- Rethinking Design -
An Embodied Perspective on Computation

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ABSTRACT
An increasing interest in the role and nature of the human body can be identified in our designs of computational systems. This follows the emergence of new types of computer functionality and interfaces, particularly systems that expand into a wider range of settings, look less and less like traditional computers and are based on multi-modal interaction. This paper adds to critical evaluations of our current design practices and suggests the introduction of a phenomenological understanding of embodiment as an alternative philosophical basis.

Keywords
Ubiquity, embodiment, computation, context awareness, virtual environments

1. INTRODUCTION

Devices based on computation are multifarious and we think about them with various degrees of attention, affection and satisfaction. Obviously spreadsheets, microwave ovens, ABS-brakes and Tamagotchis are very different things and they have different places in our lives. However, even with the multiplicity of devices and uses, we find a commonality in much of our relationship to computation. This certainly is true for our use of more traditional computational devices, easily recognized as 'computers', such as desktops, PDAs, portable MP3-players, play stations, cell phones with animations on color displays, but the design practices that underlie all of our experiences with computational artefacts are in fact very similar with regards to the set of assumptions and metaphors that guide the design. This has some critical implications for the usefulness of the systems we build.

We shall see that our designs are currently based on a limited concept of the human body and of bodied activities. This becomes increasingly clear as technology keeps entering into new areas of our everyday life.

This particular view is examined through concrete examples on (approaches to) designs. This analysis also leads to alternative perspectives and allows us to consider how we can provide a coherent alternative to the prevalent approach to computing - philosophically as well as practically.

The paper is structured as follows.

- First the notion of "fundamental assumptions" is developed. This paper adds to a larger critical engagement with computation.
- Context awareness and systems based on ideas of human bodies in interaction are used to examine the consequences of the assumptions. Problems related to the assumptions and alternative approaches, that explain the problems and provide means for solving them, are discussed.
- These insights are used to reflect on the benefits of introducing a different set of ideas about human action, based on phenomenological notions of embodiment.

2. THE FOUNDATION OF COMPUTATION

Our computational practices are laden with metaphors and assumptions about human action and experience. They provide the ground rules for how we produce and use computers, from high-level functionality and interface designs to the structure of programming languages and hardware components. Our way of thinking about design is shaped by an origin of computers, where the main concerns of designers were about math and electronics, an evolution tied to psychology and organizational theory, and to conceptions of the world through the lenses of the natural sciences. This has resulted in a view that is closely related to what could be called a classical western, rationalistic, positivists or scientific perspective. Within this perspective users are often seen as disembodied symbol processors. The role of the body in interaction is either disregarded, or ideas about the human body are used in simplistic ways that lead to problems.

These assumptions are in most cases not deliberately chosen, nor are they reflected much upon. They are not explicit and shared uniformly across all computational practice. They can rather be seen as sets of metaphor or a paradigm that shows its head in many forms and in ways that are not clearly interconnected. Characteristics of how this manifests itself related to central concepts in computation such as abstraction and representation,

ontology, semantics and procedures are discussed in Agre, Dourish, Smith and Suchman.

The ideas are built into the technology; they make us blind to or hinder certain types of interaction and enforce others. As this is brought to more and more spheres of our world, cultures, practices, that are further and further away from the traditional application areas (e.g. mathematical models for simulation, accounting, paper work in offices) where they have arguably changed our way of looking at work, information and ourselves. We must carefully examine how technology is part of a reconfiguration of these environments and practices. This is the core of any responsible computational practice.

There are a few good reasons for taking a closer look at the assumptions underlying computational practice:

1) This specific approach to understanding the world has shown to have harmful consequences in other fields, and to fail to describe or allow understanding of what goes on in the world - this clearly mandates an examination of the consequences for our designs.

2) Some of the problems we experience with building useful computer systems can be explained through an understanding of the shortcomings of this perspective.

3) There are alternatives to this worldview. In some cases they can fix the problems we meet now, in other cases they may provide new ways of thinking about computing providing us with new useful ways of building and using computing.

The examples discussed here provide *one way* of looking at the assumptions. The concerns here are mainly with how technology can be part of a meaningful life of people – of how technology can be designed to be part of the environment that we meaningfully navigate in our everyday activities. In the examples and the discussions there is a focus on *work* and *work environments*. However, the focus is on mutual understandings and on coordination which is basically about interaction in general. So even if the discussion here is centered around systems, that are built to be "efficient", the underlying perspective on design has all human action - work as well as play - as it object.

Implications of the assumptions will be examined and alternatives are developed. First related to the idea of context aware computing and then to various experiences related to the appearance - and lack of appearance - of the body in systems design. In addition to showing concrete instances of the materialization of the assumptions in computational artefacts, the discussion of the examples also allows us to consider alternative ways in which to approach design and to see how this will look in actual designs.

First however we consider how these ideas relates to the current changes in our technology, towards devices and applications that are brought "into the world".

3. UBIQUITY AND INVISIBLE COMPUTING

As our ability to create smaller, more efficient and less energy consuming computer devices grows, a new trend in information technology has appeared. This is a trend that can be described as ‘bringing the computer into the world’. Either in the shape of portable devices or in the shape of distributed devices covering larger areas, both are different from the classical setups where use of computing is confined to dedicated computer areas. Computing is becoming pervasive or ubiquitous. (for various perspectives see Dey, Dourish, Harrison, Ishi, Ulmer and Weiser)

An increasing interest in new input and output devices is an important part of the new types of systems. Often related to this are new types of devices, where the means of control and representation moves from traditional monitor, mouse and keyboard to alternative methods - often again, so to speak, bringing the computer out into the world and in fact making the computer look and function differently from what we today call a computer. In a sense making the computer disappear or be invisible whereas the functionality and the interfaces are still there. Of special interest are interaction styles that are more physical and devices that could be described by words such as "*tangible computing*" - since these especially clearly breaks with the idea of computers handling and mediating "textual" information. Tangible computing is about systems (not just input devices but the entire "feel" of the system) that are material and bear tailored representations in themselves. Some of these are argued not simply to be control and representation devices, but objects of a different type of engagement. Difference between digital and analogue or physical manifestation and underlying system representation is not all that interesting in itself - what is interesting is how either type of system may lend itself to various forms of engagement and shifts in engagement.

Also, with computing spreading into various parts of the environment and with a range of portable devices it will be possible to configure and re-configure the work environment dynamically. Configuration is here not referring to changes to the functionality of an application, but to the general setup of the work environment. Our environments that have often been structured around geographical places with dedicated, stable practices are potentially made fluid and overlapping by the changes in technology.

This development further motivates a critical examination of our current approaches to design.

1) these new types of technologies may make it possible to use ideas and insights to a degree never seen before - thus making the potential benefits - and the ease of use of the ideas much larger.

2) the technologies make problems more easily visible

3) they introduce flexibility as they give rise to new ways of thinking about computation, especially where these ideas can be embraced without having to retrain people or break down boundaries between disciplines

4) they change the way in which we work and experience the world (as new interaction styles, new types of experiences, new types of work are allowed through the technology) - thus making a continuous redefinition of the subject matter necessary. Philosophy is never finished - it evolves with society. A continuous reflection on our presence and the way in which we find ourselves in the world is a necessary component of an informed design practice.

It is however important to note that the importance of the embodied nature of action and the role of the human body in human activity is not restricted to 'novel' areas of computing. Our understanding of these matters are equally important for more traditional systems, as we for instance find them in office environments and for the rare person doing isolated work in front of the computer.

4. CONTEXT AWARE COMPUTING

Before looking at the uses of the body and the understanding of the body in design, we shall look at a recent idea coupled to ubiquitous computing (e.g. mobile computing and pervasive computing). This idea is an excellent example on a perspective on meaning and interaction often found in systems design.

Context aware devices are systems that "read" state information from the environment (e.g. a location, who is around, what they are doing), possibly makes inferences from these readings to more abstract descriptions of what is going on and arrange functionality accordingly. This is motivated by 1) the often changing locations of portable devices, 2) the possibility of reading physical location (e.g. because of improved sensor technology) and 3) limits of in and output on small devices, making automatic data entry and inference more valuable. (Agre, Dey, Svanæs)

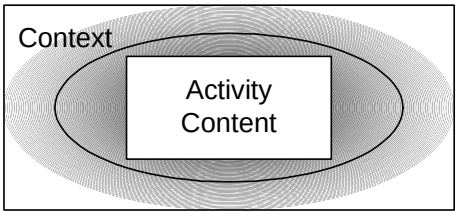

Figure 1 : The typical 'design model' of context starts with two concepts. A world consisting of a stable set of explicitly representable information and a subset of this that is relevant to the activity or content that is the focus of the design. The goal is to provide a framework that will allow the designers to easily gather and use as much of the information as will be relevant -' to expand the bubble' - and to choose the right amount of information and an appropriate presentation of it.

Examples on devices are portable devices that will automatically categorize notes according to where they are taken and who was present and devices that will remind you about meetings and bring our relevant documents if you by chance find yourself walking by a person that you need to talk to.

This idea of context gives us some insight into the model of the world that the design is based in. The function of the technology and the corresponding organizational arrangements are approached from a perspective modeling or seeing people and computers as rational, logical symbol-processing entities between which symbols or information is transferred and within which they are processed. We have unequivocal correspondence between signs and what they refer to. Representation is a practical matter of modeling, securing data quality and reducing user error. It is a purely economical/practical issue and is for managers, not computer scientists to deal with. This should be done on a local, low level that does not warrant 'scientific' consideration and is of little relevance to design.

But is this a good model for how people understand each other and for how they make sense of the situation they find themselves in ?

This question, which is of central importance to social science, shows to be no less important for computer science - and analysts have turned to the same sources as social scientists. Thus the work of the phenomenologist Alfred Schutz is widespread in the computer science literature that looks for alternatives. *Intersubjectivity* is Schutz term for people understanding the world and each other. He uses *subjectivity* to point to a persons understanding of something - as opposed to objectivity which denotes "abstract" descriptions or meanings without any actual content e.g. a word in a dictionary or a plan for how to buy bread.

Intersubjectivity is tied to another concept of Schutz - the natural attitude - which is our default state or stance, an orientation to the world without detached interpretation of own activities and experiences. This includes a generally un-reflected acceptance of other people and environment in everyday life. We assume that there are other people who share this environment and have similar relationships to it. When interacting face to face interactants share time, they grow older together and they share an environment.

It is 1) the natural stance and 2) the access to the fellow man in the shared world that allow us to make sense of each other and in and of the world. Schutz describes our making sense of the 'fellow man' in terms of people understanding each other through interpretations of what their conduct could be about. This means that we are able to understand the 'fellow man' exactly because of the assumed similarities in the experiences - generally and in the particular situation. It is by the possible imagination of yourself in the place of the other that intersubjectivity is possible. Understanding is achieved when conduct is read from the overt actions (bodily activities, talk) of the other, seen through the lens of what you yourself would expect to experience or feel if in

similar situations. This is held up to types of activities and people and your previous experiences with the specific individual - and allows you to ascribe meaning to the actions of the 'fellow man'. You understand him without telepathy. It is important to note that these understandings of the other are for practical purposes and are held to be true till evidence for the opposite appears.

The environment that allows us to make sense of each other is not a stable, external frame of interaction - on the contrary - it emerges from interaction and *context is reflexively* tied to action as a product of peoples activities.

This is a central point in the sociological branch ethnomethodology proposed by Harold Garfinkel. In particular Garfinkel argues that all social order is upheld by people continuously producing and reproducing sensible, orderly conduct. Norms, rules, etc. are found, created and given meaning as people act in accordance with them. People are continuously engaged in making sense in and of the world. Actions are read and designed to be read in accordance with the above principle. The term 'accountability' is used to refer to the way in which people, as part of the practices, make themselves available to interpretation and design their activities to allow interacting parties to find an interpretation in which these activities are orderly. Here it is central to note that people actively tailor their expression to be read by others and that any action take meaning only and fully as part of the context that it is reflexively tied to. Actions are embedded.

Various mechanisms for rendering our activity and situation normal and for reading situations and activity normal are used – some very general other very situation specific, requiring people to have a common appreciation of the engagement – something that is more likely to be useful and found in relation to specific activities in smaller groups. The interpreter as well as these contingencies is the product of an ongoing effort of the members involved in the practices that give the systems existence. People are not isolated manipulator of symbols with stable meaning, nor are they isolated interpreters of symbols, the meaning of which is constructed/resolved/emerge in concrete situations. They are "thrown" in a world, with no time-outs. The condition is to be engaged in the construction of the context that is given by and gives meaning to the members. Context is now not only actual circumstances, but produced circumstances in which the producer is partly a product. Reflexivity is the word used to describe this mutual ongoing construction and it can be said that the individual is embedded. Embeddedness describes its condition.

Another point can be made about the relationship between context and portable devices or ubiquitous computing. This concerns blending and meshing of contexts, the disappearance of borders. The new types of computing does not just mean that access to the environment of the other may disappear - it may also mean that areas, that were before associated with certain activities, strategies and conventions blend together. Several of these distinct areas may become one - or that context may be a complex construct of overlaying, meshing and blending concerns, frames of references, tool setups etc.

With this idea of the importance of seeing human action as being embedded - of context as a reflexive construct we move to looking at the way in which this mutual configuration takes place; to the nature of the ties between activities and the surroundings.

5. BODIES IN ACTION / MEDIATED INTERACTION

Needs for coordination or other types of involvement among geographically distributed parties has been and is a central concern for designers of information and communication technology; ranging from telephones to video conferences and from shared file repositories to virtual office environments. In this section the role of bodies and embodiment in two "types" of systems for mediated interaction is considered. First media spaces where video and audio connections supplemented with other mainly continuously open links between physical settings are provided to support interaction. Secondly, systems where bodies are used as basis for representations - either in virtual environments, where the interacting parties are placed in a shared computerized environment, or in systems using "bodied" agents as part of their output/interaction strategy.

Concepts of bodies and embodiment are often related to specific aspects of computer mediated interaction and computer use. For the purpose of getting an overview the analysis is somewhat structured accordingly. Thus we consider a) face to face interaction, b) persons effecting change on a machine, c) a machine being designed to be readable by a person and d) people interacting "through" a machine. Understanding actual systems of course may involve all these aspects (e).

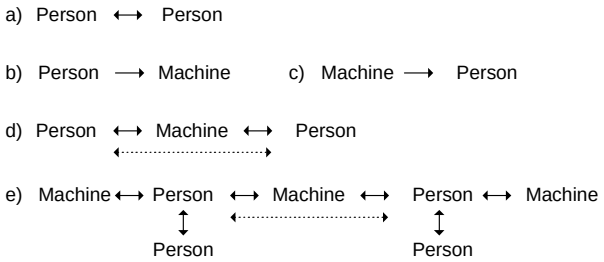

Figure 2: Concepts of the body and embodiment appear in relation to a) face to face interaction, b) a person effecting change on a machine, c) a machine being readable by a person and d) people interacting "through" a machine. Understanding actual systems often involves all of these aspects (e).

No clear distinction is sought between these ways to mediate interaction - in fact some systems clearly feature aspects of both. The distinction made here is related to the role of the body in the two approaches. In the media spaces the role of the body appears when differences between the modalities of face to face interaction in a normal physical

world on the one hand and the technologically constructed shared environment on the other either result in problems for the users or in alternative interaction strategies - corresponding to a) and d) in the diagram above. In the virtual environments the body appears "in" the systems and "bodied" representations and their usefulness is the concern - making b) and c) more prominent. Humans reading "bodied" computer-based entities is also the basis of systems making use of on "bodied" agents.

5.1. Media spaces

The media space strategy is to offer open audio and video channels as well as various continuous monitoring and display technologies, to create a shared or common "space" in which people can interact. The aim is to provide technology that allows people to interact in a way that matches their needs. In some cases a phone line is well suited, in other cases the needs are different e.g. interaction techniques that are less obtrusive or richer in modalities give better results.

These spaces are useful not only in that they allow interaction between distributed parties, but in that they support various types of interaction. Simple examples are the recording and re-use of sessions or the ability to temporarily close connections in a way that would have been impossible in a shared physical space.

Studies reveal a range of interesting phenomena regarding the interaction of people using media spaces. Some of these are problems related to specific implementations, other are related to modalities or types of interactions and yet other concern more general issues for mediated interaction.

It is primarily the latter we take an interest in here - however this is approached in the form of concrete experiences in actual uses of systems. It is critical to analyze these phenomena and see how they relate to the methods that people use for getting the job done - and the mechanisms or the functionality that they find the systems provide them with. The studies tell us about how a system or type of system can be made more useful and for what they are useful. They also tell us about interaction between people and the use of artefacts, more generally informing our work with building useful technologies.

Use of media spaces have often been investigated with a set of philosophical and sociological insights informing the analysis. Also here, phenomenology and in particular the sociological branch ethnomethodology have been used to make sense of the experiences. Central to these approaches is a focus on the way in which people create and perceive an orderly world. Many of the studies of interaction in media spaces have focused on how people actually interact and it is through this analysis that bodies and embodiment appear.

The following analysis is based on a series of studies of media spaces. Heath et. al. have made several studies of uses of video and audio links between offices as well as of the introduction of a 'pointing' robot. Dourish adds to these by a study of use of a media space for longer periods of time and Gaver adds experiences with various types of media channels. We go through several of their observations in the following sections. The discussion is for presentation purposes ordered after six higher level insights - even though, as it will be seen, these observations are actually heavily interconnected and blend together. For details on the studies see Dourish, 1996, Gaver and Heath.

- understanding the other, intersubjectivity
- context, accountability and embeddedness
- asymmetric and incongruous environments
- restricted access to the other
- bodily conduct and engagement
- objects in a shared physical environment

The two first observations were introduced above when considering indexicality and reflexivity of context. We continue with considerations of how this looks in environments where the interactants are not co-located.

5.1.1. Asymmetric and incongruous environments

In general, a range of asymmetries heavily influences the interaction in media spaces. These are technical as well as social.

The mediating systems do not provide compatible views of domains and coherent distributed environments allowing the users to establish common standpoint or mutual understandings.

This particularly pertains to systems where a "translation" between domains is intended. It may be noted that translation is an unfortunate term since a translation suggests something like a correct substitution of referents to meaning from one well-defined domain to another - change or maybe even obfuscation would be better - at least in areas where the translation is opaque and designed without consideration for the actual implications and uses.

5.1.2. Access to the other

In addition to not allowing access to the environment of the other participants, the systems are found to not provide full access to the participants themselves. Seeing and hearing the other, the acts of reading each other and writing to and for each other are made less efficient. Gestures, subtle bodily cues and presence of the body of the interacting party are made invisible or less prominent and alive. This is associated with a lack of presence, of a feeling of the other being there - to some degree to be characterized by people engaging in watching more than in participating.

Both cases of lack of symmetry and expressive power leads to difficulties for the participants related to the establishment of mutual understandings. The methods for displaying accountability are not sufficient.

5.1.3. Bodies and engagement

The bodied conduct of people is clearly to some degree minded towards the interacting parties. We point, look puzzled, show attention by gazing and a host of other more or less designed ways of interacting non-vocally are found. This explains the problems with technologies that does not allow us to use these means in our interaction. However the body is more than a signaling device. In fact, often we do not consider the body a device at all.

Again we turn to phenomenology. Phenomenology is occupied with the ways in which we relate to our experiences. Of central importance to us is the investigation of characteristics of the spacial-temporal environment and object that we interact with in it. Schutz here notes a difference between orientations to "inner phenomena" (ideas, thoughts, experiences) and orientations to the outside world in which we are placed. When we are occupied with these outer phenomena Schutz says that we are "gearing into the world".

Our orientation is shaped by what is within sight and within reach. The outer world is experienced through our senses, we are through the body. This ties embeddedness to the body. The understanding of the outer world and our practices for sense-making and action are inextricably tied to the way in which we experience and act on the outer world - that is with our body.

Thinking about modes or types of engaging with or engagement with the environment may lead to useful conceptual models for technology use. Dourish envisions us seeing computer use in terms of this image. He points out that abstractions, representations and couplings between "levels" of representations are central to computer systems. An understanding of shifting types of engagements, modes of exploration and directness in the experience may guide the way in which the use of representations and especially the shift between representations are used to design systems. This would be a type of design and systems informed by ideas of phenomenological presence in the world. The same ideas are explored by Smith.

5.1.4. Objects in a shared physical environment

In our everyday life sharing of objects and information is often central to cooperation. Media space research has addressed the role of objects in the world and how counterparts (or lack of such) in the mediating settings affect interaction.

This of course is related to the above discussion of a shared environment. We are concerned with acting *on* and *through* the physical world whereas the above was more concerned with acting and interacting *in* a physical world. We look at interactants making use of particular features of the environment.

One such way is making references to specific parts of the environment. This point is investigated in a study of the use of a pointing robot controlled by a remote interactant in a setting with video and audio link between two sites. (Heath, 2001) The role of the robot is to 1) allow the remote party to move around (and thus change viewpoint) and 2) to allow the remote party to "point" with the use of a laser mounted on the robot.

The lack of symmetry caused problems as discussed above. In particular it is worth noting that the role of pointing is generally not simply to specify an object or area in the surroundings, but is part of embedded action and thus part of accountable activity giving sense to the situation. The part of the activity mediated by the technology does not provide the users with the details to be interpreted in a way allowing sufficient mutual understanding. "[In media space] these noticings, embedded actions, largely pass unnoticed, since the remote participant is unable to 'connect' the participant's action to the relevant feature of the domain. Conduct becomes disembodied." (Heath, 2001, p. 131)

5.1.5. Supporting emerging practices

Till now the main findings from the studies of media spaces have been the problems with mechanisms that have not met the needs of the users. People are often found to expect similarities between face to face interaction in a shared physical world and the technologically changed setting. They tend to use the same interacting strategies and the same remedies when they are inefficient, as they would if they were in the near proximity of the interacting parties. The assumptions that all the above-mentioned differences are not important or the lack of established procedures for how to deal with this, leads to critical problems. However there is more to be learned from this than the apparent insufficiency of the mechanisms. In fact studies have shown that part of the problem has been unfamiliarity with and poorly developed practices around the use of the mechanisms.

To some extent this is a question of getting a history with the technology leading to 1) an understanding of what will and what will not work and 2) the common establishment of new procedures. Studies of long term use have suggested how this may occur (Dourish, 1996).

This is related to a distinction made between space and place (Harrison, 1996). This distinction points to the importance of the establishment and negotiation of practices, conventions, rules, etc. for how to use a system. The idea is to provide a technical foundation that allows the creation and evolution of efficient practices.

This should not be read as a suggestion that efficient mechanisms will arise inevitably and naturally simply from using a technology long enough.

First it is worth noting that the characteristics of face to face interaction, that may fit certain purposes extremely well, are not necessarily reproducible with other mechanisms, and that systems may not be able to efficiently allow for the same type of interaction and engagement in the same type

of activity as face to face interaction in a shared physical environment.

Secondly, people may simply refuse to use a system (it may not be worth the while) if the process is too long and painful, or makes it impossible to get work done. Thus it is important to provide a useful system from the start. In fact one of the reasons for having experts designing systems is that they may be able to construct systems that are much more efficient than users could do alone.

It is important to provide for efficient modifications of the start situation. As opposed to specialized, task specific functionality systems could provide mechanisms that are 1) building blocks and 2) construction tools allowing people to create and modify this type of functionality and allow 3) more general or loose interaction with less frequent and predictable patterns.

5.2. Representing bodies and users

Whereas the above section addressed issues related to peoples bodily presence in the world and the implications for interaction, this sections is concerned with what could be called presence of bodies in systems - specifically graphical representations that are somewhat similar to humans and representation and models of users.

The interest is not in the role of representations of bodies in virtual realities as such, but generally in the role of the body in interaction with fellow human beings and the use of technology.

At least two different ways of using representations of human bodily conduct in computer systems are found. The first lends a bodied representation for the user to manipulate - most often as a pseudo self with which to interact with other pseudo selves in a pseudo world - shared virtual environments. The second lends a pseudo body to a computer application, that uses this "body" to make its state available for inspection by the people using the software - "bodied" "agents".

Just as a sea shell found on a beach can have the same meaning to me as a picture of the person that gave me the shell - so can a name in a chat room or a pointer in a shared text editing application mean the same to me as a picture or video channel to the person coupled to the name or pointer - all depending on the situation. Our concern with bodily representations here is not to discern those from other representations and claim a set of distinct features. However the designers have based their design in an assumption of the usefulness or appropriateness of mimicking aspects of what humans look like and do in the representations in the systems - and this is what we take a closer look at.

5.2.1. Collaborative virtual environments

Collaborative virtual environments employ a different strategy for allowing interaction between distributed parties than media spaces. A shared environment is provided in which users can control representations of themselves. The representations can be more or less similar in appearance to the users and to people in general and are often referred to as "embodiments of the users". Deviations from full similarity are usually explained by technical limitations of the systems and minimizing these is often an explicit goal.

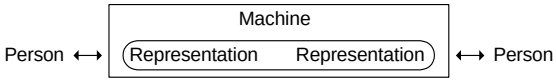

Figure 3: In the virtual environments the interacting parties are comparable to pupeteers that act through representations and must interpret their partners through these puppets. The representations are in some sense considered to be interacting.

The use of representations of the users has several functions 1) it signals presence, location, engagement, availability of the user for other to see, 2) it allows the user to send information through the "bodily conduct" of the representation (in some systems video or facial expressions are added to the representation), 3) it allows the users to move around and explore the other representations (and usually partially the state of their own representation) and 4) it provides the users with a shared environment in which to engage in interaction and specifically action on objects. Several of these points explicitly address problems found in media spaces. Benford, Hindmarsh and Trevor describe a range of findings from their work with this type of systems.

Many of the findings from the studies of media spaces are reproduced. The role of a shared environment is seen to help people interact and the increased degree of symmetry allows people to avoid some of the problems users had with establishing common orientations and making references to the shared environment. Sharing artefacts (computerized versions or simply video channels to entities with a separate physical existence) is made easier. Use of the body as a way of expression is confirmed as well.

Also some important differences in the types of system lead to additional insight. First it is noted that the representation is not the body of the user. In fact the user interacts with the system and the representation of herself; and interacts with the remote persons through interacting with their representations.

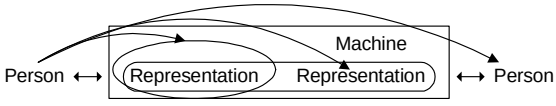

Figure 4: Interaction with 1) system and own representation, 2) representation of interacting partners and 3) the interacting partners.

In some sense the user has been made a disembodied puppeteer who controls a representation or is coupled to a representation is the system. This means that the users may have problems controlling and understanding how they appear to other users - methods for making yourself readable are changed and impaired. The world that the representations share is very different from the world that the users share (outside the system, in their world) and since

it is the users and not the representations that interact this is crucial. This to some degree is helped by allowing users to inspect the state of their representations and by letting users get used to the world. Users were thus seen to be more vocal in establishing mutual orientations towards the environment and comment on their own situation to allow efficient interaction in this type of environment.

5.2.2. Human-like interfaces and agents

Another way in which the nature of human interaction and especially the communicative repertoire has been used in computer science, software applications and psychology is related to the construction of output mechanisms that in some way resemble humans. Examples are autonomous agents and entities with facial expressions and, on the input side, interfaces that are meant to read facial expressions and other bodily action. (Dehn) Some of the research is associated with artificial intelligence and cognitive psychology and directed towards copying or revealing "underlying mechanisms" of "cognition" and human behavior, whereas other have a pragmatic interest in the matters, being interested in the technical possibilities for creating more useful in- and output mechanisms as well as application types. It is the latter effort we are concerned with.

Whereas such output mechanisms may allow certain iconic bodily conduct (e.g. a smiling face) to be read more easily and by a wider range of audiences (e.g. children) and in addition to this certainly may be more interesting, humorous or aesthetic than some other types of output, the discussion above points out some problems. In particular Schutz idea that reading the conduct of the other happens through putting ourselves in their place and imagining what type of meaning would be associated with the conduct. This makes sense from the basic assumption that for all practical purposes, till evidence of the opposite, people share a world and an interpretation of it. For most practical purposes computer applications do not share our world, our experiences or our interpretation of a shared environment. If this is made unclear by the introduction of things that look or behave like people, this is likely to lead to serious problems for computer use and furthermore to serious problems in solving these, since the reason for the problems will be just as opaque as the actual functionality of the system.

6. AN EMBODIED PERSPECTIVE ON COMPUTATION

In the examples above we saw how the trend of moving computation into the world offers us a wealth of new possibilities. The range of computational experiences and the interactional repertoire is heavily expanded. We also noted that the typical way of thinking about human action in design causes problems - especially related to ideas about how meaning occurs and how we interact with each other and with technology. These problems could be understood and to some extent ameliorated by introducing notions of embodiment from phenomenology.

Our understanding of the world and of each other is characterized by our action being reflexively tied to a mutually constituted context. Action is embedded. A feature of embeddedness is accountability. Orderly conduct is achieved as a product of our activities, which are oriented towards the people around us. Embeddedness is used to refer to the way in which our engagement with a shared world allows other people to make sense of our activities - the environment provides a context for our action. This is an important lessons for systems design. Especially for ubiquitous devices that are often based on sensor technologies for automatic input and on inference rules for acting on the data from the sensors. Meaning is created by the users, in the use - it will be dynamic, open ended and usually impossible to model in advance.

There are other features of our actions. There are ways in which we engage with the outer world. The word embodiment can be used to point to certain features or characteristics of practice. In this way it will be used to emphasize some aspects of how we go about our business, of how action takes place in its embedded condition. Embodiment is about how the embeddedness is, the methods, the practices. Embodiment is used not to single out certain practices as being embodied and others not. All practices are influenced by them being embodied. Embodiment is used to remind us about certain features of the human condition.

It seems that the human place in a temporal and physical world is central to both embeddedness and embodiment. But how much of it relates to the body in itself ? The effectiveness of the inner workings of our interaction is tied up with physicality. A physicality that is a body phenomenon - the body allows us to experience that which is physicality, and what this physicality means for us. The specific configuration of motion and sensory equipment has made time and space have the meaning that it has. Talking, understanding, thinking is partly a bodily engagement. Effects of the biological conditions can be found in interaction methods, in the metaphors, in the expectations that are possible. This could be extended by introducing ideas of the categories (or categories in general) being a product of these configurations (which is the center piece of Lakoff's notion of the role of the biological body). Meaning that these conditions are in fact caused by our specific bodies. However there may be more visible roles of the body. Studies of human activities in new types of environments will show how practices can and will evolve with changes in the world. Bottom line is that we are still exploring the nature of our embodied condition and the way in which this will appear in our continuously changing technological environments. In the rest of the section we will consider other ways in which the idea of embodiment may be useful in design.

6.1. Accountable artefacts

First let's think about what type of relationship could be created with artefacts allowing us to use similar methods for understanding them as we would when interacting with either a person, or some tangible object in our environment. Making yourself readable and as part of this giving meaning to the situation is central to interaction. Our use of machines differs in fundamental ways from the interaction between people. We note the difference between the way in which we make sense of a machine and of a fellow human being. The person will display accountability in her actions leading to a mutually constructed context in which activities find their meaning - machines will usually be designed to allow users to read them, but not in the same way. The task of constructing useful access to systems representations - making artefacts that are accountable in their own way is one of the central challenges of computer science. How can artefacts explain themselves and allow users to explore and understand them (e.g. by inspecting and changing between layers of representation and state displays). Here it is worth noting the difference between technical, planned/designed functionality and rationale and the effects of these on the material that people add to the systems, the data, the information, the letters, the legal obligations, the importance of an order, the relationships between material connected with a case, the effects of a sorting mechanisms on the merged databases from two collaborating companies. That is, that which the users may need to understand about the information in a systems and the role that this information has to him may not be foreseeable in the design situation. Designing artefacts that support this, is one of the most interesting tasks for designers at the moment.

6.2. Learning from "the natural world"

Embodiment was said to be about our strategies for acting in the world. It is often said to be about being in "real time" and "real space". So let us consider the role of the natural world. Our new technologically filled spaces are part of our natural world - just as much as bicycles, banks and rainbows are. However for some purposes it makes sense to use the term "the natural world" as short hand for the idea of a shared physical, temporal, material world that we grow up in and find most of our interaction taking place in. Particularly since the basic interactional strategies and sense making strategies that we apply have their origin in this world. Embodiment is about how we find ourselves in this natural world.

There is an important distinction to make here related to the use of the "natural world" in the analysis of for instance media spaces and virtual environments. Comparison of different settings allows us to understand how people apply certain strategies and how differences between settings may result in these strategies having different consequences than was intended and expected. Similarly the break downs point to the function of the methods and their uses in traditional settings, allowing us not just to understand the new settings better, but also to better understand the traditional ones. In some way, this is comparable to the "breaching experiments", where students of Garfinkel knowingly behaved at odds with what would be typical behavior (questioning people unendingly about the meaning of their statements, making irregular moves in games, speaking to people at closer range than you would usually have done, ...) and paid attention to the ways in which people dealt with these situations. Our new technologically shaped settings in the same way changes the environment and interactional situation for people, making them find that their strategies fail, change the strategies and address the assumptions and strategies, that they usually pay no attention to. These are all uses of the natural interaction as a source for comparison. This is not a suggestion that all differences should be minimized - that our new technologies should provide similar mechanisms for interaction and that these would, could or should be used in the same way. The features of the natural world is a construct that allows us to understand some of the problems that people meet in alternative settings - it is not a norm for how interaction must or should or can only efficiently occur - at least, we can not know that it can not be done in any other way before having tried it, and the flexible way in which people tailor their behavior to the current situation - their ability to go on - suggest that we will be able to work efficiently in a great many settings.

This allows us to identify two (not mutually exclusive) strategies for constructing systems:

- imitating "natural" environments
- learning from "natural" environments

6.2.1. Imitating "natural" environments

The basic reasons for imitating the natural environments are 1) that they work well for many purposes and "there's no need to fix what is not broken" and 2) that there will be no need for learning new ways of interacting allowing easy and fast access for any user, including children. To this comes the argument that 3) the familiarity with and flexibility of natural environments will give users a larger degree of control of the system allowing them to configure the system according to their specific purposes. This rationale can lead to systems either fully or partially mimicking our everyday physical environment. The main problems with this approach is 1) that some activities may need other types of interaction (and thus support for interaction) than found in normal face to face interaction. For instance, blinkers on cars often work well and are in general preferable to engaging in conversations with all the other drivers and 2) that the system is not completely like what it "pretends to be". If this is not made clear and if it is not possible for the users to understand what "really" is going on, the metaphor may misguide the users and make it impossible to work around the differences. Finally, 3) it seems unlikely that solutions to the problems in providing environments that are similar to our naturally shared, physical world are

forthcoming, and with this in mind it may make sense to pay special attention to point 2.

6.2.2. Learning from "natural" environments

This strategy also departs in the multitude of ways in which people make sense in and of their world. Instead of attempting to provide identical features in the systems the task is to understand 1) how systems might differ and what this means for their application areas and 2) which substitutes can be provided for the mechanisms and features of our efficient normal interaction that can not be copied into systems. This means that use of systems is investigated to achieve a better understanding of the fundamentals of human action and that this is the basis for the design of systems supporting action and interaction that may be radically different from the "natural" environments.

The shared world is of central importance to intersubjectivity, but as seen above this shared world may be different from normal physical environments. The outset is that many interaction strategies and interface models, some untraditional or even unthought of, might work. Often we will have to try them out to see if they do and under which circumstances.

Strategies for supporting richer form of engagement should be based on an understanding of the way in which we make sense of objects and of each other in the world as bodied beings seems promising.

Learning from existing practices can help, partly by showing problematic areas and possible solutions and partly by showing mechanisms that in some way should be substituted or reproduced and partly by giving directions for how such and new mechanisms might look and be used and understood by users.

It is clear that some directions may lead us to systems that are different from well known mechanisms, that training and non-intuitiveness may be an issue, and that these new things may become intuitive as people use them. This stresses the importance of systems that allow and support people to generate new ways of working as they gain experience together and as their environment changes.

Ideas for such mechanisms are flexible entities mimicking coordination mechanisms or physical clues that people use to make sense of each other as features of the embeddedness in a physical environment. (e.g. Schmidt)

6.2.3. Supporting evolving environments

A particularly interesting challenge is providing technical systems that 1) are flexible and modifiable by the users and 2) support such modifications. The aim of these systems is to allow the users to establish efficient practices and to let the entire socio-technical system evolve over time - as the group of users, their experience and the environment changes. This of course is strongly related to the distinction between space and place as discussed above. The task is to provide mechanisms (and a structural setup) that helps and encourages this type of activity. Much work still has to be done on how to provide these mechanisms.

6.3. How to proceed

Arguably a great deal is known about the nature of human action and the conditions for our practices. It is equally clear that there is also much left to understand - in particular how to make sense of the conditions following our ability to construct new types of environment, where our previously sufficient skills and methods fail to provide for what we wish to do. Continued studies in these areas will be necessary to guide development of useful systems - this done both as studies of traditional settings and as experiments with environments that are changed by various types of technology. These changes may be motivated by problems and possible solutions from studies of the previous designs, or even based on the fundamental understanding of human action that the studies are on their way to establish - thus allowing a close collaboration between or integration of studies of technology and systems design.

It was argued that our design practices are based on a perspective that makes it impossible to encompass certain features of the world in our designs. This was exemplified by context aware systems that pay little attention to reflexivity and to the connection between subject and the world; and by the lack of or misguided use of the body in systems for distributed interaction. It was further argued that ideas of embodiment from phenomenology provide us with a way in which to address some of the problems and that they may allow us to think of radically different types of systems. And finally that this could be part of the current reformation of computational practice.

Forgetting the body and building technology that only addresses a small part of our world of experiences may lead to a situation where technology, when brought into new settings, changes the practices towards this limited type of interaction and activity. It may make us increasingly tailor our expressions and interaction strategies towards this caricature of interaction - in the end leading to an impoverished society. What we need, is to allow technology to sensibly and respectfully be brought into new areas in ways that support the existing practices and experiences. This requires that the understanding of technology and its environment pays attention to how people concretely experience the world through their bodies.

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