodies and also to broader systems such as property, law, or even science and technology; for instance, see Jasanoff, 2004; Jasanoff, 2012. In its stricter, sociological sense, 'institutions' are stable patterns of human behavior or activity that define, govern, and constrain action or rules that connect an individual or organization to a larger social environment, and that reproduce themselves. Classic references include Hughes, 1970 and Scott 1995; for a philosophically-oriented exploration of this concept, see Miller 2014.

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pressures, particularly in the contemporary context of 'big science' carried out through multidisciplinary projects occurring within international networks (Price, 1965; Hughes, 2002; Davies, Frow, & Leonelli, 2013). It is clear from existing scholarship that research groups have variable degrees of continuity, longevity, and durability, depending on their relation to existing knowledge, materials, technologies, and institutions, as well as on the social dynamics within and beyond their boundaries (Galison, 1997; Knorr-Cetina, 1999; Latour, 1987). Furthermore, it is evident that the organization of research groups, and the ways in which they are constructed and managed, has a major impact on the quality and types of outputs that are produced (Longino, 2002; Rolin, 2008; Solomon 2001; Wray 2002).

Philosophers of science have paid some attention to the organization of research and its epistemic implications. They have analyzed the mechanisms that underlie collaborative work, focusing particularly on the division of labor involved (Thagard, 1997), the use of theories, models, and tools as conduits to communication and integration (Star and Griesemer 1989; Nersessian and Patton, 2009), and the typologies and patterns of epistemic dependence involved in the distribution of cognitive labor among interdisciplinary collaborators (Andersen 2016; Andersen and Wagenknecht 2013).[3] However, there is still relatively limited philosophical work on what constitutes a research community, how communities change over time, and how the development of collaborations relates to the production and development of knowledge within the various social, cultural, institutional, and economic environments in which scientific research occurs.[4] In short, philosophers of science have hitherto paid little attention to collaboration, and more generally the social organization of research, as lenses through which to think about and analyze scientific change.

Existing characterizations of communities in terms of shared theories, which in turn constitute a discipline or field, and which can be challenged and reconstituted depending on conceptual shifts, have greatly enhanced our understanding of the dynamics of scientific change and how to account for research 'progress' (e.g., Darden and Maull 1977; Kuhn, 1962; Shapere, 1977; Toulmin, 1972). However, these accounts have limited value for making sense of multidisciplinary efforts, where successful collaboration involves the harmonious merging of different types of expertise and disciplinary training. Most importantly for our purposes, they also fail to account for the critical roles played by social, political, and economic factors in the development and outcomes of research practices, and for the observation (often made within historical and social studies of science) that scientific innovations can take many forms other than the advancement of new theories or concepts, and are not necessarily tied to paradigmatic shifts.

In this paper, we propose a framework for analyzing the emergence, development, and evolution of collaborations, particularly in scientific practice.[5] We contend that this framework will facilitate philosophical analysis and explanation of critical questions around the functioning, flexibility, durability, and longevity of research groupings and their outputs, including the formation of research communities. We are particularly interested in tracing the material, social, and epistemic conditions under which individuals are able to join together to perform projects and achieve common goals, in ways that are relatively robust over time despite environmental and other types of changes, and can be transferred to and learnt by other groups interested in similar goals. We refer to these conditions, which include ways to wield and align specific skills and behaviors with appropriate methods, epistemic components, materials, resources, participants, and infrastructures, as *repertoires*. We argue that the creation or adoption of one or more repertoires has a strong influence on the identity, boundaries, practices and outputs of research groups, whether their individual members explicitly recognize these impacts or not. At the same time, a repertoire is not a necessary condition for the production of scientific knowledge and/or the emergence of stable and/or coherent research groups. Indeed, not all research groups have a repertoire, and many creative and innovative scientific initiatives grow at the margins of, or in outright opposition to, the most long-lived repertoires, with significant consequences in terms of their visibility, reputation, and resources. This perspective has implications for various research practices including credit attribution, and supports a highly distributed model of how science is done.

This argument builds on empirical insights by historians and philosophers of science on practices within contemporary research communities in the experimental life sciences, as well as cases drawn from social and historical studies of other sciences including physics, psychology, and medicine. We analyze the parallels and dissimilarities between our approach and philosophical discussions of scientific change, and discuss in detail the characteristics, composition, and performative nature of repertoires. We then reflect on what it means for a repertoire to be resilient and transferrable, the relationship between repertoires and communities, and the significance of the alignment of repertoire components in terms of evaluating the success and longevity of particular repertoires and its broader epistemic and social implications. Finally, we discuss the scope of repertoires and their usefulness as methodological frameworks for philosophers to reconstruct, compare, and evaluate scientific strategies and developments across time, space, cultures, and disciplines, without being forced to focus solely or primarily on examples involving substantial theoretical or conceptual change.

2. Paradigms versus repertoires: capturing performance

In his seminal work *The Structure of Scientific Revolutions* (1962), Thomas S. Kuhn uses the term 'paradigm' to identify activities that are simultaneously conceptual, social, and material and that are constitutive of research communities, and points to 'revolutionary' paradigmatic shifts as ways to identify and circumscribe such activities into coherent and stable assemblages. This intertwining of conceptual, social, and material factors in research is a core idea that serves as a starting point for our own work. However, as many commentators have observed, paradigms are not very useful as a framing concept particularly for the analysis of contemporary science. First, they are highly static and inflexible entities in which change only occurs in dramatic fashion. This conceptualization of scientific change does not adequately capture the dynamic nature and pace of scientific practice, nor does it do justice to the shifts in technology, theorizing, and methods that happen within research communities at any one point in time (Galison, 1997; Hoyningen-Huene 2013). Second, conflicting paradigms are considered by Kuhn to be incommensurable, which implies that the adoption of a

[3] Detailed discussions of integration also are provided by Mitchell (2009) under the heading of 'integrative pluralism'; Chang (2012) in his discussion of the three modalities through which systems of practice can interact to produce knowledge, one of which is integration; and the contributors to a special section on integration (Brigandt, 2013), particularly Gerson (2013) on organizational mechanisms.

[4] We do not attempt to define which parts of scientific practice are 'external' or 'internal' to it, as this distinction is often arbitrary (see Shapin 1992) and is unnecessary for our arguments; see also Longino's rejection (2002) of the usual distinction made between the 'social' and the 'rational.'

[5] Although we focus in this paper on scientific researchers, we believe our framework could be useful more generally to a range of types of research including in the humanities.

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