Doctoral Thesis Proposal

Sociotechnical Worlds: The Visions and Realities of Bodynets

(working title)

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SECTION 1

PEOPLE and ARTEFACTS:

CONCEPTUAL FRAMEWORK

My interests lie not so much in finding out about human-computer interaction, but have more McLuhanite character. I am interested in investigating the processes of adaptation, translation, negotiation and transformation that humans and artefacts undergo as a new sociotechnical setting is created. Two moments stand out as particularly important: the initial development of a prototype artefact, and that artefact's implementation. For my doctoral research I propose to study these two moments. The prototyping of bodynets provides important data regarding the visions and practices of those involved in its development. This prototyping is mainly conducted in the lab or in research departments of commercial entities. The implementation process takes place in a "real life" setting and constitutes the best moment to see the changes occurring as both individuals and artefact interact.

To conduct this inquiry I adopted a theoretical stance that permits me to see artefacts not as passive tools, but rather as active agents in the social world. In this way I am able to examine the deep mutual shaping between individuals and artefacts, between the social and the natural.

Such a conceptual perspective is informed by the two theoretical approaches that guide this study— sociocultural psychology and 'science and technology studies', or, 'science, technology and society' studies (STS). Sociocultural psychology emphasizes the mutual constitution of humans and nonhumans while maintaining their differences. It brings to the foreground the importance of studying bodynets. STS provides an analytical framework to observe and narrate the construction (and de-construction) of the sociotechnical. It shifts the attention from artificial

categories—humans and nonhumans, social and natural—to focus on their mutual constitution and relational agency.

In what follows, I will introduce each of these approaches, and examine their strengths, weaknesses and commonalties. This section is not a comprehensive review of these approaches, but rather an explanation of specific arguments drawn from these approaches that are useful in understanding my research.

'Science and Technology Studies' or 'Science, Technology and Society' (STS)

As may already be gathered from its generalized name(s) STS is not a unified or uniform body of theoretical approaches. Rather, it is an umbrella term for a group of scholars and theoreticians for whom "society is... [a hybrid that] is held together... by heterogeneous means. Or, to put it somewhat more radically, that the social is not purely social [but sociotechnical]" (Law 1991: 7). STS is, above all, a descriptive approach that arms its users with conceptual tools for portraying and analysing the 'world'.

Although most scholars acknowledge the differences between STS approaches, Bijker, Hughes and Pinch (1999) point out that they are held together by a few common tenets:[1]

[1] Other common elements, particularly those pertaining to methodology, e.g., the use of thick description or "deep hanging out" (Geertz 1973) in the process of data collection, will be described in the methodology section.

(1) The rejection of technological determinist analysis, which views technology as the force that drives and determines social and cultural change (e.g., Toffler 1980; Gilder 1989). The argument here is that once introduced into society, technology will bring about changes which are exclusively related to its own properties and can only be studied within the technology itself.

(2) The rejection of social determinism, which sees the original inventor(s) as the central explanatory concept of technological development, and emphasizes the role of society in determining technical change.

(3) The rejection of *a priori* distinctions between social, economical, cultural and political aspects of sociotechnical development.

Bjiker, Hughes and Pinch (1999) also identify three main streams within STS: social construction of technology (SCOT), actor network theory (ANT) and systems theory. Systems theory, developed mainly by Thomas Hughes, analyzes technological development and stabilization by stressing the connections between the artefact being built and the social, economic, political and cultural factors surrounding it. The systems approach was developed for—and has mainly been applied to—large infrastructure projects, such as the development of the electricity grid (Hughes 1983) or guiding systems for ballistic missiles (MacKenzie 1990). As such, it does not fit my research purposes. In what follows, I will focus on SCOT and ANT.

Social construction of technology (SCOT)

Social Construction of Technology (SCOT) is a descriptive and exploratory model developed from grounded data. Its intent is not to establish prescriptive or normative principles to be applied to any empirical study, but rather to inform researchers of concepts that can be useful in analysing and describing a

technological artefact. Its primary function is, in Pinch's and Bijker's words, heuristic: it helps highlight all aspects that are relevant for the researchers purpose (Pinch & Bijker 1984).

SCOT was formulated as such in the mid 1980s when Pinch and Bijker (1984), still two of its most prominent supporters, published the well-known article, *Social construction of facts and artefacts: The Social Construction of Facts and Artefacts: or How the Sociology of Science and the Science of Technology might Benefit Each Other*. One year later, in 1985, Mackenzie and Wajcman (1985) edited *The social shaping of technology: How the refrigerator got its hum* , where they collected the works of a series of scholars who had been arguing for a more nuanced approach to the relationship between social and technological development.

In spite of some renewed interest in this body of knowledge (at least three books on the subject were re-edited and re-published in 1999)[2] interest in this conceptual approach has been declining. Some of the reasons pointed to are SCOT's "neglect of the reciprocal relationship between artefacts and social groups" (Kline & Pinch 1999: 114) and the heightened role it attributes to the social (over the natural and technical) as a measure of explanation (e.g., Law 1999; Latour 2000).

On the issue of the mutual adaption of people and artefacts, Bijker puts forward the notion of *sociotechnical ensembles* (ibid), emphasizing the idea that the social and the technical are two sides of the same coin, and that this is *the unit* of analysis. However, Bijker has problems operationalizing this concept within the process of 'construction' of an artefact. The concept of sociotechnical ensemble seems to appear as an after-thought, not well integrated into the

[2] The Social Shaping of Technology (1999); The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology (1999) & The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology (1999).

theoretical/analytical framework.[3] More work needs to be done on the integration and operationalization of the notion of mutual constitution within a social constructivist approach.

This said, I think it important not to cast aside SCOT as a *passé* framework. SCOT is still being used and studied within academic circles (e.g., Klein & Kleinman 2002). Besides, SCOT and other STS approaches, such as ANT, overlap in a variety of issues (e.g., both are agency centered). I will base this analysis primarily on the work of Wiebe Bijker, one of the pioneers of SCOT and its most renowned spokesperson.

SCOT's main propositions

At SCOT's heart stands the notion of ***interpretative flexibility***, i.e., the belief that the meaning of a technical artefact does not reside in the technology itself, but is determined by the meanings—problems and solutions—attributed to it by those participating in its development. Thus, "the meanings given [to the artefact] by the different relevant social groups actually constitute the artifact" (Bijker 1999: 77). Whenever a new problem or solution is perceived, the artefact itself changes, implying a multiplicity of artefacts (ibid). As the artefact stabilizes or 'hardens', one meaning (and social group) becomes dominant and interpretative flexibility diminishes.

Bijker's analysis of the development the bicycle is illustrative. During the long process that led to its stabilization, some social groups described it as having a safety problem that required the front wheel to be made smaller. However, for others, the bicycle was a speed machine, and speed was better achieved with a

[3] This difficulty in operationalizing one of the core aspects of the theory is, perhaps, the main reason why SCOT has not been taken up by many other researchers.

larger front wheel. For this social group, falling was part of cycling and thus, it was not a problem (Bijker 1995).

Thus, when studying a technical artefact one is studying how its ***relevant social groups***—such as designers, developers, users, and opponents—imagine and shape it. These relevant social groups may be identified using two heuristic methods: the *snowball method*—in which one source of information leads to another; and by *following the actors*, a practice which will give the researcher more information regarding the actors' actions and beliefs.

For SCOT, then, an artefact's ***workingness*** is determined by the beliefs and practices of the *relevant social groups* involved in its construction, rather than from some inherent technical characteristic. Studying the beliefs and actions of these groups—and the artefact's interpretative flexibility—is how SCOT proposes to study the process of (socio)technical change.[4]

In order to operationalize and interpret the interactions within a relevant social group, Bijker advances the theoretical concept of ***technological frame***.[5] Technological frames guide both the thinking and the (inter)action within a relevant social group, and "include different elements [such as] current theories, goals, problem-solving strategies, and practices of use" (Bijker et al. 1999: 171).

A technological frame is formed whenever interaction around an artefact begins; it is found in the interactions among actors and not above them (Bijker 1999). Bijker's tentative configuration of technological frame includes elements such as goals, key problems, problem-solving strategies, requirements to be met by solutions, tacit knowledge, user's practice and exemplary artefacts.

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[4] As the interpretative flexibility of an artefact decreases, the process of closure starts leading to the artefacts' stabilization (or black-boxing). For more on black-boxes see subsection on *heterogeneous engineering.*

[5] Also called *frame with respect to technology* or *sociotechnical frame*.

The last point I want to stress is SCOT's handling of ***nonhuman agency***. As its name indicates, SCOT's approach is favorable to the idea of the 'social' directing the growth and stabilization of artefacts—a fact which explains the centrality of the notions of relevant social groups and their understanding of the artefact. However, Bijker does argue for the need to "extend 'the agency of others' to include the agency of machines as well as of human actors, because technologies can... be instrumental in realizing certain goals" (Bijker 1999: 262). Following a constructivist framework, Bijker is arguing for a definition of *agency* that focuses on the capability to shape the actions and reactions of others, but not on the ontological properties of the participants[6] (ibid). Yet again, this theoretical point is not really translated into the empirical research, where the notion of 'dominant social groups' take center stage.

Summary

SCOT's concept of technological frame is especially important for the study of the development of artefacts and the visions they are meant to fulfill. SCOT emphasizes the importance of the moment before the actual 'construction' of an artefact, and how this moment affects the subsequent shape of the artefact by highlighting how different beliefs, assumptions and theories about the world will play a role in the intended (final) shape of an artefact. SCOT operationalizes the various underlying elements that shape each different entity. SCOT is thus important to framing my case study.

Actor-Network Theory (ANT)

Actor-network theory is not a unified, stable and established branch of STS. Rather, it is an 'on-going' process. Like SCOT it is not being developed in the

[6] A fact that is crucial to differentiate between SCOT and ANT.

abstract, but based on empirical analysis. Its goal is not to provide solutions, but ways of looking at the world and our interactions with it.

ANT deals with two different, though connected, subjects: scientific facts and technological artefacts. It is, in a sense, a logical (yet highly disputed) extension of David Bloor's (1976) "strong programme" which defended the need for impartiality in the explanation of true and false scientific beliefs. ANT goes a step further, arguing for impartiality in the description of human and nonhuman actors, of things and non-things.[7]

ANT's main proposition is that the split between nature, society and artefacts is artificial in itself. Latour argues that modernity relies on the "complete separation between the natural world (constructed, nevertheless, by man) and the social world (sustained, nevertheless, by things)" (Latour 1993: 31). ANT's task is to reconnect these two spheres, not through the construction of bridges, but through observing the multiple networks that compose the social, and that, in turn, are composed of actors, human and nonhuman, which possess the same ontological status. For Latour, *the world is ontologically flat*, that is, people and artefacts are part of a continuum. Their differences, rather than pertaining differences in kind (to an ontology, to an essence that is given a priori), are differences in degree.[8]

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[7] Once again I stress that the goal of this section is not to provide the reader with an in-depth theoretical review of ANT, which would take much more time and space than is allotted here. My objective is to provide readers with the tools necessary for an understanding of the foundations of my own study.

[8] It is important to note that a 'soft' version of this same argument is made by contemporary sociocultural advocates. It is important to note that this notion has also been picked up by contemporary sociocultural psychologist. Wertsch (1998a), for instance, advocates that the establishment of dichotomies is bound to create notions of true/false. Instead, he says, it is useful for the purposes of research to see these terms as conceptual and theoretical tools.

Two important conclusions derive from this: (i) the need for the bringing together and leveling of the status of the actors involved in each of these spheres, and (ii) the study of the social as a set of distinct networks. It is within these networks, these sets of relationships, that we can understand the mutual constitution of the different actors. Human and nonhuman can only be understood one through the other. We cannot understand people without their artefacts, nor can we understand artefacts without a human context (Viseu 2000).

ANT's main propositions

In their remarkable analysis of baboon societies Shirley Strum and Bruno Latour (1987) conclude that the main difference between baboon and human social organization is that baboons rely solely on their naked bodies to create and enforce their views of society. The personal stories that together constitute the collective space start and end with the birth and death of each member. Society, thus, is constantly being created and re-created in every interaction. History, here, is as ephemeral as those who make it.

This does not imply that baboon society is simplified or homogenous. On the contrary, baboons do not passively accept society, they are constantly and actively testing and negotiating what it is and what it will be like. Baboons, like human beings, are ***active social actors***.

Strum and Latour (1987) argue that if the difference between baboon and human societies does not come from the abilities/nature/qualities of their participants, it must come from somewhere else. The difference, they claim, lies in the practical means available to actors to enforce their view of society, that is, on the artefacts and things, on the nonhuman. While baboons can only make use of their mortal bodies, intelligence and 'personal history' to enforce their views of what society is or should be, human beings can enforce and perpetuate it through their artefacts. In human societies physical presence is no longer necessary: symbols, institutions, texts and artefacts successfully extend human beings, replacing them

in the role of enforcing certain modes of social ordering. While baboon societies are regulated by the 'here-and-now', human societies are extended over time and space.[9]

Artefacts, then, constitute the social glue between humans. What makes humans "human" are material entities, and what makes the social "social" are nonhuman entities.[10] The social is constituted by 'hybrid' networks, or sets of relationships created among people through the use of artefacts. Without these artefacts, the relationships could not be established/maintained. ***The social is materially heterogenous***.

Hence, the distinctions between social and natural, between individual and collective are not ontological, but artificially constructed (cf. Latour 1992; Latour 1993; Callon & Law 1997). A proof of this artificiality is that the boundaries are not identically placed or defined in different cultures. For example, in Japan the distinction between 'me' and 'others' is often blurred (Markus, Mullally & Kitayama 1997); and for the Irku of the Eastern Sahara, the centre of a person's consciousness resides in the nearest Carob tree, not in one's body (Menteur 1928; quoted in Woolgar 1991). But, we do not have to look to other cultures for examples of the proliferation of 'hybrids' that cross the boundaries between the natural and the sociocultural. Our everyday life is full of such examples: we have, for instance, artefacts such as bodynets, implanted chips, artificial hearts and Prozac, and phenomena like global warming, all of which cannot be placed in the neat categories of social and natural.

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[9] This idea is neither new nor an invention of STS approaches. In the field of media studies Marshall McLuhan (1964) wrote extensively on the role of technologies as extensions of (wo)men, and of electronic media as extensions of the nervous system; Harold Innis (1951) explored how different media were biased towards time or space.

[10] In a wonderful critique of the state of social sciences Latour defines the social as "[an] adjective... [that] now codes, not a substance, nor a domain of reality (by opposition for instance to the natural, or the technical...), but a way of tying together heterogeneous bundles, of translating some type of institutions into another" (Latour 2000: 113).

Entities[11] (human, nonhuman, textual or symbolic) are neither an 'essence' nor fixed. Their boundaries are not given, but defined by their relationships. Their reality is the result of a process of compromise, transformation and negotiation among different actors. Thus, ***entities are sets of between heterogenous elements that materialize in the form of networks***.

Networks are sets of heterogenous relationships which connect, and in the process of connecting, define different entities. By being constituted of humans and nonhumans, networks are hybrid in nature: they are and create beings that straddle the boundaries of nature and culture. What an entity *is* is determined in its total existence, that is, in the network of relationships that sustains it. ***Network and entity are co-extensive***, i.e., they mutually constitute each other (cf. Latour 1991; Callon & Law 1997). And this network, as we have seen, is a hybrid, it is composed of 'active' heterogeneous materials. For instance, a bodynet is constituted by a network of different actors: a computing device, a chip that transmits data, at least one device that receives it, and a body. If any of these elements is missing, or fails, the bodynet no longer exists.

Finally, although entities are never so fixed they cannot change, not all changes are equally feasible. For example, a bodynet can be used as a surveillance tool, a health care tool, a communication tool or an orientation tool, but cannot become a transportation tool. However, what is feasible and what isn't is not predetermined, but decided in interaction.

Taken to its extreme this logic of 'reality' as a network of networks leads us to a point of infinite regression: If every entity is a network composed of other entities (and networks), when can we stop? ANT's answer for this question is that when one entity acts as a single entity, it may be regarded as such.[12] ***One stable entity***

[11] Used here as a synonym of 'actor'

[12] Although upon closer look it is actually a network.

is equal to one actor. Taking the above mentioned example, the bodynet can be considered one single entity the moment it is able to translate the interests—concerns, considerations, demands—of the different actors of which it is composed. However, if users are not convinced that the bodynet is safe, venture capitalists that the project will be successful, computer chips that they should always be reliable, and screens that they should work even when placed towards the sun, if one single actor is reluctant or recalcitrant, then the bodynet can no longer be considered as a single entity, but as a network of independent actors.

In order for a bodynet to stabilize, become a "black box",[13] or be considered one actor it needs to be able to translate the various elements that compose it. "It translates [these elements] by co-ordinating them, by fronting for them, and by standing for them in a simple and coherent form. This means that for the moment the fronted network acts as a single unit. It does not fall apart. And (again for the moment) that it can be distinguished from its environment, distinguished as an object with its own consistent identity" (Callon & Law 1997: 174)

Thus, when building a new technology engineers are not simply building a single device, they are working with an entire network of actors—social, natural, technological, etc—which will support and give "reality" to this new technological artefact. They are engaged in a process described by Law as "heterogeneous engineering". For example, when building a bodynet engineers and designers are putting forward not only a new artefact, but also a certain vision of society, one in which the use of bodynets will, for example, "make us more connected" (Lightman 2001). They are imagining a world in which, for instance, houses, buildings and public spaces are equipped with data transceivers; a world in which the need to be networked and online is vital for a full participation in society.

When designing a new technology innovators are forced to deal with a variety of actors. For example, deal with relations among humans (e.g., ensure that the

[13] Black boxes are "taken-for-granted elements (well-established facts, unproblematic artefacts) that can be employed, risk free, for a variety of purposes" (Latour 1987:398).

team is able to work together), relations among nonhumans (e.g., ensure that the software is compatible, there are no bugs or virus) and relations among humans and nonhumans (e.g., ensure that the bodynet does not have loose cables that can give its wearer a shock). In Latour's words the "innovator has to weave humans and nonhumans together by imposing the politest possible behavior on both" (1996: 72).

Mutual adaptation

As we have seen the process of mutual adaptation stands at the core of ANT's theoretical approach. Entities (human, nonhuman and symbolic) are defined in interaction. Their reality is built through struggles and compromises between actors. Humans and nonhumans are mutually constituted.[14]

It is not hard to get a sense of how technology affects and shapes us. A look at our lives at present—for instance, the constant checking of email, or commuting from home to work—are indicative of these changes. The contrary is also true, when building a new technology we are defining its character, we are defining what it can experience and how it reacts to this experience. To a great extent we are exchanging properties with it, with the hope that it can serve us or even replace us (e.g., automatic pilot). In a technological project "the anthropomorphic expressions must be taken not figuratively but literally: it is really a matter of defining the human (anthropos) form (morphos) of a nonhuman, and deciding on the limits of its freedom" (Latour 1996: 62).

[14] Sociocultural psychology, as we shall see, has a similar approach. If the human mind is not independent but co-constructed by humans and tools (cf. Vygotsky 1978; Wertsch 1998a; Cole 1995) and if it is distributed in the surrounding artefacts (e.g., Bateson 1972; Cole 1996), then we can conclude that we, as human beings, are no longer "pure" but "hybrids".

The origins of agency (and knowledge)

What may seem counter-intuitive in this analysis is not so much that society is constituted by heterogenous entities—human beings, buildings, texts and technologies, and so forth—nor even the hybrid nature of humans actors, but the active role attributed to material, nonhuman entities. However, if we agree that society and nature are "hybrids", that the social is materially heterogenous, and that all these materials actively participate in social ordering, then we must also agree that nonhuman entities are, indeed, potential actors.[15]

Agency in ANT is less than intuitive in regards to common sense. Usually when talking about agency we discuss human beings. Some philosophers, like Dennett (1996) extend agency to other biological entities, such as cells, but even there it is discussed as a property of living things. However, as we have seen one of ANT's main objectives is to break down this dichotomy of passive, idle things on one hand, vs. active non-things on the other. ANT then rejects the idea that only humans have agency. Agency here is not correlated with intentionality. As Donna Haraway puts it, "agency is not something you have but something you do" (Haraway & Goodeve 2000).

When thinking about agency within the context of ANT it is important to keep in mind that agency, for ANT, has no identifiable source, it is not a property of an actor. It is not the located within a specific actor, but between actors, in their relationships:[16] what an actor can do is a result of its position within the network. Describing agency does not mean assigning it to a given source, but rather finding

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[15] This constitutes a very simplified explanation of a much larger and more complex argument, in which Latour differentiates between *actants* and *actors,* an *actant* being the 'thing' itself with its unspecified nature, and an *actor* being the 'thing' plus the competencies which are attached to it (Akrich & Latour 1992: 259). However, for our purposes it is only necessary to grasp the main idea, i.e., artefacts possess, in and of themselves, agency.

[16] Donna Haraway (1999) extends this relational principle to knowledge, in particular scientific knowledge, which she names 'technoscience'.

ways of portraying and characterizing patterns in relationships. Thus, rather than focusing on the origins of action (an approach which has lead us to Western dualism: individual/collective, body/mind) it is necessary to analyse how knowledge and devices are distributed or disseminated (Callon & Law 1997).

Latour (1997) provides one of the best clearest definitions of "actor" within ANT. He says, "*actor in ANT is a semiotic definition - an actant - that is, something that acts or to which activity is granted by others.* It implies no special motivation of human individual actors, nor of humans in general. *An actant can literally be anything, provided it is granted to be the source of an action*" (Latour 1997: 4; my italics).

To the extent that ANT grants individual actors with agency it does so in the context of '*existence'*. By existing artefacts transform, or at least, have the potential to do so: The technology itself becomes an actor/actant (cf. Latour 1999; Suchman 1997; Akrich & Latour 1992). For instance, a street light that is green for only a few seconds makes drivers race through it, and pedestrians cross it at their own pace; the contrary, however, makes pedestrians hurry. Agency here is not in the light, nor in the pedestrian but in their combined activity. Or, imagine a blind man and using his bodynet, equipped with sensors, for spatial navigation. Is the bodynet part of 'him' or can we separate them? Who performs the action the sensors that guide or the man that walks?

Nonhuman entities act by fixing human faculties into non-human material. They act by perpetuating and enforcing certain views of society;[17] and they also act through recalcitrance, by refusing to cooperate[18] (cf. Latour 2000). The notion of technological artefacts as agents is easily understood in artefacts such as icons, where double-clicking on them leads to an action of some sort, or technologies

[17] For instance, in the context of the Internet, Lawrence Lessig (1999), argues that code, the architecture(s) of cyberspace, structures and constraints social dynamics, enable and disable certain actions and ways of life.

[18] In a sense this notion of recalcitrance is the equivalent of human choice: where humans choose, nonhumans recalcitrate.

with possibilities of (re)action, for instance, the already in use court-ordered monitors of car ignitions, which automatically disable the car, blow its horn and flash its lights if an onboard Breathalyzer detects alcohol. “The machine detects and decides whether a violation has occurred, and takes action.[19]

The argument made by ANT is that agency can be extended to all artefacts, since their existence already causes changes in behavior, routines and abilities: In order to understand human behavior we must study the technological artefacts. The technology is not a passive recipient of experience, it contributes to the creation of experience. is an artefacts’ competency(ies) that give it agency. *The mere existence of a bodynet and its competency gives it agency. By existing it has the potential to transform what we do, how we think, what we think about, and whom we think with* (cf. Resnick 1996).

Summary

ANT’s provides me with an analytical framework with which to study the process of innovation and implementation of a technological artefact. It does so by highlighting the heterogeneous nature of the social, and their dynamic interaction. ANT allows me to map the development of bodynets both at the technological and social level without distinguishing or categorizing between them. ANT allows me to “suspend ...[my] belief” (Latour 1988) in the ontological nature and status of all participants in order to see their interaction, not as social construction or technological determinism, but rather as a process of heterogenous shaping.

Sociocultural psychology

Sociocultural psychology complements, in many ways, social construction of technology and actor-network theory. While SCOT and ANT focus on the dynamics of sociotechnical change, sociocultural psychology focuses on how the individual is shaped by (and shapes) the nonhuman actors that are available. We could say that while the former take as the focal point the development of the artefact, it

[19] <http://www.prairielaw.com/articles/article.asp?channelId=8&articleId=1306>

provides me with the 'how', the latter focuses on the transformations that occur when human and artefact interact, it provides me with the 'why'. Where Latour (1991) argues that "technology is society made durable", sociocultural advocates argue that humans are, to a great extent, reflections of technology.

Sociocultural psychology focuses on the relationship between human functions and the cultural, historical, and institutional situations in which they occur. Many sociocultural psychologists trace their foundations back to Vygotsky, a Russian developmental psychologist, who wrote mainly in the 1920s and 30s and whose work started being known in the West in the 1960s, when it was first translated into English.

In recent years sociocultural psychology has been adopted, and transformed, by a variety of Western scholars, e.g., James V. Wertsch (1998a), Michael Cole (1996), David Bakhurst (1995) and Jerome Bruner (1986). A number of different strands such as cultural psychology (cf. Cole 1996), mediated action (cf. Wertsch 1998a) or activity theory have been developed in recent years. I draw freely from each of these different strands as they suit my purposes. Many of the conclusions expressed here do not necessarily reflect the positions adopted by the above mentioned scholars.

Vygotsky's approach is composed of four interacting notions: mediation, psychological artefacts,[20] appropriation,[21] and higher mental processes. These notions interact in the following way: Human psychology is *always mediated*. This mediation is done through the use of psychological artefacts that are social by nature. As human beings appropriate these psychological artefacts, they are able to distance themselves from the world and act instrumentally upon it, that is, they

[20] In the literature these are usually named psychological tools, cultural tools or cognitive tools. In this paper I use the term artefacts in order to establish continuity with the previous sections and because it possesses a less utilitarian connotation.

[21] Also called internalization.

'acquire' higher mental functions. In this process of appropriation, two things happen: the social becomes private and, both human(s) and artefact(s) are transformed (cf. Vygotsky 1983; quoted in Kozulin 1990).

The similarity with ANT is striking. In the same manner that Strum and Latour (1987) argue that artefacts are the glue that holds the social together, Vygotsky's argument infers that artefacts (material or symbolic) are what makes humans "human" (cf. Cole & Wertsch n.d.).[22] From a sociocultural perspective, what is unique about humans is their need and ability to mediate their actions through artefacts (including symbolic systems) that are transmitted from generation to generation.

This formulation has important consequences. It implies that (i) every time we act we do it through the use of cultural artefacts that are social, pre-exist us, mediate our actions and transform and restructure our 'nature' in the process (cf. Lock 1996; Kozulin 1990). For example, having a language changes the way in which we perceive reality: Words expand our consciousness but also limit us, as it is hard to express a feeling or mental state for which we have no words. It also implies that (ii) artefacts do not simply facilitate certain mental functions, they shape and transform them. Moreover, it indicates that (iii) all psychological functions begin and to a large extent remain culturally, historically and institutionally situated and are context specific (Cole & Wertsch, n.d.). Finally, it presupposes that (iv) the mind is distributed. It is not exclusively in our bodies, but also in the artefacts that mediate our actions (cf. Bateson 1972; Cole 1996). The above mentioned example of the blind man equipped with a bodynet is a good

[22] Vygotsky argues that while other animals possess lower mental functions, which only permit a direct, instinctive and impulsive response to the environment, humans make use of higher mental functions. Higher mental functions involve a symbolically mediated action upon the world—through the use of psychological tools—and thus are always mediated (Nicholl 1998). Vygotsky's depiction of higher vs. lower mental functions (and his general framework) was deeply influenced by Marxist theory. In fact, Vygotsky quotes Marx's *Das Capital* as the source of his theory and method.

example. Where does the man stop and the 'machine' start? Can we even distinguish between them. And, who performs the action the sensors that guide or the man that walks?

Sociocultural psychology's main propositions

The notion of ***activity*** is central for sociocultural psychology (just as agency is central for ANT). For Vygotsky *thinking is an action*, so when we think we are engaging in activity. Action, however, is always mediated, and this is the central fact about human psychology (Vygotsky 1982; quoted in Nicholl 1998). Action is mediated by artefacts, material or psychological, that allow human beings to engage with world. Language is used to talk and think, maps to find directions in space, numbers and calculators to pay when shopping. Humans always access the world indirectly, both when obtaining information about the world and when engaging with it. Hence, conclude Wertsch, Del Rio and Alvarez (1995), the notions of action and mediation are inherently related, and to distinguish between them is artificial.

Similar to ANT, it can be argued that for sociocultural psychology artefacts act because they are a constitutive part of all human activity. Agency is not to be found in the human actor nor in the artefact alone: it is located between them, in their relationships. The unit of analysis is not the human or artefact, but human and artefact, for they are mutually constitutive. As much as humans are constituted by biology and artefacts, artefacts are constituted by physical properties and human use (Wertsch 1995; Cole 1996).[23]

[23] To this Cole (1996: 117) gives the name of "dual nature of artefacts", that is, they are simultaneously conceptual and material.

Artefacts don't think, but they *act*.[24] This is a crucial difference between these them and human actors.[25] Sociocultural psychology allows us to introduce shades in the character of agency of humans and nonhumans, while maintaining their equal status and mutual constitution. Wersch's (1998a: 11) review of the debate between *individual* and *society* is useful to illustrate this point. This debate, Wertsch argues, has on one side those who argue "everything depends on the individual", and on the other, those who say "everything depends on society". The first groups says, "it is always particular individuals who decide to do this and not that". The other replies, "their decisions are socially conditioned". And so on. Wertsch goes on to argue that setting the debate on ontological interpretations that are seen as "essences" is bound to create notions of true and false. Instead, he says, "it is useful for the purposes of research to see these terms as conceptual and theoretical tools". The same argument can be applied to the notions of *social* and *technical*. However, the difference between what is argued here and ANT is that here the difference is erased for research purposes, while in ANT it is erased for all intents and purposes.

One of the frequent critiques of ANT is that by leveling the status of human and nonhuman actors, it loses the particularities of both. Suchman (2000), for example, argues that we need to find a discourse that allows us to recognize the relational character of agency and the mutual constitution of humans and artefacts while retaining their differences. Sociocultural psychology, by introducing differences in degree (but not in kind) between things and non-things allows us to do this.

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[24] This is my personal interpretation of sociocultural psychology, taking action in the sense used by Actor Network Theory. Most of its proponents do not attribute agency directly to artefacts, or tools, as they are frequently called. They are usually seen as powerless except when they are being used by humans (Wertsch et al. 1995).

[25] Actor Network Theory is quite dismissive when it comes to the subject of cognition, and it is not clear what the "official" position is. In part, it seems as if ANT deals with the subject by ignoring it, taking a rather behavioristic approach to humans, that is, by accepting only thoughts that become tangible actions.

Mutual shaping

Sociocultural psychology's position on mutual shaping is similar to that of ANT: The interaction between humans and artefacts is not neutral, both are transformed by it. In this mutual interaction process artefacts become part of our identity, and we become part of them.

Sociocultural psychology emphasizes the importance this mutual shaping has at a mental level. Artefacts do not simply facilitate certain activities or mental functions, they shape and transform them, they transform the ways in which we interact with, and think about, the world. For example, seeing the world through an augmented reality bodynet device will change the way we interact with it. The artefacts do not remain immutable either, as they are employed they change, e.g., new usages are found.

Consequently, for sociocultural psychology in order to understand the relationship between sociocultural settings and human action it is necessary to study the artefacts being developed and used (Wertsch 1998b).

Situatedness and appropriation

Sociocultural psychology holds that artefacts are culturally situated, that is, they are not equally available in different cultures. Different cultures, or/and networks, give rise to different objects and to different individuals. When new artefacts are introduced, or old ones disappear, activity changes.

This explains cultural differences. But how to account for personal differences? Vygotskians put forward the notion of 'appropriation' to explain this phenomenon. The process through which an individual masters an artefact, that is, the process through which he/she appropriates it, is not neutral. The process of appropriation changes the 'message', both the knower and the known change. This is very similar to McLuhan's famous sentence "the medium is the message", but it goes a step further. Not only does the medium change the message, but it also changes

itself in the process, and its user. For instance, when cell phones were introduced their identity was that of a facilitator in/for emergencies situations. However, as the telephone signal become stronger and the prices lower, its meaning changed (from emergencies to status symbol), the messages it transmitted also change (from important messages to trivia), and the behaviors of those who use them changed with it (calling is no longer in the realm of the private but of the public; you no longer call a place but a person).

Summary

Sociocultural psychology, by highlighting that who we are and how we act is influenced by the nonhuman actors that surround us—when these change so do we—allows me to investigate what happens once bodynets are introduced into daily routines. How do our views of ourselves and the world change? And, what will this mean for our future?

CONCEPTUAL CONCLUSIONS:

STUDYING THE TECHNOLOGICAL ARTEFACT

Technologies are not created in a vacuum: when designing a new technology, engineers and other practitioners are putting forward a vision of the world. They design the technology per se, plus the world that will adopt it, what John Law calls "heterogenous engineering". The invention and development of a technology is accompanied by the creation of socio-psychological theories about the world that it will help shape and create (Latour 1996; Callon 1986; Berg 1999).

For example, in my interview with Alex Lightman, the founder and CEO of Charmed Technology, a bodynet manufacturer, he spoke of a future where wearables are ubiquitous and all human beings connected and united like unicellular organisms, a world where we have the hardware, software, systems, culture and experiments to create a super-organism (Lightman 2001).

Lucy Suchman describes the process of "design[ing] technical systems... [as] a process of objectification, of the inscription of knowledges and activities into new material forms" (Suchman 1999: 263). Other authors discuss it in terms of "inscription", i.e., actors inscribe their views of the world in the artefacts they are producing (Akrich & Latour 1992).

Thus, when studying the creation and development of bodynets (the technological artefact) we acquire insights into the motivations, problems and solutions inscribed by the different actors involved in the process of their construction.

Now, this is not to say that the users have no influence in the process of stabilization of a technology. "Inscription" is not a golden rule because technology is not a fixed process, it is open to interpretation by all the different actors, users included (Akrich & Latour 1992). However, observing what happens in those early

stages of development, before it reaches the user, is vital to understand what happens subsequently (Berg 1999). In his essay “Beyond the information revolution” Peter Drucker (1999) gives examples of this need to study the assumptions embedded in a technology as it is being constructed. One is the Japanese railroad system, built in the late 1870s and 1880s by British engineers, who thought of railways as designed to carry passenger not cargo. Because of this, he says, “to this day Japanese railroads are not equipped to carry freight".

Technological artefacts are not used in a vacuum. They are used within existing networks and relationships. When a new technology is introduced the network will re-adapt itself, or fall apart, but it will not remain unchanged (Latour 1991; Sennett 1984; Winner 1980; Suchman 1999; Haraway 1999; Callon 1987). For example, the use of bodynets in the workplace will affect the practices and routines of their wearers: it may increase inter-personal communication with other bodynetworked colleagues, and decrease socialization with non-networked colleagues.[26]

Being located in an intimate personal sphere and being seamlessly integrated with their environment, bodynets have a great potential to change the ways we relate to ourselves, to others and to the environment. In a bodynet the individual, technology and environment are connected in new ways. Each one of these elements has to adapt to the others, and the distinctions between them blur or are reconstituted. Focussing on the development of this technology provides an ideal focus point to analyze the interaction between these different elements and determine what influence bodynets as social, personal and cognitive technologies could have in our changing relationship to our environment and our developing sense of self.

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[26] Julian Orr’s (1996) study of photocopying technicians found that they acquired much of their expertise in informal meetings after a day’s work. Orr concluded that the best way to use technology to support the technician’s work was to provide them with radio equipment so that they could remain in contact all day.

The technology of bodynets, thus, provides a focal point for observing the interaction of the multiple actors involved in their development and implementation, and also the issues that arise from that interaction. Studying bodynets makes visible the different assumptions that are negotiated by the different actors, and how they are inscribed into the technology.

In the long run (beyond the thesis) we will be able to see how the assumptions really played out, i.e., how the environment changed under the impact of these technologies, and how individuals adapted. But for now, the focus should be on the technologies and the activities of their construction.

With this in mind, some specific questions and sub-questions this study addresses are:

What is currently being developed? (Design Issues)

- What is being designed today?
- For whom are these technologies being imagined?
- What implicit and explicit assumptions about society and individuals motivate these technologies/their developers?
- What are the problems and solutions that these technologies address?
- What are the technological frames of the dominant social groups involved in the development of bodynets and how are they materializing into artefacts?

How is the actor-network of a particular bodynet established? (Implementation Issues)

- How are these differing views negotiated and inscribed in the technology?

What happens once the technological artefact starts being used? (Usage Issues)

- How are the assumptions played out at the level of users?
- How do users understand the technology?
- How is the relationship between individual and environment redefined by the construction of bodynets? What biases are introduced?