THINKING INFRASTRUCTURES

RESEARCH IN THE SOCIOLOGY OF ORGANIZATIONS

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THINKING INFRASTRUCTURES

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INTRODUCTION TO THINKING INFRASTRUCTURES

Geoffrey C. Bowker, Julia Elyachar, Martin Kornberger, Andrea Mennicken, Peter Miller, Joanne Randa Nucho and Neil Pollock*

WHY THINKING INFRASTRUCTURES?

If the long nineteenth century is known as a time of large-scale material infrastructure investments in roads, rails and wires stretching across Europe and its Empires as well as in the United States, the early twenty-first century is notable for investments in "thinking infrastructures." We propose the notion of thinking infrastructures to consider a broad range of phenomena that structure attention, shape decision-making and guide cognition such as rankings, ratings and algorithms. To speak of "investments" in thinking infrastructures refers to more than direction of wealth into a particular economic activity. Rather, we think of what Thévenot (1984) termed "investments in form": concepts, classifications, categorizations, commensurations and evaluations with reference to the notion of the market. Investments in form organize thinking and thought and direct action across multiple settings and multiple temporal scales. Platforms such as ride sharing apps are one such investment in form and organization. They render visible, knowable and thinkable complex patterns of human interaction in and out of the market, in feedback loops of learning, reformatting and redoing. As such, we emphasize, from the start, that much more than "thought" as colloquially understood, and more than fixed physical infrastructure, is at play with thinking infrastructures. Lauren Berlant (2016) gets to the heart of this problematic by pointing out that when a "glitch" appears, infrastructure becomes visible for what it always already was: not a reflection of structure, but rather a "convergence of force and value in patterns of movement" (p. 394). Implicit in any thinking infrastructure, we propose, is the potentiality to rethink, redo and

* The order of authors reflects the arbitrariness of the alphabet.

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rework. And since thinking infrastructures are exemplars of distributed agency as well (Enfield & Kockelman, 2017), they can be upended, inverted and recaptured (Elyachar, 2014): the parasite is always part of the channel (Kockelman, 2010; Serres, 1980).

Some aspects of a world of thinking infrastructures stand out, such as machine learning (enabled by high speed, distributed information processing), algorithmic governance (Rosenblat & Stark, 2016) and other forms of automated authority (Pascale, 2011). Similarly, recommender algorithms developed and deployed by Netflix, Amazon and others make us more and more the kind of consumer who responds positively to recommendations. For a century if not centuries, of course, the analog world featured something like thinking infrastructures – from classifications in libraries, through categorizations of the yellow pages, to calculative infrastructures of accounting (see Star & Bowker, 1999; Miller, 2008; Kurunmäki & Miller, 2013). While the digital is in some ways not so different from the analog, and the divide between the digital and the "real" often fictive (Boellstorff, 2016), the sheer scale (temporal and spatial) of thinking infrastructures in the early twenty-first century is striking. This motivates the obvious question: how to approach the study of today's thinking infrastructures?

Thinking and thought, in our approach, are not a Cartesian *cogito*; nor are they a Freudian super-ego. Rather, we join those who focus on the technologies, epistemic cultures and social practices that make thought and thinking possible in the first place. In perhaps more philosophical words (and with others thinking about infrastructure), we render visible the a-priori of (the conditions of possibility for) thinking, not in Kantian universals but in material and social infrastructures. Thinking infrastructures configure entities (through tracing, tagging); organize knowledge (through search engines); sort things out (through rankings and ratings); govern markets (through calculative practices, including algorithms) and configure preferences (through valuations such as recommender systems). In short, thinking infrastructures fold into themselves an archaeology of concepts, tasks and processes that make thought and thinking possible. In Woolgar's (1990) classic phrase: they configure the user, cognitively.

For thinking infrastructures to emerge, social practices in and out of markets must be disclosed and enclosed, be rendered visible as potential economic value and as value-transmitting channels (Elyachar, 2010). They can be mobilized, for example, as payments platforms by firms leap-frogging absent nineteenth century wired investments or to use mobile phones as payments infrastructures (Maurer, 2012). While all of this takes place in a vast realm of social practice, repeated loops of NGOs, as well as community based and empowerment infused experimental learning (Elyachar, 2012), we argue that thinking infrastructures gives us a robust metaphor for thinking past infrastructure as public good, to a mode of distributing and distributed infrastructure in which agency, cognition and endless potential for misfire is baked into the system as pirate and parasite (Kockelman, 2010; Serres, 1980) as much as an endless loop of "learning from failure"; and in which the capture of thinking infrastructure to enact other strategic goals is multiplex and unending. In this phase of thinking infrastructures as organizational imperative for profit, peril or planning; infrastructure

bleeds out of any fixed material location in a dissolving environment, or the bounds of a "public" or "private sector" and across obsolete boundaries of the material, the human and the social. Thus, thinking infrastructures, we collectively claim in this volume, inform and shape distributed (Hutchins, 1995) and embodied cognition (Penny, 2017), including collective reasoning, structuring of attention and orchestration of decision-making. In the process, and running through multiple insights that infrastructure stretches across the domains of the once excluded material world outside the "social," we note that the material itself is now impregnated with the capacities of a thinking infrastructure. It has even permeated the barrier of the human skin, lodging smart devices such as neural dust in our bodies.

In this short introduction, we set ourselves three tasks: first, we identify key features of thinking infrastructures. Second, we distinguish our approach from ongoing conversations about infrastructures, devices and materiality. Third, we introduce the different contributions to this edited volume, highlighting the figure in the carpet (James, 1896).

THINKING INFRASTRUCTURES AS ANALYTICAL VOCABULARY

We propose three analytic elements of thinking infrastructures: valuing, tracing and governing. While analysis of thinking infrastructures can usefully focus on any one of these elements alone, we find greatest analytic purchase in how these elements criss-cross with impunity among people, material worlds, markets and governance. We deploy this analytic vocabulary at the point of tactic, not strategy – at the local point of action where thinking infrastructures endlessly reorganize processes of thinking, sensemaking and decision-making through categorizations, classification, commensuration, calculation and other forms of sorting things out (to use Star and Bowker's 1999 ingenious book title once again). Our analytic vocabulary is scalar. It allows us to scale up and down in the chapters that follow from micro-settings such as freelance workers plugged into the thinking infrastructure of the gig economy (Erickson & Sawyer, this volume), to wider institutional macro-contexts such as governing markets (Pflueger et al., this volume), to management of public sectors (Reilley & Scheytt, this volume) and re-ordering of global industries (Mehrpouya & Samiolo, this volume). To start, it helps to clarify what we mean by each of these three analytic elements.

Valuing

Thinking infrastructures produce value as they relate preferences, behavior and decisions in hitherto unprecedented ways (see Adkins & Lury 2012; Berthoin Antal, Hutter & Stark, 2015; Kornberger, Justesen, Madsen & Mouritsen, 2015; Kornberger, Pflueger & Mouritsen, 2017). Thinking infrastructures give form to properties and relative positions that have not hitherto been defined. They engage in qualifications (Callon, Méadel & Rabeharisoa, 2002), making

possible new modes of quantification (Mennicken & Espeland, 2019) and new distinctions: for instance, being a "5-Star" Uber driver is a hitherto unknown quality; likewise with the new Chinese citizenship scores which will soon track and control citizens in their interactions with business and government, sorting previous flotsam of experience, orienting attention and associations in new ways through infrastructural sieves. In the process, they allow for new forms and practices of adjudicating (Miller & Power, 2013), new evaluations of individual and organizational performance, and new definitions of success and failure. Thinking infrastructures constitute objects (such as success, failure, quality, etc.) – something which Kurunmäki and her colleagues (this volume) show in their analysis of accounting as the central "infrastructuring" practice. Thinking infrastructures, we propose, are always valuation regimes that constitute orders of worth (Boltanski & Thévenot, 2006; Berthoin Antal et al., 2015).

Tracing

For thinking infrastructures to emerge, they must be traced. And then, traced again. Tracing is an organizational practice that we propose gives analytic purchase on much that is essential and yet overlooked with thinking infrastructures. Thinking infrastructures trace their objects, making them visible and available as objects of and for possible interventions (see Power, this volume; Power, 2019). Tracing happens in clear fashion with clicks and traced searches, rendering ratings and rankings as platforms through which relations are remade, reworked, reestablished and, crucially, tested and objectified in an endless feedback loop (Kornberger et al., 2017). But that is not all. Thinking infrastructures build on relationality rendered visible – in which relations and nodes of connectivity among channels have been traced out via financialization or NGOification of social relations, friendship and mutual aid (Elyachar, 2010, 2014; Federici, 2014). In this sense, Uber as thinking infrastructure does more than just matching: it traces behaviors, preferences, choices, expectations and experiences (such as customers ranking drivers and drivers their customers) that provide the essential resource for its value creation process (Rosenblat, 2018). Of course, relationality has been one focus of infrastructure research since the 1990s (see Star & Ruhleder, 1996), and more recent research shows how relationality in social infrastructures is financialized, platformised and politicized (Srnicek, 2016). In this volume, we take further what was done through financialization in the realm of circulation and distribution, and move back into the realm of production itself where it began with logistics (Cowen, 2014), but now thought, acted from the bottom up, through tracing. Indeed, the business plans of the dominant corporations of our day known collectively as FANG (Facebook, Amazon, Netflix and Google) are fundamentally about tracing – and then packaging and selling the traces. In the process, that which used to be the "real deal" of economy – producing, distributing and consuming stuff – becomes the pipes and channels through which value flows and is reformatted by thinking infrastructures, with their capacities to influence thought and action.

Governing

Thinking infrastructures are also infrastructures of and for governance. Thus, in this volume, we analyse the ways in which nascent and established thinking infrastructures reciprocally enable the assembling of a wide variety of actors and entities (Miller & O'Leary, 1994). We ask: how do thinking infrastructures enable interventions into, and reorganizations of, the governing of individuals, communities, organizations and entire markets? Thinking infrastructures enable interventions through establishing a distinct conception of the objects and objectives of government – be this by the state, the private sector, NGOs or fields of power that stretch across all three (Elyachar, 2003). Here, we pay attention to how thinking infrastructures enable new modalities of distributed agency and paradoxes of power: thinking infrastructures are a form of distributed cognition and distributed agency that structure collective reasoning, attention and decision-making across multiple sites, as the set of chapters that focus on market design demonstrate (see Folkers; Pflueger et al.; Kjellberg et al., in this volume). In these settings, thinking infrastructures govern and exercise power through protocol (Galloway, 2004; Lessig, 1999) – that is they distribute control while centralizing power.

RELATING THINKING INFRASTRUCTURES TO ONGOING CONVERSATIONS

We present this volume as a performance (as Callon might have it) of thinking infrastructures: revealing, reconnecting, reworking and interlinking a range of ideas about infrastructures. We aim to create an infrastructure (if a tentative one to soon be rethought, reworked and revised by the text's readers) for thinking infrastructures. We bring into conversation thinking about infrastructure in a range of fields: anthropology, accounting, organization studies, science and technology studies, and information sciences that have focused on infrastructures with insufficient cross-cutting ties. We strive for connectivity between communities and conversations, as one small effort to take back the apparent monolithic power of "thinking infrastructures," in the spirit of Clifford Geertz's words about walking side-by-side rather than climbing onto the shoulders of giants, we walk side-by-side in our different fields with the thinking infrastructures we study. Walking together with an ethnographic sensibility, we can be attuned to ruptures, parasites and processes of undoing that are integral to the formatting, reformatting, stitching together, sieving and channeling of thinking infrastructures, creating more nuanced and robust analytic differentiations and distinctions in the process. In what follows, we highlight three distinct conversations that are challenged, perhaps even changed, by thinking infrastructures.

Materiality and the Performativity of Devices

A thinking infrastructure can be programmatic: it can articulate aspirations, it can envision new realities, it can make and mobilize new desires; it can also

intervene to act on the objects and objectives it makes and mobilizes. In the literature to date, consideration of such issues has been indirectly addressed by work on devices. Why is device itself important here? First, it is helpful to recall (potentially back to Heidegger or Foucault) that the very word device anticipates some kind of thinking or at least forward-looking planning through its user: a device is designed to carry out a specific task. Implicit in the device is the human, objectivized in the device, to carry out certain actions. All devices that are imbricated in society and economy – as "mediating instruments" (Miller & O'Leary 2007), "market devices" (Callon, Millo & Muniesa, 2007) or "intellectual equipment" (MacKenzie, 2009) become an important area of research. Consequently, a staggering array of artifacts have been studied as devices, including measuring tools (Preda, 2006), 2×2 matrices (Pollock & D'Adderio, 2012) and double-entry bookkeeping and other calculations (Miller, 2008). Analytically, the notion of device is useful because it captures how each device is an "artifact," the product of a practice. The term can also be used to describe an object that offers affordances and constraints, while at the same time capturing the aspect of "clever contrivance" and "artful design." All that allows scholars to show how devices can embody or be inscribed with certain ideas or assumptions which in turn shape specific contexts.

Introducing the term thinking infrastructures invites recalibrating the notion of device. This is a fruitful move because it remedies the somehow narrow focus of devices on singular tools, (local) framings and atomistic interactionism (Pollock & Williams, 2009). In contrast, infrastructures can be imagined as series of interconnected devices that are joined up to form a web. For instance, in their paper on evaluative infrastructures at eBay, Kornberger et al. (2017) show that eBay does not just use singular valuation devices to organize its platform: rather, a whole infrastructure made up of ratings, visualizations, feedback loops, recommender systems, categorizations and so on is mobilized to organize the encounter between producer and consumer. We propose to use "thinking infrastructures" to capture the level of analysis where local interactions with devices are part of and feed back into wider networks of knowledge and power (Williams, 1997). In other words, thinking infrastructures are apparatuses in which distributed agency and cognition are cojoined, held together, reinforced and (re)directed. Paraphrasing Star and Ruhleder (1996, p. 114), thinking infrastructures occur where tensions between local and global, technological and social, mind and matter, are (if momentarily) resolved.

Miller and O'Leary (2007, p. 707) develop this line of thought by addressing interactions between "programmes" and "technologies." Programmes refer to "the imagining and conceptualizing of an arena and its constituents, such that it might be made amenable to knowledge and calculation" (Miller & O'Leary, 2007, p. 702). Technologies denote the "possibility of intervening through a range of devices, instruments, calculations and inscriptions" (Miller & O'Leary, 2007, p. 702). Thinking infrastructures take shape in the interaction between programme and technology. With thinking infrastructures we build on this conception while sidestepping the easy dichotomizing of programmes and technologies as if they were distinct ontological realms: thinking

infrastructures link together material artifacts, material practices and broader circuits of ideas and visions.

Distributed Cognition and Social Infrastructures

Without wandering too far into analytic philosophy or theory of mind, we cannot escape mention of what we mean – or perhaps what we do not mean – by the concept of "thinking." As mentioned before, it is not sufficient, when thinking "thinking infrastructure," to reduce thought to conscious cognition. Thus, like the original impetus behind the first infrastructure studies (a rejection of an overly narrow or local lens when studying complex and often distributed sociotechnical phenomena; see Hughes, 1983), the notion of thinking infrastructures rejects narrow framings around cognition and decision-making. It takes a critical stance toward the idea of a "*res cogitans*" as locus of cognition. Instead we relate thinking, thought and cognition back to basic socio-material strata and build on what cognitive scientists and philosophers of mind have called distributed cognition (Clark, 2008; Hutchins, 1995).

Distributed cognition cannot be separated from practice. Indeed, thinking infrastructures we analyse in this book continuously dip into, and attempt to reorganize under a different frame or organization, a whole range of social practices. Initiatives to trace, enclose, and value outcomes of such social practices as thinking infrastructures lie at the heart of our inquiry. And yet, "human infrastructures" (Simone, 2004) and "social infrastructure of communicative channels" (Elyachar, 2010, 2014) formed through social practices resist attempts to turn them into platforms for profit or other organizational aims. As outcomes of social practices, commons and the nodes of distributed cognition within them are never fully captured. There is always a potential for upending and rechanneling the political potential of the commons (Elyachar, 2014; Federici 2017).

This also invites reflection on the realm of "preconceptual thought" that refuses to divide "thinking" from "feeling." Aesthetic dimensions of infrastructures – even thinking infrastructures – are as important as functionality and in fact cannot be isolated from function (Larkin, 2013). Infrastructures work on the senses; they shape perception as well as cognition. Thinking infrastructures are neither neutral nor disembodied. Thinking infrastructures channel the flow of signals from proprioceptors to the brain, to muscle and across the bounds of a human/non-human interaction that is programmed into machine learning and robotics, and into the collective action of a populace in mass revolt (Elyachar, 2014). Here, we encounter the politics of thinking infrastructures once again: Safiya Umoja Noble's *Algorithms of Oppression* (2018), for instance, challenges the presumed "neutrality" of algorithms which format search results in ways that reflect and reinscribe racism and bias (cf. Sweeney, 2013).

Recent ethnographies of infrastructure emphasize this point, showing how navigating mundane infrastructures ranging from bridges and roads to electricity, are part of how forms of membership and relationality are developed over time. They imply collective processes of sorting and classification that produce

forms of identification as well. For instance, Joanne Nucho (2016) demonstrates how provision of services in Lebanon for medical care, credit access and electricity moves through channels of belonging, excluding and sorting along roads and neighborhoods of urban space in a process usually glossed as "Sectarianism." Fourcade and Healy (2013) argue that economic classifications and other evaluative infrastructures such as credit scoring technologies increasingly determine life-chances. What emerges is a kind of thinking infrastructure that produces meaningful categories in relation to changing material conditions and relationships that develop while people negotiate the dynamic processes of everyday life. These categories are sometimes official and bureaucratic "classificatory tools" (Fourcade & Healy, 2013), but they are also affective, deeply embodied forms of connection. The latter is crucial and to date little considered. Thinking infrastructures shape modes of feeling, memory and the senses. For instance, experiencing a neighbourhood after a highway overpass has been built, One feels the impact of increased sound and air pollution on the body, the feeling of being cut off from the other side of the street by the impasse of a concrete barrier, nostalgia for the time before etc.

Information, Knowledge and Thinking Infrastructures

The initial goal of infrastructural analysis, we have said, was anti-reductionist in that the unit of analysis was never a single device or actor, but rather complex interdependencies between material practice, knowledge and social organization. The early focus on technical infrastructures was quickly complemented by a focus on the less tangible notion of information and later knowledge infrastructures. Monteiro, Pollock, Hanseth and Williams (2013, p. 576), for example, define information infrastructures in terms of:

> openness to number and types of users (no fixed notion of "user"), interconnections of numerous modules/systems (i.e. multiplicity of purposes, agendas, strategies), dynamically evolving portfolios of (an ecosystem of) systems and shaped by an installed base of existing systems and practices (thus restricting the scope of design, as traditionally conceived). IIs are also typically stretched across space and time: they are shaped and used across many different locales and endure over long periods (decades rather than years).

Similarly, in an earlier contribution Bowker, Baker, Miller and Ribes (2010, p. 98) defined information infrastructures as technologies (telescopes, supercomputers, big science labs …) and organizations (research institutions, funding agencies, publishing houses, etc.) that enable knowledge work. These are strong and rich definitions which cover much of what we talk about in this volume. However, "thinking infrastructures" hint at two dimensions lacking in that prior work. In the heady early days of information infrastructures, "information" was something that could be well defined through the work (in telephony) of Claude Shannon. Much recent work has shown the impossibility of any reasonable demarcation between data, knowledge and information – data are already imbued with and in itself a form of knowledge (Gitelman, 2013); infrastructures produce knowledge as much as they channel information. Secondly, the term information infrastructure is passive. In contrast, just like road infrastructure (see Harvey & Knox, 2015), thinking infrastructures configure and transform their users and the world.