Materiality, Sociomateriality, and Socio-Technical Systems:

What Do These Terms Mean? How Are They Different? Do We Need Them?

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Many articles about information technology use in organizations published during the past five or so years employ one of the following three terms: "Materiality," "Sociomateriality," or "Socio-Technical Systems." Some critics claim that the use of these terms represents the diffusion of "academic jargon monoxide" and scholars should stick to simply talking about "technology" – a word that is understandable by "normal human beings" (Sutton, 2010).[1] Others argue that a basic term like "technology" is too simplistic because its use creates the illusion that there is some object, device, or artifact out there doing things and it ignores the empirical reality that those objects, devices, and artifacts only come to have meaning and effects when they are enrolled in social practice (Suchman, 2007). Others suggest that using a simple term like "technology" focuses too much attention on particular pieces of hardware or software and, consequently, directs researchers' attention toward the period of adoption as a "special case" instead of recognizing that technologies permeate all aspects of organizational life (Orlikowski, 2007: 1436). And still others argue that studies of technology and organizing have veered too far in the direction of rampant social constructivism and that a way back to a middle ground between the poles of voluntarism and technological determinism is to recognize that technologies have certain material and institutional orders that transcend the particularities of the contexts in which they are used (Kallinikos, 2004). Despite the differences in their arguments, it seems that everyone has a point.

The motivation for this chapter is quite personal. Over the past five years I have attended at least a dozen conferences, workshops, and colloquia that used the terms "materiality," "sociomateriality" or "socio-technical systems" in their titles. Each time some participant at one

[1] This blog post, by Robert Sutton, is characteristic of his iconoclast tone. Sutton is certainly an advocate of and important contributor to studies of technology use in organization. His point about the development of new terms is good and was one major impetus in the writing of this chapter.

of these events (often it was me!) asked, "What do we mean when we talk about materiality?" or "How is sociomateriality different from socio-technical systems?" the questioner was critiqued for aiming to exclude some, privilege others, or perhaps worst of all, close off productive debate. These concerns are certainly warranted. But without some definitional clarity, the terms remain jargon – criticized even by scholars who sympathize with this line of inquiry – instead of serving as useful tools for understanding and explaining the symbiotic processes of technological and organizational change. Certainly to outsiders, these terms all look quite similar to one another and appear little more than fancy synonyms for the quotidian word, "technology." This chapter makes a modest attempt at definition by comparison. That is, I explore the history that led to the use of each of these terms in organization studies and I make some tentative arguments about how these terms are similar and different to one another and, ultimately, how we might think about their relationship to one another. I focus specifically on non-physical information technology artifacts in this chapter, but I suspect that many of the arguments will also hold for other physical technological artifacts like hammers and bicycles as well as other non-physical technologies not (information technology artifacts) like language. By no means is this chapter aimed at stamping out debate about what these terms mean. Instead, the goal of this chapter is to begin a movement in the direction of clarity so that scholars can use these terms productively to theorize the complexity of collective endeavors, generally, and organizational dynamics specifically.

Materiality

Since Joan Woodward's (1958) provocative claims about the deterministic relationship between manufacturing processes and organizational structure she uncovered in the 1950s and Charles Perrow's (1967) hospital studies, conducted in the 1960s, out of which he concluded that

technologies were independent variables affecting the dependent variable of work organization, researchers have sought to understand what role technologies play in the process of organizing. For many years, organizational scholars who were interested in technological change operationalized "technology" broadly as work processes conducted in conjunction with machines and conducted macro-level research (with organization's as the unit of analysis) into the effects that changing core technology had on an organizations' formal structure (e.g. degree of centralization, span of control, layers of hierarchy, etc.) (for discussion, see Robey, Raymond, and Anderson, this volume). As this generation of research began to offer a diminishing number of interesting insights and die off, a new spate of micro-level research (with the individual or the group as the unit of analysis) began to explore how people in organizations used technologies to accomplish their work. Whereas the first generation of studies looked to make law-like, often deterministic, claims about how particular technological arrangements would or should change formal organizational structures, the studies in this second generation were more comfortable showing how one technology could engender various unexpected shifts in informal organizing processes. In fact, over time, demonstrating emergence and unpredictability seemed to become this second generation's explicit goal.[2]

The zenith of this second generation came when researchers began to argue that technologies did not always bring predictable effects to the informal organization of work, or that one organizational structure best suited a particular type of technology. Instead, it was only once technological artifacts were enmeshed in a web of organizational, occupational and institutional forces that people interpreted them and variously employed them in the practice of their work. With such recognition, terms like "technology-in-use" (Orlikowski, Yates, Okamura, & Fujimoto, 1995) and "socio-technological ensembles" (Bijker, 1995) began to replace the

[2] For a detailed discussion of this point see, Leonardi and Barley (2008).

word “technology” in many discussions about the genesis of organizational change. Taken at its extreme, this constructivist position suggested that technologies themselves mattered very little in the way people worked, but people’s interpretations of the technology mattered a lot. The “if a tree falls in the forest and no one is around to hear it, does it still make a sound?” kind of argument that such writing provoked was very interesting on a theoretical front. But from a practical standpoint it proved problematic because the vast majority of studies of technology use in organizations never even described the technology that was under study (Markus & Silver, 2008; Orlikowski & Iacono, 2001).

To combat this problem, some scholars began advocating that researchers should renew their focus on what features a new technology actually had and what those features did or did not allow people who use them to accomplish (Griffith, 1999; Monteiro & Hanseth, 1995; Poole & DeSanctis, 1990). Enter the term *Materiality*.

Orlikowski, (2000: 406), for example, wrote about groupware software that the technology embodies “particular symbol and material properties.” She provided several examples of the “material properties” of groupware, which included features contained in the menus that were embedded in the program. Volkoff et al. (2007: 843) described the enterprise resource planning software that they studied as having “material aspects” such as algorithms that allowed financial transactions and features that permitted only certain people to authorize accounts and payments. Leonardi (2007: 816) documented use of a help-desk queuing software by IT technicians and argued that its “material features” made possible activities such as assigning jobs or documenting what one did to solve a particular used problem.

The use of the adjective “material” by these authors, and many others like them, seemed carefully chosen to remind readers that there was some aspect of the technology they described

that was intrinsic to the technology, not part of the social context in which the technology was used. In other words, when everyone packs up their bags and goes home at the end of the day, those inherent properties of the technology do not go away. Perhaps the slippery language around what exact properties the technologies had or what they were made of came from the fact the these researchers casted their gaze upon software based, digital technologies. If one were to consider a physical technology like a hammer, it would be relatively easy to isolate and describe a set of properties intrinsic to it. For example, one could point to the steel out of which the head was fashioned, the fiberglass that was shaped into the handle, and the rubber that was placed on top of the fiberglass. We could easily say that the materials from which the hammer was made were steel, fiberglass, and rubber. But when one moves from the realm of the physical to the digital, it is much more difficult to isolate the materials out of which a technology is built. Try it! What are the materials out of which a Microsoft Word Document is made? What are the materials that constitute simulation software? What are the materials out of which social media tools are fashioned? Most information technology artifacts like computer programs and various software applications (the kinds of technologies with which I am concerned in this chapter) have no physicality. Such information technological artifacts may be accessible through certain technological artifacts that have physical properties – that are made of identifiable materials (e.g. a computer program is accessible to users through a monitor and keyboard) but the physical properties of the artifacts that serve as "bearers" (Faulkner & Runde, 2011) for the non-physical artifact do not change the composition of that non-physical artifact in any real way.

But, as Kallinikos (this volume) reminds us, matter is not the only thing that identifies a technology. Form is also important. If one were to take the same mass of steel out of which a hammer head is normally made and form it into a long, thin cylindrical shape and reaffix it to the

fiberglass handle, the hammer would no longer be useful for driving nails, knocking holes in drywall, or dislodging jammed boards. But it might be useful for poking holes in leather. Thus, matter (or whatever constituent materials out of which a technology is fashioned) and form together constitute those properties of a technological artifact that do not change, by themselves, across differences in time and context. It is this combination of material and form that I call "materiality." To be clear, "materiality" does not refer solely to the materials out of which a technology is created and it is not a synonym with "physicality." Instead, when we say that we are focusing on a technology's materiality, we are referring to the ways that its physical and/or digital materials are arranged into particular forms that endure across differences in place and time. Such a definition suggests that the usefulness of the term "materiality" is that it identifies those constituent features of a technology that are (in theory) available to all users in the same way.

Although the observations above may seem trite, they are important because if a technology did not have a fixed materiality, extreme constructivist theorizing would not be possible. The prototypical constructivist study shows that people in two different organizations use the same new technology differently and, consequently, change (or do not change) their informal organizing in distinct ways (e.g. Barley, 1986; Robey & Sahay, 1996; Zack & McKenney, 1995). The only way that scholars have been able to demonstrate these findings empirically is because the materiality of that technology was the same in both organizations under study.

Given the arguments made above, it makes most sense to use the term "materiality" to refer to those properties of the artifact that do not change from one moment to the next or across differences in location (recognizing that the uses to which they are put can change greatly, as

will be discussed in the following section). Faulkner and Runde (2011: 3) refer to this aspect of materiality as "continuance:"

> In saying that objects endure, or exist through time, we mean that they are things that are fully present at each and every point in time at which they exist. Objects can therefore be said to be "continuants", in contrast to events or "occurrents" that take place and whose different parts occur at different points in time. The length of time an object typically endures, what we will call its lifespan, depends on the nature of the object under consideration. Thus while an organism such as a housefly might have a lifespan of no more than a few weeks, an artefact such as a hammer or skyscraper might endure for decades or even centuries.

The use of the term in this way seems almost contrary to Orlikowski's (2000) well-cited claim that…

> Technologies are… never fully stabilized or "complete," even though we may choose to treat them as fixed, black boxes for a period of time. By temporarily bracketing the dynamic nature of technology, we assign a "stabilized-for-now" status … to our technological artifacts. This is an analytic and practical convenience only, because technologies continue to evolve, are tinkered with (e.g., by users, designers, regulators, and hackers), modified, improved, damaged, rebuilt, etc. (pp. 411-412)

Orlikowski is undoubtedly correct that technologies, and their uses, continue to evolve over time. To say that materiality refers to the properties of technologies that do not change is not to disagree with her point; it simply changes the time scale. A popular software program like Microsoft Excel evolves over time. Its materiality is far different today (Version Excel 2010)

than it was when it was first released for the PC as Version 2.0 for in 1987[3], or when its predecessor, Multiplan, debuted in 1982. Excel's materiality changed when Version 3.0 was released in 1993 and it changed again with Version 2000.[4] Over time, Excel's materiality has evolved. But to discount the five years or so between version changes that its materiality remained quite constant is to adopt a time horizon that exceeds practical utility. Saying that a technology has a materiality is to say that its materiality has indeed stabilized… for now. And it is this stabilization that allows two people working on the same document, drawing, or database to share work with each other.

One argument made by several authors in this book (e.g. Pentland and Singh, this volume; Cooren, Fairhurst, and Huët, this volume) is that even if a technological object is constructed of particular materials, not all of those materials "matter" for all individuals in particular contexts. They argue that certain aspects of technological artifacts are materialized when they have consequence in a particular setting. Extended to the example of the hammer, we might say that the rubber coating on the handle is a material that does not much matter in one's ability to drive a nail into a board in most circumstances. However, if one's hands are wet, the particular material may suddenly matter in that it has consequence for one's efficacy at driving the nail. In the case of advanced information technologies the argument is less trivial. Consider the following example provided by Leonardi (2010) of the use of the software application Adobe Photoshop:

> …one can pick from any number of menus and discover a variety of features (e.g. blur, sharpen, pixelate) that can be used at a given time. Some are extremely important to a certain set of users, while others are not. You might imagine that the "blur" feature is

[3] Excel was released two years earlier, in 1985, for the Macintosh.
[4] There were other small changes in intermediate version. I highlight only the major version changes as promoted by Microsoft.

> important for editors of high school yearbooks attempting to hide blemishes, while the "sharpen" feature is important for law enforcement professionals who are attempting to read the license plate numbers on a passing car. Conversely, if an amateur user is trying to touch up a nighttime shot of the Burj Al Arab hotel from his vacation, it is possible that none of these features make a significant difference in his ability to accomplish his goal. Just like a material fact in a case, a piece of software can have certain material features – features that are "more significant" to the user than others. Of course, significance changes across populations of users, and may even change for one user over time. So, researchers should ask, when examining practices of use, which features are "material" (significant) for this user and how those features become significant for the type of work she does, for whom she interacts with, or for maintaining control.

Although it seems inappropriate, at least when speaking of physical and digital artifacts, to define materiality solely as that which matters to users, the point is well taken. Thus, when referring to physical or digital artifacts, specifically, a general definition of materiality would be, "The arrangement of an artifact's physical and/or digital materials into particular forms that endure across differences in place and time and are important to users."

It is important to focus research attention on materiality if we aim to understand social interaction. Take social media tools – like social networking sites, blogs, wikis, micro-blogging platforms – as an example. The materiality of most social media tools enables editability. In other words, a user can edit and re-edit comments and additions to a site before actually clicking "post" or "share." As researchers have shown editability derives from asynchronicity and spatial distancing (Dennis, Fuller, & Valacich, 2008; Ramirez, Walther, Burgoon, & Sunnafrank, 2002). The materiality of social media tools also enables persistence of text, images, and sound. That is

to say that one's communication is stored in the system where it remains over time and can be accessed later (Binder, Howes, & Sutcliffe, 2009; Erickson & Kellogg, 2000). But editability and persistence are not germane to social media. Email offers a high degree of ediability and persistence as does podcasting. Social media differ from technologies like email and persistence because their materiality enables people's posts to be immeditably broadcast to a large unknown audience (see for example the Scott and Orlikowski chapter in this volume). In this way, other people have visibility into an individual's actions. This difference in materiality means that people who use social media will have to contend, in some way, with the fact that their posts, comments, and queries, are public. Whether or not they realize that their actions are visibile to others, this materiality may have direct consquences for organizing. To undesrtand what these consequences are and the conditions under which they are likely, researchers must first recognize that the technology has a matetiality that makes certain actions possible and others impossible, or at least more difficult to achieve (see Faraj and Azad, this volume).

In short, the term materiality seems useful if it can direct attention to the properties intrinsic to technological artifacts and remind researchers that those properties are fixed, at least for some short period of time, and encourage them to explore not only how they become fixed (as researchers in science and technology studies have done so well), but also how their fixedness affects what people deem to be important to their work. Why not simply use the term "technology" instead of materiality? To answer this question, we must turn to a discussion of another term: "sociomateriality."

Sociomateriality

The term "sociomateriality' is, obviously, the fusion of two words: social and materiality. Why should we use this new term? And, why would a term like this exist at all? The simplest

answer would be that this term reminds its readers that (1) all materiality (as defined in the prior section) is social in that is was created through social processes and it is interpreted and used in social contexts and (2) that all social action is possible because of some materiality.

The first point has a long tradition in the sociology of technology and in organization studies. Researchers in the sociology of technology, including the areas of social construction of technology (Pinch & Bijker, 1984), actor-network theory (Latour, 1991; Law, 1992) and large scale systems theory (Hughes, 1987, 1994) have shown, convincingly, that the development of any new technology is the product of contestation and negotiation amongst groups (Bijker, 1995), redefinition of problems and the alignment of actors' interests by powerful actors (Callon, 1991), and the results of definitions of what it means to say that a particular technological artifact "works" (Pinch, 1996). Actor-Network theorists have taken these observations the farthest in their suggestion that the distinction between that which is social and that which is material is a distinction that scholars have invented to demarcate disciplines of study; it is not a distinction that exists in the empirical world (Latour, 2005). Authors such as Mohl (2002) and Barad (2003) who are sympathetic to these ideas have argued that the boundaries between the social and the material are not pre-determined, but rather are enacted in the practice of one's work.

Organization theorists have also argued for an intertwining of the social with technology's materiality, but they have primarily focused on how a new artifact merges with an organization's social system during adoption and use. Researchers in communication studies such as Fulk and her colleagues (Fulk, 1993; Fulk, Schmitz, & Steinfield, 1990) and Aydin and Rice (Aydin & Rice, 1992; Rice & Aydin, 1991) pioneered a line of study suggesting that people's attitudes and beliefs about what new technologies could do and how they would be useful in one's work were influenced by communication processes and social dynamics. Authors

such as Poole and DeSanctis (Poole & DeSanctis, 1992; Poole & DeSanctis, 2004) and Orlikowski (Orlikowski, 1992; Orlikowski, 2000) who adopted a structurational approach toward technology use suggested that people's decisions about how to use the technology were affected by institutional and organizational norms and, once those technologies were used they began to shape the way that future effects of the technology could unfold. Other studies by Barley (1990), Edmondson et al. (2001) and Boudreau and Robey (2005) demonstrated that changes in the use of a technology over time – changes that were negotiated socially – could shift the dynamics of teams, organizations, and occupations. In short, it would be incorrect to say that a technology "caused" a particular change when ample evidence shows that people decide how they will let the technology influence their work.

Scholars straddling the line between these two areas of study – technology development and use – have made the claim that if organizations are as much material as they are social and if technologies are as much social as they are material, then perhaps it makes sense to break down the distinction between the social and the material altogether. For example, in a study of the organization of civil engineering work Suchman (2000, p. 316) argued:

> Like an organization, a bridge can be viewed as an arrangement of more and less effectively stabilized material and social relations. Most obviously, of course, the stability of a bridge is a matter of its materiality, based in principles and practices of structural engineering. This material stability is inseparable, however, from the networks of social practice—of design, construction, maintenance and use— that must be put into place and maintained in order to make a bridge-building project possible, and to sustain the resulting artifact over time.

Orlikowski (2007: 1437) has made a similar argument

> Materiality is integral to organizing… the social and the material are *constitutively entangled* in everyday life. A position of constitutive entanglement does not privilege either humans or technology (in one-way interactions), nor does it link them through a form of mutual reciprocation (in two-way interactions). Instead, the social and the material are considered to be inextricably related — there is no social that is not also material, and no material that is not also social.

Thus, in support of the first point above, the term "sociomaterial" is a bold reminder that when we talk either about technologies or organizations, we do well to remember that social practices shape the materiality of a technology and its effects.

Interest in establishing the second point mentioned above – that all social action is possible because of some materiality – is, perhaps more political or agenda-setting in nature. Over the last two decades, a number of reviews of papers in the literature on organizational behavior, organizational communication, and organizational theory have concluded that organizational researchers do not spend much time and effort thinking about the role that technologies play in their areas of inquiry (e.g. decision making, status, strategy making, etc.) (Liker, Haddad, & Karlin, 1999; Markus & Robey, 1988; Orlikowski & Barley, 2001; Rice & Gattiker, 2001). Orlikowski and Scott's (2008) recent review is perhaps the most striking. The authors claim that less than 5% of all articles published in top American management and organization studies journals considered the role and influence of technology directly. They argue that part of the reason that technology may be "missing in action " (p. 434) is that most organizational researchers do not consider themselves scholars of technology. Their natural predilection to overlook the role technology plays in the particular organizational processes that capture their interest is further exacerbated by the fact that new technologies change often and

the study of them requires that scholars continue to learn about these changes. Orlikowski (2007) has also made the point elsewhere that most existing studies of technology in organizations focus on new technology "implementation." The continued appearance of implementation studies marks technology implementation off as a specific and unique area and people think that if they are going to study technology they need to study implementation.

The term "sociomateriality" has the potential to address these concerns by reminding organization scholars that materiality is present in each and every phenomenon that they consider "social." To be sure, strategies are formed based on the ways people use PowerPoint presentations to share information with one another (Kaplan, 2011); routines are both made possible and performed through the use of checklists and forms (D'Adderio, 2011); and quadrants and algorithms shape perceptions of risk and spur the formulation of institutional categories (see Pollock, this volume). In short, one need not study new technology implementation to respect the ways that materiality is a constitutive part of all practice that organizational scholars typically call "social."

Scholars who adopt the term "sociomateriality" would likely argue that it is unique from the term "materiality" in that it shifts the unit of analysis from materials and forms to the development or use of materials and forms. In other words, talking about sociomateriality is to recognize and always keep present to mind that materiality acts as a constitutive element of the social world, and vice versa. Thus, whereas materiality might be a property of a technology, sociomateriality represents that enactment of a particular set of activities that meld materiality with institutions, norms, discourses, and all other phenomena we typically define as "social."

Although one could say that a technology has a certain materiality, it would make little sense to talk about a technology's sociomateriality. For this reason, Orlikowski (2007) and others

have suggested that what is sociomaterial is not the technology, but the "practice" in which the technology is embedded. Social theorists such as Giddens, Lave, and Bourdieu offer nuanced definitions of what counts as *practice*. For each of these authors, practice is not equivalent to individual activity (e.g. doing something); rather it is a socially shaped arena in which activities are collectively negotiated. In Giddens' (1984) terms, the arena of practice is the medium and outcome of institutional structures that guide individuals' processes of interpretation and evaluation, and hence, their activities. Thus, practice is shared in common by people and its production and perpetuation is a collective accomplishment. For Lave (1988), the arena of practice is a negotiated order in which people's patterns of action are contingent upon specific structural conditions of their own making. Thus, practice is a social space that is shared in common by members of a community. Bourdieu (1977) conceptualizes practice as an arena in which the dialectic of subjective experience and objectified reality is played out. Building on the work of Bourdieu and Lave, Cook and Brown (1999: 388) go so far as to define the term "practice" as "the coordinated activities of individuals and groups in doing their 'real work' as it is informed by a particular organizational or group context."

In this formulation, practice is the space in which the social and the material become constitutively entangled (Orlikowski, 2010). Although most studies up to this point have sufficed to simply show that social and the material are thoroughly intertwined, scholars are just beginning to consider how such intertwinement occurs. Leonardi (2011), for example, has offered one theory about how the social and the material become entangled. This theory suggests that coordinated human agencies (social agency) and the things that the materiality of a technology allow people to do (material agency) become interlocked in sequences that produce

the empirical phenomena we call "technologies," on the one hand, and "organizations," on the other.

Human agency is typically defined as the ability to form and realize one's goals (Emirbayer & Mische, 1998; Giddens, 1984). A human agency perspective suggests that people's work is not determined by the technologies they employ. Studies show that even in the face of the most apparently constraining technologies human agents can exercise their discretion to shape the effects that those technologies have on their work (Boudreau & Robey, 2005). People often enact their human agency in response to technology's material agency.

Material agency is defined as the capacity for nonhuman entities to act absent sustained human intervention. Pickering (1995: 6), for example, observes that the weather "does things" that absent human intervention – it rains, winds blow, and heat and cold fluctuate: "Much of everyday life, I would say, has the character of coping with material agency, agency that comes at us from outside the human realm and that cannot be reduced to anything within that realm." Kaptelinin and Nardi (2006) extend Pickering's discussion of material agency to technological artifacts specifically, arguing that artifacts such as information technologies represent a particular kind of cultural object that produces effects and can realize the intentions of humans (e.g. the people who designed, built, or implemented them), but that they cannot act according to their own biological or cultural needs.

As nonhuman entities, artifacts like information technologies exercise agency through their performativity; in other words, through the things they do that users cannot completely or directly control (see Robey, Raymond and Anderson, this volume). For example, a compiler translates text from a source computer language into a target language without input from its user and a finite element solver calculates nodal displacements in a mathematical model and renders

the results of this analysis into a three-dimensional animation without human intervention. Although each of these actions is instigated by a human (presumably to address a particular, local need), the technology itself acts (exercises material agency) as humans with goals engage with its materiality.

Coordinated human (social) and material agencies both represent capacities for action, but they differ with respect to intentionality. Pickering (2001) offers a concise and useful empirical definition of human and material agencies that illustrates this difference. For Pickering, social agency is a group's coordinated exercise of forming and realizing its goals. Thus, the practice of forming goals and attempting to realize them is a concrete operationalization of social agency. Material agency, by contrast, is devoid of intention and materiality does not act to realize its own goals because it has none of its own making. In other words, "machine artifacts have no inherent intentionality, independent of their being harnessed to or offering possibilities to humans" (Taylor, Groleau, Heaton, & Van Every, 2001, p. 137). Thus, material agency is operationalized as the actions that a technology takes, which humans do not immediately or directly control. Given this important difference with respect to intentionality, even though social and material agencies might be equally important in shaping one's practice, but they do so in qualitatively different ways.

Leonardi (2011) uses the metaphor of imbrication to suggest how social and material agencies become entangled. The word "imbrication" may appear, at first glance to be more jargon lining the already detritus-filled road to scholarly enlightenment, but its origins are both humble and practical. The verb "imbricate" is derived from names of roof tiles used in ancient Roman and Greek architecture. The tegula and imbrex were interlocking tiles used to waterproof a roof. The tegula was a plain flat tile laid on the roof and the imbrex was a semi-cylindrical tile

laid over the joints between the tegulae. The interlocking pattern of tegulae and imbrices divided the roof into an equal number of channels. Rainwater flowed off the row of ridges made by the imbrices and down over the surfaces of the tegulae, dropping into a gutter. The imagery of tiling suggests that different types of tiles are arranged in an interlocking sequence that produces a visible pattern. A roof could not be composed solely of tegulae nor imbrices - the differences between the tiles in terms of shape, weight, and position, prove essential for providing the conditions for interdependence that form a solid, structure. Social and material agencies, though both capabilities for action, differ, phenomenologically with respect to intention. Thus, like the tegula and the imbrex, they have distinct contours and that through their imbrication they come to form an integrated organizational structure.

This perspective takes a wholly different approach than that offered by authors such as Barad (2003: 818) who claims that "Agencies are not attributes [of either humans or technologies] but ongoing reconfigurations of the world." Instead, it argues that the materiality of a technological artifact affords certain uses and actions. Although materiality, itself, transcends variations in space and time, those uses and actions can be different depending upon the context in which the materiality is used. For example, Microsoft Excel has many features that do not change across contexts (materiality). But those features do not automatically calculate modal values in a numerical list (material agency) until some user (with social agency) tells that materiality to do so. Even a simple physical technology like a hammer whose materiality (steel formed into a flat head and hook, fiberglass formed into a semi-cylinder, and rubber formed into a thin sheet) does not change can have many functions in that the same materiality can support driving nails into wood or holding papers down on a desk so they don't fly away. Whereas materiality refers to properties of the object, material agency refers to the way the object acts

when humans provoke it. This distinction between materiality and material agency is akin to the distinction between the arrangement of physical or digital materials into particular forms – what I have called "materiality" – and what Kallinikos (this volume) describes as "function" (what I suggest could alternatively be called "material agency"). What the technology *is* does not change across space and time, but what it *does* can and often changes. Function – or material agency - is a construction that depends, in part, on materiality but also depends on one's perceptions of whether materiality affords her the ability to achieve her goals or places a constraint upon her.

Materiality exists independent of people, but affordances and constraints do not. Because people come to materiality with diverse goals they perceive a technology as affording distinct possibilities for action. The perceptions of what functions an artifact affords (or constrains) can change across different contexts even though the artifact's materiality does not. Similarly, people may perceive that a technology offers no affordances for action, perceiving instead that it constraints their ability to carry out their goals. In this view, affordances and constraints are constructed in the space between social and material agencies. Peoples' goals are formulated, to an important degree, by their perceptions of what a technology can or cannot do, just as those perceptions are shaped by people's goals. Depending on whether they perceive that a technology affords or constrains their goals, people make choices about how they will imbricate social and material agencies. Thus, while it makes sense to talk about material and social agencies as attributes that are activated in response to one another in the space of practice, it seems empirically inaccurate to say that agencies themselves are "reconfigurations of the world." Social and material agencies are distinct from one another, and it is only once they become imbricated in particular ways that they can then reconfigure technology's materiality and organizations' communication patterns.

To weave the arguments in this section together, I suggest that (1) "sociomateriality" is not a property of a technology but the recognition that materiality takes on meaning and has effects as it becomes enmeshed in a variety phenomena (e.g. decision making, strategy formulation, categorization) that scholars typically define as "social;" (2) "Sociomaterial" is an adjective best used to modify the noun "practice" where (3) "practice" is understood as the space in which social and material agencies are imbricated with each other and, through their distinct forms of imbrication, produce those empirically observable entities we call "technologies" and "organizations."

Socio-Technical Systems

Many papers on technology use in organizations published over the last two decades use the term "socio-technical system" (STS) to describe their object of study. In general, when employed in studies of technology development, technologies are often referred to as "socio-technical systems" to bolster the recognition that the technology under design will be implemented and used in a social context that will, to some degree, shape whether and how it is adopted (Benders, Hoeken, Batenburg, & Schouteten, 2006; Bostrom & Heinan, 1977). In organization studies, authors will sometimes use the term "socio-technical system" to claim that the organization is made up of social systems (hierarchies, communication networks, etc.) and technical systems, which are usually defined as technological artifacts like imaging devices, numerically controlled machine tools, enterprise resources planning systems, and the like (Barley, 1990; Griffith & Dougherty, 2001; Thomas, 1994). Although these contemporary uses of the term "socio-technical systems" rightly point to the interdependencies between people and things, researchers at the Tavistock Institute of Human Relations who coined the term in the 1950s had a more nuanced definition in mind.

Shortly after World War II, Eric Trist and Ken Bamforth, two researchers at the Tavistock Institute conducted a series of field studies of the organization of work around a new process of coal-getting in British mines. In an influential paper (Trist & Bamforth, 1951), they charted the response of workers who were migrated from a traditional "hand-got" method of extracting coal from mines to a new semi-mechanized "longwall" method (sometimes called "conveyor method") for coal-getting. The major difference between these two methods concerned the way that tasks were apportioned among workers. In the traditional hand-got method, small groups of workers labored at individual coalfaces in a large mine. These groups were in charge of their own face. Each member performed a variety of different tasks using a number of different tools (pick axes, shovels, etc.) and they substituted for each other frequently. In short, they had a high degree of what Hackman et al. (1975) call "elements of job enrichment" – autonomy, task significance, and task identity.

As Trist and Bamforth observed, the hand-got method eventually gave way to the new longwall method: "With the advent of coal-cutter and mechanical conveyers, the degree of technological complexity of the coal-getting task was raised to a different level. Mechanization made possible the working of a single long face in place of a series of short faces" (p. 9). As the authors argued, new technologies made possible a new system of work in which the coalfaces could now reach lengths of up to 200 yards, meaning that the coal could be extracted much more efficiently than through the old hand-got method. To take advantage of this new semi-mechanized longwall method, management split work into three different shifts over 24 hours. During the first shift, miners used an electric coal cutter (instead of pick axes) to cut the coal from the seam. During the second shift, it was hand-loaded onto a conveyor (instead of removed manually from the mine in hand-filled tubs) that was placed parallel to the seam. And during the

third shift the equipment at the face and the hydraulic jacks that supported the roof and walls of the mine were moved forward. Trist and Bamforth argued that the departmentalization of work into these three shift represented not only the demise of an intact and interdependent work group, but also the loss of team identity, pride, status, and the fractionalization of work into tasks that were boring and repetitive.

Trist and Bamforth documented in great detail (pp. 16-17) the various tasks that each individual conducted with and around the new technological artifacts used in the mines. Interestingly, and contrary to much subsequent interpretation of their study, they operationalized the technical subsystem of the coal mine not simply as the technologies that the miners employed, but also those tasks that the miners conducted around the technological artifacts. What makes their analysis so interesting is that Trist and Bamforth identified various ways that miners could organize their tasks around the technologies' materiality. For example, they found that miners who experienced job dissatisfaction after the implementation of the longwall method due to the dissolution of their work teams often created new informal teams on their shifts such that they could change who conducted what tasks and when. These informal groups defied management logic about the kinds of tasks that workers needed to conduct to use the technologies, and the way those tasks were distributed among workers (see pp. 30-35). In other words, they found that there was an indeterminate relationship between tasks and technologies such that a technology's fixed materiality could support multiple task structures depending upon people's desires and goals.

But in addition to discussing this technical subsystem (technology's materiality and the tasks conducted in interact with it) Trist and Bamforth showed how the social subsystem in the mines was changed from its structure during the era of the hand-got method. They document in

great detail how communication patterns among miners changed, how status hierarchies became unsettled, and how power relations calcified. These elements comprising the "social subsystem" were entirely abstract in that they were institutionalized ideas about how people could and should relate to one another.

Researchers within the STS tradition drew on this initial, detailed study to suggest that an organization's performance was directly correlated with the degree to which the social and technical subsystems were "jointly optimized" (Emery, 1959) – the demands of one system fit the demands of the other. Rice's (1953, 1958, 1963) work in the weaving sheds in Ahmedabad, India demonstrated how the social and technical systems could be jointly optimized. He suggested that the social organization of work in the sheds was out of alignment with the demands of the looms used to produce textiles because the workers had organized the social subsystem so that they could work independently, while the technical subsystem demanded that people work interdependently in order to maximize use of the machines. In what has now become the most popular take away of the STS literature, Rice attempted to solve this problem by creating autonomous teams based on interdependent roles. Despite the rhetoric of jointly optimizing both the social and technical aspects of work, Rice's innovation adjusted the social organization of work to fit the demands of the loom technologies, thus privileging the demands of the technical subsystem over those of the social subsystem.

What is interesting about the early work on socio-technical systems theory is that conceptualization of a technical sub-system very much resembles what scholars today call "sociomaterial practice." STS scholars showed, empirically, that the materiality of a new technological artifact could be used in a variety of different ways to support various tasks and/or task apportionments. Although they did not have the language to describe it, their findings do

suggest that social and material agencies became imbricated in ways that produced various local orientations to work – whether in coalmines or weaving sheds. The technical subsystem, then, was not just comprised of technological artifacts but was instead a sociomaterial practice in which people's goals and the technology's materiality became, to use Orlikowski's (2007: 1437) term "constitutively entangled."

But unlike scholars who study materiality or sociomaterial practices, STS researchers raised the level of analysis to focus on the way that the technical subsystem became integrated into the macro organization of work. The concept of "joint optimization," while it may be criticized for being too normative, was intended to showcase how the abstract properties of a social subsystem could be strengthened or disturbed based on the particular ways in which social and material agencies were imbricated in the technical subsystem. In their formulation, STS researchers seemed to imagine that while the boundaries between materiality and task that characterized the technical subsystem were enacted in practice as opposed to alternating between causalities, the broader relationship between the technical and social subsystems was one of mutual shaping over time. Once a particular set of relations emerged from the technical subsystem, managers had to decide if and how they would reconfigure the abstract social subsystem. And, of course, reconfigurations of the social subsystem could then catalyze new cycles of sociomaterial imbrication in the technical subsystem (Cummings & Srivastva, 1977; Pasmore, 1988). Although they seemed to recognize this mutual influence was possible theoretically, in practice they normally advocated that the social subsystem was more influenced by the technical subsystem than the reverse and that it should be modified accordingly.

In summary, the term "socio-technical system" appears distinct from the term "materiality" in that materiality simply refers to the properties of a technology that are used in

various ways to support various tasks in the technical subsystem. The notion of a technical subsystem in socio-technical systems theory does not seem very different from the term "sociomaterial practice" because both refer to a space in which work is made possible through the imbrication of social and material agencies. But a "socio-technical system" appears to be distinct form a "sociomaterial practice" in that it refers to the entire organization of work (abstract institutional constructs and patterns of sociomaterial imbrication), as opposed to a group's localized experiences around a particular or various technologies. Thus, an organization might be conceptualized as a "socio-technical system" but not a "sociomaterial practice." Sociomaterial practices (or "technical subsystems," should we choose to use this more antiquated term) influence and are influenced by broader abstract social structures such as roles, statuses, hierarchies, power relations, communication networks, and other similar constructs. Kallinikos (2011) calls such abstract social structures "institutional forces." He suggests that institutions are temporally bound and, consequently, should not be simply seen as a way for researchers to vacillate between micro and macro levels of analysis, but that they are useful for moving from static to dynamic patterns of analysis such that each layer of sociomaterial imbrication becomes more substantial in that it shapes action in a path-dependent manner because of its history of accumulation.

Defining and Interrelating Terms

Early on, I argued that the goal of this chapter was to stimulate debate and discussion about popular terminology used in contemporary explanations of technology and organizing. In this spirit, I have reviewed the historical foundations of the terms "materiality," sociomateriality," and "socio-technical systems" and I have made some first, undoubtedly contentious, steps to define how these terms relate to one another. In doing so, I have placed certain boundaries

around these concepts for the sake of definitional clarity. Below, I summarize the preceding discussions into a rough and entirely tentative glossary of terms:

Materiality:	The arrangement of an artifact's physical and/or digital materials into particular forms that endure across differences in place and time and are important to users.
Sociomateriality:	Enactment of a particular set of activities that meld materiality with institutions, norms, discourses, and all other phenomena we typically define as "social."
Sociomaterial Practice:	The space in which multiple human (social) agencies and material agencies are imbricated. (Also called a "technical subsystem").
Social Agency:	Coordinated human intentionality formed in partial response to perceptions of a technology's material agency.
Material Agency:	Ways in which a technology's materiality acts. Material agency is activated as humans approach technology with particular intentions and decide which elements of its materiality to use at a given time.
Socio-Technical System:	Recognition of a recursive (not simultaneous) shaping of abstract social constructs and a technical infrastructure that includes technology's materiality and people's localized responses to it.

Figure 1 provides an illustration of how these various terms might relate to one another. The shaded boxes at the right side of the figure indicate that people have intentionality and

technological artifacts have materiality. As people approach technological artifacts they form particular goals (human agency) and they use certain of the artifact's materiality to accomplish them (material agency). These collective human (social) and material agencies become imbricated in the space of practice. Certain imbrications produce changes in the abstract "social" formulations (e.g. roles, status, etc.) that occupy so much of organization theorists' attention. Alterations in these abstract formulations can shape future patterns of imbrication, which, in turn, can bring changes to an artifact's materiality or a person(s)' intentionality. This mutual shaping of social and technical subsystems (indicated by shaded ovals) is what defines a socio-technical system. We might usefully be reminded that organizations are socio-technical systems.

INSERT FIGURE 1 HERE

To be sure, the road to nuanced and empirically grounded understanding of the relationship between technological and organizational change is littered with academic jargon. Some of that jargon - terms like "strategic choice," "joint optimization" or "equifinality" – is rarely used today while other jargon – terms like "structuration," "inscription," and "morphogenesis" - is still widely in use. In the past couple of years, students of technology and organizing have added three additional terms to the jargon-lined road: "Materiality," "Sociomateriality," and "Socio-Technical Systems." Sometimes, authors use these terms interchangeably. Sometimes they seem to use them quite distinctly. Sometimes these terms include hyphens. Sometimes they don't. To assure that these terms don't become "academic jargon monoxide" requires some definitional clarity. This chapter has taken an initial step in providing this clarity. All definitions include some ideas and exclude others. Also, all definitions reflect the author's view of the world. This chapter offers these tentative definitions without any aspiration that people will use them, but with only the hope that they will spur debate and seed

discussion about what they mean, how they relate to one another, and whether we need them at all.

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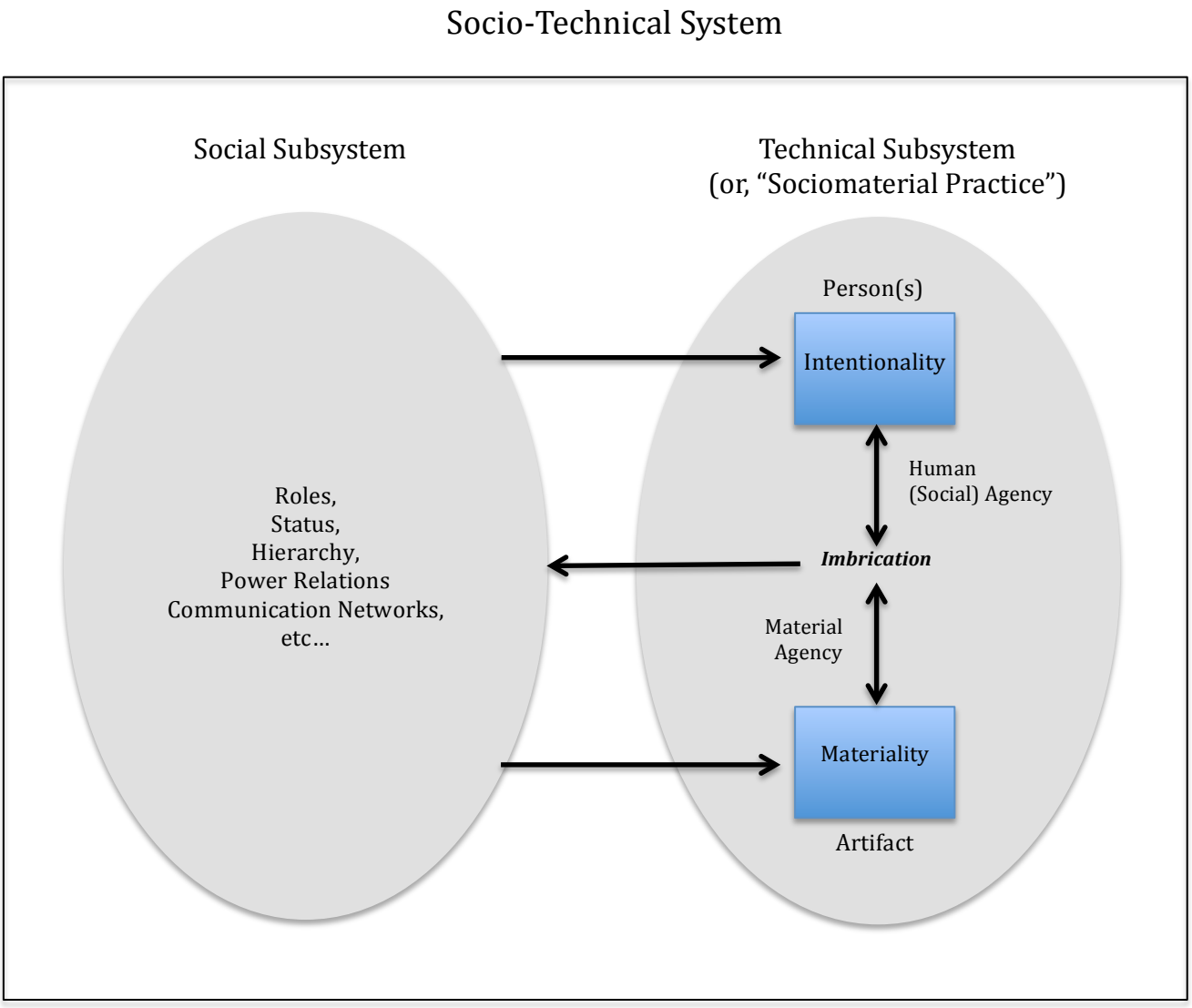
Figure 1


Socio-Technical System
Social Subsystem
Technical Subsystem
(or, "Sociomaterial Practice")
Person(s)
Intentionality
Human
(Social) Agency
Roles,
Status,
Hierarchy,
Power Relations
Communication Networks,
etc…
Imbrication
Material
Agency
Materiality
Artifact