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## The Morphogenesis of Socio(-)material Relations in Organizations

*Completed Research Paper*

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### **Abstract**

*Recent debates in information systems research on the relationship between organizations and the technologies they deploy have deployed the concepts of the social and the material, either fused without a hyphen in sociomateriality, or layered with a hyphen in socio-materiality. This paper contributes to theory by arguing that a morphogenetic perspective developed from Archer's distinctively sociological version of critical realism can move this debate on and combine the strengths of both perspectives. This, we will argue, is necessary because of the differences in the temporal dynamics of the development of technology and organization. We will thereby demonstrate the theoretical importance of holding technology and organization as temporally distinct each with its own dynamic of emergence which managers continually grapple to align. On this basis we will make a distinctive contribution to theory by presenting a "tectonic" model of socio(-)material relations in organizations.*

**Key Words:** Sociomateriality; socio-materiality; morphogenesis; critical realism; tectonic approach

## Introduction

The relationship between the organisation and the technologies it deploys in order to meet its obligations to its customer has long been a central theme in organisation and management theory. Early contingency theories of organization (e.g. Perrow, 1967; Woodward, 1980) identified technology, defined as the operational processes of the organization, as one of the principal contingencies in the “structuring of organizations” (Mintzberg, 1979). However, the inherent determinism of contingency theory led to its decline as a theoretical perspective, and hence a loss of interest in how technology relates to organization (Orlikowski and Scott, 2008; Zammuto, Griffith, Majchrzak, Dougherty and Faraj, 2007). The revival of research interest in technology and organisation waxed with the growing realisation of the implications of information technologies (IT) for organization and was accompanied by a greater theoretical sophistication drawing in particular on the work of Giddens (1979; 1984) and structuration theory which became widely influential in research in the area (Jones and Karsten, 2008).

Orlikowski (2000) criticises this body of work because it argues that technologies embody structures which are then appropriated by users, which is not in alignment with Giddens’ own insistence that structures are merely virtual representations rather than real entities. She goes on to argue for a perspective focussing on technologies-in-use rather than technologies-as-artefacts. This critique, further complemented by drawing on insights into the nature of technology within practice theory (Barad, 2007) and actor-network-theory (Latour, 2005), stimulated the development of the *sociomateriality* perspective (Orlikowski, 2007). However, within sociomateriality two distinct lines of development can be discerned (Jones 2014; Leonardi 2013). One (Mazmanian, Cohn and Dourish, 2014; Orlikowski and Scott, 2008; Orlikowski and Scott, 2013; Scott and Orlikowski, 2014) emphasises the deep and recursive entangling of the social and the material – *sociomateriality* with “no hyphen” (Orlikowski and Scott, 2008: 456) or what Jones (2014: 916) calls a “strong sociomateriality” in which humans and technologies are ontologically fused. Another (Gaskin, Berente, Lyytinen and Yoo, 2014; Leonardi and Barley, 2010; Leonardi, 2013;) draws on critical realism as well as Giddens to suggest that humans and technology are ontologically layered while mutually constitutive – *socio-materiality* with a hyphen or what Jones (2014: 918) calls a “weak ... sociomateriality” which opens up the possibility of the material and the social evolving separately from each other as well as entangling. The deployment of critical realism connects *socio-materiality* with broader trends in recent empirical research on IT and organisation such as that of Volkoff, Strong and Elmes (2007).

In this paper we prefer the sociomaterial/socio-material contrast to the strong/weak one because the latter could be read as if strong is somehow superior to weak, and the presence or absence of the hyphen encapsulates the crucial point of difference between the two theoretical positions. At first sight, it appears as if the difference between the two could be one of levels of analysis. While advocates of *sociomateriality* tend to study the interactions between individuals and information technologies (e.g. Mazmanian *et al*, 2014; Scott and Orlikowski, 2014), advocates of *socio-materiality* tend to study the implementation and use of large information systems by organisations (e.g. Leonardi, 2007; Volkoff *et al*, 2007). However, to invoke levels of analysis is to suggest a deeper ontological difference between the two: *sociomateriality* views humans and technology as ontologically fused while *socio-materiality* views them as ontologically separate. The nub of the issue, then, is the question of whether a perspective that fully takes into account the mutually constitutive relationship between the social and the material in a variety of contexts from human/machine interfaces, large information systems in organisations, and social media is more helpfully founded in a layered or flat ontology.

The theoretical contribution of this paper will be to address this question by drawing on Archer’s (1982; 1993; 1995) critique of structuration theory, and show how that critique can be used to develop an approach to socio(-)materiality in organizations with a strong temporal dimension. We start with structuration theory for a number of reasons. The first is that it is foundational for both *sociomaterial* and *socio-material* scholarship, and Archer’s critique of it therefore provides the basis for the development of a more temporally nuanced approach to the relationship between IT and organization. Second, Archer’s critique of Giddens also provides the basis for developing the critique of actor-network-theory (Elder-Vass, 2008; Mutch, 2002) and practice theory (Archer, 2000; Porpora, 2015) which is important in *sociomateriality*. Third, we will suggest that the most important legacy of structuration theory for both *sociomateriality* and *socio-materiality* is that it leads to a conflation of the

different temporal dynamics of the development of technology and organization. We will indicate the importance of the temporal dimension which has, in our view, been inadequately emphasised in current debates around socio(-)materiality through two empirical vignettes drawn from published research.

We will then move on to develop a “morphogenetic” approach (Archer, 1988) to information systems change in organizations by drawing on Lockwood’s (1964) theory of social change through the relationship between social and systems integration underpinned with a critical realist philosophy (Archer, 1996). This will show that when the social and the material are temporally aligned organizational morphogenesis emerges, but when they were not adequately aligned temporally organizational morphostasis persists. We will dub this the *tectonic approach* to socio(-)materiality for information systems change. In practical terms, organizational morphostasis means that the full potential of IT to improve organizational performance is not realised while organizational morphogenesis means that it is. We will conclude by arguing that work in the *socio-material* perspective contributes to deepening our understanding of what Archer (1995) calls the “morphogenesis of structure” and the work in the *sociomaterial* perspective contributes deepening our understanding of what Archer (2000) calls the “morphogenesis of agency” and that Archer’s work therefore offers the potential for a synthesis between the two perspectives. In developing this argument we will build on the work of Mutch (2010) and Volkoff and her colleagues (Volkoff et al, 2007; Volkoff and Strong, 2013) who have already introduced Archer’s work to the information systems research community. We do this by emphasising the implications of Archer’s critique of Giddens’ (1979) conflation of the synchronic and diachronic in social change, and, in particular, the theoretical implications of the differences in the temporal rhythms of technological and organizational elaboration. We will also build on the work of Volkoff and Strong (2013) by developing a more nuanced conceptualization of “affordance” which is clearly aligned to Bhaskar’s ontology. Moreover, we build the argument in such a way that those who do not adopt critical realism and prefer empirical realism can also accept the argument about temporality in information systems change. In summary, these elements will be brought together in a tectonic model of socio(-)material relations in organizations.

## **Morphogenetic Theory and the Critique of Structuration Theory**

The “two sociologies” (Dawe, 1970) addressing respectively the “problem of order” and the “problem of action” have riven enquiry into the “vexatious fact of society” (Archer, 1995). The founding thinkers of sociology such as Durkheim, Parsons and Weber continually, if unsuccessfully, grappled with this thorny theoretical conundrum. However, over the last 60 years two “doctrines” (Dawe 1979) have evolved associated principally with positivist structural functionalism on the one hand and the various forms of interpretivism on the other. Organization theory is riven along similar lines (Burrell and Morgan, 1979). Those starting from the problem of order have tended to see action as being the result of the socialisation of the individual into the social, in what Archer (1988) has called “downwards conflation” from macro to micro. That is to say, agency is typically theorised as the outcome of structure in a more or less deterministic way. For those starting from the problem of action, apparently structural phenomena are theorised as mere aggregates of individual actions or, in the more sophisticated versions (e.g. Berger and Luckmann, 1967), as socially constructed through agential interaction in what Archer has called “upwards conflation” from micro to macro. Structure is theorized as a voluntaristic outcome of human activity. In either case, the result is typically unsatisfactory because these attempts fail to give ontological autonomy to either agency or structure (Archer, 1995), but theorise the macro as an epiphenomenon of the micro or the micro as an epiphenomenon of the macro.

Giddens (1979; 1984) made a highly influential attempt to move beyond this rift in social research and to resolve the tensions between structure and agency with the development of structuration theory. In structuration theory, structure and agency are mutually constitutive of each other in the “duality of structure” mediated through practices in which humans interact reflexively. However, Archer (1982) argues that Giddens merely achieves a “central conflation”, rather than truly transcending the agency/structure dichotomy. For Archer, structuration theory cannot address “when” questions regarding under which conditions agency shapes structure and structure shapes agency. From the perspective of our concerns here for the relationship between organizational and technological change, this leads to a crucial weakness. One of the principal contributions of structuration theory is

its bringing of space/time into social theory (Urry, 1991), yet in Archer's view, the job is not well done because its time-frame is entirely in the present, rather than the past or future (Archer, 1993). The reason is that in the *duality of structure*, agency and structure are so tightly bonded in their mutual instantiation in space/time that the possibility of structure and agency evolving through different temporal rhythms is occluded. Giddens (1984) tackles this methodologically with an *epoché* of one or the other to gain deeper insight into the evolution of institutions or strategic action, but as they are the two sides of the same coin in their mutual constitution this methodological device means that the *epochés* must be simultaneous and that "*temporal relations between structure and agency logically cannot be examined*" (Archer, 1993: 70; emphasis in the original). In other words, one cannot look further backwards (or forwards) when investigating structure than when investigating agency, nor *vice versa*.

While Archer's critique of structuration theory (1982; 1993) does not depend upon a critical realist philosophy of science, adopting such a philosophy adds considerable weight to the argument (Archer, 1995) because agency and structure can now be theorised both as ontologically distinct and epistemologically problematic. She proposes a morphogenetic theory of social stasis and change which retains structuration theory's insistence on the mutual constitution of structure and agency, while deploying a layered rather than flattened and conflated ontology in which the layers have emergent properties which are not properties of their constituent parts. This implies that structure cannot be deconstructed to agency, and that agency is not a mere outcome of structure. This is achieved through an "analytical dualism" in which structure and agency are held in analytic tension rather than conflated to each other through practice. Further, this approach develops structuration theory's approach to time by allowing structure and agency to evolve through different time periods rather than being mutually constituted in the analytic present. Thus the morphogenetic approach rests on two temporal axioms: 1) structure necessarily pre-dates the actions which transform it and 2) structural elaboration post-dates these actions. In other words, actors are both constrained and enabled by the institutions (and associated rules and procedures) which were developed by others prior to their arrival on the scene and then, through their actions, leave an institutional legacy for those who come after.

The point is well illustrated by the division of labour in pin manufacture (Smith, 1970), an example used by both Archer (1996) and her critics (King, 1999). Archer argues that the increase in productivity is emergent from the interaction between the individual workers but is the property of none of them individually and therefore cannot be reduced to their individual efforts. King accepts this, but argues from an interpretivist perspective that the increased productivity is a construct of the interactions of the group of workers, and therefore cannot be reified as a property of the group alone. But King here misses the elaboration phase. Once the division of labour is established, it requires coordination, and hence a managerial class to do that coordination with, therefore, an interest in maintaining that division of labour. Moreover, as Smith argues, the division of labour then allowed the development of specialised machines leading to increased specialization and higher productivity. Once this morphogenetic cycle is mobilised, these developments constrain further groups and it becomes impossible for any one group to opt voluntaristically to reduce the division of labour significantly because it is constrained by the reality that any alternative organisation of production needs to be at least as efficient as the divided one which binds both the managers (owners) and the workers. The effect of the division of labour, therefore, is, to establish over time *relations* between productive organisations (whatever their internal group organisation might be) which constrain the actions of the groups in those organisations (Porpora, 2015). For instance, research comparing two manufacturing organizations (Young-Hyman, 2017) has shown how a cooperative ownership structure generates relative inefficiencies in manufacturing due to less crisp division of labour, and hence authority structures. Giddens (1984) in his own discussion of the division of labour is obliged to make an awkward "*epoché*" of agency to focus on structure because of the temporal bonding of structuration analysis.

## **The Critical Realist Perspective**

"Critical realism" underpins the mature version of Archer's morphogenetic theory. Critical realism is a philosophy of science combining Bhaskar's (2008) "transcendental realism" in natural science and his extension (1998) to social science in "critical naturalism". The essence of Bhaskar's philosophy is to combine an ontological realism

with a relativist epistemology whereby there is an objective reality, but the material facts about that reality are available to human cognition only with difficulty. The aim of scientific enquiry, therefore, is to approach iteratively that reality and its underlying “generative structures and mechanisms” (Bhaskar, 2008), while remaining open to revision and critique in the awareness of the fallible human role in creating particular understandings. The challenge of extending this philosophy to the social sciences is that the reality in question is constituted through human activity and reflexivity in enquiry becomes paramount. In organization theory, as in sociology more generally, this philosophy of science has opened up an intellectual space for those wishing to move beyond both the empirical realism of positivism and the ontological relativism of interpretivism in its various guises (Porpora, 2015).

While Bhaskar’s approach is realist, he is very critical of the empirical realism shared by positivist social science and some interpretivist approaches which holds that reality is observable as empirical regularities or patterns. In contrast, Bhaskar (2008) holds that reality is layered. The first layer is the empirical and is what is experienced by the scientist as empirical regularities. The second layer is the actual which is the level of events which happen in the world, which may not be experienced because the scientist did not measure it or was looking in the wrong place. The third layer is the real, which may not be manifest in actual events because the real mechanisms at play may counteract each other. This layering can be illustrated by examination of a concept that will become important later in our argument. Gibson’s environmental psychology (1986) lays great stress on the concept of “affordance” defined as what the natural environment offers an animal by way of the means to survive (food and shelter). Any particular terrain has the potential to offer a set of affordances as a function of its generative mechanisms (lithosphere; atmosphere etc). However, that reality may not be realised in the actual because, for instance, a drought event means that the terrain’s potential to grow its affordance of food is not available in a particular year (i.e. the normal interaction between lithosphere and atmosphere is not realised in the actual). Even if it is realised in a non-drought year, it may not be experienced in the empirical by the particular group of animals in question and hence not support the life of that animal. It follows that in Gibson’s framework, an affordance is the *relationship* between the actual and the empirical with the focal animal of analysis experiencing the event of food being available or not this year.

## **The Structuration of Socio(-)material Relations.**

Applications of structuration theory to the analysis of IT and organization share these weaknesses as can be seen by examining two seminal case studies in information systems research which creatively adapt and apply structuration theory and which underpin the *socio-material* and *sociomaterial* perspectives respectively. Barley’s (1986; 1990a; 1990b) study of the implementation of new radiology technologies (particularly CT scanning) in two Massachusetts hospitals is a masterly example of empirical realist ethnography. It skilfully weaves detailed observation and sociometric instruments with narrative reporting and quantitative analysis to reject determinism – downwards conflation – in technology implementation. While the empirical studies deploy structuration theory only as a general orientation, a later theoretical piece (Barley and Tolbert, 1997) articulates the central concept of “scripts” from the empirical analysis in attempted alignment with structuration theory. However, reading this work with a critical realist eye some issues are raised. From this perspective, we have little sense of how the interactions that generate structural change within the radiology department are shaped by the broader context of the hospital organisation. Empirical differences are noted between the two hospitals in the outcomes of the social construction of reality (1986), but we do not understand why these differences have emerged because we know little empirically about the pre-existing structural differences between the two hospitals and how they shaped the agency of the radiologists and technicians. As a result, the analysis of the changed social networks following technology implementation (1990b) is a sophisticated example of upwards conflation because a number of structural features existing prior to the change process researched are outside the analysis, including the technology itself as a social artefact; the structural relationships between radiologists and technicians, including whether they are gendered; and the structures of the two hospital administrations.

Orlikowski’s (1992; 1993) ethnography of the implementation of CASE tools for software development has been as influential as Barley’s work. She studied a supplier of information systems contracting to a variety of clients, and the in-house information systems function of a major energy company. The former case received more analytic

attention as the empirical basis for the concept of the “duality of technology” to the effect that “technology is physically constructed by actors working in a given social context, and the technology is socially constructed by actors through the different meanings they attach to it and the various features they emphasise and use. However..... once developed and deployed, technology tends to become reified and institutionalized, losing its connection with human agents, losing its connection with the human agents who constructed it or gave it meaning, and it appears to be part of the objective, structural properties of the organization” (1992: 406). This is a highly sophisticated application of Giddens’ “duality of structure”. However, it is also open to Archer’s (1982) critique of central conflation in that it conceptualises the social structuring of technology in the present, rather than analysing the antecedents, implementations, and elaborations of technological change. This can be seen more clearly in the comparative study (1993) where the structural point that one case company develops its own CASE tools in alignment with its existing practices, while the other implements off-the-shelf CASE tools to effect a much broader organizational change is not analysed. Most importantly, the ability to shape the technology through agency is much wider in the first case than the second. It could also be argued that Orlikowski (1992) does not fully incorporate the competitive pressures upon the information systems supplier and thereby concludes with a rather voluntaristic account of the degree of agency open to the developers, and hence an upwards conflation, as illustrated in Leonardi (2013: figure 1).

Over the last 10 years, the argument has moved on from a complete reliance on structuration theory to the incorporation of practice theory and actor-network-theory (ANT) by the *sociomaterialists*, and critical realism by the *socio-materialists*. However, from a morphogenetic perspective, these developments do not address Archer’s extended critique of conflationist analysis in social science. The morphogenetic critique of ANT (Elder-Vass, 2008; Mutch, 2002; Porpora, 2015) identifies three points of difference. The first is that morphogenetic theory is essentially humanist (Archer, 2000), and so the melding of human and non-human agency as “actants” (Latour, 2005) and hence the treatment of the two as equals in analysis is misconceived. The second is that ANT advocates a flat ontology, while morphogenetics advocates a layered ontology (Archer 1995) where empirically identifiable layers with causal powers are emergent from one another and hence not reducible to each other. A third is that ANT commits the “epistemic fallacy” (Bhaskar, 2008) of collapsing epistemology into ontology, and thereby not distinguishing between the real world (ontology) and our knowledge about that world (epistemology). Thus, to the extent that ANT is concerned with structure, it tends towards an upward conflationism.

Turning to practice theory, similar arguments can be made. At one level practice theory (Schatzki, Knorr-Cetina, and Savigny, 2001) moves along lines similar to morphogenetic theory by arguing that *practices* are an emergent property of interactions between individuals but cannot be reduced to those individuals. Indeed, Archer (2000) expounds a humanistic version of practice theory. Practice theory addresses Dawe’s problem of order by arguing that “order should not be conceived of as regularities but instead as arrangements of people, artefacts, and things” (Schatzki, 2001: 6) i.e. as *practices*. However, as Porpora argues (2015), practice theory stops at the level of group practices and does not go on to elaborate a broader conception of structure which might be conceived in this context as an emergent property of interaction between practices. This leaves practice theory solving a very local problem of order without the ability to address higher levels of analysis except through some sort of “zooming” between levels of practice (Gaskin *et al*, 2014; Nicolini, 2009) or to address the constraints posed on present interaction by pre-existing practices from earlier interactions. A further issue is that sociomaterial practice theory as articulated by Barad (2007) – in common with ANT and other interpretivist perspectives – collapses ontology into epistemology and thereby does not distinguish between empirical observations where scientists are indeed “entangled” with their instrumentation, events in the actual world, and the real causal mechanisms driving those events. This suggests that we need to move beyond practice theory to develop a morphogenetic analysis of *sociomaterial* relations where entanglements are analysed as features of the “experience” (Bhaskar, 2008) of doing science and technology but do not necessarily go “all the way down” to reality.

The socio-materialists have been strongly influenced by critical realism while retaining the influence of Giddens upon their work. This is compatible with earlier formulations of critical realism (Archer, 1996; Porpora, 2015); indeed Bhaskar (1998) draws upon Giddens’ (1976) work for the development of “critical naturalism” in the social sciences. The resulting analyses hold the social and the material as distinct, while echoing the emphasis of socio-technical system theory on the mutual adaptation of the social and the material through cycles of “imbrication”

(Leonardi, 2011; 2013) in a manner similar to that envisaged by Leonard-Barton (1988). This gives the impression that the social and the material evolve in continual complementary interaction of temporal alignment rather than allowing for the possibility that the achievement of alignment is contingent and not guaranteed. The imbrication metaphor – derived from roofing technology - is also peculiarly static in a context where we are challenged by the *sociomaterialists* to address the unprecedented dynamics of technological change and remains at the level of the empirical observation rather than reality (Volkoff and Strong 2013). Archer's critique of Giddens is now widely accepted by most critical realist scholars (Elder-Vass, 2010; Porpora, 2015), and so we suggest that we need to move on from a structurationist approach to socio-materiality and follow the lead of Volkoff *et al.* (2007) and Mutch (2010) to develop a morphogenetic analysis of *socio(-)material* relations which analyses the causal powers of social and material structures.

## Vignettes of Information Systems Change in Organizations

In order to illustrate why we argue that there is a need to hold the social and material temporally distinct in the analysis of socio(-)materiality, we will review two empirical contributions on major information system implementation. Both are examples of *integrating technologies* (Winch, 1994); that is they are information technologies enable the integration of the information flows between functionally or spatially separated parts of the organization as a central element of their affordances (Volkoff and Strong, 2013: table 1). As Lawrence and Lorsch (1967) pointed out long ago, organizations are both differentiated for contingency (i.e. structural) reasons, and also require integration in order to deliver on their organizational purpose. Integrating technologies are characterized by the ambition of those who choose to implement them to integrate (in the sense defined above) the organization that they manage. Whether this ambition is actually achieved is a central question for the research on these types of organizational change processes.

The first case (Winch, 1994) is on the implementation of CAD/CAM systems which aim to integrate between the engineering and manufacturing functions in organizations (Adler, 1995) in order to improve product quality, responsiveness to customer needs, and efficiency in the product development process. At their heart is the manipulation and communication of graphical (2D and 3D) product information. Computer-aided Design (CAD) involves the configuration and analysis of the characteristics of the product, while Computer-aided Manufacture (CAM) takes that product information and uses it to plan the manufacturing process and to program automated manufacturing machines. The research method was a cross-analysis of 15 case studies of metalworking companies which were implementing CAD/CAM systems. While 5 companies had achieved both technical and organizational integration, 6 had achieved neither<sup>1</sup>, and 2 had each achieved one of the two dimensions of integration (Winch, 1994: figure 12.1). Technical integration was measured by whether graphical information actually flowed within the information system (as opposed to on paper), and organizational integration was measured by the existence of organizational practices that bridged the engineering and manufacturing functions. What distinguished the organizations that were successful on both dimensions of integration from those which were unsuccessful was that the former group had changed their organization because of the need to address competitive challenges *before* they implemented the technology, while the latter group tried to implement the technology and *then* to change the organization. Interestingly the two companies which had achieved technical but not organizational integration used CAD/CAM for surface modelling of complex curves (shipbuilding and aerospace) where the affordances of CAD/CAM were so strong that the companies had skunk-works-type operations (Stalk and Hout, 1990) to make technical integration happen.

This research indicates the importance of maintaining the development of the social and the material as autonomous but mutually constitutive in particular organizational outcomes. The socio-organizational changes that were enabling for CAD/CAM implementation were largely driven by the intensification of the market competition, rather than directly by the material changes associated with the technology, but these changes then allowed the subsequent elaboration of the social and material to further improve the effectiveness of integration

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<sup>1</sup> These organizations were still obtaining positive benefits from the separate operation of their CAD and CAM systems.



along both dimensions. The evolution of CAD/CAM technology from the 1950s onwards has proceeded in fits and starts and down many wrong turns (Arnold, 1983) – all the case study organizations were engaged in active bricolage to achieve working systems with elements purchased from different vendors. It is difficult to see either the fusion or the imbrication of the social and the material in these cases, more a continuing struggle for contingent alignment. Most importantly, the social and the material in these cases evolved due to different emergent dynamics and at different temporal rhythms.

The second case (Berente and Yoo, 2012; Berente, Gal and Yoo, 2010; Berente *et al.*, 2016) is on the implementation of an enterprise resource planning (ERP) system in NASA. Developed from the 1960's onwards (Jacobs and Weston, 2007), ERP systems aim to record, manipulate and communicate numerical information in order to generate efficiencies from improved control and improve managerial decision-making by providing more up-to-date information on the organization's performance. They typically interface with CAD/CAM systems through their manufacturing resource planning modules. NASA had tried to integrate its accounting and control systems a number of times before they decided to implement a SAP ERP system. This implementation proceeded through a number of iterations but was eventually successful at achieving a high level organizational integration even if this was not fully achieved at a local level. Indeed, Berente and his colleagues argue that it was the compromises made at the local level with particular groups of users that allowed the integration at the level of the overall organization to be achieved. In parallel with the ERP implementation NASA went through two different changes in organization structure first towards a matrix of programmes and operational centres aimed at breaking down the relative isolation of the geographically dispersed centres (the One NASA initiative) and the second towards ensuring the financial viability of the separate centres (the Ten Healthy Centers initiative). These organizational developments were conditioned by broader strategic issues, while the SAP system played an important enabling role in achieving the organizational changes once the broader organizational changes had gained momentum.

The experience of NASA with ERP again shows the importance of holding the social and the material analytically separate. NASA continued as a functioning organization through two failed attempts at implementing an ERP before opting for SAP, and it took several iterations before the SAP system was meeting the integration aspirations of senior management. Thus the temporal dynamic of the technology was faster than the temporal dynamic of the organization. Moreover, major organization-wide changes were made during implementation driven by factors largely unrelated to the technology, but which the technology could support to work more effectively.

We are arguing that the transformation the social and material at the 15 metalworking companies and at NASA implementing integrating technologies was typically messy, error-prone, and halting while eventually achieving a measure of success. These processes could certainly be described empirically as “entanglements” (Barad, 2007) as system users struggled to do productive work, but we suggest that it is unhelpful for causal analysis to see the material and the social as in some sense ontically fused in a duality or neatly imbricated in a dualism. Rather, from a morphogenetic perspective, the empirical experience of entanglement is conditioned by events such as the strategic decisions to implement technologies; failures of technology suppliers to deliver working systems; and organizational changes experienced as external pressures on the organization. We therefore argue that it is important to follow Archer's lead and suggest that morphogenesis is a process through time and that the material and the social evolve with different temporal rhythms which managers continually struggle to align. This benefit is well illustrated in Iannicci's (2014) case study<sup>2</sup> where organizational changes in the justice system and technological changes in information systems, each with their own independent dynamics, were brought together through several iterations to provide an effective service.

## **The Morphogenesis of Socio(-)materiality**

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<sup>2</sup> Iannicci uses the later version of Bhaskar's Transformational Model of Social Activity (TMSA) (2011) which is closely related to Archer's morphogenetic framework which she sees as preferable for the “working sociologist” (1995: 161).

How might this insight be developed into a more general theory of the morphogenesis of socio(-)materiality? Lockwood's theory of social change defined as "a transformation of the core institutional order of a society" (1964: 244), underpinned by a critical realist philosophy (Archer, 1996), suggests a way forward. Lockwood distinguished between "social integration" and "system integration" where "the problem of social integration focuses attention upon the orderly or conflictual relationships between the *actors*, the problem of system integration focuses on the orderly or conflictual relationships between the *parts*, of a social system" (1964: 245; emphasis in the original). He goes on to argue that contradictions between the structural parts of the social system and conflict between the actors of the social systems do not necessarily align, but it is only when they do align that social change is possible. Archer argues that this analytic (rather than philosophical) distinction between the "parts" and the "actors" yields "a new form of non-conflationary theorising whose explanatory power derived from treating their properties as *separable* and the interface between them as the locus of intensive investigation, since this is where outcomes for them both were determined... The increase in explanatory power [is] derived from concentrating upon neither element, but rather from forging explanations in terms of their *variable* combinations" (1996: 680; emphasis in the original).

Archer concludes that

Basically, analytical dualism is possible *due* to temporality. Because 'structure' and 'agency' are phased over different tracts of time, this enables us to formulate practical social theories in terms of the former being prior to the latter, having autonomy from it and exerting causal influence upon it. In other words, we can talk about 'system integration' conditioning 'social integration' which necessarily confronts the former, and similarly speak of systemic elaboration being posterior to a particular sequence of social action (Archer, 1996: 694; emphasis in the original).

While care should be taken in directly comparing Lockwood and Archer's concepts of social and system integration at the societal level with our application at the organizational level, we can take the fundamental points that the social and the material need to be held analytically distinct as a duality; that the different temporal rhythms of their respective evolutions needs to be analysed rather than conflated into a duality; and that the focus of our empirical research needs to be on their mutual but variable constitution through time.

One of the principal arguments for the *sociomaterial* perspective is that it is best placed to understand the implications of the growing rapidity of technical change (Orlikowski, 2007), yet evidence from the vignettes suggests that even in successful implementations of integrating technologies, organizations evolve more slowly than the technologies that they deploy. This would appear to be more generally true. For instance, Orlikowski (2007) shows how Blackberry message push technology changes the behaviour of private equity workers. However, she does not analyse the earlier generation of technology that such workers would likely have used (pagers and voicemail), and the technology she studied is now completely defunct, replaced by smartphones. Yet, private equity firms still play an important role in the financial sector and have done so through at least three different technological evolutions; the organizational has a slower temporal rhythm than the technological in this case. Also the failure to hold the organizational analytically independent from the technological means that the tenor of the argument has an air of technological determinism (push technology is there so everybody used it) and does not address why push technology offered such an advantage in the private equity sector that its adoption was both quick and widespread, nor why the case firm chose to implement this functionality.

In making this point, we do not follow Mutch (2013) and argue that *sociomateriality* is a "wrong turn". Rather, we argue that the work inspired by this perspective is particularly valuable for understanding the morphogenesis of agency which could usefully be complemented by research on the morphogenesis of structure along the lines developed in this paper. For instance, the work by Orlikowski and Scott (2014; Scott and Orlikowski, 2014) comparing evaluation by accrediting bodies (AA) and user reviews (TripAdvisor) of UK hotels is profoundly thought-provoking and probably captures a significant shift in 21<sup>st</sup> century society across a large number of retail sectors. From a morphogenetic perspective, the next step in the analysis would be retroduction (theoretical inference) to identify the potential causal factors at work. For instance one might consider the ways in which the TripAdvisor algorithm embodies assumptions about the structural nature of markets. Arguing by analogy from Mackenzie and Millo's work (2003) on option pricing theory, we can suggest that the TripAdvisor algorithm embodies certain notions of consumer preference in open market structures and is therefore "performative" (Callon, 1998) of those

market structures. A second step in this process of retrodution might then be to suggest that TripAdvisor is an instantiation of the “causal powers” of the market institutional logic (Thornton, Ocasio and Lounsbury 2012; Ocasio, Thornton and Lounsbury, 2017) in (probably successful) competition with the professional institutional logic instantiated in independent evaluations by trained, expert assessors from the AA.

Our argument is not, of course, that the published papers should have addressed these questions; rather it is that the conflation of the social to the material inherent in the practice-based sociomateriality perspective vitiates retrodution from the empirical observations to identify the causal powers of the prior conditioning of structure and agency. While critical realism’s layered ontology can accommodate a practice perspective analytically focused on one layer within its epistemological flexibility (Bhaskar, 1998), a flat ontology is not compatible with critical realism’s layered ontology. We agree with Scott and Orlikowski (2013:77) that we need to keep our “avenues of thought” open, but we also suggest that a morphogenetic approach underpinned by a critical realist philosophy of science is a more inclusive way to do this than practice theory.

The *socio-materiality* perspective acknowledges the analytic dualism between organization and technology thanks to its influence by critical realism (Leonardi, 2013), but, we suggest, it also displays its influence from the socio-technical systems perspective by assuming that an iterative “mutual adaptation” of organisation and technology is possible in the manner articulated by Leonard-Barton (1988). Even if such mutual adaptation were possible in the era of mass production, the rapidity of contemporary technological change suggests that it is no longer viable either practically or theoretically. The experience of implementing integrating technologies such as CAD/CAM (Winch, 1994) and enterprise systems (Berente *et al*, 2016; Volkoff *et al*, 2007) is a lot messier and contingent than the “imbrication” metaphor would suggest and can lead to failure of both organization and technology (Chen, Law and Yang, 2009) with resulting serious financial losses. Archer (1995) suggests that Bhaskar’s early conception of TMSA change (1998) was rather too close to Giddens and benefited later from greater attention to the temporal discontinuities in social and system integration. We suggest that research in *socio(-)materiality* could similarly benefit from greater attention to temporal discontinuities between the social and the material by relying for theoretical inspiration upon Archer, rather than on Giddens or directly on Bhaskar.

Our findings here are closest to those of Volkoff *et al* (2007) who also adopt the temporal aspects of Archer’s morphogenetic cycle. However, their analysis of the structural conditioning of change is restricted to way the technology “embeds” practices and thereby uses the material to shape the performative aspects of practices during social interaction and under-analyzes the social (Bygstad, Munkvold and Volkoff, 2016). We therefore have little insight into how the organizational structural conditioning has in turn shaped the ways in which ostensive practices were embedded in the materiality of the enterprise system. Hence the analysis of “affordances” (Volkoff and Strong, 2013; Bygstad *et al*. 2016) offered by different technological choices needs to be complemented by an analysis of the structural, cultural and agential conditioning constraining the strategic choice of the organization and its managers (Herepath, 2014).

In summary of our argument, we propose the tectonic model shown in figure 1 inspired by Archer (1995: figures 10; 12) applied to the morphogenesis of social and material relations in organizations. In terms of conditioning, the version of the technology offered to the organization by vendors (or in-house system development function) forms the technological (the material) structural conditioning of change. Both the existing organizational structure and group processes (the social) provide the organizational conditioning of change at the organizational and group levels respectively. Interactions as the organization acts to realize the desired affordances of the technology mutually constitute the organizational change to achieve an implemented technology. Further elaboration of the technology then takes place as vendors develop it to meet their customers’ further needs by learning from the interaction phase, and as the organization and its members learn to make best use of the affordances of the technology that were emergent in the interaction phase.

Figure 1 captures both the diachronic and synchronic dimensions of change. In figure 1, the vertical dimensions in phases 1 and 3 capture the synchronic in terms of an analysis at a moment *in* time of the systemic relationships between the parts and the whole, while the horizontal dimension captures the diachronic development *through* time of the morphogenetic cycle of conditioning> interaction> elaboration. The diachronic and synchronic mutually

reinforce each other in phase 2 as the organisation grapples with the *relationship* between organizational action and technological affordances. Barley and Tolbert (1997) attempt to argue that both a synchronic and diachronic analysis are required to understand organizational change while positioning their argument as a contribution to structuration theory. However, Giddens' (1979) clearly rejects Saussure's classic distinction by, in effect, proposing a temporal conflation of the past, present, and future in the diachronic dimension to complement his central conflation of structure and agency in the synchronic dimension.

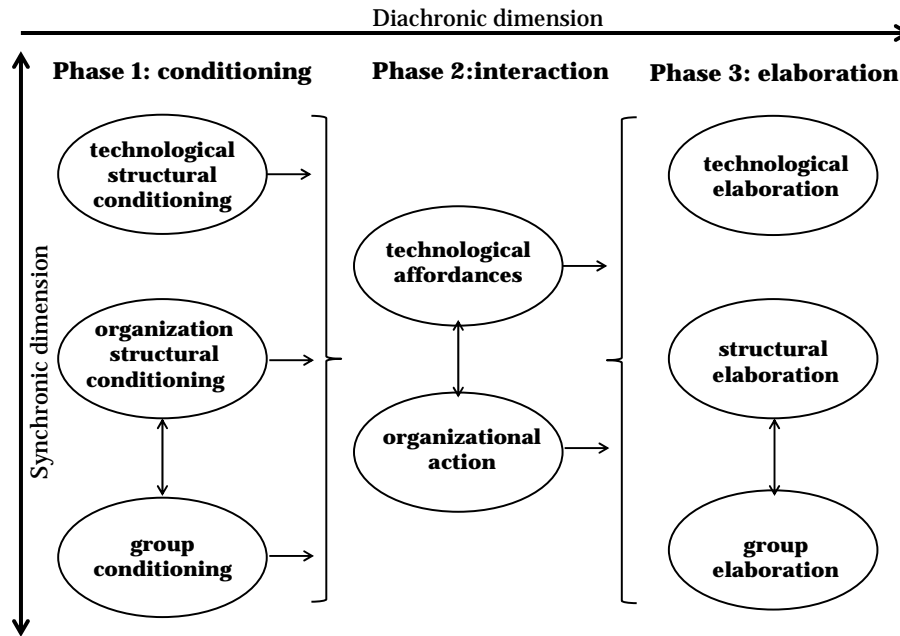


Figure 1: The Tectonic Model of Socio(-)material Relations in Organizations

We suggest that this tectonic model represents an advance on the models of socio-material relations presented by (Mutch, 2010: figure 2) and Volker et al (2007: figure 1) because it emphasises the temporal autonomy of technological conditioning and technological elaboration from dynamics within organizations around organization structure and group processes, while also incorporating the concept of affordances (Volkoff and Strong, 2013) and the synchronic/diachronic distinction (Mingers, 2014). Within the interaction phase various conceptual approaches are viable, such as Mingers and Willcocks' (2014) approach derived from Peirce's semiotics while the rich data base of ethnographic studies influenced by the sociomaterial and socio-material approaches offers significant potential for reanalysis. We further suggest that for empirical realists, this tectonic model would work through a focus on the diachronic dimension alone.

### Towards a Research Agenda for Information Systems Change: The Tectonic Approach

Critical realism is a philosophy of science, not a research methodology, so for it to enable "practical social theorizing" (Archer, 1995: 4) researchers need to develop and adopt appropriate methodologies within critical realism's broad epistemological flexibility. Coleman (1986) argues that positivistic research has selected methodologies that have focused on the micro-level of analysis because this is much more tractable empirically than the macro; similarly interpretivists, drawing significantly on ethnography, have also tended to focus on the micro for pragmatic reasons. It is simply easier to ask individuals their opinions on their immediate situation or to immerse oneself in a relatively small group context than to attempt to grapple with large macro-level entities which are inherently less observable. Thus it can be suggested that empirical realism in the social sciences has an

inherent tendency towards upwards conflation derived from its choice of methodology either through aggregation for the positivists or constructionism for the interpretivists. This pragmatic methodological choice is compounded epistemologically by an empirical realism which holds that only the observable is real. It is simply easier to observe agency in action - people doing things – than to observe structure and the causal powers which shape what they do. Thus the fundamental epistemological problem is how to empirically observe structure in its analytical dualism with agency when it can only be observed by its effects. Agency can be observed through a variety of methods ranging from psychometric scales to participant observation, yet organisational structures of various types are much less easily observable and have to be inferred by their effects on agency. In critical realism, this inferential process is called “retroduction” as the process of theorising what the world must be like for the effects observed to be as they are and not otherwise (Porpora, 2015; Wynn and Williams, 2012). While organisational structures are not amenable to direct observation, they can be visualised. This can be done descriptively such as in an organigram (Mintzberg, 1979) or process map (Wheelwright and Clark, 1992) or analytically as in causal loop diagrams (Sterman, 2000) and social networks (Burt, 2005).

Much remains to be done in this research agenda, which we dub the “tectonic approach”<sup>3</sup>, to capture its mutually constitutive social and material aspects. The epistemological flexibility of critical realism is inclusive rather than exclusive of a variety of research methods (Edwards, O'Mahoney, and Vincent, 2014). However, for research on organizational change of the type reviewed in the vignettes, we need a research method which both visualizes organizational structures and processes, and also elicits managerial actions and behaviours in relation to those structures and processes. This suggests an intensive (Tsang, 2017) approach, and, in particular, a comparative case study methodology because this is particularly suited to identifying, and hence theorising, structural effects (Kessler and Bach, 2014). This benefit can be seen in the discussion of Barley's and Orlikowski's work above, because the lack of attention to structure only becomes clear in the comparisons between their case pairs. For those who prefer an extensive (Tsang, 2017) approach, Van de Ven and Ferry (1990) provides a cornucopia of scales which, in our view, would be appropriate for quantitative research aligned with this agenda. Ideally, the two would be combined in mixed methods research (Hurrell, 2014; Mingers, 2014; Tsang, 2017). We now need new research inspired by the debates around the relationship between the social and the material in organizations rooted in a critical realist philosophy of science for further development of information systems theory.

In developing such a perspective, the concept of “affordance” is a very important one for critical realist approaches to information systems research (Volkoff and Strong, 2013; Bygstad, *et al.*, 2016). As discussed above, the concept is derived from Gibson's (1986) realist ecological psychology and intends to capture the productive potential offered by the information system to the organization which is implementing it. However, an important distinction between the natural world with which Gibson was concerned and the artificial world with which we are here concerned is that the latter is designed (Simon, 1996). In other words, an information system is a “rational artefact” designed with a specific functional intent by agents drawing on experiences in both the natural *and* artificial worlds. This suggests that we need to think of affordances as the structural properties of the (information) technology which has been designed to afford them, but this leaves it unclear whether an “affordance” lies at Bhaskar's (2008) level of the real, actual, or empirical. Volkoff and Strong (2013) appear to imply that an affordance lies at the level of the real, because they relate affordances to generative mechanisms. However, they also claim “an affordance, as an emergent property of the relation between an object (IT artefact) and an actor” (Volkoff and Strong, 2013: 829). In Bhaskar's (2008: table 1.1) domains of generative mechanisms>events>experiences, all that actors can directly perceive is the empirical level of experience, not the real level of generative mechanisms because the actual level of events intercedes. This suggests that affordances are most helpfully characterized at the level of the actual in relation to the empirical which would align with our reading of Gibson outlined above.

If this point is accepted, how can it be applied to our tectonic model? We suggest that *technological structural conditioning* captures the design activities of system vendors such as SAP which work with a combination of the fundamentals of computer science, technology development, and their perception of market demands. The

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<sup>3</sup> “a series of arts which form and perfect vessels, implements, dwellings and places of assembly.... We call this class of artistic activities tectonics” (Oxford English Dictionary, 2<sup>nd</sup> edition).

*interaction* phase in figure 1 can be seen as starting when the organization chooses to implement a new or upgraded system and identifies the *intended* affordances of the type itemized by Volkoff and Strong (2013) which provide the rationale for investment in the new system. Whether the organization then achieves successful deployment of intended affordances as *realized* affordances at the level of the empirical in the interaction phase 2 – a question which is at the heart of the issue of the relationship between the social and the material – is an empirical question at the level of experiences. Retrodution of generative mechanisms can then be used to explain differences in the “actualization” of intended affordances in realized affordances through the comparative analysis of the experience of organizations as a result of the synchronic conditioning of technology, structure and group and the diachronic (project) management of system implementation. This conceptualization is in distinction to that of Bygstad *et al.* (2016) who suggest that retrodution is required to identify the intended affordances which are, surely, more easily identifiable by asking the system vendor or reading the manual. The actualization of *latent* affordances not intended by those who made the investment decision, or even the designers of the technology in the system vendor, would then be emergent in the elaboration phase 3 in figure 1. These sketchy considerations suggest that more work is required on the concept of affordances in the sciences of the artificial as opposed to natural world; indeed, critical realism as a philosophy of science has paid almost no explicit attention to the sciences of the artificial.

## Conclusions

We have identified the crucial distinction between the *socio-material* and *sociomaterial* perspectives as their underlying ontologies. The *sociomaterial* perspective builds on Giddens’ structuration theory and more recent developments in ANT and practice theory to adopt a flattened ontology in which humans and technologies are ontologically fused. The *socio-material* perspective also builds on Giddens, while adopting the more layered ontology of critical realism in which humans and machines are ontologically independent. This shared reliance on Giddens, we suggest, has led to a failure to appreciate the temporal dimension in organizational change associated with information system implementation. While early critical realism in Bhaskar’s philosophy compatible with structuration theory, later critical realism has been strongly influenced by Archer’s critique of structuration theory and now emphasises the temporal dynamics of the morphogenetic cycle of conditioning > interaction > elaboration of the mutual constitution of agency and structure in a “double morphogenesis” in which “agency leads to structural and cultural elaboration but is itself elaborated in the process” (1995: 247).

We inferred from the review of the empirical vignettes the importance of maintaining the ontological distinction between technology and organisation – the material and the social – for analysing how they mutually constitute each other as in the *socio-material* perspective. However, a closer examination of the emergence of organization and technology in the vignettes also suggested the importance for analysis of the differences in the temporal dynamics of organisational and technological evolution. We therefore argued for a tectonic approach to *socio(-)materiality* which would leave behind the influence of structuration theory and its emphasis on the simultaneity of the mutual constitution of the social and the material and the adoption of Archer’s morphogenetic theory as suggested by Mutch (2010) and Volkoff *et al.* (2007). Further, we suggested that a full application of morphogenetic theory should include an analysis of the conditioning of the mutual constitution of the social and the material in the interactions between the two in organisational change. The debates around the social and material in information systems research have raised that research to new theoretical levels (Leonardi, 2013); we hope that this paper has successfully developed these debates towards a new theoretical synthesis on the “vexed question” of technology and organization.

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