12-31-2012

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1   Introduction

Aboard a sailboat, when the wind changes unfavourably for our course, we can adjust the sails. We perform the operation of pulling a rope—but when the rope is fastened to the sail as a sheet, pulling the rope means adjusting the sail, while also paying attention to the wind, the sea current, the movements of the boat. The rope-with-sail is the very rope we are pulling: a sociomaterial entanglement as well as a physical element in that same entanglement. We can only know if the pulling is successful by looking at the sail and noticing how the boat reacts to the adjustment. We are able to handle the entanglement of the boat, the sail, the wind, the current as a whole while at the same time making small, incremental adjustments with the material rope. With both the whole and the material in mind we elaborate our position in the debate.

In our paper 'Conditions for Autonomy in the Information Society: Disentangling as a public service' (this issue) we argue that the tax advisors of the TICC help citizens with tax issues by disentangling the sociomaterial entanglements of the tax system as it plays out in their lives, by creating a space for action for the citizen. We suggest to extend the theory of sociomateriality by differentiating between an imbrication (Leonardi 2011) and an entanglement (Orlikowski 2007; Orlikowski and Scott 2008; Orlikowski 2010) to approach this space. We empathize with the taxpayers calling in to the TICC feeling that they are caught in a difficult situation that they do not know how to change or escape. In a design perspective the focus is to improve the situation by changing one (or more) of the constituents of the sociomaterial entanglement characterizing the situation. How we talk about the ways we understand and perform the identification of technical, organizational, institutional, cultural or social possibilities for changing the sociomaterial whole is the topic of this commentary paper.

Response to the comments

2   Positions in the debate

We are grateful to the SJIS debate forum editor Margunn Aanestad for organizing a debate about sociomaterial entanglements with commentaries from some eminent scholars, also providing us with the opportunity to clarify and broaden our line of arguments. We build our argument in this paper on our original paper (this issue) and the three commentaries. We will briefly sum up our take on the commentary papers as an introduction to our response.

Leonardi and Rodriguez-Lluesma (this issue) formulate their view of sociomateriality as a lens for design. They see entanglements and imbrications as metaphors and claim that *imbrication* is a better metaphor for understanding design than *entanglement*. The concept of imbrication allows for seeing the materiality of the overall structure when looking close. The imbrication, where the tegula and imbrex are understood as different but act together to produce certain outcomes, opens up for a conversation between social and material agencies that allows for design (change) to take place.

We agree with Leonardi and Rodriguez-Lluesma that we are discussing metaphors. All theory is to some extent metaphors, in that we by the help of language and its limitations try to convey complex relations. A limitation here is our ability to conceptualize extremely complex phenomena and relations. We need to stretch our metaphors to the limit (and possibly beyond) to be able to discuss at all.

However, Leonardi and Rodriguez-Lluesma indicate that the imbrication explains it all, that "some imbrications are more interlocked than others—some so tightly interlocked that they may appear to be completely entangled". The entanglement is something that is perceived, but can be changed: "What matters is one's ability to see which imbrication can be dismounted easily and which will require more work". This is in line with how we think, although we will argue that there are some entanglements that are so entangled that there is no immediate available way of disentangling them.

Whereas Leonardi and Rodriguez-Lluesma write about suitable metaphors, Kautz and Blegind-Jensen (this issue) write about ontology. They claim that entanglement and imbrication are ontologically different entities: "Imbrications are not entanglements". They argue that we do not need the notion of disentangling as we thereby risk reintroducing the sides of the phenomenon that the concept of entanglement aims to overcome.

The notions of entanglement and imbrication have been used inconsistently in the literature. We agree with Kautz and Blegind-Jensen that *entanglements* and *imbrications* describe different 'things', and we offer a way to differentiate them within the same conceptualization. We want to discuss the suitability of metaphors, and take the notion of *entanglement* to be the superior concept in a hierarchy of gradually increasing entanglements, where the notion of *imbrication* will cover the less entangled ones. The imbrication and the entanglement are not more different than a mackerel and a vertebrate. We will explain this in detail in the next section.

Bjørn (this issue) also to some extent writes about ontology, and argue that our use of imbrication as a basis for a stepwise approach "does not embrace the complexity that a sociomaterial analysis must entail". She claims that our analysis does not escape the dichotomy of the social and the technical and that a sociomaterial analysis can only be based on an understanding of

entanglements. Instead she suggests a concept of *bounding*, with the double meaning of binding together and setting the boundaries for an entity.

We appreciate that Bjørn reminds us that things need to be bounded as well as separated. "Disentanglement cannot be achieved in a stepwise manner. Instead each string of yarn will always be interwoven in multiple other practices with increasing complexity", she writes. We find, however, that sometimes a string of yarn can be disentangled from the others in the knot, but also that sometimes it cannot without cutting the knot. In order to disentangle we have to think of the whole knot and the particular thread at the same time. Bjørn suggests that we claim that a logical end of the problem exists: "that it is possible to identify a clear source of the problem". We do not, and will elaborate on this in the next section.

3   Technical details can improve the analysis

Consider the example given by Orlikowski (2007) "to examine the constitutive entanglement characterizing sociomaterial practices" (p. 1441) about the use of BlackBerry wireless email in the fictitious company Plymouth. The example illustrates how a technical feature (email push) gets intertwined with the ways in which work is organized and carried out: the employees of Plymouth feel obliged to respond to work email after working hours. The choice to use a particular technical possibility (email push) changed the sociocultural work environment and threatened the family-friendly values of the company.

A new dimension is added to the discussion of how the technical and the social are intertwined as Orlikowski opens the 'black box' of the BlackBerry and identify a particular function—a technical element of the solution—as the interesting material feature of the technology, instead of treating the BlackBerry as a black box. We think that the identification of this technological detail improves the analysis. However, Orlikowski stops at the function of email push, however, and does not discuss if or whether it can be turned off or modified in some way.

Which space for action towards change does an unhappy and overworked employee at Plymouth have? He can try to turn off the setting in the BlackBerry that pushes email. If this works, then all is maybe fine. However, doing this might have a downside if our employee feels left out of important work-related communication and experiences coming unprepared to meetings in the early morning where all his colleagues are better prepared, because they reacted to their email before they went to bed the night before. Such experiences can lead him to turn the email push function back on again. But this will also indicate that he cannot change the situation alone: some kind of collective action may have to be evoked. If all employees turn off the email push function, everybody's expectations towards reading email after work hours might change. This might involve talking with the managers in order to change the company policy. If a technical step does not fix his problem, our employee can see that he can direct his efforts towards change in other directions, by talking to his colleagues or his manager. However, none of these attempts will deterministically lead to a better situation.

Orlikowski (Orlikowski 2007, p 1439) gives another example of a sociomaterial entanglement: information search by Google. As a response to a search Google displays the results according to its internal 'page rank', where displaying links to web pages will be displayed with

decreasing page rank on the screen. Page ranks are not static, but dynamic and relative, and are calculated from the links on millions of other websites. These change as the web editors change their sites, and so the result of a Google search changes accordingly. This change is not deterministic, but it is planned by Google and developed by its programmers to achieve high relevance search results as the information on the web is updated and changed from day to day. However, nobody can foresee the results of the Page Rank algorithm tomorrow, as it depends on the behavior of millions of people. A search result is sociomaterial as the human and material agencies are entangled in the result, whereas it is analytically possible (but difficult) to separate them in the executing apparatus (Boell and Cecez-Kecmanov 2012).

Because the result will change with time, a researcher risks missing important links or an editor can find her web site has decreased in relevance according to the calculated page rank and is not displayed on the first page of results. What is the space for action for an unhappy researcher or web editor?

In contrast to the BlackBerry example there is no local setting that offers a possible solution. Nobody is responsible except Google, and the PageRank algorithm is their company secret. Spoofing is a strategy to increase page ranks, but this is met with counterstrategies from Google. The space for action is not obvious, but saving or printing them out could help to preserve important relevant links for the careful researcher.

Both these examples are given by Orlikowski (2007) as sociomaterial entanglements. We think they are very different in that the BlackBerry situation provides more space for action and change for a dissatisfied user than the Google Page Rank example. It is little you can do with Google Page Rank. We would say that the sociomaterial entanglement of Google Page Rank practices is more entangled than the BlackBerry email push.

4 Entanglement levels and degrees

The notion of *constitutive entanglement* is inspired by physics and the works of Barad (1999; 2003) and Pickering (1995). Barad writes about the constitutive entanglement of the phenomenon under study and the apparatus to study it. A quark can only be observed through the specially designed apparatus to see it, which is created by a mangling of practice over time (Pickering 1995). The quark and the apparatus to see it are mutually constituted, and we can only locate the agencies within this entanglement with an agential cut (Barad 2003).

The entanglement of the quark and the apparatus to observe it is more entangled than the examples discussed above. Even though the quark can only be observed in the apparatus, it lives on in theoretical conceptualizations and in people's understandings, and in this respect gets a life of its own outside the apparatus.

A similar entanglement is computer simulations for the testing of nuclear weapons (Dourish and Mazmanian 2011). Advanced simulation technologies have been developed for testing such weapons because the real-life testing has been banned. The weapons and explosions are simulated but

> As the simulation regime continues, the disjuncture between physical weapons and their simulations grow. Simulations of nuclear warheads become simulacra in Baudrillard's sense – simulations of objects (in this case, explosions) that never themselves existed. The materiality of the simulation displaces that of the weapon. (Dourish and Mazmanian 2011, p. 17)

This intricate mangling of the technology, the apparatus, and the phenomenon which is represented in the technology, can be seen in many disciplines and research areas where the focus of the research is drifting towards the representation, the model, rather than the phenomenon itself (Kallinikos 2012). Similar constitutive entanglements can be seen in computer simulations for car crash testing (Leonardi 2012) and the Black-Scholes model for option pricing in the financial market, where the representational model of the market gets a *performative* effect when the real financial market becomes more like the model as millions of finance actors acts as if it was real (MacKenzie 2006).

The constitutive entanglement is more entangled than email push on the overworked employees' BlackBerry. The BlackBerry can be manipulated, used, configured, reused and redesigned by its users, who can influence at least parts of the setup and use of their smartphone. Constitutive entanglements are also more entangled than Google's Page Rank algorithm as a search engine. The Page Rank algorithm builds the result of people's link behavior into the technical algorithm, hence the result is a sociomaterial entanglement although the algorithm itself enables us in principle to see how the entanglement comes about. The space for action lies, however, with Google even though many web editors do their best to outsmart them.

We think these examples describe entanglements on different levels. It is a vast difference of space for action and change between the BlackBerry email push-entanglement, which leaves some space for action from a user, and the entanglement of nuclear warhead simulations, where reality cannot be discerned from the simulation. In the first case a person or a group of persons are able to intentionally change the entanglement for better conditions for themselves, in the second case this is not possible. It is only by analyzing the technical arrangements that we can see how the space for action is different in the two cases, hence we argue that knowledge about technical characteristics of an entanglement should be an important dimension of sociomaterial analysis.

We suggest reserving the notion 'entanglement' for constitutive and performative entanglements like the nuclear warhead testing, and the notion 'imbrication' for the BlackBerry email push. When looking for a space for action and improvement the imbrication offers openings for a place to start. Google Page Rank comes somewhere in between, but on the imbrication side even though only Google controls the space for action.

For a designer, the difference between entanglements and imbrications is important for finding a space for designing better work and life conditions for other people who will use the technology.

5   Disentangling for intra-actions

Disentangling implies creating a way by opening up for different intra-actions. Barad (1999, p. 5) defines intra-actions as "the inseparability of objects and agencies of observations". The agencies get defined by the agential cut through intra-actions that mutually constitute the phenomena we observe and conceptualize within the sociomaterial entanglement.

Disentangling does not imply separating the social and the material, but looking for possibly better intra-actions to *harness the agencies* involved to improve life and work conditions. If we want to create spaces for action and improvement, people need to know where to start acting. Such openings are neither given nor obvious, but must be sought after or constructed. The entanglement can be in the eye of the perceiver: if some tax knot looks like it is impossible to handle, it becomes de facto not handled. Looking more carefully and stubbornly might uncover openings for action of the kind "I can at least try to send in some documentation for my claim". This might solve the issue, or it might reveal that there is still some other problem.

Let us go back to the BlackBerry user wanting to change the current settings of his smartphone in order to avoid email push. The action is quite simple when you know: (1) that it is possible to turn off the email push, (2) where the off switch is located, and (3) how to perform the operation. During the "turning the email push off" operation the focus of the user is on the Blackberry artefact and its user interface (where the button is, how to push it). However, the clicking of this particular button has no meaning in itself: it gets its meaning only as a relation between the Blackberry settings, the email, the work, the family etc. in the user's life. Maybe the email push is the default setting decided by the telephone vendor – or the company policy – or just accidentally: these three options will accompany the pushing of the button in different ways: if email push is the company policy the Blackberry user will have to negotiate with his manager about turning it off. If it is set accidentally as a default, he may not have to do anything unless everyone else reads email 24/7 and he is not. Clicking the button is also intra-acting within the entanglement.

How can we talk about actions—and the space of actions—in sociomaterial entanglements? The fact that clicking the button makes us pay attention to the BlackBerry: how it is designed and how to operate it, does not make us not pay attention to its relations to other aspects of the context. When we search for spaces for action i.e. ways to alter technical, social, organisational, cultural elements of the situation we need to consider the BlackBerry as a relational part of a sociomaterial situation: not as something technical separate from the social.

In the BlackBerry example we can see that it is possible to talk about complex entanglements by addressing levels of entanglements: the individual clicking the button, the group of colleagues that read email 24/7, the organization—the company policy advocating being connected at all times, the society in which 24/7 services is seen as necessary. Entanglements stretching over several analytical levels are common, where the entanglement of entanglements may make the space for action smaller and more difficult to discover for the individual. Our analysis of the TICC advisors conversations with citizens can be understood as the TICC advisors operating on a 'higher' level of the entanglement, knowing and seeing more of the imbrications and hence more openings for action. Focusing on the entanglement as an activity would enable looking at the actions within that activity and the operations within each action as levels of analysis in

order to identify spaces for action. Disentangling may then be seen as a process of "constructing 'do-able' problems" (Fujimura 1987) aligning the action across several analytical levels.

6 Conclusions

We started our commentary in a sailboat. As sailors we appreciate the sociomaterial complexities which make up the joy of sailing. In this text we have argued that the notions of imbrication and entanglement are useful for talking about how the material elements of our sociomaterial practices play a role for understanding as well as changing those practices. Firstly, there is a difference between constitutive entanglements (like the quark) and entanglements that can be disentangled into imbrications. We may experience that constitutive entanglements become more common as complex simulations and models—representations—get performative power as they become part of and redefine the phenomenon they model (e.g., the finance crisis). Secondly, there are imbrications that are presented as or perceived as entanglements by people in a way that create problems for them. This is the point we have wanted to address: how do we create a space for action for people when they find themselves in the midst of an entanglement? We have argued that we can talk about degrees of entangling when it comes to how accessible they are to open a space for change and action. We can talk about levels of entanglements as a way of explaining how an imbrication became so entangled that it seemed impossible to handle. Moreover, we claim that disentangling does not happen along the social-material dichotomy: we see disentangling as intra-actions within different levels of entanglements.

There are numerous examples of seemingly technical details that can make a difference. In design we open up spaces for action but also close some action spaces deliberately (the ATM does not let us withdraw cash from somebody else's bank account, for example). As designers we must be able to discuss and learn from how people experience technologies in use – as elements in larger sociomaterial entanglements – because technology design is *our* space for action.

Before we close off we want to briefly remind the reader why we are concerned about the space for action and change. Our starting point for the discussion is how we can create conditions for autonomy for the citizens. Making one's own choices is basic for autonomy, together with being able to act upon the choices. Disentangling into an imbrication seems like a necessary element of a public service that appears as an entanglement: presenting public services as impermeable and incomprehensive—with no room for action—appears to act contrary to democracy.

7   Acknowledgments

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