

Exploring Collaborative Rhythm: Temporal Flow and Alignment in Collaborative Scientific Work

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ABSTRACT

Recent studies of large-scale distributed practice in the sciences and elsewhere have taught us important things about space and place as props and barriers to distributed collective action, but they have had relatively less to say about time. This paper offers a typology of collaborative rhythms and argues for the importance of *temporal alignment* as a neglected but crucial element underpinning distributed collective practice in the sciences (and we believe other spheres of distributed collective activity). Specifically, we argue that joint scientific work is organized around four separate and potentially dissonant temporal registers, or ‘rhythms’ – *phenomenal, organizational, biographical, and infrastructural* – and that efforts to align such rhythms constitute an important and under-recognized aspect of collaborative work. The ideas and examples are drawn from the authors’ own field studies around IT infrastructure (‘cyberinfrastructure’) and collaborative practices across a range of scientific fields.

General Terms

Management, Design, Human Factors, Standardization, Theory.

Keywords

Time, rhythm, collaboration, science, cyberinfrastructure, ethnography.

1. INTRODUCTION

Recent studies of large-scale collaboration in the sciences have taught us important things about space and place as props and barriers to distributed collective action, but they have had relatively little to say about time. This paper offers a typology of collaborative rhythms and the ongoing work of temporal alignment as neglected but crucial elements underpinning distributed collective practice in the sciences (and we believe, many other spheres of distributed collective activity). The ideas and examples are drawn from our own field studies – joint and individual, past and current – around IT infrastructure (‘cyberinfrastructure’) and collaborative practices across a range of scientific fields (Ribes 2006; Edwards, Jackson et al. 2007; Jackson, Edwards et al. 2007; Ribes and Finholt 2007; Ribes and Bowker 2008).

As Lakoff and Johnson have argued (Lakoff and Johnson 1980), far from a figurative add-on to the basic business of cognition, metaphor structures our fundamental categories of thought and expression. Time, we are told, is a river, by which is usually meant that it flows uniformly and ineluctably forward. But this metaphor may be richer than we know, for as any white water

canoist or first year hydrology student will tell you, one of the more fascinating, and theoretically challenging characteristics of rivers is that they flow at many different speeds – and even in many different directions – at once. More importantly, part of managing collaborative rhythms is the work of temporal alignment, bringing heterogeneous patterns in synch for moments of coordinated activity. Following Heraclitus, it true that you can never step in the same river twice, but the complex eddies and whorls of streams, in combination with our human dams and levies, paints an image of time more complex both in its nature and in our ability to act upon it. In this paper, we will argue that the rhythm or timeliness of collaborative scientific work has this blended, layered, and every-which-way-at-once quality while also being the active object of our efforts to bring it under control– and that this fact has been routinely neglected in the study of large-scale scientific collaborative work to date.

2. TIME AND COLLABORATION

Research on distributed collective work in recent years has paid considerable attention to the variable effects of distance and spatial location on collaborative form and practice, including their effects on collaborative outcomes – i.e., ‘success’ and ‘failure’ as measured along definable parameters like publication rates, co-authorship patterns, and other markers of collaborative productivity (Cummings and Kiesler 2007). This research has led information and other scholars towards more nuanced and specific understandings of the ways in which spatial constraints and affordances may shape and condition the nature of distributed work. Much of this work has focused on the secret assists that shared place provides in the structuring of collaborative activity: from its effects on contextual awareness and interpersonal trust (Kiesler and Cummings 2002; Schmidt 2002) to its role in sustaining group-level identities, mediating conflict, and building effective common ground (Clark and Brennan 1991; Hinds and Mortenson 2005). In response, much of the work coming out of the design wing of the CSCW and HCI communities has been about recreating the hidden affordances of place in now distributed technical and organizational forms, seeking to restore through design the ever-elusive experience of “being there”(Hollan and Stornetta 1992). In broad keeping with the ‘spatial turn’ in the social sciences at large, we now generally acknowledge that in the design and practice of large-scale collaborative organizations, “distance matters”(Olson and Olson 2000).

The same cannot be said about our thinking around time in such settings, the study of which remains rudimentary, fragmented, and

both theoretically and empirically under-analyzed. A recent review of key journals in the organizational science and computer-supported cooperative work (CSCW) fields reveals a relative dearth of articles tackling questions of temporality and collective work in serious and sustained ways. There is a literature that focuses on incongruent temporal rhythms that arise from collaborators working in different time zones, usually in inter-continental work teams of transnational corporations, where temporal differences are reduced to side effects of distance. Other works on time and distributed teams distinguish between synchronous and asynchronous communication among team members, discussing the ways in which these support collaborative activities. Aspects of synchronicity are also often discussed in the context of affordances of different communication and information technologies that support collaborative work. However, most studies have treated temporal issues in rather narrow scope, focusing on one facet without paying attention to the many different and fluctuating rhythms present in collaborative work. There is a relative scarcity, for example, of efforts to incorporate social rhythms into discussions of distance collaboration.

This general absence sits against the backdrop of a renewed and growing interest in social theory and the social sciences at large. Beginning in the 1980s (but reviving themes as old as Marx), scholars became interested again in the reciprocal effects of large-scale social and economic restructuring and the distinctive experiences of speed (Virilio 1986) and time-space compression (Harvey 1991) or ‘distanciation’ (Giddens 1991) that marked and structured the social forms of “modernity” (late, post, second, etc.). More recent work has sought to extend and nuance this analysis, introducing various and revived forms of time geography, some building from traditions of geographic research dating to the 1950s. Heroes of the spatial turn such as Henri Lefebvre have returned in later life to consider the under-articulated temporalities implicit in the spatial forms of things, likening the Mediterranean city to a sort of time machine built around the compression and coordination of historical rhythms of variable kinds and periodicities; such studies constituted fragments and beginning points for a larger project, unfinished at the time of his death, that Lefebvre referred to (but never fully described) as “rhythmanalysis” (Lefebvre 2004). Other sources for the revival of temporal thinking in social theory have been drawn from the field of history, most notably the work of the French ‘Annaliste’ historians and their efforts to mark both distinctions and connections between histories of the short, medium, and long ‘durees’ (Braudel 1992; Braudel 2004). Still others have been inspired by linguistics and literary theory, including Foucauldian and Bakhtinian-inspired ideas around ‘pluritemporalism’ or biologically inspired examples around ‘heterochronicity’ (Nowotny 1992; Lemke 2000). Together these explore the coexistence of multiple modes or registers of time in the structure and practice of ongoing social activity and point to the difficulty of coordinated time across institutions, professional bodies and career trajectories; unfortunately they each ignore the phenomenal rhythms so key to the Annalists. In this way they represent an unfortunate branch of studies of new forms of science which entirely black-box the domain of science (and its objects of study).

In organizational science, early work by Barley (Barley 1988) and more recent work by Orlikowski and Yates (Orlikowski and Yates 2002) has made forceful arguments around the ‘enacted’ character

of time and its relationship with organizational form and practice. Orlikowski and Yates take particular issue with the long-standing theoretical split between objective (‘clock time’) and subjective (‘event time’) understandings of temporality in organizational practice. They note that

difficulties arise when these positions are treated – not as conceptual tools – but as inherent properties of time. Focusing on one side or the other misses seeing how temporal structures emerge from and are embedded in the varied and ongoing social practices of people in different communities and historical periods, and at the same time how such temporal structures powerfully shape those practices in turn. (686)

From this classically structural perspective, time appears as both medium and outcome of ongoing social practice, simultaneously shaping and shaped by the choices of human actors. One important advantage of this perspective comes with the seriousness it accords individual and group-level choices in altering the temporal forces that would otherwise appear to impinge on them very much from the outside; from this perspective

people are purposive, knowledgeable, adaptive, and inventive actors who, while they are shaped by established temporal structures, can also choose (whether explicitly or implicitly) to (re)shape those temporal structures to accomplish their situated and dynamic ends. (688)

The same principle supplies an account of temporal change, and reminds us of the potentially fragile nature of apparently objective or ‘timeless’ temporal orders. For Orlikowski and Yates, temporal structuring also provides a vehicle for talking across a series of entrenched divides – universal vs. particular, linear vs. cyclical, natural vs. social, open-ended vs. closed – that have hobbled social scientific research on time to date.

Broadly parallel interests can be found in recent CSCW work by Bardram (Bardram 2000) and Reddy, Dourish, and Pratt (Reddy, Dourish et al. 2006). Like Orlikowski and Yates (and in broad sympathy with their critique of objectivism), these authors explore “the production and negotiation of temporal order... as a practical accomplishment of social actors” (Reddy et al. 31). In particular, they seek to account for the temporal organization of work in the surgical settings they study as the outcome of three central features: temporal *trajectories* (focused on the illness trajectories of individual patients); temporal *rhythms* (manifested in repeated patterns of work at the collective level); and temporal *horizons* (roughly, the ways in which individuals order and orient their work within the constraints of broader organizational rhythms). Having articulated such features of organizational time, the authors conclude with an argument for building time-sensitive notions of flow and awareness into the conceptualization and design of medical information spaces.

These early forays of organizational science and CSCW into time haven’t been taken up in a robust way by the community at large. Our immediate concern is that the centrality of time and rhythmic alignment to collaborative practices of all sorts has yet to be charted in a place we see these effects turning up in interesting and surprising ways: the practice of large-scale collaborative science. Building from our own studies of distributed collective practice across a range of scientific fields, this paper explores the

inherent and diversely-constituted timeliness of collaborative work and the practical barriers this diversity may pose, as well as pointing to the distinctive work of alignment required to hold collaborative time – and the forms of collective activity it underpins – together.

In particular, we seek to account for the role of *non*-human forces and actors in the shaping of time. We fear that in ‘socializing’ time we may run the risk of *denaturing* (and even, rather oddly, *dematerializing*) it; or more precisely, obscuring its specific and consequential nature(s) and materialities behind a too-general abstraction. We argue that there remain highly specific categories of time (articulated in the typology that follows) that tend to disappear behind the too-neat distinction between subjective and objective time. In the cases of distributed scientific practice we study, these intersect in a fluid and dynamic way with what might be called the ‘social’ properties of time, but which here we further articulate as institutional, biographical and infrastructural time. The collaborative rhythms we study are both highly ‘natural’ and ‘material’ as well as highly ‘social’.

3. MAPPING COLLABORATIVE RHYTHMS

All forms of collective activity, human and otherwise, are subject to rhythm. Things emerge, grow, evolve, and give way to new phenomena according to distinctive patterns. In this paper, we consider those elements of rhythm that touch, impinge on, emerge from, or otherwise implicate the world(s) of distributed collective practice, with principal examples from efforts to organize and design supporting technologies for large-scale collaborative science. In this context, we note three general features of rhythm that cut across each of the more specific typologies offered below.

First, all rhythms are *specific*, emerging from discrete sources and structured according to particular patterns; this sets them apart from the more formalized and abstract categories of time used to mark and track them. Second, as encountered in the real world (as opposed to our neatened analytic descriptions of same), all rhythms are *multiple*, showing up in messy and heterogeneous form and rarely if ever alone. Any given site or activity, or any isolated moment in time, may be best thought of as a gateway or constriction through which multiple rhythms are flowing at once, some of which will be contradictory or dissonant in nature.

Third, all rhythms (at least of the sort we’re interested in) are potentially *meaningful*, caught up in the world of perception, interpretation, and experience. This opens up certain representational or ‘imaginary’ dimensions of time as “real in their effects” – for example, as organizational actors account for and reconstruct rhythms both forwards and backwards (consider here the (contested!) role of origin stories, life histories, and futures in orienting individual and joint action). In the worlds we study, in many regards that matter, the ‘experience’ of time is inseparable, both practically and analytically, from its ‘fact’. Our last and by now hopefully obvious point has to do with the endogeneity of rhythms and the forms of collective action they support. Rhythms are constitutive of distributed collective practices, and vice versa. The whole is the sum of its flows.

If we believe these points to be true in a general sense, they’re especially salient in the worlds of scientific collaboration we study. In particular, successful scientific collaborations must seek to accommodate and align four separate kinds or modalities of

time, each of which shape and structure the rhythms of collaborative work in specific and often challenging ways:

phenomenal rhythms –the distinctive forms of time emanating from the field and objects of study themselves.. For instance, in the ecological field sciences, these rhythms may be seasonal: animals mate, snow falls and melts, and vegetation grows, buds, matures, and declines according to distinctive. In such cases collaborative work time is organized in part around the phenomena under study. Other rhythms may be more episodic or event-driven in character: in the medical world, medical teams group and pace themselves around the rate of tumor growth, and epidemiologists organize their work practices in part with an eye to the spread rate of diseases. Rare but unpredictable events such as cosmic ray bursts, supernovae, tsunamis or earthquakes require rapid mobilization of teams and equipment.. Other rhythms may be circadian in nature – for example, the patterns imposed by the nocturnal activities of certain species, or the traditionally night time art of astronomy. Still others impose rhythms of a far more extended or truncated sort – for example, efforts to study long-term climate change, or conversely, the splitting of sub-atomic particles. In these and many other fields, phenomenal rhythms carry deep, immediate and often challenging implications for the nature and organization of collaborative work.

institutional rhythms – a second set of rhythms can be found embedded in the organizations and institutions, large and small, that structure and govern scientific work. These range from the rhythms set by local academic calendars (e.g.,the timing of summer and winter breaks, annual patterns marking the arrival and departure of new students and research assistants), to the rhythms established by the deadlines and review processes of national funding bodies, to the (discipline-specific) submission and event dates for key academic conferences. Other institutional rhythms may operate at the lab or research group level – for example the perpetual difficulty of scheduling meetings and joint calls between colleagues balancing radically different teaching and service schedules in their home departments or research units. Like phenomenal rhythms, institutional rhythms may pose collaborative challenges of their own – for example, the difficulties of working with colleagues at institutions with different academic calendars (whether the distinction between ‘quarter’ and ‘semester’ systems in the U.S. or the more radical seasonal offset that separates researchers in the northern and southern hemispheres).

biographical rhythms – other temporal patterns and limits emanate from the life choices and circumstances of collaborative participants. This is an often overlooked category of rhythm, largely because it tends to spill across the line between professional and personal lives.. In this category we see the timing of children, illness and recovery, divorces and new relationships, births and deaths. We also see patterns of activity associated with various stages or moments in the development of biographical trajectories, from the doctoral apprenticeship through the pressures of junior faculty development to the post-tenure gravy train, along with rhythms emanating from a variety of less canonical routes (e.g., movements into and out of administration, or back and forth across the lines separating academic from government, industrial, and other locations). Shifting roles, identities, and career trajectories are central constituents of biographical rhythm – though we would note that careers themselves are built (and sometimes challenged) at the intersection of institutional and biographical time.

infrastructural rhythms (or rhythms of the built environment) – a final category of rhythm emanates from the nature and rhythms of the built world itself, including (in our case) the extensive assemblage of equipment and infrastructure attending the production and sharing of scientific knowledge itself. This is the timeliness of machines, artifacts and systems, from the durability of the Periodic Table of the Elements to the development and operation of the Large Hadron Collider. It's the time of software upgrades, hardware replacement schedules, and the time it takes to build adoption of a new protocol, instrument or data standard within a research group or across a field (weighed against the time required to build interoperability between otherwise 'local' systems down the road). It's the time it takes to a spacecraft to Mars and the window of opportunity before the Rovers go dead. In many of the fields we study, the built environment itself imposes certain and often exacting constraints on the nature and rhythm of scientific practice and collaborative work. Large-scale histories of technology have articulated such principles largely as matters of direction, pointing to forms of 'path dependency' that often accompany the development of new technological systems and infrastructures; we argue here that they are also matters of rhythm and pace.

4. HYBRIDS, TENSIONS, AND ALIGNMENT

While the above typology points to collaborative rhythms in their separate and purified forms, temporality in the real world(s) of scientific collaboration and other collective practice rarely shows up in anything like as neat or seamless a form. In practice, collaborative scientific practices combine elements of most, and usually all, of the above. The distinctive temporalities attending specific instances of collaborative work are usually shaped precisely at the intersection of often-contradictory tendencies embedded within and between each of the categories noted above. This makes rhythmic disjuncture or dissonance a frequent and under-examined tension within distributed scientific forms – and the complex art of rhythmic alignment a much-understudied category of organizational work.

Some such tensions have already been hinted at within the category descriptions given above: the alignment challenges posed by different institutional calendars; the tensions attending choices between short-and long-term costs and payoffs in infrastructural development; etc. Such tensions only multiply as we (as analysts) or they (as collaborative participants) move between the categories. What happens when work moves across the purely conceptual lines distinguishing phenomenal, institutional, biographical, and infrastructural time (or more precisely, where the temporal patterns embedded in each fail to mesh)? Our fieldwork suggests that the world of collaborative science is in fact rather full of such mismatches, and just as many efforts (small and large, local and systemic) to ameliorate, deal, or simply live with them. We illustrate such tensions with the following set of stories:

Story 1: Studying Long Term Phenomena on Short-Term Funding

Our first story illustrates a classic tension between phenomenal and institutional time. As academic researchers well know, science has long been funded in short-term chunks, structured in the U.S. around the canonical three-year grant (or shorter still). This poses no particular problems for fields built around discrete experiments – the psychological experiment, the biological lab

study, the one-off opinion survey, etc. But what if your phenomenon of study and the methods it requires unfolds on a different sort of timescale (decadal, centennial, millennial, etc.)? For analysts of long-term ecological change, institutional rhythms have long posed a particular challenge. As one ecologist explains,

Trees grow for hundreds of years, hurricanes may decimate a site every 50 years, and droughts may last for decades; thus, a long-term perspective is needed to understand the ecological response to these slow changes or rare events. (Hobbie 2003).

Such misalignments between short-term process and long-term phenomena have led to some famous and costly errors. For example, the 1922 allocations of water under the Colorado River Compact were based on a period in the early twentieth century that turns out (we now believe) to have been among the wettest in centuries. This has led to the famous problem of 'paper water' in the Southwestern United States (Jackson 2005).

The contemporary Long-Term Ecological Research (LTER) Network has emerged as an effort to redress this misalignment between phenomenal and institutional rhythms. Rather than short term grants LTER is reviewed on a decadal basis, and its 26 geographically distributed sites are reviewed every six years. In this manner LTER has itself become a relatively stable institution for ecological research. At the level of the science this has meant longitudinal monitoring of research sites with an emphasis on data curation, sharing and dissemination. Thus, while the majority of research in ecology is still grant supported, behind these cycles of funding stands an organization oriented to the study of ecological phenomena.

Story 2: Living on Mars Time

Our second story is drawn from the NASA Mars expedition rover (MER) project (as recounted in recent dissertation work by Zara Mirmalek) (Mirmalek 2008). Here the rhythms (and tensions) are multiple, with collaborative activity pulled between the competing demands of phenomenal, institutional, and biographical time. The story begins with a minor (but consequential!) solar discrepancy: the Martian day is precisely 2.7% longer than that on earth. To make up the difference, and to not lose crucial sunlight needed to recharge the Rover's solar batteries, NASA made the decision to put its Rover team on Mars time for the duration of the project. Members of the project team were to live, literally, on Mars time, organizing their work (and broader lives) around a day that was 24 hours and 39 minutes long. Clocks and wristwatches were redesigned to operate on Mars time. As the mission went on, members of the MER team literally drifted across the earth day, as the Martian sunrise moved from morning, to afternoon, to evening, and back again.

As the project progressed, strains between this phenomenally structured time and the normal biographical rhythms of the project team began to emerge. The medical team working with the project noted marked physical consequences for the work team, who began manifesting symptoms that looked like (and amounted to) an interplanetary form of jetlag. Such physical problems were joined by even more pronounced consequences for the personal lives of project participants, who found themselves arriving home to sleeping spouses and children one week, and at breakfast the next. As time passed, many participants opted to essentially live at the lab with their temporally aligned colleagues, rather than face a forever-receding schedule back on Earth.

CONCLUSION

The brief stories offered above suggest just some of the ways in which, in distributed collective practices in the sciences and elsewhere, "rhythm matters." This paper has sought to provide an initial account, theoretical and empirical, for the under-recognized temporal rhythms and challenges that structure collaborative scientific practice – a point meriting further research within organization science, CSCW, and other information school fields. In particular, we argue for the salience of four central and often imperfectly aligned categories in establishing the consequential rhythms of collaborative life: phenomenal, institutional, biographical, and infrastructural. Our present work seeks to build on this understanding, developing new methods, tools, and heuristics for the understanding of collaborative rhythm across a range of distributed collective practices in the sciences and elsewhere.

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