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2023

Silvast , A & Virtanen , M J 2023 , ' On Theory-Methods Packages in Science and Technology Studies ' , Science, Technology & Human Values , vol. 48 , no. 1 , 01622439211040241 , pp. 167-189 . <https://doi.org/10.1177/01622439211040241>

<http://hdl.handle.net/10138/355608>

<https://doi.org/10.1177/01622439211040241>

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Science, Technology, & Human Values

2023, Vol. 48(1) 167–189

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DOI: 10.1177/01622439211040241

journals.sagepub.com/home/sth

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Abstract

Our review essay contributes to the long-standing and vibrant discussion in science and technology studies (STS) on methods, methodologies, and theory–method relationships. We aim to improve the reflexivity of research by unpacking the often implicit assumptions that imbue research conduct and by offering practical tools through which STS researchers can recognize their research designs and think through them in a new way. To achieve these aims, we analyze different compositions of theories, methods, and empirics in three different STS approaches—actor–network theory, the biography of artifacts and practices, and ethnomethodology—by employing the concept of a theory–methods package (TMP). A selection of theoretical cornerstone texts and case studies in infrastructure research from each tradition serves as our material. Our findings point, first, to differences between the TMPs of the reviewed approaches and to the internal diversity of theory–method relationships in each approach. Second,

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we found some intriguing similarities between the approaches and discuss potential complementarities of their theory–method fits.

Keywords

methodology, actor–network theory, biography of artifacts and practices, ethnomethodology, infrastructure

Introduction

How do theories, methods, and empirics relate to one another in science and technology studies (STS)? Our review essay advances this ongoing discussion of the methodology and methods of STS by analyzing different theory–method fits to think through them in a new way. The discussion stretches back to the roots of social sciences. Methodological questions pose a persistent problem, especially in sociology, where the key research principles of the discipline and uniquely sociological methods to expose and study social facts have concerned scholars since its canonized classics (Durkheim [1895] 1982; Weber 1949; Swedberg 2021).

STS has developed an identity that builds on and diverges from sociology. Within the field, methods are approached both as research practices and as objects for study (Law 2017), and a priori theories are not typically used as research concepts or middle-range theories (Hine 2007) to guide empirical inquiries. Instead, the conceptual and the empirical are kept close to affirm the empirical richness of the intricate practices linked to science and technology (Gad and Ribes 2014). Yet—although their theoretical underpinnings are often implicit—STS methods do not stand alone but remain connected to their meta-theoretical parents. By recognizing these synergies, we aim to discover the complementarities of different theory–method combinations. The approaches reviewed here are not competing commitments but present scholars with different theory–method fits as the “right tools” for a given research task.

Our study contributes to the discussion of theory–method relationships, which has already been the subject of special issues of *Science, Technology, & Human Values* (Gad and Ribes 2014; Wyatt and Palmer 2007) and the *Journal of Cultural Economy* (Law and Ruppert 2013). In fact, the methodological discourse in STS appears to run in cycles: explicit and normative prescriptions about appropriate research methods and designs (Geels 2007) alternate with calls for conceptual minimalism (Gad and Ribes 2014; Jensen

2014) and methodological pluralism (Sovacool and Hess 2017), both of which are criticized for lacking explicit research designs, methodological choices, and research theories (Hyysalo, Pollock, and Williams 2019). This cyclic discussion has yielded no consensus on the theory–methods–empirics relationship; even if consensus is not desirable, the issue merits continued scholarly attention to keep STS research reflexive.

Our argument develops along three key dimensions: first, we address the interrelationships between theories, methods, and empirics in STS in a general way and introduce our analytical concept of a *theory–methods package* (TMP). Second, we employ the concept to analyze theory–methods–empirics compositions in three key approaches within STS: actor–network theory (ANT), the biography of artifacts and practices (BOAP), and ethnomethodology (EM). Third, we draw the argument together by highlighting the prospects and pitfalls of each approach and discuss their combined potential to further STS research.

The TMP Approach

TMP was created as part of the intellectual tradition of Chicagoan sociology and interactionist science studies to stress the co-constitution of theories and methods in brain and cancer research (Clarke and Star 2007; Fujimura 1987, 1996; Star 1989). In both fields, scientific theory and scientific method merged into a combination of abstract and concrete techniques that bring empirical phenomena under scrutiny in a particular way, presenting researchers with “doable problems” (Clarke and Star 2007, 117).

Instead of tracing interlockings of theories and methods in natural sciences, we employ the concept as an analytical tool to designate combinations of theories and methods in various approaches to and actual research practices in STS. Jensen (2014, 196) uses the concept similarly in critiquing the dominance of established TMPs in STS “that purport to capture the diversity and complexity of everything within the field.” However, STS research has remained vividly diverse. The most recent handbooks (Felt et al. 2017; Hackett et al. 2007), for instance, include EM, symbolic interactionism, the social shaping of technology, and cyberfeminist theorizing among the key TMPs in contemporary STS, along with ANT, the social construction of technology, the empirical program of relativism, and the strong program pointed out by Jensen (2014).

To fine-tune our empirical analysis of TMPs used in ANT, BOAP, and EM studies, we elaborate the theory part of each package by distinguishing meta-theoretical from research-theoretical components. With meta-

theoretical, we refer to general ontological and epistemological orientations; with research theoretical, we refer to presuppositions from field theories and research concepts used in actual research. Furthermore, as conventional, we differentiate between methodologies (comprehensive ways of doing research) and methods (research techniques; Gobo 2008) albeit both these distinctions could only be partly followed in the analysis that follows, given that not all the works reviewed draw on the distinctions.

Methods and Materials

We review three approaches aimed for and used throughout the STS field: ANT, BOAP, and EM. The reviewed case studies conducted along with these approaches focus on our own subfield of infrastructure studies. In addition to addressing the general STS audience, we thus contribute to debates on theories and methods that have intensified recently in the subfield (e.g., Hess and Sovacool 2020; Köhler et al. 2019; Labanca 2017; Sovacool and Hess 2017). The combination of wide-ranging empirical work on diverse topics on infrastructures and intensified discussion about ways of conducting this research provides us a perspective for reviewing the different uses and compositions of TMPs.

Below, we unpack the TMPs of ANT, BOAP, and EM, which were selected for the following reasons:

- All three are used widely in STS and also in core infrastructure studies.
- The configurations of methods and theories of these traditions differ from each other from meta-theoretical positionings to intricate research practice and are of interest for the self-understanding of STS.
- The three approaches are of different ages and at different stages: EM is based on program announcements in the 1950s and 1960s, especially in sociology; ANT emerged in laboratory studies of the 1970s and 1980s; and BOAP is a newer methodological opening compatible with many STS discussions.

For materials, we use a selection of theoretical cornerstone texts and case studies from each tradition. These were pinpointed through a systematic review of the key journals in infrastructure studies. In addition, we use pivotal review essays that cover the fields, short-term reviews of the

literature, and our own involvement in infrastructure studies (see Table A1 in the Online Appendix for details).

ANT

We focus first on ANT, an original and influential analytical approach that pivots around inquiries of sociomaterial networks of diverse actants and objects—human or nonhuman—enacted as multiple, interconnected, and fluctuating. Despite its name, ANT is not a theory; in fact, its general orientation is intentionally atheoretical. ANT guides to refrain from conceptual abstractions and to approach phenomena as they concretely unfold. In this sense, it is “a method and not a theory, a way to travel from one spot to the next” (Latour 1999a, 21). Yet, this method (at large) is built on a robust meta-theoretical undergirding.

ANT’s roots begin with the Centre de Sociologie de l’innovation (CSI), a small research center in Paris created in 1967 to nurture industrial innovation. During the 1980s, the institution, directed by Callon (1984), became an “obligatory passage point” for the formation of the early ANT assemblage of such scholars as Bruno Latour, Madeleine Akrich, Antoine Hennion, and John Law, who were later joined by Annemarie Mol, among others. Meta-theoretically, ANT relies on three mutually supporting pillars: nondualist philosophy, both in terms of knowledge and reality (Serres, American pragmatism); semiotics (Greimas) based on materialist signification and circulating reference (Deleuze); and material constructivism (CSI’s engineering science) combined with strains of sociology of incessant making of the social (Tarde and Garfinkel) as contrasted with the mainstream “sociology of the social” as substance (Latour 2005).

These pillars form no axiomatic system to ground ANT as a unified research program or strict methodological guideline. Rather, ANT builds on them as a certain kind of intellectual mode, intellectual project, or even intellectual movement. To adapt its own terminology, ANT is a “gray box”; it is not “blackboxed” to codify studies into an immutable unity, thus rendering the diverse hands-on research work invisible (Latour 1999b), but neither is ANT—including its concepts, methods, and mode of working—entirely transparent to the scientific community. In fact, this porosity is central to ANT’s success: a gray box is loose enough to combine different theory–method fits but still tight enough to be deployed in a wide range of research fields without losing its identity (for a recent collection, see Blok et al. 2019).

ANT's intellectual identity pivots around hands-on descriptive inquiries that avoid theorizations at a distance (Latour 1988). Following its philosophical roots, the distance between the observation and constant unfolding of the world is kept minimal; ANT's methodology is "hermetic in the sense of... making no mediation, suppressing mediation" (Serres and Latour 1995, 64). Therefore, concepts are not abstractions but attached to the real-world processes as they happen: a "translation" is a concrete transforming operation, not an interpretation of it; a "network" or "assemblage" is not an interpretation of the issue at stake as a network or assemblage but tied to the concrete, real-time unfolding of networks and assemblages. At the same time, no a priori substantial differences of—or asymmetries between—the actants of these assemblages are postulated. More generally, ANT follows the principle of generalized symmetry and describes all actants and objects in the same terms.

Therefore, ANT is theoretical, even though not as an explicated theory but a general meta-theoretical orientation combining the ontological and the methodological: reality is constantly enacted as assembling, disassembling, and reassembling of multiactant associations, and empirical inquiries both trace these assemblages as they are enacted and produce new ontologies that are at least partly unpredictable. When Ants inquire how the world unfolds, they fuse meta-theoretical assumptions with real-world processes. Methodologically, ANT invites ethnographic engagement to these constant unfoldings (Garforth 2012; Hirsch 2020; Howe et al. 2016; Winthereik 2019). At the same time, ethnographic skills and imagination become important in inquiry work:

Following human and nonhuman actants and their translations, ethnographers are charged with describing the dynamic, though not necessarily successful, work of enacting particular realities. (Baiocchi, Graizbord, and Rodríguez-Muñiz 2013, 336)

These general premises fit the reviewed infrastructure studies: ANT appears as an extensive approach where meta-theoretical orientation and methods flow into each other; it forms an assemblage methodology that affirms empirical nuance and avoids a priori conceptualizations that limit observations. Cities, for instance, unfold as pluralities of concrete interconnected sites from infrastructures to places, materials, and communities (Blok 2013). Similarly, heating system installers make continuous translations between networks of industry guidance and regulations, tangible components, and the configurations of domestic space (Wade 2020). The

designers of these systems produce specific scripts about end users and uses of the heating controls; the controls have agency in trying to configure the user that is then reconfigured by household practices (Silvast et al. 2018). Also, public participation becomes a network of “human and non-human actors, devices, settings, theories, social science methods, public participants, procedures, and other artifacts” (Chilvers and Kearnes 2016, 13; see also Ryghaug, Skjølsvold, and Heidenreich 2018; Soneryd 2016). Meanwhile, in electricity provision, the actors that produce effects or even initiate actions range from legislation to economic theories, lifestyles, computer programs, wires, heat, fuels, and electron streams (Bennett 2005).

As long as they fit the general idea of sensitizing to the empirical, research can use a wide range of method–material pairs. Existing studies rely heavily on fieldwork and onsite interviews, reflecting the promises of ethnography to ANT studies. But our review also shows a large roster of other methods, including the use of media materials, technical literature, and other texts produced by architects, legislators, and engineers, for instance (e.g., Blok 2013; Cointe 2017; Iskandarova 2016). In fact, some studies use no direct observational method; Bennett (2005) reconstructs the actor networks of a North American electricity blackout from written reports, and Carroll’s (2012) analysis of state formation and water politics in California draws on conventional research methods using historical records.

In our reading, such a flexible TMP reflects the meta-theoretical and methodological assumptions of the ANT program: scholars are not given a specific research theory but guided to directly access sociomaterial networks to produce theoretical insights. Similarly, the actual research work is done by whatever methods are necessary for the task at hand, but this flexibility holds only if those methods are consistent with the meta-theoretical orientation: attune to the empirical and avoid a priori abstractions. No study reviewed here uses attitude surveys, for example, in combination with ANT; the general orientation of ANT forms a different cognitive style than surveys that measure human attitudes at a distance (see also Gobo 2008).

All inquiries translate their objects, and in so doing, also themselves. From this point of view, the reviewed set of ANT studies suggests a variety of different translation processes from relatively loose, document-based object-making to close attachment to diverse research materials to construct actor networks out of them (cf. Guggenheim 2015). As these differences combine with varying theory–method fits, several clarifications need to be

made to the methods used and their relation to the undergirding meta-theory.

First, the precise presentation of methods varies in the studies reviewed. Some works explain their qualitative analysis step-by-step and describe analytical software utilized (Wade 2020), and some offer suggestions to develop research methods from multicriteria mapping to Q-methodologies (Chilvers and Kearnes 2020). Others contain very little explicit descriptions of methods and materials and fuse not only theoretical approach to methods vis-à-vis empirics but also methods (choices) to writing in their research narratives (De Laet and Mol 2000; Marres 2013). ANT's gray box is at work within ANT infrastructure studies: methodological transparency is neither barred nor required.

Second, both methods and theories have a dual meaning that we associate below also with EM: the actors studied also have methods, theories, and data. This includes citizen participation methods in wind power planning (Jolivet and Heiskanen 2010) or data on eco-homes (Marres 2013) that become the object of the studies. The principle of generalized symmetry hence extends to research practice: the work of Ants is not privileged in this respect, and the methods of both the social scientists and the actors studied are included in the research assemblages.

This turns, third, to reflective points on the co-constitution of research, research methods, and even researchers (Gobo 2016; Michael 2017). Certain methods, for instance, perform certain kinds of publics (Chilvers and Kearnes 2020), and ANT research is potentially political in its active forming of assemblages. While ANT has been critiqued for its managerial and power-political biases (cf. Latour 1999b), some scholarship on ANT of infrastructure argues against such views and chooses the side of public deliberation and engagement (Soneryd 2016).

To conclude, ANT's ontological commitments find their corollary in the TMPs of the infrastructure research reviewed. The studies examined highlight the diversity of both method use and argumentation over method choices, while adhering to the meta-theoretical underpinnings of the approach. Methodological but not passionate about prescribing methods, some STS scholars seek to create more prescriptive designs for conducting research, which we address next.

The BOAP

The second research orientation reviewed is the emerging BOAP perspective. In contrast to ANT, BOAP is not an established research orientation in

STS but is still being articulated and promoted for different domains and research interests. Roughly a hundred substudies in two dozen long-term BOAP studies have been conducted to date. BOAP emerged from multiple interconnected research sites, primarily from research projects among STS scholars at the University of Edinburgh and the Finnish universities of Helsinki and Aalto (Hyysalo 2021). BOAP also differs from ANT—and EM—in terms of methodological guidance and research theory. In their various guises, both ANT and EM are skeptical of a priori guidelines and research concepts or suggesting specific methods, building instead on nuanced empirical inquiries vis-à-vis meta-theoretical underpinnings. BOAP, by contrast, provides a set of guideposts for empirical inquiries and explicates an a priori TMP in so doing.

In further contrast to both ANT and EM, BOAP develops no meta-theory but builds methodological combinations and research recipes based on and compatible with various theories of technology studies and social science more generally: the ideas of social shaping of technology and domestication are combined with influences from symbolic interactionism, situational analysis, the social construction of technology, and some aspects of ANT (Hyysalo, Pollock, and Williams 2019; Pollock and Williams 2010). None of these approaches accept asymmetrical distinctions like sorting out use, design, users, and designers of technology from one another to guide research. Instead, technology and technological innovation should be explained in a balanced manner, not assuming that producers are active and influential, and users are passive when it comes to sociotechnical change.

By the 1980s, early BOAP developers detected a discrepancy in STS between ambitious theoretical positions and underdeveloped corresponding methods (Hyysalo 2021). BOAP opposed “snapshot bias” and analyses of “intricate practices of one particular setting”; its criticism is aimed at the “neglect of structural conditions” and privileging “overly situational and potentially internalist analyses” (Hyysalo, Pollock, and Williams 2019, 33). BOAP addresses these gaps by drawing on the theoretical idea of the co-constitution of phenomenon and context to develop an ambitious methodology for addressing a wide range of settings, their linkages, and the intricate practices therein.

To fulfill this aim, scholars reach beyond situational particularities both spatially and temporarily. BOAP’s research methodology covers, first, the multiple locations and time spans where sociotechnical change happens. This distinguishes the approach from both studies of a single location and from broad historical overviews of technological change such as high-level social science theories. Second, BOAP combines the theoretical,

methodological, and empirical in a particular way. It requires appropriate theoretical insight from across STS (without prescribing certain theories to scholars), diverse tools and methods that can merge short- and long-term focus, and an empirical approach to the social studies of technology and the study of the various interconnected actors that affect the technology in focus.

These guidelines aim to actively steer the hands-on research work, and our review found a variety of themes and topics under the BOAP approach. The general trait of these infrastructure studies reviewed is that the approach builds a whole package of theories and methods: this contains explicit theory building and “operationalization” of theories into research methods to apply theoretical insights in research. A study of the long biography of living lab projects—a research concept of a user-centered innovation that sits between different social worlds—builds from explanatory theories of social learning, domestication, and intermediation (Hakkarainen and Hyysalo 2016), whereas a study of the biography of user innovation in mobility draws from established user–designer and peer innovation theories (Hyysalo and Usenyuk 2015; Usenyuk, Hyysalo, and Whalen 2016), and the examination of heat pump users in energy transitions applies theory from sustainability transitions and user intermediaries (Hyysalo, Juntunen, and Martiskainen 2018).

Some of the BOAP studies reviewed build theoretical syntheses in a pragmatic tone, but others are more critical. Pollock and Williams’s (2010) version of BOAP—which they call strategic ethnography—criticizes dominant studies in the field as methodologically weak and often short-lived single-site examinations of how technologies are implemented. Their critique targets not only the “narrowness” of technology impact studies but also explicitly ANT and EM (Williams and Pollock 2012). Our review qualifies this critique; in fact, it is difficult to find any infrastructure-oriented ANT and EM study that would subscribe to the criticized “single-site” focus. To start from a single research site does not automatically lead to internalist analyses, and even situationally anchored EM studies also analyze extra-situational factors. However, BOAP distinguishes itself from both approaches by focusing on a set of pre-chosen concrete locations and by tracing historical trajectories of artifacts and practices between them.

In BOAP, theoretical insights typically turn to methodological recipes. To address the decades of the biographies of maturing technology, unique methodological combinations were necessary. This has usually meant adopting methodologies (and research methods) from historiography (such

as historical source criticism) and ethnography (such as participant observation; Hyysalo and Usenyuk 2015; Usenyuk, Hyysalo, and Whalen 2016). However, many of the studies reviewed draw not only from conventional qualitative research, such as semistructured interviews, but also analyze project reports, plans, and marketing materials (Hyysalo and Hakkarainen 2016) or national sales statistics (Hyysalo, Juntunen, and Martiskainen 2018) and contents of online interactions (Johnson et al. 2014). As these varied materials show, conducting a full biographical study is arduous and demands different research strategies. However, chance and opportunity are also at stake. Several studies (e.g., Pollock, Williams, and Procter 2003; Pollock and Williams 2010; Williams and Pollock 2012) draw from participation in multiple research projects regarding the same infrastructure over several years. Hence, this situation enables examining the history and situatedness of the infrastructure by merging different ethnographic projects originally conducted for almost entirely distinct purposes.

BOAP addresses methodological needs that have been well rehearsed in STS theories since the 1980s: the multiple temporalities of technology and the need to bring balanced representations of users and designers of technology, including the various intermediaries between them. However, the implementation of this recipe is demanding for any researcher who needs to empirically match real time with a historical focus. Wiegel's (2016) BOAP study on the auto industry demonstrates this issue. The technological planning tool he was studying had a long and complex narrative, and he wanted to distance himself from looking at "solitary confinements of single-site and short-termed analyses" (Wiegel 2016, 4). However, he also notes that BOAP did not offer him a precise selection of guidelines or tools to examine the biography of the technology. BOAP is more a set of principles for research designs that should follow the same object during a long period of time; multiple timescales, multiple sites, multiple methods, and multiple practices are to be covered within the same study (Wiegel 2016, 63).

In sum, the M of BOAP's TMP consists of methodological guidelines for researchers focusing on technology and its trajectories, while the T adds research-theoretical components to the mix. As the approach aims to inform concrete study practices, BOAP's TMP keeps a middle ground: it is explicitly distanced from suggesting meta-theoretical commitments for STS scholars but does not prescribe how biographical studies are to be practically conducted. While we suggest that ANT is eclectic in its methods use, BOAP takes it a step further: its scholarship uses not only different methods but also a wide variety of theories to explain the trajectories of the technology in focus. We examine a third approach in STS to show that there is

another way to bridge the gap from (often implicit) meta-theoretical to empirical practice by merging them into the study of situations.

EM

Emerging at the University of California in the 1950s and associated particularly with the classic work of Harold Garfinkel, the EM approach examines mundane social practices as they appear in everyday situations. Like ANT, EM combines philosophical approaches with empirical epistemology and research practice. Alfred Schutz's translation of Husserlian general phenomenology into the sociology of mundane and socially shared sense-makings is conjoined with detailed and nonironic analyses of how these happen in situ: the world is how people make sense of it, how mundane "worldings" take place (Pollner 1987). Ethnomethodologists study these worldings with an attitude of not knowing better. They share with the actors they focus on not only the same world but also a "naive" or "natural" attitude toward it and thus refrain from analyzing the mundane sensemakings and reasonings behind people's backs.

Another and related combination is made between philosophy of language and EM analyses of "indexical" and "reflexive" properties of ordinary talk. Garfinkel (1967) dwells on the late-Wittgensteinian notion of meaning as inescapably tied to situational language use: all talks are full of indexical expressions such as "you," "here," and "tomorrow," whose meanings are context sensitive. Talk is inescapably incomplete and may always need further clarification; the meanings of words and utterances cannot be fixed a priori but are situationally achieved during the talk and through the talk.

Instead of encouraging merely relativist research, this idea of indexicality is combined with the notion of reflexivity in current EM studies:

[I]t is because indexical expressions . . . can be reflexively related to familiar settings, types, rules, norms, and so forth, that we do not—or only exceptionally—encounter the world as undetermined. (Sormani et al. 2017, 125)

Taken together, indexicality and reflexivity make situations meaningful in specific ways and, at the same time, mediate the meaningfulness of different situations. This combination bears importance for STS scholars as it invites observing how both internal contingencies and extra-situational factors are dealt with in situational practice, an invitation long overdue in infrastructure studies.

Furthermore, despite their philosophical underpinnings, EM studies are, like ANT, skeptical of a priori conceptual abstractions. EM is not a research-theoretical tool kit but an extensive and long-standing research orientation for studying how actors make sense of the world socially in their ordinary settings and doings. Developed as an open criticism of the then-dominant Parsonian view of normative structures, Garfinkelian EM targets norms as they appear in (nuances of) interactions, especially in conversational encounters. No concepts are developed to abstract the phenomena under scrutiny nor used to study them from a distance; the research focus is kept incessantly on the fine-grained and constant unfoldings that would be lost if subsumed under a priori concepts.

For EM, the reality is in constant flux, and the existential philosophical idea of the contingency of (the situational accomplishment of) the social world is another meta-theoretical root of the approach. This root provides EM studies also with the critical potential to reveal the intrinsically contingent nature of taken-for-granted social practices. As there is no structural order consolidated over time, the fragile orderliness of the social world must be continuously achieved through mundane processes by using “ethnomethods.” Not only the actors but also the methods they routinely use to make sense of the world are followed. For Garfinkelian EM, methods are targets rather than research tools.

Despite these common roots, EM is not a single approach or research design but has different strains depending on how “scientific” scholarly aspirations are in the study of everyday interactions (Arminen 2008) or how the indifferent attitude of not knowing better is combined with the critical potential of the approach (Lynch 1997). Here, we concentrate on a specific set of ethnomethodological infrastructure studies that have some critical potential and range from scientific—such as methodologically sophisticated conversation analysis focusing on the interactional logics in detail (Heath and Luff 2000)—to more radically phenomenon-driven approaches to EM, where daily reasoning itself is the topic for analysis (Suchman 1997).

The corpus of EM related to infrastructure studies is a large set, including nearly any research work on any professionals who plan, maintain, manage, or use infrastructures—with STS studies ranging from oceanographers (Goodwin 1995) to civil designers (Suchman 2000) and many more. Here, our focus is on the established EM topic of infrastructure control rooms (Heath and Luff 2000; Luff and Heath 2019; Randall, Rouncefield, and Tolmie 2021). EM studies approach control rooms as “centers of coordination” (Suchman 1997) whose workers are responsible for continuously

maintaining the coherence of the infrastructure as it is experienced by end users. This focus sharpens the points on situated practices vis-à-vis extra-situational factors and networks that were the locus of BOAP critique in the above. Control-room practices are intrinsically mediating, and focusing on them requires a theory–method fit that is not confined to internalist research on a single location yet grasps the intricate control-room practices in sufficient detail.

What the reviewed studies make clear is, first, that the entire idea of a TMP must be turned upside down. In some sense, many infrastructure-related works in EM do not have a TMP but rather a methods–theory package. Whether studying space control operations (Almklov, Halvorsen, and Johansen 2020) or air traffic control training (Arminen, Koskela, and Palukka 2014), social science methods take precedence in producing new knowledge. Second, a characteristic feature of EM studies of control rooms is their staggering variety, which extends from choices and strategies to general research designs (Blomberg and Karasti 2013; Randall, Rouncefield, and Tolmie 2021). Third, despite their variety, EM studies are grounded on an accumulated body of knowledge, and theories are largely framed as research that has already been accepted by the scientific community; a large body of previous studies provide tried, tested, and accepted assumptions and approaches for infrastructure EM.

In taking this stance, most of the reviewed studies draw on a Garfinkelian anti-theoretical vein and Suchman’s (1997) critique of sociological theorizing, exemplified more recently by Randall, Rouncefield, and Tolmie’s (2021) notion of theory as an “overused” concept. In studying control rooms, the authors do not subscribe to any ideas about generalization beyond the research context at hand. In addition to theories, some works are critical of methods and methodologies, for example, flagging “methodological fetishism” that refers to the dominance of method over content (Randall, Rouncefield, and Tolmie 2021). This highlights the divide in the history of EM: the approach offers a methodology upon which both specific research techniques, such as detailed procedures of conversation analysis, and comprehensive critiques of those techniques can be constructed.

However, also theoretical research interests appear in the reviewed case studies. These ideas contain a heterogeneous mix, ranging from theories of talk and workplace studies to anthropology, STS, and organizational studies, but they have a weak position and are typically referred to as general theoretical assumptions. Relatedly, roots in certain theoretical strains such as human geography theories concerning events in control rooms are

present (Anderson and Gordon 2017). Finally, some works also appreciate theoretical development, even mentioning BOAP (Blomberg and Karasti 2013). Yet, even the more theory-affirming studies convey the strong sense that theory is decoupled from the method and materials: theories are at one end with operationalizations, fieldwork, and data collection practices at the other. As the fit between theories and methods is kept loose, there is space for both to be used in a rich and nuanced manner.

Another way to characterize how the reviewed EM works use TMPs is their “scientific” orientation. Of the three traditions reviewed, some EM studies are closest to the natural science research model. These studies are built on an implicit acceptance of the idea that empirical research generates explanations and predictions that are then combined into theories. In some ways, the theories can even be falsified by methods and empirics, including the conventional reliance in these studies on video recordings, onsite interviews, and sustained observations in workplace settings. Furthermore, the framework of the studies—EM itself—does not need to be extensively explicated or defended; it suffices to take an “ethnomethodologically informed” approach to the study of work practices (Hartswood et al. 2002) and to use EM principles when observing work like control-room operations (Anderson and Gordon 2017). This implicitness of the framework posits EM as an established approach that needs no detailed explication. This is also reflected in the choice of methods which can be argued for via their familiarity with the research community, such as “documenting and analysing current work practices, understanding the properties of the technology in question, and perhaps most importantly how the technology functions in use” (Pettersson, Randall, and Helgeson 2004, 125).

Yet, while EM studies are empirical to the extreme, this does not imply a narrow situatedness in control-room research. This qualification has two angles. First, EM studies dwell on their Garfinkelian roots of tracing ethnomethods and acknowledge that actors have their own theories, methods, and data (Suchman 2011), such as methods for detecting events in infrastructure networks (Anderson and Gordon 2017) or theory lessons that are part of the work of air traffic controllers (Arminen, Koskela, and Palukka 2014). Like ANT, the tools and technologies that the participants use and embody in their social organization are central to the analyses; they are approached as they appear, not explained away with concepts (Heath and Luff 2000).

Second, by studying actors’ methods and tools, the connectedness of control-room practices to wider the infrastructure opens up. As Blomberg and Karasti (2013) point out, “already the foundational studies of

coordination centers revealed aspects of a more distributed workplace, where the hot-spot centers are directly connected via technologies to distant locations” (p. 385). On the one hand, single-site studies analyze in situ processes that mediate the situational and the extra-situational; on the other, control rooms are studied multisitedly (Silvast and Virtanen 2019) from the outset (Luff and Heath 2019).

To summarize, EM offers a long-standing orientation and tested strategies and choices to conduct studies of infrastructures in the making, but also a general grounding to research packages that merge methods with theories in multiple ways. The rich variety of EM studies of infrastructure provides intriguing additions to the research designs of ANT and answers criticisms voiced by BOAP scholars. EM works do not assume any extra-empirical motives but do not fall into the traps of singlesitedness or a situated, internalist account for which EM is often criticized. Unlike ANT, some of the studies reviewed conduct research while receiving clear methodological guidance. Yet, this clarity of research design comes with a quasi-natural scientific model, where theory–method fits appear as already accepted by the research community, potentially leading to less reflexive research practice than is typical in the STS context.

Conclusion

We have analyzed the approaches of ANT, BOAP, and EM by utilizing the TMP concept to recognize the often implicit assumptions that underpin research. Even though we found salient differences in how meta-theories, research theories, methodologies, methods, and empirics are packaged in the three reviewed approaches, some similarities in their TMPs were also detected. We do not address the approaches as simply competing commitments in STS but discuss the possibilities of using TMPs in a complementary fashion instead.

In summary, ANT merges meta-theory and method; BOAP is a middle-range step-by-step combination of research theory, instructions, and methods; and EM conflates insights from a general orientation into a particular path to reach empirics in detail. This suggests an intriguing conclusion: there are three successful approaches in STS that seemingly do not have a coherent and explicit TMP. As a complete package is not available, STS scholars are encouraged to choose the best possible tools at their disposal. This reflects the identity of STS as fundamentally an empirical and thus pluralistic field.

Our review has shown that the recognized “conceptual minimalism” (Gad and Ribes 2014) of STS conceals how much impact different theoretical assumptions and methodologies—and their interrelationships—have for conducting research. To discover these differences, STS scholars would benefit from using the TMP concept—developed in STS but underutilized in current reflexive discussions on the rigor of research methodologies—to move beyond programmatic statements to studying the actual theories and methods used to add reflexivity to the choices of them in research. This is especially important because, while ANT, BOAP, and EM, for instance, have all provided vital components for research conduct, their discussions are typically generous or even inaccurate when it comes to critiquing other STS approaches.

As an example, ANT’s overt criticism of the social sciences and sociology largely conceals how much ANT infrastructure research is built on theories, methods, and empirical topics from the mainstream social sciences. BOAP’s criticisms of single-site studies and actor-centric approaches are apposite, but it has been difficult to find an infrastructure-related ANT or EM study that builds on a single-sited, internalist focus. EM advocates a commitment to empirical work and the examination of concrete circumstances, but that advocacy may inherit an implicit anti-theoretical stance toward the social sciences generally, which is neither necessary nor helpful for the conceptual development of theoretical insights that many STS scholars favor. By using the TMP concept, STS researchers can also recognize their own research designs and think through them in a new way, while avoiding repeating inexact, polarizing statements.

Acknowledgments

We acknowledge the helpful comments received from Ilkka Arminen, Geoffrey Bowker, Sampsa Hyysalo, Turo-Kimmo Lehtonen, Tapio Reinekoski, Knut H. Sørensen, and two referees.

Declaration of Conflicting Interests


The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.


Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: Antti Silvast wishes to acknowledge the funding received from the NTNU Energy Transition Initiative. Mikko J.

Virtanen's research was funded by Strategic Research Council at the Academy of Finland (project number 312624) and Academy of Finland (project number 338557).

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Supplemental Material

The supplemental material for this article is available online.

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