Maintenance & Repair in Science and Technology Studies

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Abstract Notably taking root in the first laboratory ethnography studies and in the interactionist sociology of work, several studies have recently provided an in-depth account of maintenance and repair work in very different sites (workplaces, urban settings, homes). They have provided great insights to not only reconsider largely invisible operations, but also to pursue the discussion of issues such as innovation, ordering processes and materiality in Science and Technology Studies. In this introduction, we focus on two topics of discussion. First, we show how maintenance and repair studies expand our understanding of sociomaterial work and object agency. Second, we highlight reasons for exploring maintenance and repair practices to challenge and decenter innovation studies.

Keywords: maintenance & repair; vulnerability; innovation; materiality; modes of ordering.

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For several years, interest in maintenance and repair practices have been growing in science and technology studies (STS), and numerous investigations have been conducted on the expansion of the seminal works of Akrich (1993) and de Laet and Mol (2000). The emerging stream of research explores overlooked sites and practices and contributes to various issues such as "ontological politics" (Mol 1999), "new materialism" (Coole and Frost 2010), and "knowing capitalism" (Thrift 2005). Considering papers from different European countries, this special issue of *Tecnoscienza* offers ethnographic insight on specific political, economic and technical configurations. The current work examines the enactment of material vulnerability in e-waste practices (Blanca Cállen and Tomás Sánchez Criado), the "distributed correction process" in the design of

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advanced driver assistance systems (Oana Stefana Mitrea), the mundane interventions of building caretakers (Philippe Sormani, Ignaz Strebel and Alain Bovet), and a major breakdown in an industrial pharmaceutical plant (Cynthia Colmellere).

Before describing the analytical contributions of the articles in more detail, we outline a brief genealogy of maintenance and repair in STS and highlight two main topics of discussion that are particularly worthwhile: 1) sociomaterial work and agency and 2) innovation and concrete conditions

1. Work and Material Agency: Living in a Vulnerable World

For a long time, laboratory studies have stressed the material side of work involved in the daily production of scientific facts, relying on a diverse range of documents, machines, instruments, inscriptions, chemical and physical substances, etc. (Latour and Woolgar 1979). Consequently, studies have emphasized the role of technicians in the maintenance of places, instruments, and experimental materials (Mukerji 1989; Barley and Bechky 1994).

In a well-known article, Shapin (1989) investigated the work of lab technicians ("servants," as they were called in those times) in the 17th century, showing the crucial role they played in experimental arrangements. Remaining largely invisible in scientific reports, lab technicians used to regularly prepare and build machines, calibrate and repair instruments, and fix damages directly caused by unsuccessful experiments, sometimes leading to fire or explosions. As Shapin emphasized, technicians not only performed experiments and maintained the different devices assembled in experimental settings, but they also assumed the corporal risks of dangerous experimental trials.

More recently, Knorr-Cetina (1999) showed that researchers in molecular biology are also caretakers of the living organisms prepared for experimental manipulation in laboratories. Animals are bred and nourished, plants are warmed and observed, and other materials (bacteria, plasmids, cell lines, viruses, etc.) need careful attention on a daily basis. As she clearly demonstrated, caretaking also encompasses technical devices such as glassware, flasks, pipette tips, and test tubes that must be cleaned, sterilized, and stored to prevent degradation.

Laboratory studies investigate maintenance and caretaking practices from the angle of work organization, indicating the boundary between the scientist that thinks and produces original ideas and the technical workers that manipulate instruments and remain in the background. Criticizing the disembodied figures of the scientific genius stressed out by some historians and philosophers of science (such as the superior mind of scientists) is related to what Hughes (1962) has shown regarding the na-

ture of the tasks carried out in workplaces, which are barely considered honorable or respectful. He emphasized that professions are not just organized by the technical distribution of tasks, but they are also affected by a moral division of labor. Every profession, even the most prestigious, involves some "dirty work," generally conducted by those considered outside of the "real" or "core" professional circle. Such a monopoly defines "what counts" as a job, particularly in the professional world (Strauss 1985; Star and Strauss 1999). At the crossing of laboratory studies and the interactionist sociology of work, a new domain of research has emerged, making room for an explicit interest in how "work is the link between the visible and the invisible" (Star 1991, 265). It has notably laid the basis for the study of infrastructures and the distribution of work enacted through daily functioning, and it has invited us to reconsider the role of mundane operations, including maintenance and repair, in their "taken-for-grantedness" (Star 1999).

On the margins of STS, some scholars have investigated maintenance and repair practices (Orr 1996; Henke 2000). They notably insisted on the dynamics of knowledge within occupational communities and highlighted the irreducibility of repair work, which inherently resists attempts of rationalization and planning (Orr 1996). Through in-depth ethnographic investigations, scholars have dramatically enriched previous studies concerning what Shapin (1989) has termed "invisible technicians", foregrounding the crucial role of improvisation in maintenance work (Orr 1996) and the kind of material and bodily commitment required (Henke 2000; Dant 2008).

More generally, these works aim at expanding one of the main assumptions of interactionist sociology and ethnomethodology, i.e., that social order is not a given, but the vulnerable outcome of a ceaseless process which draws on mundane "remedial interchanges" (Goffman 1971) and on conversation repair (Garfinkel 1967; Schegloff 1992; Schegloff et al. 1977). Taking inspiration from these crucial theoretical claims, maintenance and repair studies strive to broaden the focus from conversational exchanges and face-to-face interactions to the material features of our daily lives and environment. Social order, then, can be conceived not only as sociomaterial order, but also as the concrete result of the everyday practices of material maintenance and repair. Insisting on the perpetual production of social and material order, these studies stress the instability and potential failures and fragility beyond a definition of sociomateriality that only focuses on "affordances" and "scripts" (Jarzabkowski and Pinch 2013).

A particularly promising set of studies regarding architecture preservation (Edensor 2011; Jones and Yarrow 2013) and art conservation (Dominguez Rubio, forthcoming) pushes the discussion further, questioning the status of the "order" maintenance and repair are supposed to create. These studies notably show that authenticity, for which preservation practices strive, is distributed amongst heterogeneous arrays of agencies

and, above all, is always negotiated. Hence, sociomaterial order would be, by no means, a shared and univocal horizon toward which all repair work would be oriented; on the contrary, investigations of maintenance and repair foreground the relationality of sociomaterial order. Maintenance and repair practices are embedded in social worlds that bear specific normativities (Gregson et al. 2009) and enact various, and sometimes opposite, orders.

Similarly, following Mol (2008) and Puig de la Bellacasa (2011), scholars recently discussed maintenance and repair as deeply inscribed in a logic of care (Jackson 2014; Denis and Pontille 2015) that starts from decay and vulnerability instead of denying them (Tronto 1993). Because they concentrate on the material fragility of things (Connolly 2013) and the constant necessity of taking care of them, maintenance and repair actually offer an opportunity to reconsider the traditional view of the role of artifacts in society and, more generally, of object agency (Law and Singleton 2005), pursuing feminist reflections on human and nonhuman relationships (Haraway 1991). Studying the ways in which maintenance workers or mundane users explore matter and its various modes of existence is thus a particularly efficient means to think materially, beyond inertia (Barad 2003; Ingold 2007) and sturdiness (Denis and Pontille 2014).

2. Maintenance, Repair and Innovation

Within STS, maintenance and repair, as a matter of concern and as a field of inquiry, challenge the more widespread images of innovation. Innovation is "a highly politicized construct taken up by specific actors and made to work in particular ways" (Suchman and Bishop 1999, 7).

We can clearly distinguish two ideas of innovation: a more widespread series of representations focused on the relation between designers and users or a series of analyses focused on the overall articulation process. The spectrum can be characterized following the roles played by things and matter (Barad 2003; Puig de la Bellacasa 2011).

Innovation has been mostly defined as a successful two-step process consisting of relevant actors articulated in invention and diffusion. Innovation in public space and discourse is accepted without specifying consistency or characteristics (Godin 2013). However, if we consider every change in processes and products, in use and configurations, and in tasks (touching the sociotechnical or hybrid sets as an element of process innovation), we must admit that heterogeneous actors in common settings of maintenance and repair continuously produce a large amount of innovations (Jackson 2014). Unfortunately, these innovations are not easily acknowledged as such (Mongili 2015).

Largely drawing on feminist studies, maintenance and repair studies is concerned with "decentering" sites of innovation (Suchman 2009) and

widening the interest in design, use, organizations, corporations, and markets (Graham and Thrift 2007; Graham 2010). Because maintenance and repair studies take the fragility of technology as a starting point (Denis and Pontille 2014) and focus on object breakdown rather than closure (Jackson 2014), maintenance and repair studies explore overlooked innovation practices. Graham and Thrift (2007, 5) state:

> But when things break down, new solutions may be invented. Indeed, there is some evidence to suggest that this kind of piece-by-piece adaptation is a leading cause of innovation, acting as a continuous feedback loop of experimentation which, through many small increments in practical knowledge, can produce large changes.

Most designers limit themselves to assembling elements that already exist, rarely introducing new elements. They verify or produce interoperability among the elements driven to converge in a new device, and their job is characterized by an extended use of the tools, infrastructures, and materials at hand (Oudshoorn and Pinch 2003; Mongili 2014; Sefyrin 2012; Suchman 2002). Therefore, repair is at the heart of a continuous process that includes patching up, reconfiguring, interpolating, and reassembling settings from previous forms of existence.

Repair practices show that the "articulation" of a device is as relevant as its design. The concept of articulation is derived from interactionist matrices. Geoffrey Bowker and Leigh Star (1999, 310) defined "articulation" as a "work done in real time to manage contingencies: work that gets things back on track in the face of the unexpected, that modifies action to accommodate unanticipated contingencies." Decentering our interest from design, conception, projects, and stabilization and moving toward the big domain of articulation, we have found a junction element between innovation and maintenance and repair studies because changes and innovation occur during articulation. In studying maintenance and repair, we shift toward more ordinary technical devices (Denis and Pontille 2014) and their fluidity and fragility (de Laet and Mol 2000). Outside and beyond representational understandings of innovation, we consider innovation as occurring every day, but we consider it often invisible. Shifting to the ordinary has important consequences. First, the changing processes of devices and their assemblages must be studied in unexpected places and temporalities. In particular, the extension of sociotechnical networks to the countries of the South, transformations endured during those processes, and the changes they enact all seem particularly interesting. Second, the changing processes should be investigated in studying design and use, maintenance and repair, and their convergence, specifically, the convergence between these aspects digitally. As Suchman recently asserted, the digital "undoes professional boundaries historically drawn between making and using" (Suchman 2014, 129) and, we can add, between making, using, and repairing.

STS have insisted on the role of crises and breakdowns in innovation processes for years. Research in the social construction of technology notably highlighted how innovation occurs far after its last official steps and how technologies constantly oscillate from open states to closed ones. However, considering the many possibilities of innovation, maintenance and repair practices show differences in foundational studies. Indeed, the constant ordering processes that maintenance and repair studies have foregrounded (Orr 1996; Henke 2000; Denis and Pontille 2014) have little to do with closure or the dynamics between the moments of crisis and stabilization. Through dismantling, disassembling, and reassembling activities, maintenance and repair practices are grounded in a disordered ground, not in an immanent order to be reproduced or defended. They enact multiple realities (Mol 2002; Law 2004) and multiple "vulnerabilities" (Callén and Sánchez Criado, in this issue) that are the grounds for innovation.

3. The Papers in this Issue

The papers gathered in this special issue emphasize, revisit, or pursue the aforementioned topics, investigating distinct empirical cases.

We saw that maintenance and repair studies highlight the material vulnerability of our world. In "Vulnerability tests. Matters of 'care for matter' in e-waste practices", Blanca Callén and Tomás Sánchez Criado try expand on this stance, exploring the diversity of the ways in which vulnerability is experienced in practice. Studying the case of electronic waste, they show that mending, fixing, and maintaining obsolete computers involves at least three kinds of, what they term, "vulnerability tests:" sensing matter, setting up informal experiments, and intervening in obsolescence. These tests bear witness to very different ways of enacting vulnerability through specific and situated "care for matter" practices. Moreover, they each participate in sustaining a particular ethical and political alternative order that resists the current e-waste regimes and their focus on obsolescence. Using these vulnerability tests, the authors, following Puig de la Bellacasa (2011), ask us to think about how we, as STS researchers, can approach fragility with care, and they ask us to not quickly see maintenance and repair processes as mere restorations of a preexisting sociomaterial order.

In "Instances of Failures, Maintenance, and Repair in Smart Driving", Oana Stefana Mitrea questions the designers' point of view on maintenance and repair in investigating the ways that failures are envisioned in advanced driver assistance systems. In autonomous car experiments, which actually appear semi-autonomous, repair is not perceived as a mainly human practice to help objects or technologies retrieve their full functionalities; conversely, they are perceived as complex technological

activities aimed at surveilling humans, which are considered major, if not unique, causes of failure. Such a specific case invites a more symmetrical view on maintenance and repair, sometimes made of "distributed reciprocal monitoring." Moreover, it shows the importance of considering the broad ecology of maintenance and repair and questioning, beyond the situated practices, the ways that failures or weaknesses are attributed in sociotechnical structures.

The ethnomethodological roots of maintenance and repair studies have been stressed many times. Garfinkel (1967) and Schegloff and his colleagues (1977) have been crucial in studying the vulnerability of social order and the continuous role of repair in its daily accomplishment. In "Reassembling Repair: Of Maintenance Routine, Botched Jobs, and Situated Inquiry", Philppe Sormani, Ignaz Strebel, and Alain Bovet return to these early questions, investigating the daily maintenance of a building. Drawing on video ethnography, they investigate maintenance and repair as a practical issue instead of a theoretical topic. The authors examine the methods of situated inquiry conducted by professionals (plumbers) and laypersons (tenants) to recognize and fix particular housing problems (such as sink and bathtub aerators). At the core of these situated inquiries, the practices of reassembly emerge as crucially at stake. Repair operations draw upon the coordination of different participants who, as Sormani, Strebel and Bovet put it, "configure the very site and situation of their (inter-)action *in vivo*." Thus, the participants evolve during the course of their actions (for instance, switching from a maintenance routine to an urgent repair) and are defined in their own terms, concepts and distinctions, which do not necessarily fit with the researcher's preconceptions.

In "Repair in socio-technical systems: The repair of a machine breakdown that turned into the repair of a shop", Cynthia Colmellere addresses the issue of crisis in repair, analyzing the implications of a major breakdown occurring in a large sociotechnical network; namely, in an industrial plant. In particular, she focuses on negotiations that emerge between different actors trying to identify the needs for repair, produce a reliable diagnosis, and designate the actors entitled to repair. The author points out the specificities of repair, and she identifies how repair intertwines with power, social relations, and technological issues as activities characterized by contingency management and *bricolage*. Maintenance and repair are here characterized as a distributed activity within an organizational framework, and they raise important organizational questions in terms of their visibility as a recognized activity and their relevance in the workplace and in organizations.

This collection of articles does not cover the range of topics falling under the extensive scope of maintenance and repair studies. Based on an in-depth case study, these articles investigate maintenance and repair practices in contrasting sites and workplaces that involve distinct occupational communities. By doing so, the articles do not exclusively focus on

the singularities at play. Rather, they simultaneously examine the ways in which the peculiar issues addressed are related to larger topics such as planned obsolescence and tinkering, the distribution of action and the ascription of responsibilities in innovative sociotechnical networks, and the ongoing process of reassembling people and things in particular settings.

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