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Technology

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> Technology itself has no agency: it is the choices people make about it that shape the world.
>
> "Pessimism v Progress," *The Economist*, December 21, 2019

> Whether your greatest concern is climate change, air pollution, plastics, food security or one of the many existential threats the world is facing today, it seems that there are technological solutions that may actually help us meet the goals of the 2015 Paris climate agreement or achieve the Sustainable Development Goals by 2030.
>
> Felicia Jackson, *Forbes*, January 17, 2019

> Both viewpoints [techno-utopia and techno-dystopia] treat technology as if it had a life of its own, as if it possessed agency. This makes it more difficult to answer the vital question: not "Is technology good or bad?"; but "How should we organize ourselves as citizens to make the best use of technology?"
>
> Kenan Malik, *Guardian*, October 20, 2019[1]

An anthropology of technology might as well use these epigraphs as ethnographic vignettes or, perhaps even, as transcripts of field interviews. They indeed summarize the place "technology" occupies in contemporary imagination: they seem to refer to a set of means designed to serve specific ends, after all, not unlike a simple hammer. As such, then, it appears logical that it can be used to solve some of the most pressing issues, such as climate change, democracy, social and economic development, or that, in a more pessimistic or even dystopian view, it can invoke the spectre of global surveillance, environmental degradation, or unemployment. Implicit in these debates is the issue of responsibility for either positive or negative effects. The answer is easy: if "technology" is neutral, then indeed anthropology should investigate mainly humans and their (good or

https://doi.org/10.1017/9781108622639.018 Published online by Cambridge University Press

bad) choices. Maybe when we deal with a hammer, this is a valid argument (this remains to be demonstrated). But then, if the neutrality of "technology" is itself under scrutiny, we might want to think about whether indeed the powerful machines and organizations that have emerged over the last 150 years, and the transformations these have brought to society, environment, health, warfare, or indeed politics, are just about choices.

I would add that we could also wonder about the actual ground on which one can really put together a hammer, social media, a driverless car, and an automated border control system. Indeed, the authors of the above epigraphs are not talking about hammers. We implicitly know that they are referring to "digital technologies." The shortcut "technology" covers such a wide array of things, people, and organizations and at such a wide scale (far beyond the one of a hammer), that it cannot but appear ubiquitous. In this perspective, "technology" is everywhere and everything.

Despite both its ubiquity and these recurrent moral and ethical dimensions, "technology," as a phenomenon deeply associated with colonial, industrial, and modern capitalism, does not constitute an anthropological subfield, such as art, religion, politics, or gender. While there have been attempts from both anthropologists and archaeologists,[2] material culture studies seem to have a hard time in making it a proper focus of inquiry, and what pertains to "technology" seems to be distributed between several subjects: digital anthropology, anthropology of infrastructures, design, art, the body, etc. This is even more surprising given that, as a topic, it has been explicitly examined by many twentieth-century influential thinkers working at the intersection between philosophy[3] and sociology.[4]

There are several reasons for this paradoxical situation, some pertaining to the actual phenomenon and the possibility of ethnography – technology being so ubiquitous that it would be hard to locate the field site – others being epistemological or emerging from the particular histories of anthropological traditions. But all stem from the complexity of "technology" as a domain of inquiry and the type of knowledge required to anthropologically investigate it. Indeed, the exponential increase in technical innovation since the end of World War II presents the ethnographer with such a diversity of phenomena, devices, and organizations, that it can be seen as thwarting any attempt to elaborate an interpretive frame able to unpack the trope "technology" presents.

Yet, in this chapter, my aim is both to present a range of analytical and methodological approaches which have tackled and tackle today what is encompassed in the category of "technology," and to propose a wider analytical frame which might help us to investigate it. To do so, I start by a brief summary of the epistemology of Euro-American perceptions of technical phenomena and examine "technology" as a problematic analytical category of the same order as "Nature" or "Society," before suggesting resorting to the category of "technique"/"technical" to qualify the ethnographic content of what constitutes "technology."

https://doi.org/10.1017/9781108622639.018 Published online by Cambridge University Press

"Technology" as an Epistemic Category

"Technology" finds its etymological source in the combination of the Greek words, *techné* (τέχνη, in latin *ars*), that is "skills," "arts," or "crafts" and *logos*, "discourse," "knowledge," or "science." "Technology" was thus supposed to be to techniques and material culture, what *meteorology* was to the *weather*, or *biology* to *living processes*: the science/discipline which study arts, crafts, or material culture.[5]

Originally meant to refer to a reflexive attitude toward the performance of techniques and practices, the "study of the thing" has become replaced with "the thing itself," in a classical Magritte manner. "Technology" today encapsulates a diversity of empirical phenomena under a single universalizing category which is used to refer to such a broad range of actions, material things, and contemporary phenomena that it can literally encompass anything. This is particularly relevant when examining how, like with many categories, attempting to define "technology" does not always help identifying the anthropological or even sociological domains it is supposed to cover.[6] As Tim Ingold suggested some time ago,[7] instead it is more fruitful to examine the types of implicit claims made when using the term "technology."

The main clue for a critical analysis can be found in how "technology," as a category, is intimately linked to the emergence of a white, middle-class male form of capitalist modernity.[8] Following Leo Marx,[9] Eric Schatzberg, in his recent book on the critical history of the concept of technology,[10] details how, since the end of the eighteenth century, translations into English of French and German classical texts,[11] combined with both spectacular changes in the material culture of the era and the conceptual divide between, on the one hand, fine arts and, on the other hand, useful or mechanical arts, progressively led to the use of "technology" to refer to modern industrial material processes. Wedged between deterministic discourses of progress and what Schatzberg called a "continued confusion between technology as industrial arts and technology as technique,"[12] both public and academic discourses ended up confusing the means and methods for transforming the material world with the skills, devices, and procedures for achieving a specific end (material or not), erasing its original meaning of a discipline dedicated to analyzing them. Such a conflation not only led to "consigning technologies to the realm of things" thus distracting "attention from the human – socioeconomic and political – relations which largely determine who uses them,"[13] but the confusion also helped sustain "a mystifying, deterministic discourse that portrays technological change as the inevitable fruit of scientific discovery," as Schatzberg concludes.[14]

As seen in the epigraphs at the start of the chapter, the use of "technology" in public discourse and the media refers directly to a neutral force of

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progress, inherently rational, whose positive or negative effects only lie in social choices made about its use. More critically, as both Ruth Oldenziel and Judy Wajcman[15] have demonstrated, the category is not only associated with Euro-American vernacular ideas of rationalist, deterministic, and efficiency-driven conceptions, it is also profoundly gendered and politically loaded. While this appears to be an issue of semantics, the black boxing of several phenomena (objects, skills, scientific and applied knowledge, infrastructures, etc.) within the single term of "technology" contributed to making it a hegemonic category. It is not only ubiquitously used in daily public life and the media as shown in the epigraphs, but it has also colonized other languages.[16] While the term "technology" might convey the importance of particular modalities of action which intertwine devices, ideas, and standardized forms of behaviors,[17] its semantic void also folds these modalities within a universalizing neutral and utilitarian category.

"Technology" has become a category vernacular to Euro-American-led modernity, infused with forms of essentializing determinisms, placing it implicitly outside of the scope of most social sciences. The question, then, is to find which analytical category might be less intrusive and still able to take account of the phenomena encompassing such a diverse range of operations involving material culture, which anthropologists are able to recognize in their many guises, from fertility rituals to political actions, from New Guinea gardens to London design studios and the emergence of "machine-learning."

The issue lies in the sheer diversity of phenomena that the category itself can be (and has been) applied to, and it is perhaps this very pervasiveness that creates an obstacle to its coalescence into a specific subfield. Investigating the ways in which "technology" is mobilized in anthropology shows that, at its most basic scale, it refers implicitly to modes of action and processes of creation or transformation (including destruction), which themselves can be observed in the field and commented upon by actors. At a minimal empirical level, what "technology" seems to be dealing with is ways of doing and making,[18] weaving together living beings (humans and/or nonhumans) and things or artifacts, enrolled in a process, within specific historical and socio-historical settings. At a more general level, including in its vernacular use, "technology"[19] includes three orders of phenomena: (1) technical processes and knowledge, usually referred to in English as "technique"; (2) devices and objects (virtual or actual) such as tools, instruments, machines, apparatus, weapons, often implicitly "High-Tech" – to which one can add digital objects such as software and algorithms; and (3) modern infrastructures, modes of organization, sociotechnical systems and/or networks. These three orders of phenomena, though not happening at the same scale, are nevertheless deeply – one can say *structurally* – interrelated. In addition to revealing the vernacularity of the category of

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"technology," the task of an anthropological investigation of "technology" should be to examine and specify the modalities of these relations. In what follows, I shall examine all three orders. However, as with every anthropological enquiry, one should be aware of the issue of scales: of the phenomenon to be studied; of (ethnographic) observation; and of analysis itself. In this particular topic, and because of its conceptual payload, I take my starting point on a premise: whatever "technology" refers to, our first ethnographic point of entry should be at the level where humans actually experience it: it arguably starts with the body and its modalities of actions.

From Bodies to Subjects, Skills, Materials, and Magic: Technical Activities and Techniques

Over the course of the past three decades, a renewed interest in the body has brought "practice," "performance," or "embodiment" to the center of many ethnographies of material culture. These analyses weave together – though not all with the same weight and at times in debates with one another – several theoretical strands: phenomenology, cognition, praxeology, identity, and politics constitute some of the major theories investigating the body. However, actual practices do not occupy the same analytical position in all.[20]

Shifting from "technology" to "techniques," the adjective "technical" might prove analytically fruitful particularly because of its empirical and descriptive dimension. The idea of techniques as analytically paramount was first formulated by Marcel Mauss, in his foundational text on *Body Techniques*,[21] where he pointed out the fundamental relational performativity of techniques in a simple definition: "I call technique an action which is *effective* and *traditional* (and you will see that in this it is no different from a magical, religious or symbolic action). It has to be effective and traditional. There is no technique and no transmission in the absence of tradition."[22]

Despite a deceptively anodyne quality, Mauss provides us here with a formula[23] powerful enough to deal with "technology" in its different guises. Its analytical power lies in the combination of the two conditions, "effective" – or "efficacious" – and "traditional." By "efficacy" (not to be confused with "efficiency"), Mauss brackets the Western concern for an actual result, turning our attention instead toward the efficacy *according to the actor*, to vernacular conceptions of effectiveness, that is intentionalities (realized or not) and reasons for actions,[24] a focus which is indeed ethnographically essential to dislodge Eurocentric definitions of rationality. With the second condition, "tradition," Mauss points out the fundamental sociohistorical dimension of practices as being inscribed within a longer history of transmission and change.

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Mauss's methodological stance is that the study of techniques begins at the scale of the body itself and in the ways in which people do things, be it walking, sleeping, or weaving – even having sex.[25] This claim was based on three central premises: first, a holistic conception of the body, not only biological but also both psychologically and socially molded, the three aspects being "indissolubly mixed together";[26] second, the central role of the set of acquired bodily abilities, or *habitus*,[27] embedded within a sociohistorical frame; third, the recognition that body techniques were also central to magical and ritual actions, something already adumbrated in his work *On Prayer*.[28] Through a focus on bodily practices themselves, Mauss offered a crucial analytical shift toward *the modalities of actions*, rather than on their actual (material) results. These three premises broaden the analysis of technical activities in three directions, often intersecting one another.

The first direction deals with the way a holistic understanding of the performing body allows for an empirical and pragmatic approach to processes of subjectification, be it political, sexual, or racial. This is particularly exemplified in the works of Jean-Pierre Warnier and his group Matière à Penser ("Matter to Think"), which combines Foucauldian, praxeological, and phenomenological frames to extend Mauss's conception of efficacy onto other modes of action to include the self and others.[29] Categories such as "identity" or the "subject" appear then as immersed in and emerging from sets of efficacious and traditional actions – be they on and with materials (tangible and intangible, or even invisible, such as spirits or substances such as the Polynesian *mana*), on and with the subject/self (e.g., sport or ritual), or on and with others (e.g., military training or sports.)[30] The crucial point here is that this subject/self construction happens everywhere and every time *with* material culture: built environments direct, encourage, or hinder mobility and possibilities of action; chefs master their knives to the point of sensorial perfection; drills turn weapons into a soldier's bodily extension. Workshops become not only places of production, but also of socialization as masters and apprentices perform, transmit, and learn their technical skills, in a web of social relations with the space, the materials, and with each other, and where the learning of a craft implies also the transforming of the self.

The second direction prolongs the previous one and deals with how, while bodily practices are evidently highly social, their performance does not necessarily require actors' consciousness. The *habitus*, as a set of norms and discipline,[31] by becoming embodied through the learning of skills, including through the complex cognitive processes at play in the performance of activities, becomes a constitutive part of the body itself. It encompasses both a "tradition" – a sociohistorically inscribed modality of action transmitted and sanctioned by a community as being appropriate – and a vernacular conception of efficacy – social values striate everyday gestures and actions lending it a capacity to bring results, in a way that

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can impose political domination without direct violence, as Warnier brilliantly demonstrated.[32]

Ethnographically speaking, the crucial point is that, at this level, an analysis of technical activities opens a window into both conscious and unconscious norms, some verbalized and others only embodied. The verbal dimension – particularly the modalities of evaluation of actions, of actors or of what is acted upon – thus gives an insight into vernacular conceptions of efficacy (in its pragmatic sense) and appropriateness (aesthetics, reference to a "tradition") as a background against which all actions are judged. As for the embodied nonverbal dimension, techniques imply the acquisition of skills, imparting the actor with a procedural knowledge or memory, shaping together the body and the mind of the actor through the acquisition of *habitus*, and actively partaking in the construction of the socialized, sexual, and political self. Simultaneously, skills appear as performances that actualize and reaffirm both technical ("efficacy" and "tradition") and social values, through the ways in which actions and their results are evaluated.

The nonverbal dimension of skills also brings in two other scales of analysis. The closer scale deals with cognition and how actions, bodies, and material things can be experienced as both a material flow and a flow of consciousness by the actor,[33] as well as extending beyond his/her actual body. Cognition and operational memory[34] appear then as situated, extended, and distributed over the human and nonhuman (materials, technical objects, spaces, texts) participants of the technical activities.[35] From an ethnographic perspective, this means paying attention to the ways humans perceive, engage with, and imagine materials.[36] At the wider scale – which leads to my discussion of technical systems – it deals with the socializing effect of technical activities, particularly relevant in terms of gender,[37] social hierarchy,[38] as well as community[39] and politics.[40]

At both levels, though, nothing is static or homogenous. Some technical activities are subject to dynamics of change and improvisation, even resistance or rebellion. Depending on the scale of analysis, they can, more rarely, be smooth and continuous or, instead, have different rhythms and velocities, and include breaks, both intended and unintended. The introduction of new technical objects might require a change in the activity to follow the operational mode of the new tool/instrument, or, on the contrary, a tinkering of the introduced object to adapt it to the local practice – and even at times, reject it.[41]

The third direction pushes further the very notion of technical activities themselves and challenges the category's restriction to material activities of production and/or consumption, and the suspension of Euro-American conceptions of rationality.[42] This is where Indigenous (vernacular) conceptions come back into the fore, through Mauss's simple yet powerful realization that technical action, physical action, and magico-religious action

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were often undifferentiated by actors themselves.[43] Mauss's original formula thus extends our analytical frame to activities usually excluded from the classical field of "technology," such as religious or magical rituals,[44] often contrasted in anthropology.[45]

It concretely means paying attention to vernacular conceptions of actions, of their efficacy, as well as of the things acted upon, be it persons, materials, or substances. Hence, whether associated with metallurgy,[46] gardening,[47] tattooing,[48] art[49] or interactions with animals,[50] magical or ritual practices are not only undifferentiated from "purely material" ones,[51] but because of their vernacular efficacy, they also qualify as "technical activities." This third direction is also analytically crucial for exploring how the logic of actions, in rituals and in other production processes, allows for an investigation of Indigenous ontological regimes.[52] Indeed, the logic of actions is necessarily related to the underlying assumptions about the actor, the thing acted upon and the action itself. Yam growers of the Nyamikum village in Papua New Guinea sing to the yam vines to make them grow;[53] such an action mobilizes vernacular conceptions of singing, of songs, of breath, of the singer's body, as well as of the plant and the processes which make it grow,[54] in turn delineating Indigenous conceptions of vital processes.[55]

Moving to a wider scale, the analysis of technical activities thus requires making visible the complexity, the heterogeneity, the temporality and spatiality of processes, as well as the logics, including vernacular ones, as performed by actor(s). Body techniques are indeed performed in relation with technical objects and their functioning, as well as spaces and places where the activity takes place – be it a workshop or a hunting territory. In order to empirically examine the interactions between the different elements, human and nonhuman, at play in a single technical process, the ethnographic method of the *chaîne opératoire* (operational sequence)[56] appears as one of the most fruitful, though demanding, ways to document and visualize the unfolding and the interweaving of logics, the role of materials, tools, instruments, or machines, the cooperation of human and nonhuman actors, the contingencies, incidents, and accidents that populate the technical process.

There is, however, a risk of confusion – like that plaguing the category of technology – between the technical process, the experience of the actor(s), and the analytical model built by the anthropologist. Far from referring to the ways in which processes are experienced by actors or to a strict protocol that they would follow,[57] the *chaîne opératoire* is nothing but both a guideline for documenting and a graphic rendering[58] of a real occurrence, observed in the field – in contrast with the ways in which archaeologists use the concept to describe a generalized model of artifact production to reconstitute past processes.[59]

From an anthropological perspective, the *Chaîne Opératoire* has thus been used to document variations and technical choices,[60] as well as the

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interactions between its different elements, such as materials, tools, knowledge, energy, and actions.[61] It is a method that can be used to reveal the profound ontological heterogeneity of the logics at play[62] as well as the cognitive aspects of technical processes,[63] or their socialized and socializing dimensions.[64]

The adjective "technical," in its pragmatic Maussian perspective, thus offers an opportunity to account for what would be usually coined as the "materiality" of technology. As Bruno Latour recently pointed out, "technical" skirts around the Eurocentric inflexions of concepts such as "matter" or "materiality,"[65] allowing instead for the identification, not of the essence of "technological" phenomena, but of the specific and empirical manifestations of these phenomena in a given setting. The examination of technical activities, and their temporal and spatial unfolding, reveals the places, roles, and agencies of what surrounds the human actor's body, whether other human or livings beings, or spirits, tools, instruments, machines, algorithms, materials, buildings, or landscapes. As we enlarge the scale and ethnographically follow these "actors," we indeed trace associations and assemblages, of practices, objects, and institutions. I call these associations "technics," firstly, to avoid the confusing and black boxing effect of "technology," but also to refer to both the implicit logic of "efficacy" they manifest (according to the actors) and to their historical and "oecological" ("traditional") groundings. We can then recognize that technics can form networks, either informal and implicit or, on the contrary, taking the shape of planned and purposive infrastructures. But in all cases, at every point of the "network" or "sociotechnical system," technics manifest themselves as the unfolding relations between activities (actions) and assemblages of objects, in more or less structured forms. The next section will focus on the latter, to examine "technical objects" as artifacts or things (including digital objects) that are made for and/or enrolled in technical activities. The last section will explore the wider scale of "technical systems," in particular the ways in which both activities and objects can never be isolated, not only from each other but also from other social phenomena such as religion, environments, or politics.

Technical Objects: Evolution, Design, Agency

Open up the black box of "technology" and a plethora of things spring out: spears, pots, traps, pebbles, bricks, painted masks, religious figures, door closers, speed bumps, mobile phones, algorithms . . . all result from and/or are actors in technical (ritual, aesthetic, political, etc.) activities. However, "technical objects" do not necessarily designate solely tools or machines; instead, I use the term mainly to refer to the specific "traditional" and "efficacious" properties any artifact adopts when examined from the angle of technical activities.[66]

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This type of analysis of artifacts also has its place in anthropology. First, in its origin with the works of A. H. L. F. Pitt-Rivers,[67] but also in the elaboration of material culture itself.[68] In almost every early ethnographic collection, categories such as "weapons," "tools," "fishing implements," "ritual," etc. were indeed referring to the relations between a "specimen" and a specific technical process. However, such classifications referred mostly to the context of utilization of objects.

Yet, use and function might prove insufficient to analyze their technical dimension; every object can be used for different purposes: the same knife can be a tool, a weapon, an ornament, paraphernalia for an office, or a museum object; similarly, a bow and a crossbow can both be used for hunting, war, or sport competition. However, their *functioning*, or modes of operation, present some important *technical* differences. In the case of the knife, its sharpness might condition its use for cutting or piercing, but a dull knife, or even the blade or the handle (but not both, evidently!) of which might be missing, does not prevent its other usages. The importance of functioning is even clearer in the case of the bow, the mode of functioning of which is based on the combination of the traction of the string and the aiming of the actor, while the crossbow removes the traction from the release and delegates it to either a crank or a lever, which can be done before and independently of the aiming itself, the string being maintained by a notch. What distinguishes an eighteenth-century carriage from one in 2020 is not necessarily their use (transporting people, living beings and/or things). Instead the motor of a carriage is an animal, a horse for instance, attached to the transporting frame; it can be replaced by another horse or perhaps another animal, such as mule or an ox, whilst the 2020 car's motor is *integrated within* the structure of the whole artifact.[69] These differences generate different relations in the technical activity in which the object is involved, as Carlos Sautchuk demonstrated: using a spear to catch a *piracuru* fish in the Amazon materializes an egalitarian relation between the fisherman and the fish, whereby both are treated as persons; using a net instead is considered as cowardly and abusive of the fish's trust; in other words, the two technical objects, net and spear, manifest two very different relational regimes.[70]

As with activities, the adjective "technical" here refers to the relationality encapsulated and generated by objects, as the functioning structure of an object both condenses past relational regimes and can generate new ones in its vicinity. But the very idea of a relational regime generated by the functioning of a technical object, an actual form of agency, also hints at the profound ecological dimension of technical objects.

This historical and ecological aspect of the design of artifacts (tools, objects, things) was arguably highlighted first by André Leroi-Gourhan, anthropologist and prehistorian student of Mauss, who conducted an extensive survey of the Musée de l'Homme collections. This survey produced two books on *Evolutions et Techniques*,[71] which laid out

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methods and concepts for an analysis of artifacts that would deal once and for all with old deterministic and ethnocentric evolutionist and diffusionist models. Instead, he proposed what could be called an ecological analytical framework for the study of technics. Be they tools, instruments, or machines, all technical artifacts were to be understood as the historical convergence of a gesture (or several operations) and a material, both engaged in a technical activity, coalescing into an object. The materializations of these convergences in the shape of artifacts was the product of both a specific environment (which included climate) and history – in fact the history of the human species itself saw the correlation of the emergence of hominids, their physiology, their cognitive, technical, and symbolic abilities.[72] For Leroi-Gourhan, the material structure of tools and instruments had thus to be thought of as localized and situated instances of complex sociohistorical and ecological dynamics of innovation, change, and borrowing, as well as applications of empirical knowledge of the world, its materials and their physical qualities. Combined with the specific sociocultural context, all formed what he summarized as "milieus" – a resolutely ecological term.[73]

What Leroi-Gourhan did with Indigenous and archaeological artifacts, was done with industrial machines and tools by his contemporary Gilbert Simondon – to whom we owe the term of "technical objects"[74] – more known in anglophone academia for his contributions to philosophy[75] than for his teaching and methods for analyzing technical objects. In a philosophical move that precedes the more recent analytical "posthuman" turn to objects, their agencies, biographies, and social lives, Simondon proposed an enquiry into technical objects which, refusing anthropocentrism, sets aside use, consumption, and other forms of social metaphors, to examine instead their "mode of existence."[76] Like Leroi-Gourhan, Simondon started by considering that the mode of existence of a given technical object could not be investigated without considering it as a singular instance of a longer evolutionary – though not evolutionist – temporal process of re-production. Technical objects are thus historical beings emerging at the point of concurrence of ecological, cultural, and social settings, each as a form of potential realized in a unique, though reproductive, form.

The philosophical centrality of the mode of existence of technical objects was more than an intellectual inquiry only, and Simondon also practically experimented on methods for analyzing artifacts. In a similar way to Leroi-Gourhan, he saw technical objects as emerging/becoming at the point of concurrence between an organism (a body, then, but not solely human) and an environment. This point was the moment/place where mediation occurred and coalesced into the particular form, or structure, of the technical object: a hammer emerges at the junction between an efficacious (bodily) action of percussion and the type of materials

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(hardness, density, etc.) it is supposed to have an effect on. Hence, the different shapes and sizes of hammers.

This idea of coalescence of mediations allowed Simondon to approach the emergence of complex technical objects as a form of ontogenesis, always in becoming, encapsulating changes and dynamics according to the contexts and domains in which they were used. Their functioning structure changes with time, developing synergies between heterogeneous and at times incompatible effects (heat, vibration, noise in an engine, for instance). Technical objects thus become more "concrete," that is encapsulating, in a tighter way, modalities of self-regulation and autocorrelation, as they move toward autonomization and automation.[77]

The latter form opens up the possibility of expanding Simondon's method to digital objects such as software and algorithms, the mode of behavior and roles of which, in combination with other types of technical objects, such as cars, mobile phones, and computers, indeed seem to fit Simondon's ideas of technical objects, while at the same time being more analytically demanding.[78]

The second main strand in the study of technical objects is more familiar to anthropologists and emerges out of the sociology of knowledge and science and technology studies (STS, hereafter). This strand both enlarges our analytical frame of artifacts and challenges the Euro-American society/technics dichotomy by revealing the inherent heterogeneity of social and technical relations. It promotes a fundamentally sociological approach to the technicity of artifacts, how their design and functioning can itself be subject to sociological analyses, and the effects on their (mis)use. Beyond this common ground, methods and positions diverge into two further directions, intersecting one another: whether technical objects are analyzed within wider sets of relations – and this brings us closer to the scale that corresponds to "technical systems" – or whether technical objects encapsulate within themselves modalities of actions that translate and transduct moral, ethical, and political values, which in turn shape their behaviors and the interactions that humans have with them. In terms of themes, these approaches often look at processes of design, innovation, or "technology transfer" and their explanatory models often spill over into the larger scale of socio-technical systems.

In the first direction, the SCOT approach (social construction of technology) proposes a range of works on innovation, technical change, design of artifacts, and materials.[79] Based on empirical and precise descriptive methods, these authors consider technical objects as fundamentally socially constructed. In the deeply constructivist vein, technical designs and changes are seen to result from heterogeneous social negotiations of positions, framing the analysis of objects within wider political and gendered approaches to technics – and to technology as a discourse or conception of technics.[80]

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The second trend questions in more depth the ontological premise that separates human and nonhuman entities and investigates ways in which political and moral dimensions are delegated to *and* translated *into* the functioning of technical objects.[81] Translations of moral and political statements and agendas are seen as "programmed" into the functioning of technical objects that then become agents through the affordances and behaviors they present to their human counterparts. By doing so, door closers, seatbelts, hotel keys, generators, casino machines, or speedbumps become actors, in wider socio-technical networks, both materializing and stabilizing social relations.

"Technical object" as an analytical frame synthesizes these different approaches, while keeping actual artefacts and their material properties at the center of inquiry. They appear then as historical entities designed to be "efficacious" (their functioning structure, which is a condition for their actualization, is operational) and "traditional": along with humans, they are part of wider networks, from which they both emerge (history, geography, social relations) and depend on for their efficacious functioning. A mobile phone requires radio wave infrastructure (towers, roads to access these and allow their maintenance) to receive and transmit information, be it messages or upgrades, as well as a power supply for its battery; a car implies fuel – or electricity – supply, as well as mechanics, roads suitable for vehicles and increasingly, due to the inclusion of chips, computers. While all implicate human negotiators, these necessary requirements fall within what Winner aptly defines as "technological imperatives,"[82] which structure the conditions of successful functioning of technical objects and reframe the crude conceptualization of "technological determinism" in a less rigid way.

This analysis of the functioning of technical objects[83] opens into the larger scale of socio-technical systems, where control – or "power" – circulates through larger networks and infuses the relations between technical activities and technical objects.

Technical Systems: Scale, Relatedness, Behavior

No activity or object exists in isolation. Consider the simple operation of hammering a nail: it can be part of putting a picture on a wall or of the building of a mosque (or worse, crucifying someone!). The hammer, the nail, and the thing to be nailed are themselves the products of sequences of action that have gathered and transformed materials and brought them together at the moment and place of the actual nailing. Simultaneously, each sequence of operations is also molded by vernacular modalities of actions and logics, infused with conscious or unconscious intentionalities, values, and meanings such as "efficiency," "appropriateness," or even "rationality." These values can also operate in other domains, technical

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or not – a point I can easily *hammer home*. Even the carving of the visible parts of a wooden beam into figures or geometric patterns is part of a longer iconographic "tradition," learned and transmitted from one generation of carvers to the next, perhaps following kinship patterns or specific workshop practices.

Technical objects, themselves, while deceptively discrete entities, are instantiations of longer and wider chains of (re)production, change, and design (the Maussian "tradition"), themselves materializations of wider conceptions of "efficacy" and intentionality. Crucially, they also emerge from and are embedded in (increasingly so in contemporary contexts) wider material (such as "resources") and technical organizations, which are required for their functioning (from watermills requiring rivers, to mobile phones requiring radio waves) and relate their purpose to their wider environmental, sociological, political, and cosmological settings.

Investigating such relations implies widening the scale of analysis of the modes of relations between technical activities and technical objects. As we do so, we can see the nailing of a roof beam of a cathedral or synagogue as being part of a religious but also economic and political endeavor, mobilizing many materials and people as well as several institutions (the Church, the State) and organizations (guilds of carpenters, miners, transport workers, etc.). Even a simple gesture which handles a tool – prepared or improvised, such as a stick picked up in a forest – is always part of a longer and larger process that connects making, doing, using, and thinking, both here and then, or further away in time and space.

This web of relations takes the form of networks, dynamically relating energies, materials, information, things, ideas, and concepts at a larger scale than the one usually directly observed in the field. This implies that, arguably, *one cannot really see networks – or systems*: one can only encounter some features taking the form of emerging effects, or manifestations as the process unfolds (as I try to make a call, then I realize that the absence of a "signal network" stops me from using my phone). These features and events, which can be seen as indexes of distant phenomena (in time and space), are, *mutatis mutandis*, like a journey through a landscape, when one encounters on one's path other roads, skirts around emerging rocks, crosses rivers, climbs mountains, or follows ridges. Actors of a technical process are thus navigating within a wider spatial and temporal reticulated frame, the whole extent of which remains beyond their direct experience, but the effects of which can be felt and encountered along the path itself.

The ways in which technical processes are always embedded within wider phenomena is also one domain in which anthropology and material culture studies have a long research tradition, though often developed in different ways. These can be traced back at least to the ways Lewis H. Morgan identified the different components of society, such as subsistence, government, language, or family, and interpreted their relations as

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indexes of different "ethnic stages."[84] In the course of the twentieth century, this static model was pushed further by authors such as Mauss and Leroi-Gourhan, but also by Bronislaw Malinowski, C. Daryll Forde, and researchers from the American school of cultural ecology, such as Julian Stewart and Roy Rappaport.[85] To various degrees, all examined, documented, and analyzed how technical activities, often under the terms of "modes of subsistence," "crafts," or "arts," were related to other domains such as magic, religion, kinship, economics, or politics. Together, these works demonstrated, sometimes indirectly, how the production and use of artifacts were always in interdependence, material or conceptual, with their environmental, geographical, historical, cultural, and social settings – in other words, the tradition part of Mauss's formula.

From a theoretical point of view, Karl Marx was one of the first to use anthropological and historical examples to demonstrate the link between modes of production and social relations.[86] His analysis of the interdependency of technics, political economy, and general social organization aimed at demonstrating the deeply transformative potential brought by technical changes. It pointed out how time is crucial to analyze the ways in which technical change could have social and material repercussions, both intended and, more dramatically, unintended – as contemporary climate change and environmental pollution keep reminding us. However, such interactions, notably with social and political organization, were at the heart of 1970s' Marxist anthropology, which investigated the relations between kinship systems, religious belief, and social relations such as gender and inequality with modes of subsistence and Indigenous economy.[87] But arguably the main aim of these anthropological analyses was definitely the study of social relations and/or political economy; technical activities such as gardening or cattle herding[88] were rarely analyzed in and of themselves and were instead mobilized just as evidence for broader social analyses.[89]

By contrast, historians, because of their interest in dynamics of technical invention and innovation, had an earlier concern for how technical and social change were correlated. Lewis Mumford, one of the founders of the journal *Technology & Culture*, examined after World War II the ways in which the introduction of new artefacts transformed technical activities and were linked to profound historical and cultural changes.[90] While some reconstitutions were far too linear (such as in Lynn White Jr.'s hypothesis about how the introduction of the stirrup was almost directly related to the emergence of medieval social organization)[91] the fundamental idea was to examine the systemic relation between technical changes and historical and social dynamics.

Mauss was, again, one of the first anthropologists to explicitly point out that "techniques, industries and crafts, taken together, constitute the [technical] *system*[92] of a society which is essential to it."[93] However, inspired by the theory elaborated by the Austrian biologist Ludwig von

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Bertalanffy,[94] the term "system" was first consistently applied to technics by two main authors. One is the French historian Bertrand Gille, less known in the anglophone than in the francophone tradition, and the other is the American Thomas P. Hughes.

Gille edited – and was the main contributor to – a *magnum opus* on the history of techniques,[95] which had a huge influence on the development of the French research group around *Techniques & Culture*.[96] His main contributions were threefold. Firstly, like Simondon, technics could not be understood without paying attention to the specificities of historical dynamics of change and innovation. Secondly, he showed how technics – constituted by devices, their mode of functioning and technical activities – were interrelated in ensembles and structures, aiming at producing specific types of results, such as textiles, aviation, or agriculture, which formed technical systems. Thirdly, these technical systems could not be isolated from other phenomena and activities, such as the economy or social organization, but were ensconced within their context – and a crucial part of it.

Inspired by Gille, Pierre Lemonnier spelled out for ethnographers the three main levels of these systemic relations,[97] to which I have alluded at the beginning of this section: (1) at the closer scale, the five elements (materials, tools, gestures, knowledge, energy) of a given technical process are related in a systemic way; they must all be in interaction to produce the desired effect ("efficacy"): a change in one of them, such as in a material, can have repercussions on the tools used, on the actions performed, or on the knowledge required, and a change in the energy necessary to animate the action will affect either the technical objects or the gestures, and so on; (2) every element of a technical activity is itself part of a wider trajectory involving other technical activities and objects (a hammer has been made, a wooden frame has been grown as a tree, nails are factory made); similarly, every process is part of longer process (the building of a Catholic cathedral, which might also require sawing planks, building stone walls, quarries, transport infrastructure etc.); (3) every technical process is thus in relation with other social phenomena and all technics are necessarily enmeshed in economic and social (gender, class, etc.) relations, as well as political and legal institutions.[98]

When used as an analytical tool in Indigenous and historical contexts, this systemic approach examines how activities, such as gardening, fence building, mining or metallurgy, and even rituals, mobilize objects, actions, and representations[99] – where, in particular, vernacular conceptions of efficacy, the other element of Mauss's formula, play a central role. As a result, anthropological studies of technical systems necessarily mobilize topics, often seen as distinct, such as kinship, religion, economics, politics, art, or even ontology and/or environment.[100] One of the best examples is Michael Rowlands and Warnier's description of the ways in which Cameroon Grassland iron-smelting is equated with human reproduction;

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what is made visible here, on the ritual and female features of the furnace, is not a metaphorical relation, but instead a vernacular ontological parity between object and subject production.[101]

Hughes's work on the electrification of the United States focused more directly on the political economic conditions that fostered the development and the materialization of large-scale infrastructures.[102] For Hughes, the analytical dichotomies between technics and science, and technics and society ("technology" in his writings) – an analytical distinction based on categories profoundly vernacular to modernity – rely on mechanistic explanatory models which foreclose any analysis, other than deterministic ones, which would give historical change its proper place. Instead, Hughes claims, we are in the presence of a "seamless web,"[103] where dichotomies evaporate as the description of the development of an infrastructure reveals how they are inherently embedded within, and inseparable from, a political, social, and economic setting.

Both Gille's and Hughes's approaches were originally dedicated to the analyses of wider, large-scale technical systems but are also analytically valid for both Euro-American and Indigenous settings. They use a theory of interconnections and interactions of practices, apparatus, and organizations which leads the way to think about questions of control and agency, by tackling more or less directly the issue of determinisms, be they technical ("technology shapes society") or social ("society shapes technology"), to which we could add environmental determinism. These issues, however, emerged from Eurocentric conceptions of technical systems. Bertalanffy's general system theory had a huge influence on contemporary modernist thought, spilling out of academia and often leading to rigid, deterministic, and teleological models, particularly within corporate, financial, economic, social, and political discourse, as Langdon Winner rightly summarized.[104] As a result, the very idea of "technical systems," even in sociology and anthropology, is mostly equated with industrial ones, and seen as a rigid deterministic and instrumental analytical frame.

This modern, industrial, vernacular interpretive frame led to the development of technical systems as mainly "purposive,"[105] that is identified by actors according to their purpose, or the domains they are directed to, sometimes identified as "industries": food supply, health (both physical and mental), energy, mobility, communication as well as security and culture.[106] Though they manifest themselves at the level of technical objects and activities (including knowledge) associated with them, they are fundamentally different, appearing as infrastructures that "create the grounds on which other objects operate, and when they do so they operate as systems."[107] Analyses of these industrial technical systems are thus often implicitly framed within the old philosophical question of the moral dimension of "technology" as either neutral, evil, or, on the contrary, making human lives fundamentally better by solving (social and/or material) problems, and fulfilling their "needs," as this chapter's epigraphs

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illustrate. Themes emerging from these analyses deal with issues of connectedness, determinism, and control – or "power" – and have a long-lasting influence in anthropological and sociological studies of contemporary societies.

From an ethnographic perspective, however, and summarizing what authors such as Gille, Mumford, Hughes, or Lemonnier have described, I venture that it is possible to characterize further the systemic modalities of technics through three provisional analytical categories, perhaps able to specify their local ontological dimensions: their *scale*, their *relatedness*, and their *behavior*.[108] All three analytical characteristics apply both to Indigenous and non-Indigenous cases. Although the themes that emerge from the literature are not necessarily the same, small-scale communities became and keep becoming increasingly enrolled in globalized networks, infrastructures, and systems (pertaining to, among other things, resource extraction such as logging and mining).

The *scale* deals with what lies within and beyond the level of an ethnographically observed phenomenon – such as the use and discarding of a mobile phone, what happens in a local workshop, a group meeting within a design studio, the building of a canoe or a mortuary ceremony. While networks and systems are too broad a frame to be experienced fully (one cannot *see* them, but mostly their effects), following Lemonnier's three levels of systemic properties, it is at the level of processual relations – which involve activities and objects – that one can reveal structural relations with a larger world of materials, energy, knowledge, and social relations, and which merges together heterogeneous domains such as material, ritual, legal, economic conditions or relations of expertise and authority. It is possible to extend the scale temporally, to show how systems emerge slowly through time and change with "innovations" and "improvements" (and are thus "traditional" in the Maussian sense), and spatially, as the "resources" and "supply chains" (energy, information, humans, and materials) that are mobilized transcend the local to extend into – and can end up mobilizing – the global.[109] The spatial and temporal extension of the scale also helps in expanding and confirming specific conceptions of efficacy and logics that lead to and sustain their emergence: rational efficiency[110] and effective management[111] are contemporary examples of global logics made real and self-justified.

Relatedness refers to the properties of interconnection of heterogeneous assemblages of humans' technical objects and activities, whether in Indigenous settings[112] or elsewhere. While often simplified in terms of determinisms, this characteristic refers to two broad types of phenomena. On the one hand, it refers to the ways in which any event – be it exercise of control or resistance, accidents, shortages, etc. – in a specific place and time, has potential ripple effects on others, through the organic chain of people, things, and/or institutions, wherever the starting point may be, at whatever the scale the ethnographer is locating her/himself. The larger the

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system (or "infrastructure") may be, the larger the number of elements affected and the further away they are. On the other hand, relatedness also refers to the circulation of "resources" in order to maintain the network itself, especially through the making, functioning, and maintenance of technical objects, and whether these can be decided and done locally or not.

Qualifying the actual modes of relation becomes a crucial analytical objective. For instance, relatedness is central to the ANT concept of "network." As a category which has come to replace "system,"[113] "network" has helped circumvent the compartmentalization created by analytical categories that separate technical systems from social ones, as well as human actors from nonhuman ones (materials, plants, animals, technical objects). Relatedness, whether in networks or system, refers thus to the ways in which "nodes" of humans and nonhumans are linked together in what appear then as multidirectional and heterogeneous reticulated relations of causalities.[114] For ANT, these relations are material-semiotic and can be expressed in terms of delegation, translation (or transduction), and stabilization of programs[115] which link designers/engineers, artefacts, and their users, as well as all the intermediaries. Events – decisions, incidents, accidents, hopes, and regulations – do not travel neutrally through the network, but are translated to other nodes in the network, through processes of socio-material delegations (and at times through the very functioning of technical objects) and, like ripples in a pond, actualize, make present and visible the types of relations (including power relations) that connect the "nodes." In a manner familiar to anthropologists, nodes are thus less defined by their own ontic existence, than by the relations they are enmeshed in, which can be smooth, fluid, cut, or even inherently hierarchical.[116] One contemporary example of this might be found in the velocity and the extension of contemporary digital connectivity (of people and of things), which means that decisions about updates, upgrades, and auditing ("data") can have a faster, further, and bigger reach – whether actors want or know them or do not – through a whole chain of human and nonhuman intermediaries.

Finally, I use *behavior* to refer to the dynamics, temporal and spatial, of interactions and interdependencies that animate technical systems/networks and to how different agencies, while circulating and encountering each other, manifest themselves at a more empirical level. This is arguably the main way in which an ethnographer can witness, if not the network (or the system) itself, but some of its *effects*, as indexes of wider (longer, larger, older) reticulated entities (organizations, systems, institutions). What I call their behavior concerns the modalities of concretization, thus of actualization of intended (and unintended) effects and the ways in which these relate to, at the closer scale, both human and nonhuman agencies, activities, functioning, hopes, or desires.

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This is particularly relevant for modern settings (including in developing countries), as the inherent Euro-American *vernacularity* of the purposive dimensions of technical systems[117] orients them toward general *ends*,[118] not only "material" ones, such as food supply, mobility, communication, or health but also more abstract ones, such as entertainment, safety, justice, or democracy. To reach these ends, they require setting up, at a very large scale, an organized control ("management" and "audit") of the functioning and activities ("training," "maintenance," "repair") of both human and nonhuman participants, so that they can then act as indeed efficacious, but mostly *efficient* delegates: as the input/output ratio becomes paramount, it implies, as Winner remarks, that the *means* of organization become, *at the very least*, as important as the results.[119]

This is where the idea of technical "imperative" appears politically crucial, sometimes taking the appearance of technical "determinism," when technical objects impose upon human activities, or of "technocracy," when the organization imposes its (vernacular) values of "rationality" and "efficiency" upon people's activities and behaviors.[120] On the one hand, technical systems – or networks – indeed *tend to* stabilize social relations,[121] while also creating effects of black boxing and invisibility. On the other hand, because of their temporal and spatial nature, they also are, like all nonlinear systems, *simultaneously* determined and unpredictable, shifting with time and space.[122] Thus, for technical systems, modern ones in particular, to achieve their assigned role in an efficient way they require constant control, maintenance, and readjustments, the effects of which give protocols and regulations an increasingly central role, at the expense of contingencies and idiosyncrasies, folding together technical imperatives with technocracy in an obviated form of socio-technical determinism. This is what concepts such as Ellul's "technical order"[123] or Feenberg's "technical code" refer to: a "'regime of truth' that brings the construction and interpretation of technical systems into conformity with the requirements of a system of domination."[124]

Such domination is not smooth, however. Technical systems constitute, at the ethnographic level, the theater where "technological dramas" of regularizations, adjustments, and reconstitutions[125] are played out, and where every counter-signification and counter-appropriation of technical processes or technical objects ends up being reintegrated within the system – such as personal computers that emerged out of wresting power away from corporations before becoming their main products,[126] or hackers recruited to design security systems or new Apps in a start-up. As Feenberg noted (and note the use of the category of "technology" here):

> [t]echnology is power in modern societies, a greater power in many domains than the political system itself. The masters of technical systems, corporate and military leaders, physicians and engineers, have far more control over patterns of urban growth, the design of

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> dwelling and transportation systems, the selection of innovations, our experience as employees, patients, and consumers, than all the electoral institutions of our society put together.[127]

At the same time, unpredictability and the effect of time and expansion of scale means that breaks and bugs, such as bridges collapsing, nuclear reactor meltdowns, high-speed train collisions, or even local wars and financial crises are bound to occur. These unpredictable events make the network and its dys/functioning visible, as the anthropology of infrastructure demonstrates.[128] However, responses to such events rarely imply the scrapping of the whole technical system, but instead prompt the setting up of a heterogeneous combination of technical objects and practices, updates, and new regulations, which, however, because of the technical imperatives that emanate from the objects involved, stop any in-depth challenge to the original "technological code."

These three characteristics, scale, relatedness, and behavior, hint at the inherent political dimensions of artefacts, activities, and systems, and at how they are locally manifested. This is also a venerable theme, whether in philosophy or sociology,[129] and the issue of power, control, and resistance has been examined in many instances.[130] Collectively, these works all think through the actual unfolding of technical (efficacious and traditional) relations between activities, objects, and systems. They give the means to investigate how the manifestations of these systemic relations in technical objects and performance of technical activities are the crucial loci of power struggles of agency and autonomy, as well as inviting imaginations and desires for equality, change, or democracy.

Conclusion

The anthropology of technology exists, then, though parsed through different domains and dealing with different scales. With the emergence of contemporary concerns and phenomena such as post- and transhumanism, the Internet of Things,[131] or artificial intelligence within a context of climate change and global tensions between populism and technocracy, the politics of technics as a general topic is far from anthropologically irrelevant. Technology as a theme is still at the forefront of public debates in the media, often mobilized as a solution to specific issues such as immigration and border control, aging and well-being, social justice and democracy, or indeed security. As a trope, it often acts as the ultimate black box, which can only appear then either as a Pandora's box, or as a treasure chest.

In this chapter I have suggested that an anthropology of technology today can be crafted by fully acknowledging the fundamental relational dimension of what the epigraphs I started with call technology. From there

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we can adopt a fully dynamic approach to the ways in which technical processes are situated in (i.e., emerging from and generating) specific milieus. It implies weaving together several theoretical trends on body techniques and performances (technical activities), on things and their mode of existence (technical objects), and on how the relation between both manifest what we call networks or (technical) systems. An anthropology of technology would thus be constituted by the study of technical activities, technical objects, technical systems, and their relations, where the adjective "technical" occupies a heuristic position previously dominated by Eurocentric conceptions of technology.

From this anthropological perspective, the question is neither whether "technology [is] good or bad," nor if "we [should] organize ourselves as citizens to make the best use of technology," but to unveil how contemporary technical configurations might foster specific social, political, and moral preconceptions to the exclusion of others.

Acknowledgments

This chapter owes much to both the undergraduate and postgraduate students in the course "Transforming Worlds: Anthropological Perspectives on Techniques and Technology," as well as the innumerable discussions (and debates) with colleagues, especially Timothy Carroll, Kimberley Chong, Adam Drazin, Hannah Knox, and Aaron Parkhurst. Very crucial were discussions and seminars with Ph.D. students, with special thanks to Chloe Dominique, Raffaele Buono, and in particular to Rosalie Allain, for her rigorous and acute reading and her suggestions.

Notes

1. https://bit.ly/3CTDcs2.
2. Such as Pierre Lemonnier, *Elements for an Anthropology of Technology* (Ann Arbor: University of Michigan Press, 1992); Bryan Pfaffenberger, "Social Anthropology of Technology," *Annual Review of Anthropology* 21 (1992), 491–516; François Sigaut, "Technology," in Tim Ingold, ed., *Companion Encyclopedia of Anthropology* (London: Routledge, 2002[1994]), 420–59); Tim Ingold, "Eight Themes in the Anthropology of Technology," *Social Analysis* 41, no. 1 (1997), 106–38; Michael B. Schiffer, ed., *Anthropological Perspectives on Technology* (Albuquerque: University of New Mexico Press, 2001); and Ron Eglash, "Technology as Material Culture," in Chris Tilley et al., eds., *Handbook of Material Culture* (London: SAGE, 2006), 327–40.
3. See, for instance, Carl Mitcham and Robert Mackey, eds., *Philosophy and Technology: Readings in the Philosophical Problems of Technology* (New York: Free Press, 1972).

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4. The list is long and venerable: from the critical works of Thorstein Veblen, *The Engineers and the Price System* (New York: B. W. Huebsch, 1921); Martin Heidegger, "The Question Concerning Technology," in *The Question Concerning Technology and Other Essays* (New York: Harper and Row, 1977[1954]); Jacques Ellul, *The Technological Society* (New York: Vintage Books, 1964[1954]); Herbert Marcuse, *One-Dimensional Man* (Boston: Beacon Press, 1964), we move to more contemporary analyses by Jürgen Habermas, "Technology and Science as 'Ideology,'" in *Toward a Rational Society* (Boston: Beacon Press, 1970[1968]), 81–122; Langdon Winner, *Autonomous Technology: Technics-Out-of-Control as a Theme in Political Thought* (Cambridge: MIT Press, 1985[1977]); David F. Noble, *America by Design: Science, Technology, and the Rise of Corporate Capitalism* (New York: Knopf, 1977); Thomas P. Hughes, *Networks of Power: Electrification in Western Society, 1880–1930* (Baltimore: The John Hopkins University Press, 1983); Carl Mitcham, *Thinking through Technology: The Path between Engineering and Philosophy* (Chicago: The University of Chicago Press, 1994); and more recently Bruno Latour, *Aramis, or the Love of Technology* (Cambridge: Harvard University Press, 1996[1992]); Ruth Oldenziel, *Making Technology Masculine: Men, Women, and Modern Machines in America, 1870–1945* (Amsterdam: Amsterdam University Press, 1999); and Andrew Feenberg, *Transforming Technology: A Critical Theory Revisited* (Oxford: Oxford University Press, 2002). Other, perhaps less direct, scholarship includes a long tradition of the critique of modernity which aligns authors such as Karl Marx, *Capital: A Critique of Political Economy*, Vol. I, Part I (New York: Cosimo Classics, 2007[1867]); Max Horkheimer and Theodor W. Adorno, *Dialectic of Enlightenment* (London: Verso, 1976[1944]); or Hannah Arendt, *The Human Condition* (Chicago: The University of Chicago Press, 1998[1958]). Syntheses of these works include Andrew Feenberg, *Critical Theory of Technology* (Oxford: Oxford University Press: 1991) and Steve Matthewman, *Technology and Social Theory* (New York: Palgrave Macmillan 2011).
5. See Mitcham, *Thinking through Technology*, 116–34 for a full discussion.
6. See François Sigaut, "More (and Enough) on Technology!" *History and Technology* 2 (1985), 115–32; Eglash, "Technology as Material Culture," 329; Matthewman, *Technology and Social Theory*, 8–20.
7. Tim Ingold, "Foreword," in Marcia-Anne Dobrès and Christopher R. Hoffman, eds., *The Social Dynamics of Technology* (Washington, DC: Smithsonian Institution Press, 1999), viii.
8. Oldenziel, *Making Technology Masculine*.
9. Leo Marx, "'Technology': The Emergence of a Hazardous Concept," *Technology and Culture*, 51, no. 3 (2010[1997]), 561–677.
10. Eric Schatzberg, *Technology: Critical History of a Concept* (Chicago: The University of Chicago Press, 2018).

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11. One of the most obvious examples comes from the translation of non-English works, for instance French: Michel Foucault's famous text, "Les Techniques de Soi" in French, was translated as "Technologies of the Self," in Luther H. Martin, Huck Gutman, and Pattrick H. Hutton, eds., *Technologies of the Self* (Amherst: University of Massachusetts Press, 1988[1977]), 16–49. Foucault was similarly discussing techniques of production, techniques of power, and techniques of signs. The same translation issue appears in the works of authors such as Jacques Ellul, *La technique ou l'enjeu du siècle* into *The Technological Society* (New York: Vintage Books, 1964[1954]), or Bruno Latour, *Aramis ou l'Amour des Techniques* into *Aramis, or the Love of Technology* (Cambridge: Harvard University Press, 1996[1991]). See also the footnote at the beginning of the recent translation of Gilbert Simondon, *On the Mode of Existence of Technical Objects* (Minneapolis: Univocal Publishing, 2017[1958]), 1, as well as Karl Marx's *Das Kapital*, where *Technologie* had retained its original meaning. Marx's famous footnote 2, chapter XV used the German term *Technologie* which "discloses man's mode of dealing with Nature, the process of production by which he sustains his life, and thereby also lays bare the mode of formation of his social relations, and of the mental conceptions that flow from them" (Marx, *Das Kapital*), 406. The mistranslation was one the sources of critiques of Marx's supposed technological determinism. As Schatzberg finally unveiled, it was *the analysis of technics* ("technology" in its original meaning), which was supposed to provide the ways to reveal these relations, not technics themselves, see Schatzberg, *Technology*, 100.
12. Schatzberg, *Technology*, 232.
13. Leo Marx, "Technology," 576.
14. Eric Schatzberg, "*Technik* Comes to America: Changing Meanings of Technology before 1930," *Technology and Culture* 47, no. 3 (2006), 512.
15. Oldenziel, *Making Technology Masculine*; Judy Wajcman, *Feminism Confronts Technology* (Cambridge: Polity Press, 1991).
16. *Teknologi* in Indonesia, *tecnología* in Spanish, *tecnologia* in Brasilian Portuguese, *teknujori* in Japanese.
17. Andrew Feenberg, *Critical Theory of Technology* (Oxford: Oxford University Press, 1991), 71.
18. Laurence Douny and Myriem Naji, "Editorial," *Journal of Material Culture* 14, no. 4 (2010), 411–32.
19. Winner, *Autonomous Technology*, 10–11; Matthewman, *Technology and Social Theory*, 12.
20. See Jean-Pierre Warnier, *The Pot-King: The Body and Technologies of Power* (Leiden: Brill, 2007), 6 ff; and Wasserman, Chapter 3, this volume.
21. Marcel Mauss, "Techniques of the Body," *Economy and Society* 2, no. 1 (1975[1935]), 70–88.
22. Ibid, 5, original emphasis.

23. François Sigaut, "La formule de Mauss," *Techniques & Culture* 40 (2003), 153–68.
24. There is a common confusion in thinking about techniques regarding the importance given to *causes* at the expense of *reasons*, a confusion which has been analyzed in the philosophy of action, particularly around the work of Ludwig Wittgenstein, *Wittgenstein's Lectures: Cambridge 1932–35* (Oxford: Blackwell, 1979), 4.
25. Mauss, "Techniques of the Body," 84–85.
26. Ibid, 74.
27. Reframed by Pierre Bourdieu, *Outline of a Theory of Practice* (Cambridge: Cambridge University Press, 1977[1972]), 72–95.
28. Marcel Mauss, *On Prayer* (New York: Durkheim Press/Berghahn Books, 2003[1909]).
29. Jean-Pierre Warnier, "A Praxeological Approach to Subjectivation in a Material World," *Journal of Material Culture* 6, no. 1 (2001), 5–24; Urmilla Mohan and Laurence Douny, eds., *The Material Subject: Rethinking Bodies and Objects in Motion* (London: Bloomsbury, 2020).
30. See Warnier, *The Pot-King*, 143–45.
31. See also Foucault, "Technologies of the Self," and Warnier, *The Pot-King*.
32. Warnier, *The Pot-King*.
33. Tim Ingold, *Making: Anthropology, Archaeology, Art and Architecture* (London: Routledge, 2012), 14–31.
34. André Leroi-Gourhan, *Gesture and Speech* (Cambridge: The MIT Press, 1993[1964]), 230–34.
35. Edwin Hutchins, *Cognition in the Wild* (Cambridge: The MIT Press, 1995); Charles M. Keller and Janet Dixon Keller, *Cognition and Tool Use: The Blacksmith at Work* (Cambridge: Cambridge University Press, 1996).
36. James J. Gibson, *The Ecological Approach to Perception* (Hillsdale: Lawrence Erlbaum Associates, 1986); Tim Ingold, "Materials against Materiality," *Archaeological Dialogues* 14, no. 1 (2007), 1–16; Lambros Malafouris, *How Things Shape the Mind: A Theory of Material Engagement* (Cambridge: The MIT Press, 2013); Carl Knappett, "The Affordances of Things: A Post Gibsonian Perspective on the Relationality of Mind and Matter," in Elizabeth DeMarrais, Chris Gosden, and Colin Renfrew, eds., *Rethinking Materiality: The Engagement of Mind with the Material World* (Cambridge: McDonald Institute for Archaeological Research, 2004), 43–51.
37. Francesca Bray, *Technology and Gender: Fabrics of Power in Late Imperial China* (Berkeley: University of California Press, 1997); Oldenziel, *Making Technology Masculine*.
38. Trevor H. J. Marchand, "Muscles, Morals and Mind: Craft Apprenticeship and the Formation of Person," *British Journal of Educational Studies* 56, no. 3 (2008), 245–71.

39. Jean Lave and Etienne Wenger, *Situated Learning: Legitimate Peripheral Participation* (Cambridge: Cambridge University Press, 1991).
40. Warnier, *The Pot-King*; Foucault, "Technologies of the Self;" Margot L. Lyon, "The Material Body, Social Process and Emotion: 'Techniques of the Body' Revisited," *Body & Society* 3, no. 1 (1997), 83–101.
41. See the example of the rejection of the use of iron tools by Māori agriculturalists in William C. Schaniel, "New Technology and Cultural Change in Traditional Societies," *Journal of Economic Issues* 22 (1988), 493–98.
42. Arthur M. Hocart, "The Purpose of Ritual," *Folklore* 46, no. 4 (1935), 343–49; Stanley J. Tambiah, *Magic, Science, Religion, and the Scope of Rationality* (Cambridge: Cambridge University Press, 1990).
43. Mauss, "Body Techniques," 75. Unfortunately, the English translation used the term "confused" for the French *confondus*, a word which I believe is a false friend.
44. Mauss, *On Prayer*.
45. Edward E. Evans Pritchard and Eva Gillies, *Witchcraft, Oracles, and Magic among the Azande* (abridged ed., Oxford: Clarendon Press, 1976); Bronisław Malinowski, *Magic, Science and Religion* (New York: Doubleday, 1954); Alfred Gell, "Technology and Magic," *Anthropology Today* 4, no. 2 (1988), 6–9; Claude Lévi-Strauss, *Structural Anthropology I* (New York: Basic Books, 1963[1958]), 167–231.
46. Michael Rowlands and Jean-Pierre Warnier, "The Magical Production of Iron in the Cameroon Grassfield," in Thurstan Shaw, Paul Sinclair, Bassey Andah, and Alex Okpoko, *The Archaeology of Africa: Food, Metals and Towns*, One World Archaeology, 20 (London: Routledge, 1995), 512–50.
47. Bronisław Malinowski, *Coral Gardens and Their Magic: A Study of the Methods of Tilling the Soil and of Agricultural Rites in the Trobriand Islands* (New York: Dover Publication, 1978[1935]); Ludovic Coupaye, *Growing Artefacts, Displaying Relationships: Yams, Art and Technology amongst the Nyamikum Abelam of Papua New Guinea* (Oxford: Berghahn Books, 2013); "'Yams Have No Ears!': Tekhne, Life and Images in Oceania," *Oceania* 88, no. 1 (2018), 13–30.
48. Sébastien Galliot, "Ritual Efficacy in the Making," *Journal of Material Culture* 20, no. 2 (2015), 101–25.
49. Alfred Gell, *Art and Agency* (Oxford: Clarendon Press, 1998); Sandra Revolon, "Iridescence as Affordance: On Artifacts and Light Interference in the Renewal of Life among the Owa (Eastern Solomon Islands)," *Oceania* 88, no.1 (2018), 31–40.
50. Carole Ferret, "Towards an Anthropology of Action: From Pastoral Techniques to Modes of Action," *Journal of Material Culture* 19, no. 3 (2014), 279–302.
51. Mauss, "Body Techniques," 75.

52. Rowlands and Warnier, "The Magical Production of Iron"; Philippe Descola, *Beyond Nature and Culture* (Chicago: Chicago University Press, 2013[2005]).
53. Coupaye, *Growing Artefacts*, 133 ff.
54. Coupaye, "'Yams Have No Ears.'"
55. Perig Pitrou, "Life as a Process of Making in the Mixe Highlands (Oaxaca, Mexico): Towards a 'General Pragmatics' of Life," *Journal of the Royal Anthropological Institute* 21, no. 1 (2015), 86–105; Ludovic Coupaye and Perig Pitrou, "Introduction: The Interweaving of Vital and Technical Processes in Oceania," *Oceania* 88, no. 1 (2018), 2–12.
56. See Lemonnier, *Elements*; Coupaye, *Growing Artefacts;* "Chaîne Opératoire, Transects et Théories: Quelques Réflexions et Suggestions sur le Parcours d'une Méthode Classique," in Philippe Soulier, ed., *André Leroi-Gourhan "L'homme Tout Simplement"* (Paris: Éditions de Boccard – Travaux de la MAE – Maison de l'Archéologie et de l'Ethnologie, René-Ginouvès, 2015), 69–84; "Making 'Technology' Visible: Technical Activities and the *Chaîne Opératoire*," in Maja Hojer Bruun and Ayo Wahlberg, eds., *The Anthropology of Technology: A Handbook* (New York: Palgrave Handbooks, in press).
57. Ingold, *Making*, 26.
58. See Lemonnier *Elements*, 37–44; Coupaye, "Making Technology Visible."
59. Hélène Balfet, ed., *Observer l'action Technique: Des Chaînes Opératoires, Pour Quoi Faire?* Paris (Editions du CNRS, 1991); Nathan Schlanger, "The *Chaîne Opératoire*," in Colin Renfrew and Paul Bahn, eds., *Archaeology: The Key Concepts* (London: Routledge, 2005), 25–31; Marcos Martinón-Torres, "*Chaîne Opératoire*: The Concept and its Application Within the Study of Technology," *Gallaecia* 21 (2002), 29–43; Marie Soressi and Jean-Michel Geneste, "The History and Efficacy of the *Chaîne Opératoire* Approach to Lithic Analysis: Studying Techniques to Reveal Past Societies in an Evolutionary Perspective," *PaleoAnthropology* 63 (2011), 334–50.
60. Pierre Lemonnier, "Introduction," in Pierre Lemonnier, ed., *Technological Choices: Transformation in Material Culture since the Neolithic* (London: Routledge, 1993), 1–35; Sander E. Van der Leeuw, "Giving the Potter a Choice: Conceptual Aspects of Pottery Techniques," in Lemonnier, *Technological Choices*, 238–88; Olivier Gosselain, "Mother Bella was not a Bella: Inherited and Transformed Traditions in Southwestern Niger," in Miriam T. Stark, Brenda J. Bowser, and Lee Horne, eds., *Cultural Transmission and Material Culture: Breaking Down Boundaries* (Tucson: University of Arizona Press, 2008), 150–77.
61. Lemonnier, *Elements*, 5–7; see discussion in Coupaye, *Growing*, 98–100, 159–63, and Coupaye, "Making Technology Visible."
62. Coupaye, "Chaîne Opératoire, Transects et Théories."

63. Nicole Boivin, "Mind over Matter? Collapsing the Mind-Matter Dichotomy in Material Culture Studies," in Elizabeth DeMarrais, Chris Gosden, and Colin Renfrew, eds., *Rethinking Materiality: The Engagement of Mind with the Material World* (Cambridge: McDonald Institute for Archaeological Research, 2004), 63–71; Matthew Walls, "Making as a Didactic Process: Situated Cognition and the *Chaîne Opératoire*," *Quaternary International* 405 (2015), 21–30.
64. For example Marcia-Anne Dobrès, "Technology's Links and *Chaînes*: The Processual Unfolding of Techniques and Technician," in Marcia-Anne Dobrès and Christopher R. Hoffman, eds., *The Social Dynamics of Technology* (Washington: Smithsonian Institution Press, 1999), 124–46.
65. "'Technical' is an adjective that is able to resonate with any layer of what I hesitate to call materiality: songs as well as wood, noise as well as steel, narratives as well as fences. In effect, whatever is woven together by the highly specific trajectory of 'technical' moves becomes 'material' as a consequence," Bruno Latour, "Technical Does not Mean Material," *HAU: Journal of Ethnographic Theory* 4, no. 1 (2014), 508.
66. While I do not discuss these in this chapter, this category could also potentially include large "objects" such as factories or even large buildings and structures.
67. A. Henry Lane and F. Pitt-Rivers, *The Evolution of Culture and Other Essays* (Oxford: Clarendon Press, 1906).
68. The literature is obviously so vast that there is no space here to recapitulate it. But for the specific topic of technical objects in the anthropology – and archaeology – of material culture, one can quote examples such as Ralph Linton, *The Material Culture of the Marquesas Islands* (Honolulu: Memoirs of the Bishop Museum VIII, no. 5, 1923); Beatrice Blackwood, *The Technology of a Modern Stone Age People in New Guinea*, Occasional Papers on Technology 3 (Oxford: Pitt Rivers Museum of Oxford, 1950); Robert Cresswell, "Of Mills and Waterwheels," in Lemonnier, *Technological Choices*, 181–213; Alfred Gell, "Vogel's Net: Trap as Artworks and Artworks as Traps," *Journal of Material Culture* 1, no. 1 (1996), 15–38; Margaret Conkey, "Style, Design and Function," in Tilley et al., *Handbook of Material Culture*, 355–72; Warnier, *Pot-King*.
69. There are many other differences, and one suspects that today's cars already present some important functioning differences with 1960s' cars, with the increasing role given to processors and algorithms.
70. Carlos Emmanuel Sautchuk, "The Pirarucu Net: Artifact, Animism and the Technical Object," *Journal of Material Culture* 24, no. 2 (2019), 176–93.
71. André Leroi-Gourhan, *Évolution et Techniques I: L'Homme et La Matière* (Paris: Albin Michel, 1971[1943]); *Évolution et Techniques II: Milieu et techniques* (Paris: Albin Michel, 1973[1945]).

72. Leroi-Gourhan, *Gesture*.
73. See François Audouze, "Leroi-Gourhan, a Philosopher of Technique and Evolution," *Journal of Archaeological Research* 10, no. 4 (2002), 227–306, for a summary, and Bernard Stiegler *Technics and Time, 1: The Fault of Epimetheus* (Stanford: Stanford University Press, 1998) for a philosophical discussion.
74. Gilbert Simondon, *On the Mode of Existence of Technical Objects* (Minneapolis: Univocal Publishing, 2017[1958]).
75. Both Leroi-Gourhan and Simondon, because of their profoundly Bergsonian processual approach and interests in processes of *becoming*, were foundational to the works of Gilles Deleuze and Felix Guattari, most known for *A Thousand Plateaus* (Minneapolis: University of Minnesota Press, 1987[1980]). Tim Ingold's recent philosophical discussion of processes in *Making* synthesizes these influences. Technical objects were to be thought of as instances and changing iterations of earlier ones, giving a shape to time, as George Kubler suggested in *The Shape of Time* (New Haven: Yale University Press, 1962). Technical objects were thus to be examined in terms of their *becoming* or, as Simondon puts it, their ontogenesis.
76. Simondon, *Mode of Existence*.
77. Ibid, 25–28.
78. Simon Mills, "FCJ-127 Concrete Software: Simondon's Mechanology and the Techno-social," *The Fiberculture Journal* (2011), Open access: https://bit.ly/3ra4NTY; Yuk Hui, "What is a Digital Object?" *Metaphilosophy* 43, no. 2 (2012), 379–95; *On the Existence of Digital Objects* (Minneapolis: The University of Minnesota Press, 2016); Bernard Stielger "Teleologics of the Snail: The Errant Self Wired to a WiMax Network," *Theory, Culture & Society* 26, nos. 2–3 (2009), 23–45.
79. For instance, Bakelite in Wiebe J. Bijker, "The Social Construction of Bakelite: Towards a Theory of Invention," in Wiebe E. Bijker et al., eds., *The Social Construction of Technological Systems* (Cambridge: The MIT Press, 1989), 159–87; bicycles in Trevor J. Pinch and Wiebe E. Bijker, "The Social Construction of Facts and Artifacts: Or How the Sociology of Science and the Sociology of Technology Might Benefit Each Other," in Bijker et al., eds., *The Social Construction*, 17–50; or missiles in Donald MacKenzie, *Inventing Accuracy: A Historical Sociology of Ballistic Missile Guidance* (Cambridge: The MIT Press, 1990).
80. See Bijker et al., *The Social Construction*; Wiebe E. Bijker and John Law, eds., *Shaping Technology/Building Society: Studies in Sociotechnical Change* (Cambridge: The MIT Press, 1992); Wieber E. Bijker "How is Technology Made? That is the Question!" *Cambridge Journal of Economics* 34 (2010), 63–76; Oldenziel, *Making Technology Masculine*; Judy Wajcman, *TechnoFeminism* (Cambridge: Polity Press, 2004).
81. John Law, "Technology and Heterogeneous Engineering: The Case of Portuguese Expansion," in Bijker et al., *The Social Construction*, 111–34;

Michel Callon, "The Role of Hybrid Communities and the Socio-Technical Arrangements in the Participatory Design," *Journal of the Center for Information Studies* 5, no. 3 (2004), 3–10; Madeleine Akrich, "The De-Scription of Technical Objects," in Bijker and Law, *Shaping Technology*, 205–24; Latour, *Aramis*; Latour, "The Berlin Key or How to Do Words with Things," in Paul Graves-Brown, ed., *Matter, Materiality and Modern Culture* (London: Routledge, 2000), 10–21; Natasha Dow Schüll, *Addiction by Design: Machine Gambling in Las Vegas* (Princeton: Princeton University Press, 2012).

82. Winner, *Autonomous Technology*, 100–06, 251–62.
83. See Ludovic Coupaye, "'Things Ain't the Same Anymore': Towards an Anthropology of Technical Objects (or 'When Simondon meets MVC')," in Timothy Carroll, Antonia Walford, and Shireen Walton, eds., *Lineages and Advancements in the Anthropology of Material Culture* (London: Routledge, 2020), 46–60.
84. Lewis H. Morgan, *Ancient Society* (Tucson: University of Arizona Press 1985[1877]).
85. Bronislaw Malinowski, *Coral Gardens and their Magic: A Study of the Methods of Tilling the Soil and of Agricultural Rites in the Trobriand Islands* (New York: Dover Publication, 1978[1935]); C. Daryll Forde, *Habitat, Economy and Society* (London: Methuen, 1934); Julian Stewart, *Theory of Culture Change: The Methodology of Multilinear Evolution* (Urbana: University of Illinois Press, 1955); Roy Rappaport, *Pigs for the Ancestors: Ritual in the Ecology of a New Guinea People* (New Haven: Yale University Press, 1968).
86. Marx, *Das Kapital*.
87. For example Maurice Bloch, ed., *Marxist Analyses and Social Anthropology* (London: Malaby Press, 1975); Maurice Godelier *The Making of Great Men: Male Domination and Power among the New Guinea Baruya* (Cambridge: Cambridge University Press, 1986[1982]).
88. Godelier, *The Making of Great Men*; Claude Meillassoux, *Anthropologie Economique des Gouro de Côte d'Ivoire: De l'Economie de Subsistance à l'Agriculture Commerciale* (The Hague: Mouton, 1964).
89. See Lemonnier, *Mundane Objects*, 16.
90. Lewis Mumford, *Technics and Civilization* (Chicago: University of Chicago Press, 2004[1934]).
91. Lynn White Jr., *Medieval Technology and Social Change* (Oxford: Oxford University Press, 1962), 1–38.
92. The original French – unsurprisingly – uses *système technique*.
93. Marcel Mauss, *Manual of Ethnography* (New York: Berghahn Books, 2007[1967]), 24, my emphasis.
94. Ludwig von Bertalanffy, *General System Theory: Foundations, Developments, Applications* (New York: George Braziller, 1968).
95. Bertrand Gille, *The History of Techniques* (New York: Gordon and Breach Science Publishers, 2 vols., 1986[1978]).

96. Bertrand Gille, "La Notion de Système Technique (Essai D'épistémologie Technique)," *Technique & Cultures* 1, 8–18; Pierre Lemonnier, "A Propos de Bertrand Gille: La Notion de 'Système Technique,'" *L'Homme* 23, no. 2 (1983), 109–15.
97. Lemonnier, "The Study of Material Culture Today: Toward an Anthropology of Technical Systems," *Journal of Anthropological Archaeology* 5, no. 2 (1986), 154–56; *Elements*, 8–11.
98. Lemonnier, *Elements*; Francesca Bray, *Technology and Gender: Fabrics of Power in Late Imperial China* (Berkeley: University of California Press, 1997); Oldenziel, *Making Technology Masculine*.
99. See Lemonnier, *Elements*; "L'étude des Systèmes Techniques : Une Urgence en Technologie Culturelle," *Techniques & Culture* 54–55 (2010[1976]), 46–67; and *Mundane Objects: Materiality and Non-Verbal Communication* (Walnut Creek: Left Coast Press, 2012).
100. For example Malinowski, *Coral Gardens*; André-George Haudricourt, "Domestication of Animals, Cultivation of Plants and Human Relations," *Social Science Information* 8, no. 3 (1969[1962]), 163–72; Philippe Descola, *In the Society of Nature: A Native Ecology in Amazonia* (Cambridge: Cambridge University Press, 1994); Coupaye, *Growing*; Laurence Douny, *Living in a Landscape of Scarcity: Materiality and Cosmology in West Africa* (London: Left Coast Press, 2014).
101. Rowlands and Warnier, "The Magical Production of Iron." Philippe Descola also developed this fundamental idea of resonances of logic through his discussion of the schemas of practices, in *Beyond Nature and Culture*, 91–111.
102. Thomas Hughes, *Networks of Power: Electrification in Western Society, 1880–1930* (Baltimore: The John Hopkins University Press, 1983).
103. Thomas Hughes, "The Seamless Web: Technology, Science, Etcetera, Etcetera," *Social Studies of Science* 16, no. 2 (1986), 281–92.
104. Winner, *Autonomous*, 223 ff.
105. Ibid, 241.
106. Ibid, 234.
107. Brian Larkin, "The Politics and Poetics of Infrastructure," *Annual Review of Anthropology* 42 (2013), 329.
108. These three analytical categories are exactly what I indicated they were: provisional. While they might be operational, they might not be as "effective" with every case study.
109. For example Joshua A. Bell, Briel Kobak, Joel Kuipers, and Amanda Kemble, "Unseen Connections: The Materiality of Cell Phones," *Anthropological Quarterly* 91, no. 2 (2018), 465–84.
110. For example Lewis Mumford, *The Myth of the Machine*, 2 vols. (San Diego: Harcourt, Brace, Jovanovich, 1967 and 1970).
111. Kimberley Chong, *Best Practice: Management Consulting and the Ethics of Financialization in China* (Durham: Duke University Press, 2018).

112. See Ludovic Coupaye, "At the Power Plant's Switchboard: Controlling (Fertile) Energy amongst the Abulës-Speakers of Papua New Guinea," in Thomas Galoppin and Cécile Guillaume-Pey, eds., *Ce que peuvent les pierres: Vie et puissance des Matières lithiques entre rites et savoirs* (Liège: Presses universitaires de Liège, 2021), 87–107.
113. Hughes, "The Seamless Web"; Callon, "The Role of Hybrid Communities"; Bruno Latour, *Reassembling the Social: An Introduction to Actor-Network-Theory* (Oxford: Oxford University Press, 2005).
114. See Akrich, "The De-Scription of Technical Objects."
115. For example Bruno Latour, Philippe Mauguin, and Genevieve Teil, "A Note on Socio-technical Graphs," *Social Studies of Science* 22 (1992), 33–58, 91–94.
116. See critiques and discussions in Marilyn Strathern, "Cutting the Network," *The Journal of the Royal Anthropological Institute* 2, no. 3 (1996), 517–35, and in Anna Tsing, "Worlding the Matsutake Diaspora: Or, Can Actor-Network Theory Experiment With Holism?" in Ton Otto and Nils Bubandt, eds., *Experiments in Holism: Theory and Practice in Contemporary Anthropology* (Oxford: Wiley-Blackwell, 2010), 47–66.
117. Winner, *Autonomous Technology*, 241.
118. Ibid, 234.
119. Ibid, 220ff.
120. Chong, *Best Practice*, chapter 3, especially 108–09.
121. Akrich, "The De-Scription of Technical Objects"; Bruno Latour, "Technology is Society Made Durable," in John Law, ed., *A Sociology of Monsters? Essays on Power, Technology and Domination* (London: Routledge, 1991), 103–31.
122. Thinking with nonlinear theory at this level allows the investigation of phenomena of sensitivity to initial conditions, unpredictability and irreversibility, and their role in wider social and environmental change; see Mark S. Mosko and Fred H. Damon, eds., *On the Order of Chaos: Social Anthropology and the Science of Chaos* (New York and Oxford: Berghahn Books, 2005).
123. Ellul, *The Technological Society*.
124. Feenberg, *Transforming Technology*, 76–77. This concept of "code" strongly echoes with works of thinkers such as Gregory Bateson, "Style, Grace, and Information in Primitive Art," in Anthony Forge, ed., *Primitive Art and Society* (London: Ely House, Oxford University Press, 1973), 235–55, or, indeed, Marshall McLuhan, *Understanding Media: The Extension of Man* (Cambridge: The MIT Press, 1995[1964]), in showing how the materialization of values into functioning objects and systems can indeed become more important than the function or purpose.
125. Bryan Pfaffenberger, "Technological Drama," *Science, Technology and Human Values* 17, no. 3 (1992), 282–312.

126. Bryan Pfaffenberger, "The Social Meaning of the Personal Computer: Or, Why the Personal Computer Revolution Was No Revolution," *Anthropological Quarterly* 6, no. 1 (1992), 39–47.
127. Andrew Feenberg, *Questioning Technology* (London & New York: Routledge, 1999), 131.
128. For example Larkin, "The Politics and Poetics of Infrastructure"; Penny Harvey and Hannah Knox, "The Enchantments of Infrastructure," *Mobilities* 7, no. 4 (2015), 521–36.
129. See Winner, *Autonomous Technology*; Feenberg, *Critical Theory of Technology*; Sarah Grimes and Andrew Feenberg, "Critical Theory of Technology," in Sara Price, Carey Jewitt, and Barry Brown, eds., *The SAGE Handbook of Digital Technology Research* (Los Angeles: SAGE, 2013), 121–29.
130. Langdon Winner, "Do Artifacts Have Politics?" in *The Whale and the Reactor* (Chicago: University of Chicago Press, 1986), 19–39; Pfaffenberger, "Technological Dramas."
131. "Technology Quarterly," *The Economist*, September 14, 2019.