Technologically Dense Environments: What For? What Next?

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Abstract: This conversation stems from and relies on the lectures presented by the three authors at the second STS Italia Summer School (2013 June 12-14, Ostuni, Italy). The text by Attila Bruni portrays in an impressionistic (and partly ironical) way the "genesis and development of a scientific fact", namely technologically dense environments (TDEs), sketching some of its basic characteristics and antescedents. Trevor Pinch, again in a personal anecdotal style, offers various examples of mundane interactions with technologies in dense and less dense environments, underlining how sociomateriality must always be unpacked, beside any innate or transformative properties of the materials themselves. Cornelius Schubert, finally, rather than closing the conversation, offers a case in point, focusing on improvisations in TDEs and, in particular, in medical practice.

Keywords: Technology; density; sociomateriality; improvisation; affordance.

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Technologically Dense Environments: The Genesis of a Scientific Fact?

Attila Bruni

The expression "technologically dense environments" (TDEs) has been gradually defined on several occasions, while (at the same time) offering the excuse to activate such occasions.

The last one was the summer school organized this year by STS Italia. But the first one was the fieldwork carried out for my doctorate thesis. This was centred on telemedicine and, in particular, on shadowing the introduction of electronic patient records (EPRs) in the oncology department of an Italian hospital. I thought that I would observe the prob-

lems and difficulties that usually arise when a group of actors begin to relate to a new technological object, but I noticed something that I found more interesting. Not only were the humans required to learn how to handle the new technological tool, but they also had to ensure that the latter 'got on with' the plethora of already-existing technologies in everyday use, both in the department and in the departments with which oncology is usually connected (radiotherapy, for example, or the blood chemistry laboratory). Having just undergone a cure based on ANT-CoP (which could be the name of a drug but instead is the acronym of Actor-Network Theory and Communities of Practice), I began to think of the EPR as a new s-object[1] encountering (and being socialized to) a more composite 'community of objects'. The EPR appeared to me a 'newcomer' in the already-existing 'community of objects' (made up of drugs, blood-test results, radiographies, and so on) which marked out the material boundaries of everyday work in the Oncology Department. I began to see the EPR as 'contending' with this community for its practical relevance and 'negotiating' with the objects already present in the organization for spaces of action. In a non-reflexive manner, as if it were a simple matter of fact, I then began to use the expression 'technologically dense' to denote the type of practices and environment that I was observing (Bruni 2004, 2005a, 2005b). After all, given the entire tradition of STS studies, it seemed to me that authors much better qualified than myself had already declared that the contemporary world is characterized by 'technological forms of life' (Lash 2001) and by an 'object-centered sociality' (Knorr-Cetina 1997).

Years later (and this was the second occasion), I was involved by Silvia Gherardi in writing a book on the study of work practices (Bruni and Gherardi 2007[2]). I was therefore pleasantly surprised by the proposal to put the expression 'technologically dense' (referenced to me!) in inverted commas, to indicate it as one of the distinctive features of contemporary work environments (and therefore of the practices that take shape within them). Also in this case, the expression was used as if it referred to a matter of fact, but the inverted commas emphasised its somewhat less irreflexive use.

The third occasion came in 2008 during the second national STS Italia conference. Together with Manuela Perrotta I organized a thematic track entitled "Working and Organizing in Technologically Dense Environments." We received around ten submissions, some more attuned, others

[1] By this trick of words, I intend to stress that objects, like subjects, always stand in relation to a social world, so that 'observing' a s-object means looking at the relations of which it is part, the contexts in which it is located, the practices that construct it socially, and the other s-objects that cross its trajectory (Bruni 2005a).
[2] Updated and authored by Silvia Gherardi, the book is now available in English with the title: *How to Conduct a Practice-Based Study*.

less so, but in any case signalling that the expression had a minimum of meaning for others as well.

One year later I was invited by Francois Cooren, at the University of Montreal, to discuss the doctoral thesis of Consuelo Vasquez, and I had the occasion to hold a seminar within the research group to which Consuelo and Francois belong. In an attempt to present something sufficiently original, I decided to make TDEs the subject of my paper. This obliged me to come up with a definition of TDEs. I started with the individual words. As regards 'technology', I resorted to etymology (*tekhne* + *logos*, crafts + knowledge), as for that matter do McKenzie and Wajcman in the introduction to *The Social Shaping of Technology*; 'density', according to the Oxford Dictionary, refers to "the degree of compactness of a substance"; by 'environment' I meant the surroundings (or the ecology of elements) in which action takes place. I sought to concentrate on 'density', as a term able to express both the quantity and quality of relations that arise among a set of elements. I framed the idea of TDEs as a 'sensitizing concept' (whilst defining concepts furnish instructions on what to see, sensitizing concepts suggest directions in which to look - see Blumer, 1969). I then identified three characteristics that, in my opinion, define TDEs:

- working implies complex sociomaterial practices and a specific technological know-how;
- human actors and technological objects work 'together';
- interaction is made possible by technologies and time and space are reconfigured on the basis of such interactions (and technologies).

I then provided some concrete examples of TDE. The first that came to my mind was a coordination centre (Engerstrom and Middleton 1998; Luff et al. 2000). Going somewhat back in time, however, also Laboratory Studies (Latour and Woolgar 1979; Lynch 1985) furnish good examples. Moving to the present day (and to recent developments in the STS debate), the most effective example seemed to me that of financial markets (Knorr-Cetina and Preda 2005). Finally, I cited medical settings, which I undoubtedly know best and which first suggested the idea to me. In regard to these settings I provided a series of detailed ethnographic examples. I concluded that the notion of TDE refers to:

- the stratification of texts, architectures, knowledges, objects, and technologies that characterizes an organizational environment;
- the essential (and practical) proximity between the 'functioning' of technologies and the 'functioning' of work;
- the heterogeneous and scattered dimension of working and organizing;
- the constitutive (in ethnomethodological terms) role of technologies for working and organizing.

Elaboration of the concept (if it can be described as such) was still in an embryonic state. But during the seminar I received comments, criticisms and stimulating suggestions. Above all, nobody disputed the idea of TDEs; rather, all those present seemed to grasp the idea intuitively and had something to say on the subject.

The fifth occasion was the EASST conference organized in Trento in 2010. In this case, Manuela Perrotta and Maurizio Teli organized a thematic track on TDEs and thus gave international visibility to this new 'label'. As part of the track I gave a paper, at the end of which a colleague asked the so-what question: "Ok, we live in a technologically dense world. Didn't we already know that?!". Probably yes, I replied, but it is precisely for this reason that it is interesting to study how this technological density is constructed, performed, and practised. Fortunately, at that point the bell rang for the coffee-break.

While waiting to find the time to write a rigorous article on TDEs, and in an attempt to involve other interested researchers in discussion of the idea, I actively constructed the next occasions. Together with Manuela Perrotta and Anne Mayére, I organized a thematic track on TDEs at the 27th Egos Colloquium (in Gothenburg, 2011), and whose call for paper received a good response. In particular, Carsten Østerlund (Østerlund et al. 2011), Jon Rennstam (2011) and Cornelius Schubert (2011) sought to 'operationalize' the idea of TDEs and show its heuristic potential[3]. Then, together with Cornelius, I organized a track at the 4S/EASST conference held in Copenhagen in 2012, which received a limited number of submissions but all of great interest and targeted on the topic. Above all, they all sought to give concreteness to the idea of TDEs and to define it more clearly. Personally, this was the occasion on which, above all thanks to my discussions with Cornelius Schubert during organization of the track, that I was able to focus more closely on the need to conceive 'density' as something that emerges from the context and from its relations, not as a property of the environment or of those relations themselves. With a play on words, the technological density of TDEs is entirely to be demonstrated. Put otherwise, it is not enough that an environment comprise a large number of technologies, or that patterns of action require the use of various technological artifacts, for that same environment to be defined as technologically dense. It is necessary instead for technological density to emerge in relational terms as a problem, routine, or a spur to improvisation. In this regard, I shall now provide a brief example.

Around a year ago, I began research in an university laboratory of environmentary chemistry. The laboratory engages in analysis of atmospheric particulates. It conducts innovative research for which a standardized methodology and/or instrumentation does not always exist. Obviously, all activities in the laboratory are accompanied by some kind of technologi-

[3] A revised version of the paper by Jon Rennstam has been published last year in *Organization Studies* (2012, vol. 33, n. 1071).

cal instrumentation and (equally obviously) numerous situations arise in which the researchers must 'support' the correct operation of the technologies and/or make sense of the numerical values yielded by those technologies. It should also be borne in mind that, given the cost of certain technologies and the shortage of funds, in very early experimental stages the researchers must themselves construct makeshift instruments, whose definitive set-up (if the hypothesis to be tested proves sensible) is commissioned from specialized firms. Yet I would not cite this as an example of a technologically of dense environment. For this it is not an environment in which, by observing the technologies, one can understand the nature of interactions and work organization practices (which I instead began to think resided in the dynamics of taking the laboratory in the environment and the environment in the laboratory). From the point of view of the actors involved, the technologies available to them were simply tools and, as such, subject to malfunctions and breakdowns, as well as having an entirely accessory role with respect to a much more complex activity, that of producing scientific knowledge.

It can certainly be objected that this is one of those situations in which technology is such a routine infrastructure for action that it becomes invisible to the researcher, because its 'density' may also obscure the practices and relations bound up in it. But the debate has just begun, and this conversation is only a further occasion to continue it.

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Sociomateriality and Technological Dense Environments

Trevor Pinch

Introduction

This essay has its origins in a lecture given to the 2013 STS Italia summer school held in a gorgeous and rustic atelier outside Ostuni in Puglia, Italy. My abiding memory of the workshop is one of the grad students, Joan Donovan, "desperately seeking signal" for her laptop. Under some definitions of technology we were definitely in a technologically sparse environment. But the environment was rich in the mundane technologies needed for nurturing a wonderful social ambience. The mistral cooperated and kept the temperatures comfortable. The seating arrangements were cushions; the food was locally produced pastas; and the drink was wine from the owner's own vineyard. Yes it was as close to heaven as you can get for academic encounters these days! I have deliberately kept

the style of this essay informal, merely polishing the text of the conversations we had at the workshop. The personal anecdotal style I find works best in teaching, so it runs throughout this essay. We as academics are first of all story tellers. Some of the crucial terms I will be referring to are technology, materiality, infrastructure, sociomateriality, affordances and scripts. Bruno Latour first discussed some of these terms in a provocative way, in an article he wrote about the missing masses and the sociology of a few mundane artifacts (Latour 1992). Bruno too likes storytelling and one version of that piece was originally framed as an account provided by a fictitious engineer called Jim Johnson, from the Colorado School of Mines. As with so much in our field, there is more to say than Bruno said. But I think the genius of that early piece was how Bruno/Jim took objects he encountered in his everyday life - doors, grooms, seat belts, speed bumps and so on – and weaved them into little stories which made them analytically interesting. In this essay I shall try do something similar. I shall describe my encounters with various mundane objects and try and see what lessons we can learn.

1. Dense and Sparse Technological Environments?

What makes an environment technologically dense or for that matter "sparse", clearly depends on your definition of technology. For instance on some definitions of technology languages are technologies and since that is the one thing all humans share then clearly all human environments are technologically dense. Defining technology is notoriously tricky. As Leo Marx has pointed out, the definition has changed throughout history. Back in the times of the ancient Greeks the word *tekhne* was used to describe the mechanical arts, but for some influential thinkers about technology (e.g. Heidegger) the *poesis* involved in the craft of pottery is very different from a technology which *enframes* humans. Karl Marx in *Capital* (Vol. II) avoids the word technology altogether preferring to talk about machines. The word technology starts to gain salience in the late nineteenth century when technology came to refer to what Thomas Hughes called "large scale technological systems" such as the telegraph, the railroad, and electric power. This meaning of technology captures not only the material systems but the new sorts of managerial skills needed to run such systems and turns engineers into what John law calls *heterogeneous engineers* who must deal with the managerial, social, economic, political as well as the technical aspects of systems. Leo Marx notes that even with the founding of MIT in 1861 technology had not yet stabilized as a word. Today technology is often associated in the media with particular devices such as cell phones, computers and the like.

A working definition of technology comes from MacKenzie's and Wajcman's classic book (1999) *The Social Shaping of Technology* where technology is defined as involving three aspects: knowledge, artefacts, and

practices. Most definitions of technology need to capture the human enabling quality of technology and it is this which separates technology from simply material stuff. A piece of wood worked into the case of the minimoog electronic music synthesizer is a material artefact, part of a technology, whilst the walnut tree growing in Robert Moog's garden in Trumansburg, New York, from which the wood was cut is simply part of the material world. Animals, of course also make use of the material world and some theories of material agency would also want to grant similar powers to animals. Indeed within science studies, "multispecies ethnography" is in vogue. The important notion of "affordances", as first suggested by psychologist James Gibson (1986), was developed as part of an ecological approach which included animals. Thus Gibson talked about a tree giving animals affordance to climb to safety. If animals use of the material environment is considered part of technology then we will find TDEs everywhere we encounter bee hives and termite mounds!

We will return to affordances later in this essay, but for now I want to suggest that it is the knowledge aspect of technology which makes it hard to classify termite mounds and the like as technological systems and termites as heterogeneous insects! Whilst animals, such as apes, may use objects they encounter in the environment, such as sticks as tools, it is as far as we know, only humans who have the capacity to make and manufacture tools. Knowledge involves language and although animals have sophisticated communication systems it is arguable whether they have developed language.

2. The Material Turn

In recent years there has been a turn towards the study of materiality more generally in the academy. Scholars in fields such as anthropology, archeology, feminist theory, and of course subfields such as the sociology of finance all lay stress upon materiality. Crude ways of measuring which academic terms are trending, such as Google N-grams, also indicate the rise of the word material. And of course our own field of science studies has always laid claim to materiality. Madonna's song title "Living in a material world" has been stolen by at least two of us (Andy Pickering and myself). This interest in materiality when it is taken up by social scientists is sometimes expressed within the lexicon of "sociomateriality".

So what is sociomateriality? One definition is provided by organizational studies scholar, Wanda Orlikowski, who refers to it as 'the constitutive entanglement of the social and the material in everyday organizational life' (Orlikowski 2007, 1438). Taken seriously, sociomateriality is more than simply a fascination with the 'things' that shape or are deployed within human action, as found, for example, in the growing research agenda which examines artifacts and boundary objects, Rather, it is a serious attempt to understand how human bodies, spatial arrange-

ments, physical objects, and technologies are entangled with language, interaction, and practices in the doing of activities. It is a useful way of capturing what I see as the essence of TDEs – how humans interact with the material artefacts that make up technologies.

3. Making Invisible Infrastructures Visible

I live in a tiny little hamlet called Forest Home just outside Ithaca in what is called upstate New York. "Upstate" says it all – it is not New York City, it is somewhere up the state. It is rural and as we like to say about Ithaca where Cornell University is located - it is "centrally isolated". But we manage.

Now Forest Home is a beautiful little place and our little hamlet has its own housing association quaintly called "The Forest Home Improvement Association". Life is good but not as good as in Southern Italy. There is always room for improvement. So citizens volunteer for the Improvement Association. One of the mundane examples I want to talk about comes from involvement with this organization.

I was attending a meeting of the Ithaca Town Planning Committee, when a rabbi from Cornell University proposed that our town be surrounded by an invisible wall - a very special form of wall known in Jewish Law as an *eruv* (the Hebrew word for mixing or blending). An *eruv* surrounds a space with a series of symbolic gates (as to a temple) and enables a blending of the public and private space within. Once in existence, this invisible wall gives the space within it special religious significance, a form of virtual temple, and allows Orthodox Jewish religious observances to be carried out in an easier way. It would permit an Orthodox Jew, say, to take property from his home that would not normally be allowed on the Sabbath.

So the Town of Ithaca got down to considering the rabbi's request. The first problem is that building an invisible wall turns out to be a non-trivial matter. The *eruv,* the rabbi explained, must consist of a continuous wire around the space with columns hanging from it at certain fixed intervals to symbolize the gates. An immense stroke of good fortune is, however, on the side of the modern *eruv* builders. Most cities and towns are already surrounded by wires with columns attached to them - telephone poles and power lines! The rabbi pointed out that the necessary wires and poles could be cleverly adapted for *eruv* purposes. There was one problem. Jewish Law stipulates that the poles should be placed precisely under the wires - a position to be determined exactly using laser measurements.

Part of the job of town planning committees is to make the normally invisible infrastructure of towns visible. In other words to make mundane artefacts a little bit less mundane. The first issue to be addressed at any

such gathering is money. How much will this cost? The Town Supervisor clarified with the rabbi that it would not cost the town of Ithaca anything as all costs were to be born by the Cornell Jewish community. But members of the committee were worried about other aspects. Wasn't there meant to be a strict separation of church and state? The town clerk had diligently gone on-line and circulated a case of a *eruv* in Palo Alto which had been opposed on exactly these grounds. "What if a less benign religious group wanted to nail crosses to every telephone pole in Ithaca?" asked one member of the committee, who prefaced his remarks by stating that he had been brought up Jewish and "to be frank I find the whole idea of a *eruv* silly". The rabbi had his reply ready. He understood where the criticism was coming from but the *eruv* demanded no precedent because it was simply allowing religious people to do what secular people did all the time. In short it permitted something secular to happen rather than prescribing something as religious.

The Town lawyer then spoke. She had researched other cases and felt that the Town could maintain its discretion in the future to ban any less benign walls. But members of the planning committee still felt uncomfortable because the request came from a specific religious group with a specific religious purpose in mind. The discussion wandered over the exact wording of the request and whether other religious groups would tolerate the wall. The lawyer questioned whether the wall would break local signage ordinances – Ithaca has strict rules about signs being posted on telephone poles and this looked like a sign. No, argued the rabbi, it wasn't a sign because it was invisible to most people. The lawyer came back; the definition of a sign is something that conveys information and since the wall will convey information to some people it could potentially be a sign. The committee decided further investigation was required. Someone whispered in my ear after the rabbi had left. "If God was really omnipotent he wouldn't be fooled by this fake wall anyway!" The last word as always was with God.

In the ten-minute discussion the Planning Committee had ranged over some of the most salient issues in sociomateriality. The example reminds us again that technologies carry no intrinsic meanings. Their meanings are always to be found amongst social groups who interact with the technology and share a meaning of the technology. Most people share the meaning of poles and wires as carriers of part of our technological infrastructure – power lines and telephone lines. Such objects are mundane and we barely notice them. Now a new meaning of the poles and wires was being asserted; that they also carried religious significance. This meaning was shared amongst a specific social group - namely Orthodox Jews.

In the case of the *eruv* it is important to note that, although the meaning of the technology is mainly symbolic, materiality is involved. The wires and pipes need to be precisely aligned. In short "religious functionality" requires its own non-trivial material alignment. Measuring each pole with laser equipment and retrofitting if necessary is a huge investment in

time, technique, and money. Furthermore technologies and their meanings do not exist detached from the rest of society, its institutions, culture, and the vast assemblages of technologies and humans we have already built. This point is nicely illustrated by the Planning Committee's discussion which ranges over economy, law, religion and the nature of signifiers.

4. Affordances Revisited

The example can also be used to exemplify a very common way of dealing with how mundane technologies interact with humans, namely affordances. As I mentioned earlier, this term comes from Gibson and has been extended by Don Norman (1990) as a way of ascribing some sort of agency to mundane objects and technologies. The chair is used for sitting and therefore affords seating. Now there are many problems with affordances. The word itself with its economic overtones is a weasel word – it is very vague to talk about what can or cannot be "afforded". Can I afford to buy a new car, for example, is a complex question. It is clear also that an affordance is a relational property depending upon the relationship between an object and someone using that object. Affordances also don't only "afford" – they prevent, prohibit and protect. The electrical power lines around my town give affordance to people who want to use power in their homes to run electrical appliances and so on. But by being raised up high on poles the power lines protect people from being electrocuted. We could express this property as giving them the "affordance" to travel in safety. This form of protection again is relational, depending upon the user. This was brought home to me by a family accident. One of my cousins likes to sail and forgot to lower the mast of the boat he was launching when he passed under some power lines. He was electrocuted and as a result today only has three fingers. The protection afforded by power lines does not apply to very tall people or people launching sailing boats! In other words built into every affordance is a particular sort of user.

Work on affordances needs to be tied in with user studies in S&TS (Oudshoorn and Pinch 2003). It is clear not only that technological artefacts have more than one affordance as the *eruv* example reminds us, but also that new affordances can arise in the context of use. For example, the affordance of the early motor car as a stationary source of power was something that only developed in the context of use (**Kline and Pinch 1996**). "Affordance" is an overly passive term as the issue of new uses of technologies reveals. It is not that affordances are waiting to be discovered in objects – the creation of a new affordance is often a struggle involving active work by users. The disappearance of an affordance, or the non appearance of an affordance that should be there, is also worth reflecting upon. It was a power play by Henry Ford and the Ford Motor Company

that helped kill the affordance of using the car as a stationary source of power.. Affordances can thus involve politics.

"Affordance" as a term, in short encourages sloppy thinking. It is often used as a convenient short hand, particularly in information science, to describe the functional attributes of a piece of technology. You will read that the internet provides the "affordance" of remote access, cutting and pasting, and copying. But as soon as one examines the particular use of a technology in context, say using the internet in Iran or copying an iTunes music file several times, you are reminded that it is only a shorthand.

We clearly need terms for describing how humans interact with technologies and the material world. The key issue for me is that even if we want to use a term like affordances, the affordances of a technology (including what it will permit and prohibit) can only be made visible and stabilized within the complex social setting of the mundane technology. Whether the retrofitted poles afford religious functionality or the mechanical functionality of carrying power and telephone lines or both or yet other affordances can only de determined by looking at the precise cultural and social setting within which these technologies are embedded and used.

5. Scripts

"Scripts" as introduced by Madeleine Akrich (1992) is another way of thinking about the same issue. Scripts can be read from an object and she allows for the possibility for objects to be "descripted" and "rescripted" in the context of use. This is a more satisfactory way of talking about the interaction between humans and non-humans than the language of affordances. In the strong form of scripts argued for by Bruno Latour with his famous examples of sleeping policemen and seat belts the danger is that the script is read from the object rather than the context of use of the object. This becomes particularly problematic when an intention is said to be embedded within a script or delegated to an object. The example of the sign "Slow down" which is replaced by a speed bump seems intuitively compelling because the sign (the intention) has been replaced by the material artifact which now "scripts" us to slow down.

An example I like to play with here which shows how complex this process can be is one where a sign replaces a material artefact. The case I have in mind is a peculiarly US one where American dog owners restrain their pets with a technology known as an "invisible fence". This technology is a wire which is buried in the ground around the owner's home. The dog is trained by wearing a special collar which administers a small electric shock when approaching the wire. Soon the dog learns to stay within the assigned area and the shocks can be replaced by sonic signals and

eventually the whole device works passively. Owners who employ this technology always put up a sign saying "Dog restrained by invisible fence". So in this case a technology - a fence - is replaced by a sign. But reading intention into the sign is problematic. My own enquiries into the meaning of the sign have produced many different sorts of readings and the intentionality implied. I have been told it is: (a) an advertisement for the invisible fence company, (b) a means of showing people that the dog is actually restrained in case they are scared, (c) a warning to people not to try and steal the dog, (d) a residue of a training exercise, (e) a legal necessity for liability purposes. No one told me it was a warning to be read by the dog! Obviously if we added in animal intentionality and behavior to the analysis, the case would become even more complicated because the fence is not "invisible" to the dog. The particular breed of dog may also be important – a rotweiller requiring perhaps more symbolic restraint than a playful poodle. This example reminds us again that the language of scripts only works with close attention paid to specific users and the context of use.

6. What to do with a Limp Clipcard!

I will introduce one last example to amplify these points. Prepaid "stripcards" or "clipcards" are commonly used to pay for rides on trams and subways in the Netherlands and Denmark. You typically pay for a number of rides in advance and each time you take a ride you "clip" your card at a machine. In a way this technology fits nicely the Latourian story of delegation. On buses in the UK ticket collectors (known as "clippies") used to "clip" bus tickets by punching a hole in them. In Denmark a machine, into which the card is inserted automatically, reads and "clips" the card (by removing a fixed part of the edge corresponding to one journey or a segment of a journey).

When visiting Copenhagen I regularly use such a card to pay for my trips on the very fast and efficient subway. On a recent visit I had one last journey to make to the Copenhagen airport from my hotel in the middle of town. I planned to use my clipcard as I had just enough segments left on it. Because I had a heavy bag I used the elevator to enter the station. On my way into the elevator I lent a hand to a woman having difficulties getting her pram inside. Once on the platform I tried to use my clipcard, but the machine would not clip it – the card had become limp from being bent over in my wallet. I struggled with the machine before the woman I had earlier helped noticed my problem and came to my rescue. She showed me with a knowing smile what to do: spit on the clipcard! I did just that and lo and behold the machine "accepted" my card and I was able to complete my journey legally and happily!

What do we make of this vignette – this little ethnographic encounter with machines? The normal use of the clipcard could be described as a case of affordances or Latourian scripts. indeed we might rename the card a "script card" in honor of Madeline Akrich! The card and card clipper give affordance to the journey. The card is scripted to be inserted into the machine and receive the requisite clipping. But a crumpled or limp card breaches the material script for which both card and machine have been designed and which are necessary parts of the sequence of actions to legally board the train.

At its most fundamental we see that the actions of the woman is in repairing the script, which had been breached by the breakdown of the interface between the card and the machine. That is, the designed affordances or scripts that enabled connection between the clip card and the machine reader have broken down, thus preventing the material script of actions encoded within them. The woman simply uses other material possibilities, such as moisture, to make the repair. It is in no way exceptional; the woman knew exactly what to do as a practical everyday behavior to enable action to continue.

Repairing is itself an important aspect to consider in understanding the situated interaction between the social and the material. But we need to look beyond the specific instance of repair to fully understand sociomateriality in context. We cannot understand this social activity of accomplishing the boarding of a train, if we do not consider the multiplicity of context and action implicit within it. First, the very act of repairing is uniquely situated within its cultural context; Danes know that clipcards sometimes fail and also what 'usually works to fix the problem (they have other ways of repairing the situation). Second, the action was facilitated by the social interaction that preceded it – the materiality of the pram and elevator through which the association was brought into being and which facilitated the woman sharing her tacit cultural knowledge of how to repair a perceived breakdown of human and material interactions (not to mention conventional gendered notions of politeness, would I have as willingly helped a man struggling with, say, a huge keg of Tuborg?). Third, which material affordances and scripts should we privilege to explain this incident: the pram, the elevator; the clipcard; the wallet in which it became crumpled; the ticket machine; the boarding of the train; or the broader Danish context within which the design of the clipcards, their possible breakdowns, and their knowledgeable repair are entangled? Of course, none can be privileged. They are all part of accomplishing activity with materials (Jarzabkowksi and Pinch forthcoming). In order to focus on and explain the specific instance of repair we must of necessity explain the broader activity and surrounding materials within which that instance is situated, and without which it occurred. Even the intentions of the actors are not always clear. We impute that both actors in this encounter intended to help each other on their journey – but maybe their intentions were less clear. Maybe they intended to fall in love as in classic

movie stories of chance railway encounters. In such a scenario the spitting on the clipcard might mean something else altogether!

All these examples of mundane interactions with technologies in dense and less dense environments serve to remind us that sociomateriality must always be unpacked. As we focus upon contexts of use we observe reappropriation, repair and also improvisation. The agenda of technology studies will be best served by situating materials, mundane artefacts, and technologies within the accomplishing of activities in multiple contexts. It is these contexts and activities that best explain the interaction of the social and the material, rather than any innate or transformative properties of the materials themselves.

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Improvisations in technological density

Cornelius Schubert

Introduction

My input to the conversation seeks to connect the idea of technologically dense environments (TDEs) with the concept of improvisation as a form of technical practice.[4] The term improvisation carries a dual meaning. On the one hand, in its original sense, it positively refers to the artistic quality of situated performances which do not follow a pre-given script and often include the mastery of (musical) instruments. On the other hand, it has taken on a negative meaning of makeshift tinkering which implies the inability of doing something properly. The latter meaning typically prevails in technical settings, where improvisation is considered to be a partial fix and inferior to pre-planned control. The former meaning entails that improvisation itself is a form of mastery and this understanding is typically found fields like the performing arts. On the following pages, I will outline an understanding of improvisation in TDEs which draws on the positive notions of mastery and competence from the performing arts and which conceptualises improvisation as an essential aspect of working in TDEs. My reflections are set against a background of ethnographic observations during surgical operations (Schubert 2007) and conceive modern medical care as a prototypical technologically dense environment.

[4] I am especially indebted with the participants of the 2013 *STS Italia Summer School* for the fruitful discussion around improvisation, TDEs, and medicine.

1. Improvising as skilled and situated performance

Let us first come to terms with the manifold meanings of improvisation. The word was originally used in the arts, starting in the 18th century and referring to a situated performance that would not be rehearsed like classical script based theatrical plays or musical pieces (literally meaning "un-foreseen"). Improvisation was performed in front of small audiences and typically consisted of creative acts like thinking up a poem. This performance did not, however, come out of thin air. The improvising artists were credited for their skill and competence in situated creativity. From there on, different facets of improvisation have become a central virtue in many artistic fields, most notably jazz music (Berliner 1994). In jazz music, improvisation typically denotes the skilled and situated variation of existing musical themes by experienced players (Becker 2000). Yet, in different performing arts, different notions of improvisation can be found. Theatrical improvisations, for instance, often aren't variations of an existing theme, but stress the ad hoc creation of the play as it is performed. This brief glance at improvisation in the performing arts should suffice to highlight two core aspects of improvisation. First, improvisation is a *skilled art* which has to be learned, often over many years of training and experience. In contrast to the negative meaning of improvisation as a lack of mastery, it connotes a highly professional competence. Second, improvisation is a form of *situated conduct* which highlights the contingency and adaptations in concrete actions and interactions. Thus, it connotes the intentional deviation from pre-planned scripts or protocols.

Such an understanding of improvisation and especially the notion of jazz improvisation have been fruitfully extended within organisation studies (Weick 1998; Kamoche et al. 2002). The idea of organisational improvisation mainly serves as an antidote to prevailing assumptions about order and control in organisational theory. Weick, for instance, argues that assumptions about order make it difficult for organisational scholars to address issues of creativity and innovation, since they impose an overly rational model of organisational structure and process. In addition, improvisation implies a situation which deals with the unexpected and unplanned. This is not to say that improvisation lacks order. Rather, improvisation is a process in which a specific situated order is created.

We can extend this thought towards a more general understanding: Improvisation is a situated combination of already existing and newly created elements. It is a creative process by which a number of situated "givens", e.g. musical themes, instruments and knowledge are recobined and adapted according to an ongoing situation. It is a process through which the situation itself is instantaneously created. But it would be wrong to equate improvisation with simple spontaneity or creation ex-nihilo. What makes improvisation an interesting concept is the creative relation of the old and the new. In such broad terms, improvisation is in

effect an essential aspect of all human action, since we are always faced with open ended courses of action and the need to adapt to changing environments, be they natural, social or technical.

2. Improvising in technical settings

Even though jazz improvisation provides a fruitful point of departure for discussing improvisation in technological dense environments, it may also be misleading in some ways. I will point out two critical issues. First the idea of the human mastery of a technical instrument and second the idea of improvisation as an end in itself.

Jazz improvisation is a capability of highly skilled experts and requires years of training and experience. This is an important point to note, since it provides the argument against notions of improvisation as inferior makeshift tinkering. At the same time, expert jazz improvisation implies the mastery of the musical instrument (Becker 2000). The instrument has to "withdraw" in a phenomenological sense (Heidegger 1996 [1927]: 65), so that the musician may exert full control over it. Only if the instrument has become "at hand" ("zuhanden" in German, ibid.: 66), i.e. if the musician can essentially forget about how he or she has to play the instrument and is therefore able to focus on making music, will improvisation become an artful and creative mastery. In this understanding, the creative aspects of variation solely reside on the side of the human musicians and improvisations in effect become a one-sided perspective, privileging the creativity of humans while depicting instruments as functional appliances. But as Heidegger has also noted, tools must not necessarily withdraw to be only ready at hand – rather they may become conspicuous, obtrusive or even obstinate in use. Indeed, some forms of musical improvisation, like experimental electronic or ambient music, use "malfunctioning" instruments or random sounds in order to create unexpected elements in their music. Even if this essentially returns a malfunction into some form of functionality, i.e. the creation of the unexpected, it counters the notion of mastery and withdrawal. In other genres, like drone metal, electric amplification and feedback are used to create lasting soundscapes (drones). The minimalist improvisations of drone metal point to the material arrangements required to create such sounds and highlight the artists reflexive engagements with the instruments during improvisation. In both cases, the locus of creativity is shifted from the solely human side towards a distributed creativity between instruments and musicians. This form of improvisation might be closer to improvisations in TDEs, where tools or instruments may resist intentional human action (Pickering 1993) and must be considered not as functioning appliances but as unruly technology (Wynne 1988) or clumsy golems (Collins and Pinch 1998).

The second and more important difference between musical improvisation and improvisation in TDEs is that artistic improvisation is an end in itself (the opus operatum), whereas improvisation in TDEs is a means for ensuring a more or less stable flow of work (a modus operandi). Improvising in TDEs means to cope with the numerous contingencies and complexities by repairing, adapting to or working around more or less unexpected disruptions in the planned course of events. In contrast to artistic fields, where improvisation is explicitly made visible (or audible), improvisation in TDEs largely remains "invisible work" (Star and Strauss 1999). This is not to say that improvisation is not valued at all. Especially experienced practitioners know about the necessity and skilfulness of improvising in technical settings and many ethnographies of work have highlighted the importance of such "repair work" in various fields (cf. Strauss et al. 1985; Orr 1996). So, even if improvisation in TDEs is not an end in itself, but rather a mode of conduct, it is by no means a negligible aspect of work. Instead, it is a constitutive element of all technical activities. This also means that we should not conceive of TDEs as clean and functional settings, but rather as more or less messy places which continuously provide for unexpected situations and call for adapting the course of work to situational contingencies. Increasing technological density thus cannot be equated with increasing integration and alignment, but should be conceived as increasing heterogeneity and the disorderly layering of manifold technologies one over another. In case of medicine, for instance, diagnostic instruments or monitoring technologies overlap with documentation systems and administrative infrastructures. All these different technological layers are enmeshed with each other and unforeseen connections between them are likely to grow as they are used in practice. Under such conditions, improvisation denotes the skilful articulation of all these layers for creating a situationally ordered sequence of events (cf. "articulation work" in the hospital, Strauss et al. 1985, pp. 151).

Let us briefly reconsider the argument so far. Building upon the idea of artistic improvisation as skilled and situated performance, a general concept of improvisation was put forward which does not equate improvisation with mere spontaneity or the absence of order, but with the competent adaptation and situated creation of order in the relation of the old and the new. In a second step, the specifics of jazz improvisation were critically discussed with regard to improvisation in TDEs. In the latter case, improvisation was conceived as a mode of conduct in dealing with unruly technologies. Following this line of thought, improvisation is neither an inferior mode of conduct compared to pre-planned control, nor is it a simple functional addition to otherwise rational technical procedures. Rather, improvisation itself combines different modes of routine and flexibility or repetition and creativity. It is skilful, situated, technically mediated and embodied, drawing both on explicit as well as implicit knowledge. Extending the concept from the performing arts to technologically dense environments highlights these features of a professional

practice, which essentially exists in the intentional and controlled deviation from standardised procedures. With growing technological density, as messiness and unruliness increase, TDEs do not withdraw into being ready at hand, but constantly challenge prefabricated scripts and demand situational adaptations. Stretching the metaphor a little, we could say that the instruments in TDEs in a way tend to play their own songs (like in drone), than that they are being played (like in jazz).

3. Modern medical practice and technological density

In the last step, I will relate the concept of TDEs and that of improvisation to the specifics of modern medical practice. In order to do so, I will provide answers to two questions. First, can we speak of modern medical practice as a technologically dense environment? Second, what implications does this have for our use of the term improvisation?

Let us begin with the question, if medicine has become technologically more dense. It can easily be argued that medical practice has always been technically mediated and socially organised. This way, medicine can be thought of as having always been technologically dense, at least since the invention of stethoscope and thermometer. The increasing number of diagnostic and therapeutic instruments over the last 200 years would then warrant the claims that medicine has become technologically more dense and that the organised settings of modern healthcare indeed constitute prototypical TDEs. However, a mere increase in instruments is not sufficient to make this claim. Technological density is not only a matter of quantity but more importantly of quality. Because technological density more often than not creates a messy state of affairs, it does not necessarily lead to frictionless integration, but to increased fragmentation and the continual need for conversions between the different layers of technologies, e.g. between circulating pieces of paper, heterogeneous electronic infrastructures and instruments and last not least, bodies.

In case of modern medicine, technological density then does not simply imply an increase in diagnostic, therapeutic, and administrative technologies, but leads to manifold interdependencies between them. Information infrastructures, such as medical records, fuse diagnostic data with therapeutic trajectories and cooperative workflows (Berg 1996). In these cases, it becomes increasingly difficult to distinguish between the epistemic and coordinative aspects of work, i.e. between diagnostic and therapeutic knowledge and administrative procedures. Modern computerised information infrastructures in a way constitute the backbone of many TDEs and this is also true for medicine. A TDE then is not a mere surrounding or frame for the actions and interactions taking place, rather, TDEs constitute basic situations which shape and are being shaped by ongoing work practices. Ogburn (1922) once noted that humans must not

only adapt to a natural environment, but also to a social environment and increasingly to a technological environment. In contrast to the former two, the technological environment is in constant and rapid change. It would thus be wrong to equate a technological environment with stable frame or surrounding. TDEs like medical care are in transformation, they change and evolve along with the work that is being carried out within them.

But how does this relate to improvisation? Interestingly, the term improvisation is also used in medicine. In the late 19th century it was borrowed from the arts to describe the specifics of medical practice under the conditions of sparsity, e.g. in military field hospitals (Cubasch 1884). Improvising was considered to be an aspect of practicing the art (sic!) of medicine without the resources of a fully equipped peacetime hospital. Even though improvisation was – and still is – considered part of the art of medicine, it is strongly linked to situations of sparsity which are technologically less dense than those of routine medical practice. Improvisation and material abundance thus do not seem to go well together and improvisation might only occur in situations where other things become sparse, e.g. the lack of time in emergency situations. Thinking of improvisation mainly as an emergency procedure, a deviation from the norm (no matter how artistic), however, falls short on two accounts. First it would imply that improvisation in TDEs is the exception and not the rule. From the perspective of complex density outlined above, this hardly seems to be the case. Second, it would overemphasise the creative aspects while neglecting the routine structure of improvisation itself.

Finally, this leads us away from the question *if* improvisation occurs in TDEs towards the question *how* it occurs. As a conceptual tool, it makes us sensitive to the interrelation of routine and flexibility, to the experience and skill required to competently improvise, to the relevance of material artefacts, bodily senses and informational infrastructures. It also leads us to questions how improvising is practically legitimated and sanctioned in different TDEs and in how far the TDE itself provides and allows for different forms of improvisation. Medical practice, as Parsons already noted, is inherently uncertain and calls for manifold mutual adaptations of standard procedures and non-standard patients, doctors, and nurses (Timmermans and Berg 1997). Related to this is the question of how improvisation can actually be learned or trained for. Unlike the performing arts, where improvisation is an end in itself, improvisation in TDEs is a modus operandi where the deviations from standardised procedures need to be accounted for in other ways.

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