Situated, Embodied Human Interaction and its Implications for Context Building in Knowledge Mobilisation Design

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Abstract: System design is mostly guided by the computational model of the mind, known as computational cognitivism. This model, traditionally based on Turing's Universal Machine, looms large behind the bulk of system design even in Intelligence Augmentation (IA) approach to human-computer interaction, although with the seemingly obvious exception of connectionist approaches (e.g. neural networks, swarm intelligence). Other extensive computational models do exist (e.g. Hintikka and Mutanen's trial-and-error computability model and Peirce's semiotic model) but they have not yet been implemented in working computer systems. Computational cognitivism pictures the mind as a disembodied, decontextualized calculating machine, operating with logical-syntactic rules and principles. This view has in contemporary times been challenged from the quarters of biology, sociology, anthropology, linguistics, psychology and economics. Perhaps the best comprehensive label for this critical approach is grounded cognition. Grounded cognition conceptualises the mind as a complex process related to and partially constituted by body, environment, other minds and artefacts, thus calling for a corresponding re-evaluation of knowing, understanding, learning, perception, action, interaction and reasoning. The aim of this paper is to tentatively examine whether these insights into natural cognition could inform the system design of mobile systems which support nomadic knowledge workers as well as the man in the street. Computer supported (automated) context building is of special interest here as the human way(s) of being in the world presents a particular challenge to this part of system design.

Keywords: mobile human-computer interaction, situated rationality, embodied rationality, grounded cognition, knowledge mobilisation, context design, abduction

1. Introduction

Throughout history, human cognition has as a rule been conceptualised as grounded in our natural environment, that is, as more or less part of our natural and social environment. Along with the rise of mathematical logic, pioneered by the works of Gottlob Frege, Charles Sanders Peirce, George Boole and Ernst Schröder, human thought was beginning to be seen essentially as a calculus that obeys universal laws, the laws of thought (Pulkkinen 1994). The things related to human cognition which do not fall under the universal laws of thought were regarded as belonging to psychology or sociology. At the turn of the 20th century, logicians spent much time and energy in criticising each other for psychologism. By psychologism was meant confusing how people really think in everyday life with how they ought to think. Psychologism was a serious professional blunder that extremely few logicians were willing to admit to (Kusch 1995). Mathematical logic with its laws of thought prepared the ground for present-day computational cognitivism. When computers entered the scene, it was a natural notion to regard human thought as computation, in analogy to the mechanical calculus performed by computing machines. It was first after computer scientists, led by Herbert Simon, focused their attention to how people reason in real life that also psychologists began anew pay more attention to higher cognitive processes and inner mental representations. Herbert Simon (1947; 1957) has also been a major contemporary influence on how computer scientists and system designers have pictured the human mind, and thereby how they picture thought, knowing and reasoning. In spite of Simon's decisive influence and contribution to the study of heuristics – inspiring the work of Kahneman and Tversky (see e.g. Kahneman 2003) as well as Gigerenzer and his colleagues – Simon remained true to (or trapped in) the computational cognitivist picture of the mind. Computational cognitivism sees the human mind as similar to the computer, focusing on syntax instead of semantics (meaning). Patterns of human cognition were reduced to algorithms, and these logical-symbolic simulations were on the whole successfully applied in computing systems on a wide range of tasks (Ibañez and Cosmelli 2008; Patokorpi 2008). Computational cognitivism is nowadays criticised from the quarters of a great many natural and social sciences. A central message is that rather than individuals being less rational than predicted by the complete rationality approach and computationalism, these approaches had a misguided conception of rationality to begin with (Hurley 2005). A good collective label for these critical voices is grounded cognition (Barsalou 2008a; see also Ibañez and Cosmelli 2008).

Reference this paper as:
Patokorpi, E. "Situated, Embodied Human Interaction and its Implications for Context Building in Knowledge Mobilisation Design" *Electronic Journal of Knowledge Management Volume 7 Issue 3, (pp367 - 376), available online at www.ejkm com*

Traditional, supply driven knowledge management is now being challenged by a number of more dynamic approaches to knowledge, e.g. system-based knowledge transfer model (Parent et al. 2007), embodied interaction (Dourish 2004), knowledge creation (Nonaka and Takeuchi 1995; Nonaka and Konno 1998), knowledge building (Bereiter and Scardamalia 1993), various decision support and soft systems approaches (Silver 1990; 1991; Checkland and Holwell 1998; Hasan 2008) and knowledge mobilisation (Carlsson 2007; Romero 2008), to name only a few. A common denominator in these approaches is that knowledge is no more seen so much as a static, supply driven asset but rather as a dynamic component of situated human interaction within a hybrid environment of technological and social systems. A host of things over and above inner mental representations is seen to be an inevitable part of human knowing and learning. Building on previous research – under such labels as Situated cognition, Embodied interaction, Ecological rationality, and so forth – the paper at hand takes a look at some of these key elements of human interaction: situation, body, mind, other minds, environment, everyday reasoning and reality. These elements are, as a rule, poorly taken into account in system design. Understandably so, one might say. However, new mobile technologies and advances in computer system ontologies, description languages, logic programming, and so forth, make efforts to weave computer systems more closely together with natural (everyday) human action and interaction seem more realistic. It is here uncritically presumed that computers are easier, more effective, more expedient and more fun to use if made to support our biologically and culturally conditioned behaviour in the real world.

For the sake of clarity, the subheadings follow the division of key features of human interaction. It should be clear that a fair and balanced account of the various alternative approaches to cognition is not on the agenda as there is both a considerable overlap between them and many differences due to for instance disciplinary differences. In line with the general thrust of these approaches, knowledge is in this paper understood as a by-product of our social and natural interaction with the world. Consequently, the above-mentioned key elements of human interaction are believed to form an integrated whole. Due to a lack of space, no attempt at spelling out what this allegedly integrated whole looks like will be made here. The main idea is to first bring forward, one by one, aspects of natural cognition, and then ponder upon whether they could be taken into consideration in context design for knowledge mobilisation. Knowledge mobilisation is an emergent field which builds on the new freedoms in users' everyday life and computer supported situatedness of action and knowledge enabled by new mobile technologies (Carlsson 2007).

2. Situation: Situated knowing

Situated cognition or rationality aims to convey how individuals act and reason in the real world. The concept is very easy to understand. Situated knowing seeks to take into account some key elements that set the stage for human reason under uncertainty in a context in the real world. Situated cognition involves the following key elements of human cognition. Human cognition takes place/is:

- in real time
- in real-world surroundings
- in interaction with the environment
- connected to goal-oriented action
- embedded in social practices
- emergent

The situated cognition approach restores some elements which the advocates of complete rationality have – in the name of scientific rigour – eliminated from the study of rational action. In its endeavour to find universal principles of rationality, the complete rationality approach sought to ignore time and place as inconsequential to human reason. Situated rationality or cognition recognizes time and place as important factors in human reason in the real world. For the situated rationality approach, knowing is an epiphenomenon of goal-oriented action rather than merely an abstract calculation made in the head. By interactivity is meant that people act in/upon the world and the world acts back. Put less simplistically, knowing and cognition are in many ways intertwined in complex social practices that have a history and a cultural background. Once you take away the social practice, the knowledge related to, or rather embedded in, it becomes virtually meaningless. Usually the social environment is underlined by the advocates of situated cognition, although the physical or natural one is also recognized as important. Human interaction includes not just thought in the head but is in many ways intertwined with perception and interaction with objects, and this interaction can be either symbolic or

non-symbolic, although many advocates of situated knowing stress the natural, unreflective dimension of human cognition. The bulk of human knowing is closely connected to the environment so that some knowledge emerges in a situation, and would not exist without this encounter with the environment, although there are of course ways of abstracting the knowledge from where it emerged (Lave and Wenger 1991; Brown and Duguid 1993; Nonaka and Konno 1998; Nonaka et al. 2000; Dourish 2001; Galea 2008).

3. Body: Embodied knowing

Essential features of the embodied rationality approach, over and above the ones listed also under situated knowing, are:

- embodied knowledge
- cultural differences in meaning making
- reality is complex

Knowledge is embodied in the sense that it is anchored in our body and thereby connected to our way of being in the world and the practices evolved during human biological evolution and cultural development (Lakoff and Johnson 2003; Barsalou 2008b). The ways we are anchored to the world (our life world) are seen as reasonably static and persevering in spite of cultural differences. The natural and social environment around us in turn is constantly changing and complex, forcing us to reuse a number of basic metaphorical interpretation patterns in order to make sense of the world and ourselves.

Ontologies for computerised systems have traditionally been devised in line with objectivist metaphysics. A central requirement for objectivist (Aristotelian or Linnaean) taxonomy is that the categories are unambiguous. Secondly, objectivist categories of a classical taxonomy are based on properties. A thing is made of objective properties. The properties are thus independent of people and how they experience things. If a thing does not have the necessary properties, it will fall outside the category. Empirical studies of human categories in the mind give a very different picture of classification. We categorize things according to prototypes. A prototypical chair has four legs, a seat and a back, but there are also non-prototypical chairs that are identified in relation to prototypical chairs. Thus there are no necessary properties; a chair may for instance not have legs at all. Chairs need to have certain interactional properties instead; we can sit on them, we can touch them, we can rest our body on them, etc. Contrary to an objectivist view on language and thought, advocates of embodied cognition regard concepts as only partly defined or understood in terms of innate properties. Hence 'love,' rather than being understood as consisting of a number of properties like warmth, passion and desire, is understood in terms of other fundamental domains of experience: madness, war, and journey. 'Love' is thus a structured, multidimensional gestalt deriving from our physical and cultural experience (Lakoff and Johnson 2003).

4. Mind: Nonclassical categories

Lakoff and Johnson (2003) argue that our conceptual system is for the most part metaphorically structured. More complex concepts are partly built on other, more familiar and easily understandable concepts. It is questionable whether there are concepts that we would understand immediately, but there are concepts that are more central to our life world. Spatial concepts like 'up-down' and 'near-far' are central to our life world, and derive from our bodily experience of the world. As we interact with the world, the fact that we have a body and stand in an upright position, lays the ground for our spatial concepts. According to Lakoff and Johnson, our everyday thinking is fundamentally metaphorical, and can be analysed into a fairly small number of basic metaphors. "He shot the mayor out of desperation" is a metaphorical expression in which desperation is a beholder and the event comes out of the beholder. We have a number of multidimensional, conceptual gestalts like "discussion" – derived from our experience – that structure our perception and thinking. "Discussion is war" is a metaphor where discussion is selectively structured from "war." In this sort of discussion one has strategies, fires away and wins or loses. The experience of discussing is understood from the experience of war. Metaphorical expressions that are as a rule systematic make us understand more complex experiences out of other fundamental domains of experience, potentially simpler ones. For instance, experiences and behaviour towards food make us understand experiences with thoughts and thinking. Both our immediate concepts ('up-down,' 'objects') and metaphors ('happy is up,' 'discussion is war') are based on our interaction with the physical and cultural environment.

Complex concepts seem to be holistic – consisting of components that become understandable through the whole – rather than aggregates of simple parts. The whole is more important than the parts. Accordingly, a given object is rather categorised based on family resemblances (i.e. prototypically) than set theory. Thus prototypical birds are for instance sparrows as they can fly and sing. Ostriches are not prototypical birds because they cannot fly, but birds all the same (Lakoff and Johnson 2003; Lakoff 1987).

- The mind's categories are based on family resemblances
- Conceptual systems are metaphorically structured

The main point here in relation to taxonomy is that language and meaning are metaphorical. Metaphors, in turn, spring from our practices in the social and physical world. Our practices are therefore constrained by our being in the world which is inescapably a bodily (as well as social) experience. Language and rationality cannot escape these ties to our body and the physical and social world. Non-classical categories with prototypical objects better reflect the reality of mind's workings as well as the outside reality than classical ones. Lakoff (1987) points out that for instance the former stronghold of classical taxonomies, biological taxonomies, have invariably run into confusion and paradox.

5. Other minds: Collective intelligence

Instead of building on methodological individualism, distributed or collective intelligence focuses on decision making in which a group of players seek to maximize the collective utility of the group. Collectively rational choices cannot be reduced to individual utility maximisation (Colman et al. 2008). The advocates of distributed cognition regard a decision maker or rational agent as inescapably connected to other people because of the social nature of knowledge and reason. They talk about socially distributed cognitive systems in which individual minds (cognitive systems) are fused with other minds; knowledge and cognition are socially distributed processes, involving other people (and artefacts) (see e.g. Engeström 1987; Bereiter and Scardamalia 1993; Lehtinen 2003; Fiske 1992).

- fusion with other minds

Recently this view has got support from neuroscience, according to which man is hardwired to read other minds (Camerer et al. 2004; 2005). However, the idea is not new. In The Phenomenology of Mind (1807/1967), Hegel observes that the servant pays close attention to the inner mental processes of the master, that is, reads his or her mind, whereas the master, by and large, treats the servant as if she or he had no inner thoughts.

6. Artefacts: Distributed intelligence

The cultural-historical school of activity (Vygotsky 1969; Leontyev 1977; Engeström 1987) and other knowledge building (Bereiter and Scardamalia 1993) and creation (Nonaka and Takeuchi 1995) movements conceptualise artefacts as parts of a cultural-historical system consisting of people and tools. Hakkarainen et al. (2004) call it the hybrid mind. The hybrid mind is without a well-defined centre, fused with external tools: "In longstanding deliberate practice and object-oriented activity, artefacts may fuse with the agent's cognitive system or become a seamless and inseparable aspect of his or her own cognitive system in the same way as in biological functional systems" (Hakkarainen et al. 2004:19). Put differently, knowledge and cognition are socially distributed processes, involving artefacts (and other people).

- fusion with artefacts

Anthropologists Jack Goody (1986) and Clifford Geertz (1983) have analysed the development of man's socio-historical relation to man-made objects from a cultural viewpoint. A central theme (with variations) in all of the above mentioned writers and schools (including Lehtinen 2003; Magnani 2004) is the dialectic of internalisation and externalisation of practices enabled or supported by artefacts (see e.g. Kaptelinin and Nardi 2006, p. 69).

7. Environment: Ecological rationality

Gerd Gigerenzer's and his colleagues' research programme of ecological rationality takes Herbert Simon's insight about the relation between the mind and the environment – Simon's famous two blades of the scissors – as its point of departure. However, Gigerenzer's programme differs fundamentally from both Simon's and Tversky and Kahneman's programmes. Gigerenzer's goal is to find heuristics in the mind that help decision makers to adapt to the environment. The heuristics

exploit the structure of the environment, thus enabling decision making that requires less time and information than linear optimal strategies. Certain environments make certain heuristics effective. One central aim of the programme is to find a collection of smart behaviours, a so-called adaptive toolbox of decision making mechanisms. The second aim is to find out what structures of the environment make a given heuristic successful. Thirdly, how do people choose between different heuristics (Gigerenzer et al. 2008; Todd and Gigerenzer 2007; Gigerenzer and Goldstein 1996)? The most important single novel element in ecological rationality is the idea of a so-called adaptive toolbox, which could here be phrased as follows:

- Mind has a collection of patterns of smart behaviour

Computational models have an important role in Gigerenzer's programme: "psychology needs models rather than labels for cognitive processes" (Gigerenzer et al. 2008, p. 236). Instead of trying to find a single general purpose calculus, Gigerenzer's group examines a host of specific simple heuristics that adapt organisms into certain specific environments. The outcome is a number of computational models of simple heuristics. The most astounding result of their research is that some simple, fast (requiring less time) and frugal (requiring less information) heuristics, in some environments, perform better than optimization for instance by multiple regression or neural networks. Computational or formal models in general, are a means of showing that these simple heuristics really do perform better than other models. Especially in predicting the future, simple heuristics beat optimal, computationally more powerful methods (Gigerenzer 2008; Gigerenzer et al. 2008; Todd and Gigerenzer 2007).

8. Reality in the raw: Fundamental uncertainty

Thanks to Herbert Simon (1947; 1957), even those researchers who find for instance context and social factors important in the study of rational action and decision making usually picture rational choice as a form of problem solving (e.g. Smith 1997; Quinn 1980). A growing number of scholars feel that reducing all rational action to problem solving is too restrictive. Karl Weick (1993; 1995; see also Selart and Patokorpi 2007) argues that often rather than a lack of information the decision maker faces confusion about the question to be tackled. No matter how much we gather information, it will not be enough if there is confusion about the problem (question) itself; as Collingwood (1939) says; questions are logically prior to answers. For instance, let us assume that we have collected all available, relevant information for a building project or a plan for tackling a famine, but when we arrive at the building site or the place where there is a famine, things look different. However much we have gathered information, when on the spot, we may discover that we have set out with a wrong problem, seeking answers to wrong questions. On the spot we need to resort to sensemaking (Weick 1995), (and sensemaking is an abductive process) (Patokorpi 2007; Selart and Patokorpi 2007). A problem (question) does not exist ready-made but has to be socially constructed, and this social construction involves sensemaking.

The study of decision making under fundamental uncertainty is an approach or a critical angle that has emerged in economics in reaction to complete rationality and computationalism. It highlights the following aspects of human knowing:

- confusion about the problem
- uncountable solutions
- language and knowledge open to redefinition by social agreement
- reality in flux, open-ended
- fundamental uncertainty

Unlike solutions to games like chess, the solutions to real-life problems typically cannot be enumerated beforehand; they are uncountable. Armand Hatchuel (2001; 2005) gives the examples of going to a movie and planning a party. The former has a countable amount of solutions, depending on what movies there are shown in the local movie theatres, whereas there is no limit to the ways in which people may design a party. The party example underlines the point that knowledge is essentially a social phenomenon, which means that there is always room for sensemaking and negotiation of meaning. Moreover, we change reality by changing our shared ways of seeing it (Selart and Patokorpi 2007). The uncertainty that actors face does not derive from complexity alone but may be fundamental, which means that no amount of structuring the problem or defining the problem area will make it well-structured because the problem (question) is shaped by actors in a changing world (Hatchuel 2001; Checkland and Holwell 1998).

9. Everyday reasoning: Logic *in situ*

Deduction has traditionally been considered the pinnacle of human thought, reflecting the universal laws of reason. However, the supposed supremacy of deduction is not unequivocally supported by empirical research. Individuals *in situ* do not universally abide by deductive patterns of thought but frequently resort to what logicians call fallacies, and yet often manage quite nicely. Recently the utility of logic in a specific environment instead of the formal correctness of it has awakened much interest in anthropologists, economists, psychologists and logicians alike (Faiciuc 2008; Smorti 2008). The heuristics movements, too, study the use of logic in specific, real-life or real-life like situations. Individuals in a real-life situation are often (though not always) more interested in how to best cope with this particular situation than in some potential universal truth related to it. For a system designer wedded to an intelligence augmentation approach, this shift of perspective is welcome. Because we nowadays have the means to make users mobile in an unprecedented way, that is, we are on the threshold of ubiquitous computing, it seems natural to turn to solutions that work locally. Grounded cognition redirects our attention to aspects of reasoning which have largely been ignored by classical views. These aspects could be presented as follows:

- Local utility of logic is more important than universal truth
- Forms of reasoning work in tandem
- Perception, action and interaction with objects contain inferential processes

According to Charles Sanders Peirce (1934–63; CP 2.623), there are three fundamental logical forms: induction, deduction and abduction. In everyday thought these three basic forms complement each other. For example, let us assume that I suddenly feel that I am passing out, fainting. Previously when I have felt like this I had trouble with my sense of balance. This is an inductive inference, generalizing from past individual instances. But then I realise that this time there is something different in my feeling of passing out. Previously I have had a feeling of the world around me starting to spin, but now it goes dark before my eyes. This is an abductive inference, focusing on differences and seeking reasons or causes for them. My first thought was that I have trouble with my sense of balance, but now, because of the differences I detected, I have to start looking for another reason. Let us say that I now remember reading in the paper that the feeling of the world turning dark before my eyes is a symptom of heart trouble. Now deduction kicks in. By deduction I conclude that having trouble with my inner ear (affecting my sense of balance) is not something I should be alarmed about but need only to sit down for a moment. In the case of heart trouble I should better consult a doctor. Consequently, wise decisions and sensible action in everyday life frequently require the use of all three basic forms of reasoning combined. What applies for the three basic forms of reasoning, in all likelihood applies for other forms of reasoning, too.

Abduction is operative in perception, action and interaction with objects. The perceptual phenomena studied by Gestalt psychology in which we automatically round up perceptions fall within quasi-automatic, species-specific abduction. An example of a doxastic abductive inference is when we hit the brakes (an action as a conclusion) upon seeing red lights in traffic. The use of auxiliary figures by hand in geometrical analysis is a case of manipulative abduction, indicating that in some cases of human interaction with the environment objects can function as parts of a reasoning process (Magnani 2004; Bertilsson 2004; Eco 1983; Patokorpi 2006a).

10. Closure: Implications for context building

We do not of course always start from scratch when stepping into a situation but sometimes enter with a plan and a firm preconception (right or wrong) of the context. Traditional Human Computer Interaction (HCI) could be seen to build on this assumption of firm preconception of the action by both the user and the designer. Insofar as the situation suits for this approach, as it may suit for instance in well-defined recurring work tasks, not much needs to be said about it here. However, as computation is starting to be everywhere around us, mobility is increasing, and the world is getting more complex, and for a myriad of other reasons, people are less likely to have prespecified plans for action in a great number of situations. Knowledge mobilisation seeks to design exactly for this sort of radical mobility and situatedness in the real world.

In the light of grounded cognition, it seems likely that clearly defined models of context (Winograd 2001) cannot solve the fundamental problems of knowledge mobilisation. Context is something we

make and maintain from one moment to another rather than observe. Thus it is not information but an outcome and concomitant of action. According to Dourish (2004), context is (i) a relation between objects or activities; (ii) its features are defined dynamically and thus cannot be delineated in advance; (iii) an occasioned property of action, and (iv) arises from the activity and thus cannot be divorced from activity or be outside of activity. In brief, what makes a context a context is the nature of the interaction we have in and through the context in question rather than a representation of it.

The aim of ubiquitous computing is to make the digital world (computation) fit our natural ways of coping with the everyday physical environment. Context-aware computing (Abowd and Mynatt 2000), tangible interfaces (Ishii and Ullmer 1997) and digital manipulables (Resnick et al. 2000) seek to bridge the natural everyday world and the digital world by bringing our patterns of natural behaviour to bear on our interaction with computational elements in the environment. The ultimate aim is to make the world into an interface. It means among other things the exploitation of physical objects and physical space in our interface use, making computational elements ready-to-hand and disappear to the background (Weiser 1991; Dourish 2001; 2004; Patokorpi 2006a). Consequently, instead of making models of contexts in advance we could model reality directly. With the help of fuzzy logic, neural networks and abductive logic it should be possible for the user, in and through activity, to create a context step by step in interaction with the system. Context building is in this sense meaning making where meaning (content) is determined by action (i.e. activity, practices) in a hybrid world whose one part is electronic or digital. Fuzzy logic and neural networks are suited for building (rather than representing) the context bottom up from local behaviours. Fuzzy logic and neural network systems do not need a representation or a plan in order to be able to approximate rational action or reach a near-optimal (or optimal) solution. In the same line of argument, some forms of abduction, too, do not need a representation and belong to evolutionary learning, which means that they are patterns of our unconscious biological adaptation to the environment. This is not to say that mental representations, for instance in the form of reasons, have no place in context building. Namely, one problem with the system disappearing into the background, becoming invisible (Weiser 1991), is that the user loses sight of the system's functions and the effects of his or her own actions to the system and the environment. The user should be to some extent able to read the system's functions and state as well as have the means to intervene (Silver 1990; Patokorpi 2006a; Patokorpi 2006b; Hasan 2008). Fortunately, some forms of abduction rely on (internal or internalised) mental representations, and it is these forms that can especially be used for securing the user an avenue of direct intervention to context building. It means making the system behave/function in a more predictable way; so that the user will for instance be able to read the signs that point towards causes or reasons behind the functions. Computing systems will, so to speak, have to whistle, whimper, blush, get startled, chuckle, clear their throat, raise their eyebrows, sweat, cry and smile more than they do today.

A context has to be made and negotiated with other people. In the words of Dourish (2004, p. 22), the question of context is "how and why, in the course of their interactions, do people achieve and maintain a mutual understanding of the context for their actions?" However, there have to be some, more stable (default) elements which help anchoring the system's functions and connecting them with activity. Here are some suggestions. The stable, but not static, features of a context could be connected to levels of action (vegetative, operational, action, activity, coordinated collective action), user roles (Fiske's 4 social relations), and a setting.

Levels of user behaviour could be: vegetative, operation, action, activity and coordinated collective action. Operation, action and activity levels have been borrowed from the activity theory, and need no explanation here; the levels of action have been applied into the principles of system design for instance by Kari Kuutti (1996). The vegetative or autonomic level requires some clarification. If we think of the operational level as people running on autopilot because the things they do have become virtually automatic, and thus in no need of conscious monitoring, then the vegetative level refers to physical (and perhaps in some cases mental) functions that are beyond conscious control. For instance, we have already numerous Information and Communication Technology (ICT) applications in health care, measuring heart beat, blood pressure, and so forth. These streams of data are going to be more and more closely tied to automatic context building in the future. As to the last item on the list above, there probably is use for something like coordinated collective action level, delineated along the lines of either Zeleny (2001) or Hatchuel (2005). The notion of collective activity used by activity theorists is in essence backwards-looking, whereas Zeleny and Hatchuel have a forward oriented, design-based perspective to collective action.

User roles are usually based on expertise (novice, experienced and advanced), authorized access levels and personal identity. An alternative or complementary conceptual framework which maps user roles, at the same time giving room for more dynamic social and human computer interaction, is required. Social relationships can be seen as roles which enable people to make sense of each other's actions, meanings, emotions and judgments, and thereby coordinate behaviour. According to Alan Fiske (undated), "relationships are patterns of coordination among people; they are not properties of individuals" (p. 1/9). Alan Fiske (1992; undated) has studied social relationships empirically and reduces them into four fundamental models: Communal Sharing, Authority Ranking, Equality Matching, and Market Pricing. Empirical research indicates that violations of relational models are strongly reacted against. Our interaction with the same person or group may vary from one situation to another, but then the model is changed accordingly (Fiske 1992). For instance, we readily give things to our children (Community Sharing) without expecting to profit (which would be Market Pricing) from it or even expecting anything in return. Fiske's relational models could perhaps be used as a basis for dynamic user classification. The patterns of coordination may involve both people and systems; e.g. commercial versus open source software or systems. The crucial difference is that social relations are not determined by the system alone and that the user is not locked in a certain pattern beforehand. Paying attention to interaction rather than properties, objects and states is in line with a more naturalised and contextualised view on knowledge.

The word setting could be used to refer to those elements surrounding an activity which are relatively stable. These elements can from time to time also become part of the context (e.g. by foregrounding). Setting is akin to Gigerenzer's structure of the environment. There is a sort of fit between the mind and the environment produced by the evolution (and cultural development) that helps us to survive. One expression of this evolutional fit is quick (fast) and simple (frugal) inferential patterns that we use without any conscious effort. Unfortunately, Gigerenzer's structure of the environment is relatively narrowly confined to 'safe' environments and conceptually connected to a traditional view on information and problem solving. Gigerenzer's so-called cues hold promise but much more study is required on how humans (and computing systems) read the environment before a working solution can be found.

The computational model does not necessarily have to be of the recursive kind created by Alan Turing. Hintikka and Mutanen (1998) have devised a more extensive, so-called trial-and-error model, which is nonrecursive, and Peirce has devised a semiotic model (Fetzer 1993). Peirce's model is indeterministic and nonmechanistic, and would thereby seem to tally well with a context building design for knowledge mobilisation based on grounded cognition principles. By the way, this goes for all anchor points suggested above, that is, they seem to be in harmony with a grounded view on cognition presented in this paper.

Predictability is important and it often makes sense to set universal rules and standards in order to ensure that development can be controlled. However, the world does not seem to become less volatile and erratic but more so: Look for instance at the world economy and the climate. The age of dinosaurs seems to be over. Should not we try to regain control locally by designing for easier rewriting of rules by the user in order to meet the ever-changing requirements of time and place?

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