18 INFORMATION SYSTEMS AND THE DOUBLE MANGLE: STEERING A COURSE BETWEEN THE SCYLLA OF EMBEDDED STRUCTURE AND THE CHARYBDIS OF STRONG SYMMETRY

Matthew Jones
Judge Institute of Management Studies
University of Cambridge
United Kingdom

Abstract

The recognition that information systems comprise both technical and social elements has not been matched by the emergence of a coherent theoretical understanding of the nature of, and relationship between, these elements. A number of approaches have been advocated that seek to transcend traditional assumptions of either technological or social determinism, but these may be seen to have their own limitations. Drawing on debates around structuration theory and actor network theory, an alternative perspective is proposed. This "double mangle" model seeks to provide a way between the idea of social structure being embedded in technology and strong claims of symmetry between material and human agency. The implications of this model are discussed.

Keywords: Structuration theory, actor network theory, material agency.

Introduction

If it is now generally accepted that information systems comprise both technical and social elements (e.g., Hirschheim 1985), the nature of, and relationship between, these elements remains a source of continuing controversy. Traditionally, this controversy had been viewed as a struggle between two positions emphasizing the primacy of the first (technological determinism) or the second (social determinism) of these elements. Arguments for a third, middle, way between these positions have been proposed by, among others, Markus and Robey (1988), George and King (1991), and Pinsonneault and Kraemer (1993). Described variously as "emergent," "reinforcement politics," or "structurational," these positions are seen as acknowledging the interplay of both social and technical factors in information systems design and use and thereby transcending the traditional polarities.

While these intermediate positions might appear to provide a more balanced treatment of technical and social aspects of information systems, a closer consideration of the underlying assumptions across the spectrum between technological and social determinism highlight a number of difficulties with a simple tripartite analysis. Thus at one end of the spectrum the supposed arch-exponents of technological determinism typically propose a more complex view of the influence of technology than is generally assumed, while at the other, social determinists do not deny that technology has any influence, but assign it a secondary role. Proponents of the intermediate position can also be seen to adopt inconsistent assumptions in their treatment of technical and social elements of information systems. For example, social-shaping of technology is seen to apply only during the design stage, at which point its properties become fixed, determining its subsequent use.

Recently, actor network theory (Callon 1986; Latour 1987) has begun to attract interest in the information systems field as a means of overcoming the perceived limitations of these intermediate perspectives (Monteiro and Hanseth 1995; Vidgen and McMaster 1995; Walsham 1997). With its insistence on the equality of treatment of the technical and the social, it is seen to provide a consistent basis for the analysis of the dual aspect of information systems. A more detailed consideration of the arguments of its proponents, however, indicates that, although it offers some important insights, it has a number of features that would seem likely to be problematic as a basis for information systems theory.

This paper reviews the various theoretical treatments of the technical and the social in information systems research to identify their strengths and weaknesses. Then, drawing on debates in sociology around structuration theory and in social studies of science and technology around actor network theory, a new perspective is proposed which combines insights from the two. This seeks to recognize both the importance of technical and social aspects in shaping the development and use of information systems, but also their distinctive character. The implications of this perspective are discussed.

The Nature of the Problem

Before commencing the review of alternative theoretical positions, however, it may be helpful to get a clearer understanding of the nature of the problem at issue. What does

it mean to talk of "treatments of the technical and the social" and why does it matter to the development of a theoretical basis for information systems?

Perhaps the easiest way to appreciate this is to consider the development and use of an information system in a particular organizational context, such as the introduction of a new Lotus Notes application into a number of different offices of a large professional services organization. This application was intended to facilitate information sharing by tracking the client leads generated by consultants engaged in a particular line of business. It was designed by a team made up of representatives from the various offices involved in this business. Each representative lobbied for the particular requirements of their office to be included in the design with the result that the database became complex and cumbersome to use.

After the initial launch, a number of offices with experience of Notes complained that the new application was unacceptably slow. Other offices, however, where this application was their first use of Notes were delighted with the new capabilities it offered them and perceived its performance as perfectly satisfactory. In one office, the introduction was used to justify the upgrading of all hardware with additional memory, and in some cases faster machines, to obtain satisfactory performance. In another, the speed problem was overcome by developing a cut-down, local version of the database, which was periodically updated with the whole organization-wide version.

While many of these issues might seem to be straightforward technical problems, and indeed appeared amenable to technical solutions, closer examination suggests that there are also significant social influences on the "speed" of the application. These relate not just to decisions about the consolidated design, but also to users' expectations of system performance. More broadly, questions might be asked about the consideration given to speed as a criterion in the design process.

How, then, do we explain the way in which information systems are designed, adopted, and used and their effects upon organizations? Are there inherent characteristics of technology, such as speed, which inevitably lead to certain outcomes? Or are these apparent characteristics simply the playing out of broader social forces, reflecting, for example, decisions made in particular configurations of organizational power relations? Could it be that these social relations somehow inscribed into a malleable technology such that they are released, or perhaps drawn upon, only when the information systems are used? Is this malleability entirely a matter of individual interpretation, or do the characteristics of the technology somehow create shared interpretations? What are the respective roles of the technical and the social in these processes? Are humans the only actors capable of influence, or should we not privilege the social, but admit the possibility of material agency?

Answers to such questions would seem central to any effective theory of information systems, as social and technical systems. Yet, as has been suggested, doubts may be raised about many commonly-held positions on these issues. In order to understand whether a consistent position can be found, the strengths and weaknesses of the alternative positions need to be examined.

Technological Determinism

Technological determinism is generally taken to mean that it is technology that shapes the forms of society and organizations, as in the famous quote by Marx, "the hand-mill gives you society with the feudal lord; the steam-mill gives you society with the

industrial capitalist" (Marx 1936). Its proponents are taken to be writers such as Heilbroner (1967), who claimed that machines make history, Ellul (1965), who talked of "autonomous technology," and Woodward (1958) , with her argument that the type of manufacturing technology determines the appropriate form of organization. In the information systems sphere, writers such as Leavitt and Whisler (1958) are taken to have proposed that information technology would lead to the inevitable decline of middle management (Markus and Robey 1988).

Closer examination of the arguments of the supposed proponents of technological determinism, however, often reveals a more nuanced stance. Thus Heilbroner's claim is qualified by the comment that machines clearly do not make all of history and by the suggestion that technology should be relegated from its "undeserved position of *primum mobile* in history to that of a mediating factor, both acted upon by and acting on society." Ellul adopts a very broad view of technology that extends beyond the artefact to include the domination of the life of society by technical goals of logic and efficiency. Bimber (1994) argues that such a "normative account" actually locates causal agency in history in human social practices and beliefs and is therefore not technologically determinist in the commonly understood meaning of the term. Grint and Woolgar (1997) suggest that Woodward (1964) in her later work adopted a more socio-technical position. Similarly, George and King note that Leavitt and Whisler's apparent determinism is moderated by acknowledgment of managerial agency and that their predictions are carefully qualified.

It would appear, therefore, that the strong case for technological determinism, which would identify technology as *the* dominant explanatory factor, is not supported, even by its supposed proponents. How, then, can the persistence of discussion of such a position in the information system literature be explained? Is it simply that this represents the lingering traces of an historical debate, as the dates of most of the allegedly technologically determinist articles suggest, which has now been transcended? While such an argument may be appealing, in suggesting that debate has progressed over time, it may also be seen to divert attention from possible technologically determinist assumptions within current positions. Thus, by setting up an historical straw figure, the "sophistication" of more recent approaches may be emphasized.

Social Determinism

Social determinism is generally taken to be characterized by positions such as that of Gallie (1978, p. 295) who argues that technology has "at most, very little importance" for the social integration of the work force and that it is the "wider cultural and social structural patterns of specific societies" that determine the way in which technology is used in organizations. This may be seen to be similar to the "strong" program in the sociology of scientific knowledge (Barnes 1974), which seeks to understand scientific knowledge as structured by the "interests" of particular social groups. Equivalently, the design, introduction, and use of information systems is to be understood in terms of the playing out of socio-political forces, rather than of any inherent character of technology.

While Barnes (1991) argues for an anti-realist conception of knowledge, for most analysts such a denial of a role for technology goes too far in the opposite direction from technological determinism. Moreover, even alleged social determinists, such as Gallie (1978, p. 300) do not propose that "technology has no effect whatsoever," but that it

does not necessarily lead to particular social effects. To some extent, therefore, the social determinist position may be seen as another straw person, in contrast to which other approaches may be presented as adopting a more balanced, reasonable line. Compared to technological determinism, however, social determinism adopts an explicitly humanist stance, arguing that scientific knowledge or technology is solely a product of human agency, which critics often appear reluctant to challenge. Debate is thus couched in terms of the constraints within which such agency may be exercised. This theme is carried forward in the intermediate approaches and gives rise to a number of problems as discussed below.

Intermediate Approaches

A number of different intermediate viewpoints may be identified which vary in their treatment of technology. One significant strand of this thinking is identified by Grint and Woolgar as socio-technical systems theory. Developed by the Tavistock Institute (Trist and Bamforth 1951) and promoted in the information systems field by writers such as Mumford (1995), this argues that the effective design of technologically-based work processes requires the simultaneous optimization of both technical and social elements. The two are, however, seen as quite distinct and independent of each other. The optimal socio-technical system, therefore, involves a matching of the inherent characteristics of the technology with the particular social and psychological properties of the organization.

For proponents of socio-technical, approaches their recognition of the importance of both technical and social elements is seen as enabling them to avoid the pitfalls of either technological or social determinism. Grint and Woolgar, however, argue that this approach retains a residual technological determinism in its assumption that technology exerts specific "demands" that need to be accommodated in the design process. By treating technology as a black box with objective characteristics, Grint and Woolgar argue, socio-technical systems theory underestimates the significance of the interpretative component of human-technology interaction.

Closer to the social determinist position are the social shaping approach (Mackenzie and Wajcman 1985) and the social construction of technology (SCOT) program (Pinch and Bijker 1987), which seek to open the black box of technology to sociological analysis. These argue, as the latter's name suggests, that technological artefacts are socially constructed and interpreted. In order to understand the effects of a technology, we therefore need to look at the social processes surrounding its design. Thus, as Winner (1986) puts it, "artefacts have politics." He illustrates this with the example of the Jones Beach bridge in New York, which was designed to be too low to permit the passage of buses, thus restricting access to the beach to those wealthy enough to have their own cars. Pinch and Bijker (1987, p. 40) also introduce the notion of the interpretative flexibility of technology, by which they refer not just to the "flexibility in how people think of or interpret artifacts, but also [the] flexibility in how artifacts are *designed*."

Within the information systems literature, Markus and Robey and Pinsonneault and Kraemer have identified the intermediate position with two main viewpoints: the web models of Kling (1987) and analyses based on Giddens structuration theory (Giddens

1984), especially those of Barley (1986) and Orlikowski (1992). Kling's web models see technology as an "ensemble of equipment, applications and techniques with identifiable information-processing capabilities," but also as "social objects which may be highly charged with meaning" (1987, p. 372). It is emphasized that computer-based systems are forms of social organization and that "human factors" cannot be separated from the delivery of information services. Rather, their development and use reflects human judgments made in complex social settings.

Barley's (1986) structurational analysis focused on the effects of the introduction of Computed Tomography scanners into the radiology departments of two hospitals, showing how the same equipment lead to quite different social organization in the two nominally similar environments. The CT technology was characterized as an "occasion for structuring" and it was proposed that structuration theory should be seen as a form of "soft determinism." This study was extended by Barley (1990) to examine how roles and social networks mediate technology's "structural effects," arguing that "technically-driven social change is likely to be rooted in a technology's material constraints," but that these must be transformed into social forces if technology is to have a significant effect on social organization.

Although defining technology as "material artefacts (various configurations of hardware and software)," Orlikowski (1992, p. 403) claims that this does not imply an "exclusive focus on technology as a physical object." Rather, it is argued, following Pinch and Bijker, that technology is "interpretively flexible," being "created and changed by human action, yet ... also used by humans to accomplish some action." That this is not always recognized in the information systems literature is attributed to the "time-space discontinuity" of design and use of information systems which "typically" occur in different organizations (those of the vendor and customer). It is also stated, however, that "interpretive flexibility is not infinite," being constrained by the material characteristics of the technology and the institutional contexts of its design and use, and the power, knowledge, and interests of the relevant actors. Thus "initial designers of a technology have tended to align with managerial objectives...with the result that many technologies reinforce the institutional status quo" (Orlikowski 1992, p. 409). This may be seen to be similar to the reinforcement politics position discussed by George and King, which suggests that technologies tend to be implemented by dominant groups in organizations in ways that sustain their position.

The influence of technology on social processes is seen by Orlikowski as occurring through its appropriation by humans. Technology is also viewed, however, as "the medium of human action," conditioning, rather than determining, the performance of social practices. The form and function of a specific technology is thus seen to "bear the imprint" of the social and historical conditions under which it is built and used and this may reinforce or transform the institutional properties of organizations. For example it is argued that "when users conform to the technology's embedded rules and resources they unwittingly sustain the institutional structures in which the technology is deployed" (Orlikowski 1992, pp. 411-412).

A common feature of the various intermediate viewpoints is their emphasis on the contingent nature of the social/technical relationship. Alternative configurations of social conditions may give rise to quite different uses of a technology. At the same time, technology is seen to be able to influence social conditions, albeit usually through the medium of human action. As Grint and Woolgar point out, however, this gives rise to

a significant inconsistency within this perspective. Thus, in seeking to preserve the notion that technologies are socially shaped/constructed, these approaches typically argue that this shaping is somehow "embedded" into the form of the technology which later contributes to its reciprocal influence on social conditions. The concrete of the Jones Beach bridge, for example, is seen as literally solidifying the politics of its designer with inescapable effects upon who can then gain access. What this implies, however, is that at some stage, usually taken to be some point during the design process (Pinch and Bijker 1987; Orlikowski 1992), the interpretive flexibility of technology is closed off and its effects subsequently depend solely upon its, now configured, intrinsic material properties. Such an "essentialist" position, Grint and Woolgar argue, amounts to nothing less than another form of technological determinism. This would seem particularly problematic in relation to technologies, such as information systems, which are argued to exhibit high interpretive flexibility (Orlikowski 1992), but also even in the case of the Jones Beach bridge, where human agency has proved able to evade the designer's "embedded" constraints, if not by designing buses that can drive through concrete, then as a result of increasing car ownership among the poor.

The intermediate approaches, therefore, while claiming to strike a balance between the social and technical elements, treat them inconsistently. For example, the humanist influences on these approaches lead them to emphasize the importance of human agency in shaping technology, while simultaneously exhibiting a residual determinism over its consequent effects. An approach that has recently begun to receive attention in the information systems field as a possible way out of this problem has been actor network theory.

Actor Network Theory

Some of the key features of the theory are reviewed from an information systems perspective by Walsham. Rather than repeat such an overview, what would seem more relevant in the present context is to identify a number of features of the theory that are seen by Grint and Woolgar as enabling it to transcend the essentialist assumptions of the traditional emergent positions.

Perhaps the central tenet of actor network theory in this respect is the assumption of "general symmetry" between the technical and social worlds. In particular, rules of method applied in the one domain should operate exactly the same in the other. The role of human actors should not, therefore, be privileged relative to nonhuman actors, such as pieces of hardware or software. Rather, the aim is to identify the configuration of the alternative heterogeneous networks of actors (comprising both human and nonhuman "actants") and the way in which they influence the development and stabilization of forms of technology.

As Callon and Latour (1992) acknowledge, this assumption brings with it some challenging implications which they are not reluctant to embrace. Thus, if humans and non-humans are to be understood as equal partners in these actor networks, then material agency needs to be considered just as important as human agency. In discussing a French research program to develop an electric vehicle, for example, Callon (1987) talked of catalysts that "refused to play their part" and of hydrogen atoms "refusing to be trapped by catalysts," alongside engineers from Renault lobbying against the project.

Similarly, Latour attributes agency to a metal key fob, a mechanical door closer, or to a sleeping policeman (speed bump) that slows traffic (Latour 1991; Callon and Latour 1992).

Interestingly, as Grint and Woolgar note, this move does not entirely eliminate essentialism. Thus, for example, Callon's analysis of the electrical vehicle program relies upon assumptions about the particular properties of catalysts to explain the dissolution of the actor-network. Moreover, in explaining the persistence of particular actor-network configurations, Callon (1991) talks of the irreversibility of techno-economic networks while Latour (1991) describes technology as "society made durable." The echoes here of notions of embedded structure, written into a technology, suggest an inconsistency with the textual account proposed by Grint and Woolgar.

Not surprisingly, the strong claims of actor-network theorists have evoked strong reactions. For the critics, there are three main points of attack: symmetry, material agency, and ethics. Symmetry is seen to be problematic by Collins and Yearley (1992a 1992b) because it constitutes an abdication of the authority of sociologists to adjudicate on scientific/technological controversy. Thus, if there is a distinct domain of scientific/technical phenomena, then an understanding of its behavior is understood to be the province of the scientist/technologist, particularly where the sociologist may be considered to lack the expertise to contribute to the controversy. If science/technology is understood to be a social product, on the other hand, then all aspects of the debate must be open to sociological analysis. Collins and Yearley also reject material agency on similar grounds.

For Schaffer (1991), material agency constitutes the "heresy of hylozoism, an attribution of purpose, will and life to inanimate matter, and of human interests to the nonhuman" and is therefore simply illegitimate. Pickering (1995) notes that material agency as deployed by Callon (1991) and Latour (1991) generally involves a shift to a domain of semiotic analysis which sees agency as operating in the realm of texts and interpretations. Although for Grint and Woolgar this would seem to be precisely the basis of its anti-essentialist appeal, Pickering argues that this stands in the way of breaking from a simple representational theory of knowledge toward more productive, performative theories. We will return to this point.

The ethical critique of actor network theory relates to its anti-humanist, or, as Pickering would put it, post-humanist, de-privileging of human agency. For Collins and Yearley (1992a), this preempts critical analysis of the social relationships that lie behind particular actor-networks that might help to account for their relative durability. Further criticisms of the "blasé, depoliticised scholasticism" (Winner 1993) of such allegedly relativist approaches to the study of technology have been countered by Law (1991) and are discussed at length by Grint and Woolgar in relation to the sort of textual approach to actor network theory that they advocate.

In treating the social and technical symmetrically, therefore, actor network theory is seen as attributing capabilities to technology that are considered to be properly human, thereby diminishing the potential for human agency. Although such a position may be a useful corrective to the inconsistencies of traditional accounts, the equivalence of technical and social would only seem semiotically sustainable. In practice, humans and machines are different, even if both deserve proper consideration in understanding the design and use of technologically-based systems.

A Way Forward?

If the alleged transcendance of technological and social determinism by structurational and actor network approaches both prove to be problematic, is there a way forward that can steer a path between the strong residue of essentialism of many intermediate theories, implied, for example, by notions of embedded structure, and the strong claims of symmetry proposed by actor-network theorists? Can the humanist assumptions of social determinism also be maintained, while allowing some possibility of material agency? A possible answer to these questions may be derived from consideration of recent debates around structuration theory and actor network theory.

With structuration theory, Giddens sought to resolve the long-standing division in the social sciences between those who consider social phenomena as products of human agency in the light of their subjective interpretation of the world, and others who see them as caused by the influence of "objective" exogenous social structures. Giddens instead proposes that structure and agency be viewed, not as independent and conflicting elements, but as a mutually interacting duality. Thus social structure is seen as being drawn on by human agents in their actions, while the actions of humans in social contexts serve to produce, and reproduce, the social structure.

In order to achieve this position, Giddens adopts a particular, subjective concept of structure as "rules and resources, organized as properties of systems." It is therefore "a 'virtual order' of transformative relations...that exists, as time-space presence, only in its instantiations in [reproduced social] practices and as memory traces orienting the conduct of knowledgeable human agents" (Giddens 1984, p. 17). This is true, Giddens argues, even in the case of the apparently material allocative resources (such as land) which "might seem to have a 'real existence'," but which "become resources only when incorporated within processes of structuration" (Giddens 1984, p. 33).

From this, we can see that notions of structure being embedded in technology are incompatible with Giddens concept, both because it implies a temporal separation of structure from agency (splitting the duality back into a dualism), but also because it gives the embedded structure an objective character inconsistent with his subjectivist ontology. Berg (1998) argues that structuration's subjectivism is evident in analyses, such as those of Barley (1986) and Orlikowski discussed above, which privilege human agency and cause "technology to vanish from their accounts, appearing only as an occasion for [social] structuring without any activity or specificity of its own." If technology is to achieve adequate recognition in structurational accounts, therefore, then an alternative to the unsatisfactory solution of embedded structure would seem necessary. If this cannot be achieved, as Berg suggests, within Giddens purely subjectivist perspective, then it would seem necessary to introduce an objectivist dimension to structuration.

This project has been the focus of critiques of structuration by writers such as Storper (1985) and Layder (1987). Drawing on the critical realism of writers such as Bhaskar (1979), they argue that allowing for the existence of a "relatively autonomous, relatively stable, institutional context" that exists independently of human actors does not preclude the possibility that structure is instantiated in situated conduct. Individuals are able to decide in what way they respond to structural conditions, whether they are objective or subjective. The properties of a technology may therefore exist independently of its use in any particular context, but their meaning is locally emergent. For

example, the speed of a Notes database may depend on the physical properties of technology, but the effective speed for any particular user will be a matter of local interpretation at the point of use. Following this line would appear to enable structuration to be extended to allow for technologies having objective material properties by which they may exert agency, although without assuming that human and material agency are directly equivalent.

Recent debates around actor network theory suggest that it too may be adapted to reach a similar position, from the other direction as it were, and that the two theories may thus be more compatible than some commentators (e.g., Monteiro and Hanseth 1995) have suggested. Thus Pickering has suggested that it is possible to preserve a notion of material agency, that there are objective properties of material phenomena that can influence action, without relying on strong symmetry. Material agency differs from human agency, Pickering argues, in that it lacks intentionality, it is not organized around plans and goals. Machines do not have a mind of their own, therefore, but it is nevertheless possible to consider them as exerting agency, "doing things" which directly influence human behavior. For example, the speed of a processor may affect the time required to use an application without assuming that the processor has any volition of its own in doing this. This is not to say that human plans and goals are always explicitly formulated or that human actors are fully aware of their motivations or effective in realizing them, but that intentions are important in understanding human agency in a way that is not the case for machines. While such a view of agency is clearly quite different from the specifically human property discussed by Giddens, it would nevertheless seem consistent with his focus on agency as "doing."

Pickering also identifies another problem with the symmetry assumptions of actor network theory in its notion of the "delegation" of human performance to machines, such as by automating a production process. Pickering argues that it is difficult to envisage how machines could equivalently delegate mechanical functions back to humans. For example, it would seem implausible to conceive of humans being able to establish and maintain the sorts of tightly integrated globalized work practices that are becoming increasingly widespread without the help of technology of many different types. The relationship between human and machines would therefore appear to be not quite as symmetrical as actor network theory suggests.

Pickering extends this argument to develop a model, which he calls the "mangle[1] of practice," which adopts an "emergent, performative, posthumanist" view of science and technology. Drawing on actor network theory he suggests that technological systems need to be understood in terms of the interaction of human and material agency and that the two can be seen as constitutively intertwined. Just as humans struggle to capture material agency in technologies, for example to exploit the properties of network hardware to produce higher transmission rates, so the technologies help to shape human practices, such as synchronous long-distance communication, which would not be sustainable without these technologies. For Pickering, technology and humans thereby become so mangled together that it is impossible to separate them clearly. Rather,

[1]Pickering is referring to an old-fashioned device in which laundry is passed between moving rollers. The verb "to mangle" also evokes the unpredictable, emergent quality of the interaction of human and material agency.

following Haraway (1991) we should understand them as comprising a machine/human "cyborg." A similar connection is made by Berg, who notes the parallels with recent writings of Latour (1996) which emphasize the mutual constitution of objects and the social. This can be seen as a subtle shift away from the strong symmetry of early actor network theory with its machines acting just like humans, toward a model of intertwined actants creating new entities, the capacities of which cannot be fully foreseen.

Pickering also argues that both human and material agency are temporally emergent. It cannot be decisively known in advance what problems are going to arise in attempts to capture material agency, nor can the ways in which human agency will be disciplined by technology be foreseen. Pickering adopts the metaphor of tuning, as of a car engine or radio, to describe the process of mutual adjustment by which human and material agency are interactively stabilized. Over time, this process may be seen as a "dialectic of resistance and accommodation" as humans seek to shape an intransigent material agency toward particular goals. This is not to propose a determinism of either a social or technological kind, though. The particular trajectory of emergence is not wholly determined either by the intentions of the human actors or by the material properties of technology, but rather by the interplay of the two. Thus, in encountering resistance in achieving an intended capture of material agency, human actors adopt strategies of accommodation, such as revising goals, intentions, or practices, or adjustment of technological parameters.

Pickering discusses the mangle of practice mainly in relation to scientists' attempts to construct devices to capture particular material phenomena, such as quarks or cosmic rays. These experiments may be seen as direct attempts to marshal material agency. Thus the material phenomena exist independently of the human actors who devise the means to demonstrate their existence. In one chapter, however, Pickering applies the mangle to an analysis of the introduction of new manufacturing technology, drawing on Noble (1986). Here, the capturing of material phenomena is not the primary objective, but rather their marshaling toward the achievement of social ends, whether this is seen to be productivity, profitability, or management control. Although not described by Pickering in these terms, we can see this as a form of "double mangle" in which both material and social agency are mutually and emergently transformed. These interactions would seem particularly complex in relation to information technologies with their intangible products and their extensive involvement in a diverse range of organizational work practices.

This temporally emergent double "mangling," where human agents seek to channel material agency to shape the actions of other human agents, may also help to explain why the achievement of consistent effects in information systems design and implementation is particularly problematic. This may be attributed not just to the emergent properties of complex physical systems identified by Pickering, but also, as Giddens argues, to the unintended consequences and unforeseen contingencies of social action. The use of a system thus continuously escapes the ordering intentions of its designers.

This view of the emergent interaction of human and material agency may be seen to be similar to the arguments of writers, such as Ciborra (1996), who describe the "drifting" and learning involved in groupware implementation. Emphasizing the improvisation and bricolage involved in the matching of the "plasticity of the artefact" and the "multiform practices" of the actors involved, Ciborra highlights the open,

situated and evolving character of the process. What the present argument would suggest is that this is an inherent characteristic of dialectic of resistance and accommodation between human and material agency that is not restricted to certain classes of "interpretively flexible," open or adaptable technologies. Moreover, this is an ongoing process that does not stop at some "design" stage when structure is locked into the technology. Rather, users are seen as engaging in a continuing process of design through their particular appropriation of the technology in use. The use of Notes by consultants, for example, creates a different appreciation of the application for each of them depending on their own background and expertise.

Since the design, implementation, and use of information systems involves the marshaling of material agency by human agency to try to "discipline" human agency, however, the locus of agency is ultimately predominantly human. Thus, if a user believes that the technical components of an information systems possess particular properties, for example perceiving an application as fast or slow, then this may influence their use. Material agency, in contrast, cannot similarly enforce itself over human agency, although material phenomena, such as a thunderstorm causing a network crash, can have direct effects on a user's capability to act. To go back to Giddens, material agency is instantiated in use. As Layder argues, however, this does not mean that it does not exist independently of use, but that human agents are able to decide, consciously or unconsciously, how they respond to it. Thus, while human agency may establish the physical infrastructure that permits data sharing, the existence of the infrastructure itself does not ensure that this happens.

This position suggests, therefore, that interpretation is central to the process of information systems design, implementation, and use. Material agency influences, but does not determine, the opportunity space for these interpretations. Rather, interpretations depend on emergent, situated social/social social/technical interactions, which will be influenced by preceding context. Since the context and conditions for action will vary between individuals, interpretations are also idiosyncratic. Thus, as Boland (1996) argues, standardized responses need not imply shared meanings, but are manifestations of common stocks of knowledge drawn upon in situated practice. Similarly, regularities in observable behavior may be seen as temporarily stabilized routines which are, in principle, continuously open to revision.

Conclusion

The "double mangle" model developed in this paper would therefore seem to offer an ontologically consistent way of combining insights from two recently-influential theoretical approaches in the information systems field: structuration and actor network theory. Although such a connection might be seen to be hinted at in a number of footnotes in Pickering, it does not appear to have been taken up, particularly in the information systems literature, where the treatment of the technical and the social continues to be problematic.

In order to achieve such a consistent model, it is necessary to adapt both structuration and actor network theory, but in ways that are in line with current debates. Thus, rather than trying to shoehorn technology into an unreconstructed model of structure and agency as Orlikowski seeks to do, the realist critiques of structuration theory suggest that

a relatively objective notion of structure is not incompatible with human agency. Technology may, therefore, be recognized as having an objective character, capable of exerting agency in its own right, rather than simply being "traces in the mind" of social actors. In terms of actor network theory, the double mangle implies a relaxation of the assumptions of strong symmetry between human and material agency. Locating intentionality as a specifically human characteristic allows for material agency while avoiding either social or technological determinism.

An important aspect of this double mangle model is the emergent nature of the dialectic of accommodation and resistance between human and material agency. This would seem to be reinforced by the doubling of the interaction in technological systems, as human agents seek to marshal material agency to direct the actions of other human agents. The outcome of technology development and use cannot be reliably predicted, as both the technical and social are mangled together in the process to produce specific, situated instantiations. Rather than seeing humans with clearly-defined goals applying technologies with clearly-defined properties to achieve clearly-defined organizational effects, therefore, we need to understand the process of information systems development and use as an ongoing double dance of agency.

Assumptions that information systems will lead to particular organizational effects, such as that collaborative information technologies will give rise to new organizational forms, would therefore be considered unsatisfactory from this perspective. This is not just because technologies do not have intrinsic social effects, or are able to have these embedded in them in the design process, but that the whole network of interaction is locally emergent. To understand the relationship between information technologies and new organizational forms we therefore need to examine the specific interactions played out in particular contexts. Our focus should be on information systems as ongoing artefacts-in-construction through the situated practice of knowledgeable agents, rather than as the product (or as producers) of predictable effects.

In seeking to move beyond the pure subjectivism of Giddens structuration and to incorporate a form of material agency, the double mangle model proposed here may therefore provide a way to give due recognition to both the technical and social elements of information systems, while acknowledging their differences. Since what distinguishes information systems as a subject is its focus upon phenomena related to the development and use of particular types of technological systems, this would seem a central issue of concern to the field.

Acknowledgments

I would like to thank Eija Karsten for her comments on earlier versions of this paper and Séamas Kelly for the empirical example.

References

Barley, S. R. "Technology as an Occasion for Structuring: Evidence from Observation of CT Scanners and the Social Order of Radiology Departments," *Administrative Science Quarterly* (31), 1986, pp. 78-108.

Barley, S. R. "The Alignment of Technology and Structure Through Roles and Networks," *Administrative Science Quarterly* (35), 1990, pp. 61-103.

Barnes, B. "How Not to Do the Sociology of Knowledge," *Annals of Scholarship* (8:3/4), 1991, pp. 321-335

Barnes, B. *Scientific Knowledge and Social Theory*, Routledge and Kegan Paul, London, 1974.

Berg, M. "The Politics of Technology: On Bringing Social Theory into Technological Design," *Science, Technology and Human Values* (23), 1998.

Bhaskar, R. *The Possibility of Naturalism*, Harvester, Brighton, UK, 1979.

Bimber, B. "Three Faces of Technological Determinism," in *Does Technology Drive History? The Dilemma of Technological Determinism*, M. R. Smith and L. Marx (eds.), MIT Press, London, 1994, pp. 79-100.

Boland, R. J. "Why Shared Meanings Have No Place in Structuration Theory: A Reply to Scapens and Macintosh," *Accounting, Organizations and Society* (21:7/8), 1996, pp. 691-697.

Callon, M. "Some Elements of the Sociology of Translation: Domestication of the Scallops and the Fishermen of St Brieuc Bay," in *Power, Action and Belief: A New Sociology of Knowledge?* J. Law (ed.), Routledge, London, 1986, pp. 196-233.

Callon, M. "Society in the Making: The Study of Technology as a Tool for Sociological Analysis," in *The Social Construction of Technological Systems,* W. E. Bijker, T. P. Hughes, and T. Pinch (eds.), MIT Press, London, 1987, pp. 83-103.

Callon, M. "Techno-economic Networks and Irreversibility," in *A Sociology of Monsters: Essays on Power, Technology and Domination*, J. Law (ed.), Routledge, London, 1991, pp. 132-161.

Callon, M., and Latour, B. "Don't Throw the Baby out with the Bath School: A Reply to Collins and Yearley," in *Science as Practice and Culture*, A. Pickering (ed.), University of Chicago Press, Chicago, 1992, pp. 343-368.

Ciborra, C. U. "Introduction: What Does Groupware Technology Mean for the Organizations Hosting It," in *Groupware and Teamwork: Invisible Aid or Technical Hindrance?* C. U. Ciborra (ed.), John Wiley, Chichester, UK, 1996, pp. 1-19.

Collins, H. M., and Yearley, S. "Epistemological Chicken," in *Science as Practice and Culture*, A. Pickering (ed.), University of Chicago Press, Chicago, 1992a, pp. 301-326.

Collins, H. M., and Yearley, S. "Journey into Space," in *Science as Practice and Culture*, A. Pickering (ed.), University of Chicago Press, Chicago, 1992b, pp. 369-389.

Ellul, J. *The Technological Society*, Cape, London, 1965.

Gallie, D. *In Search of the New Working Class*, Cambridge University Press, Cambridge, UK, 1978.

George, J. F., and King, J. L. "Examining the Computing and Centralization Debate," *Communications of the ACM* (34:7), 1991, pp. 63-72.

Giddens, A. *The Constitution of Society*, Polity, Cambridge, UK, 1984.

Grint, K., and Woolgar, S. *The Machine at Work*, Polity, Cambridge, UK, 1997.

Haraway, D. *Simians, Cyborgs and Women: The Reinvention of Nature*, Free Association, London, 1991.

Heilbroner, R. L. "Do Machines Make History?" *Technology and Culture* (8), 1967, pp. 335-345.

Hirschheim, R. *Office Automation: A Social and Organizational Perspective*, John Wiley, Chichester, UK, 1985.

Kling, R. "Defining the Boundaries of Computing Across Complex Organizations," in *Critical Issues in Information Systems Research*, R. J. Boland and R. Hirschheim (eds.), John Wiley, Chichester, UK, 1987, pp. 307-362.

Latour, B. *Science in Action: How to Follow Scientists and Engineers Through Society*, Open University Press, Milton Keynes, UK, 1987.

Latour, B. "Technology is Society Made Durable," in *A Sociology of Monsters: Essays on Power, Technology and Domination*, J. Law (ed.), Routledge, London, 1991, pp. 103-131.

Latour, B. "On Interobjectivity," *Mind, Culture and Activity* (3:4), 1996, pp. 228-245.

Law, J. "Introduction: Monsters, Machines and Sociotechnical Relations," in *A Sociology of Monsters: Essays on Power, Technology and Domination*, J. Law (ed.), Routledge, London, 1991, pp. 1-23.

Layder, D. "Key issues in structuration theory: some critical remarks." Current Perspectives in Social Theory, Volume 8,1987, pp. 25-46.

Leavitt, H. J., and Whisler, T. L. "Management in the 1980s," *Harvard Business Review*, November 1958, pp. 41-48.

Mackenzie, D., and Wajcman, J. *The Social Shaping of Technology*, Open University Press, Milton Keynes, UK, 1985.

Markus, M. L., and Robey, D. "Information Technology and Organizational Change: Causal Structure in Theory and Research," *Management Science* (34:5), 1988, pp. 583-598.

Marx, K. *The Poverty of Philosophy*, Martin Lawrence, London, 1936.

Monteiro, E., and Hanseth, O. "Social Shaping of Information Infrastructure: On Being Specific About the Technology," in *Information Technology and Changes in Organizational Work*, W. J. Orlikowski, G. Walsham, M. R. Jones, and J. I. DeGross (eds.), Chapman & Hall, London, 1995, pp. 325-343.

Mumford, E. *Effective Systems Design and Requirements Analysis*, Macmillan, London, 1995.

Noble, D. F. *Forces of Production: A Social History of Industrial Automation*, Oxford University Press, New York, 1986.

Orlikowski, W. J. "The Duality of Technology: Rethinking the Concept of Technology in Organizations," *Organization Science* (3:3), 1992, pp. 398-427.

Pickering, A. *The Mangle of Practice: Time, Agency and Science*, University of Chicago Press, Chicago, 1995.

Pinch, T. J., and Bijker, W. E. "The Social Construction of Facts and Artifacts: Or How the Sociology of Science and the Sociology of Technology Might Benefit Each Other," in *The Social Construction of Technological Systems*, W. E. Bijker, T. P. Hughes, and T. Pinch (eds.), MIT Press, London, 1987, pp. 17-50.

Pinsonneault, A., and Kraemer, K. L. "The Impact of Information Technology on Middle Managers," *MIS Quarterly*, September 1993, pp. 271-292.

Schaffer, S. "The Eighteenth Brumaire of Bruno Latour," *Studies in the History and Philosophy of Science* (22:1), 1991, pp. 174-192.

Storper, M. "The Spatial and Temporal Constitution of Social Action: A Critical Reading of Giddens," *Environment and Planning D: Society and Space*, (3), 1985, pp. 407-424

Trist, E. L., and Bamforth, K. W. "Some Social and Psychological Consequences of the Longwall Method of Coal Getting," *Human Relations* (4:1), 1951, pp. 3-38.

Vidgen, R., and McMaster, T. "Black Boxes, Non-human Stakeholders and the Translation of IT," in *Information Technology and Changes in Organizational Work*, W. J. Orlikowski, G. Walsham, M. R. Jones, and J. I. DeGross (eds.), Chapman & Hall, London, 1995, pp. 250-271.

Walsham, G. "Actor Network Theory and IS Research: Current Status and Future Prospects," in *Information Systems and Qualitative Research*, A. S. Lee, J. Liebenau and J. I. DeGross (eds.), Chapman & Hall, London, 1997, pp. 466-480.

Winner, L. *The Whale and the Reactor*, Chicago University Press, Chicago, 1986.

Winner, L. "Upon Opening the Black Box and Finding it Empty: Social Constructivism and the Philosophy of Technology," *Science, Technology and Human Values* (18:3), 1993, pp. 362-378.

Woodward, J. *Management and Technology*, HMSO, London, 1958.

Woodward, J. *Industrial Organization*, Oxford University Press, Oxford, UK, 1964.

About the Author

Matthew Jones is a University Lecturer in Information Management in the Department of Engineering and Judge Institute of Management Studies at the University of Cambridge, UK. He previously held postdoctoral positions at the Universities of Reading and Cambridge where he was involved in the development of computer-based models for public policy decision making. His current research interests are concerned with the relationship between information systems and social and organizational change and with theoretical and methodological issues in information systems research. E-mail: mrj10@cam.ac.uk