COGNITION IS NOT WHAT IT USED TO BE: RECONSIDERING USABILITY FROM AN EMBODIED EMBEDDED COGNITION PERSPECTIVE

[R E V I S E D   D R A F T]

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Summary

The theory of embodied cognition has gained increasingly support in the Human Computer Interaction (HCI) community. Embodied Embedded Cognition (EEC) can be characterized both by its action-centeredness as well as its roots in phenomenology. The phenomenological character of EEC relates to the view that what ultimately counts for HCI design is the quality of the user *experience*. At the same time, usability is still approached mostly by methods that are ultimately grounded in the problematic cognitivist framework. In this paper I argue for a renewed focus on improving usability by asking for a re-conceptualization based on an EEC perspective. In this I mainly draw on an 'action-oriented' version of EEC. Several key-aspects of the theory that are of immediate relevance for explaining user *behavior* (in contrast to user *experience*) are reviewed. This results in a tentative sketch for an 'embodied embedded usability', doing justice tot the embodied, embedded nature of interaction, while retaining the original goal of how to make technological devices easy-to-use in the practical activities of everyday life.

INTRODUCTION: THE END OF USABILITY?

In cognitive science (Clark, 1997) as well as in HCI (Dourish, 2001), the theory of *embodied embedded cognition* has gained influence as a serious alternative to cognitivism, the traditional foundation of cognitive science (Fodor, 1983; Newell & Simon, 1972). Embodied embedded cognition (EEC) holds that intelligent behavior is embodied in the internal milieu and action-possibilities of the agent's physical body, as well as embedded in the structure of the environment. EEC rejects the cognitivist view of intelligent behavior as the result of an explicit, internally constructed plan on the basis of a mental representation of the world. Cognivitism has been the principle foundation of usability practices in HCI (Newell and Card, 1985). One might therefore be tempted to believe that rejecting cognitivism as a framework will also mean the end of usability as a field of practice. Meanwhile, major industries have been changing their focus from 'usability engineering' to what is called 'user experience design'[i]. Consider this quote from a designer's *blog*:

> User-experience is not like usability - it is about feelings. The aim here is to create happiness. You want people to feel happy before, during and after they have used your product. (...) It is a touchy feeling kind of thing. Why, for instance, does a Audi S6 give you a much better user-experience than a Ford Focus? I mean, in terms of usability they are pretty much the same. (Baekdal, 2006)

Such talk is in stark contrast with the aims of traditional usability research, namely, improving functionality and ease-of-use (Nielsen, 1993). The two developments could be seen as independent, where it not for the influential work by Paul Dourish (2001) who explains how, based on an EEC perspective, 'experience' should be seen as the pivotal concept in interaction design. However, EEC is far from a coherent framework. Several traditions can be discerned within the community. For the purposes of this paper it is important to distinguish between two lines of thought. The first line of thought has its roots in phenomenological philosophy (Verbeek, 2005). It rejects the existence of an objective, external world, favoring the metaphysical priority of *experience.* This is where Dourish can be positioned. Dourish speaks about users mainly on the level of conscious reflection. He is concerned with the *experiences* that emerge in the user's mind during interaction with technology. He uses the term ‘embodiment’ to ‘capture a sense of phenomenological presence’ (Dourish, 2001). I call this the *phenomenological approach* to embodied cognition (Dourish, 2001, cf. Merleau-Ponty, 1962; Varela, Thompson and Rosch, 1991). In contrast, a second line of thought within EEC builds on the idea that cognition emerges in action, contingent on direct, ongoing interaction between brain, body and local environment. It is a materialist perspective that deals mainly with subconscious behavioral pattern formation. I call this the *action-oriented approach* to embodied cognition (Clark, 1997, Brooks, 1991). The action-oriented approach is central to the argument developed in this paper.

In order to get a feel of the difference between the two approaches, consider the WIGO (Bruns, Keyson, and Hummels, 2008). The WIGO is an interactive object vaguely resembling a pint-size milk-bottle. It is one of the *tangible* media that are currently gaining attention in HCI (Ullmer and Ishii, 2000). WIGO automatically detects patterns in the way you wiggle and roll it in your hand. The product provides haptic feedback on the basis of these patterns. If you feel stressed, this will show in your wiggling and rolling patterns. In turn, WIGO will start to counter your stressed movements with haptic feedback.

< Insert Figure 1 about here >

WIGO’s designers are foremostly interested in the affective *experience* that the WIGO provides (Miguel Bruns, personal communication). The WIGO is intended to make one *conscious* of ones own bodily state. One can then decide to relax a little bit, or remember to sign up for those yoga-classes. With the focus on eliciting an *embodied experience,* WIGO's designers implicitly adhere to the phenomenological approach to embodiment. This design objective may be very useful, but it is not the *only* logical consequence reasoning from EEC. Instead, the *action-oriented* approach offers an important alternative that is *not* directed at creating experiences at all. Thus, when Dourish writes,

> “Embodiment does not simply mean physical manifestation. Rather, it means being grounded in and emerging out of everyday, mundane *experience*” (Dourish, 2001, p125, my emphasis),

the action-oriented approach would replace the word ‘experience’ by ‘actions’ or ‘behavioral patterns’. The action-oriented approach does not (necessarily) *need* the concept of experience to explain user-technology interaction[ii]. For example, envision an alternative version of the WIGO: *WIGO-ACT*, which controls the user's stress-levels *directly*, without the user even noticing it. The design objective of WIGO-ACT would not be to elicit a user-experience. It would instead be directed at creating an interactive behavioral coupling, which in turn maintains a desired bodily state. Such a system could in principle by-pass conscious experience, not unlike the workings of a common pacemaker. But, unlike a pacemaker, WIGO-ACT would not (necessarily) have to be positioned inside the body. In fact, many of today's common tools elicit comparable effects. Consider the way in which using keyboard and monitor instead of pencil and paper subconsciously affects our writing style, and may even influence the content of the writing. Here, experience does little in explaining how the tool influences behavior. Likewise, our WIGO-ACT might at some point disappear from conscious experience, fading into the experiential background like the blind man's cane (cf Merleau-Ponty, 1962)[iii]. Most importantly, whatever the specific form a WIGO-ACT may take, the quality of the interaction would be assessed primarily by its functionality and ease-of-use: does the product produce the desired behavioral results, without serious disturbances?

Reconceptualising Usability from an EEC perspective

Is usability-practice still possible, once EEC has been adopted as a theoretical foundation? This paper argues that accepting EEC as a theoretical framework does *not* mean rejecting usability as a *goal*. Even today many of our tools (software and hardware) continue to create serious obstructions in everyday use. Too often devices do not to work as expected, fail to provide the functionality needed; cannot be controlled as intended or will not give useful feedback. In short: 'usability' is still highly relevant (Landauer, 1995).

At the same time, current methods in usability engineering do have a serious problem in that they are ultimately based on cognitivism. The problematic nature of cognitivism, and its consequences for HCI, will be discussed in detail below. In sum, this leaves us in need of an EEC-based interpretation of usability, one that does justice to the embodied, embedded nature of interaction, while at the same time retaining the original behavior-oriented objective of how to make products easy-to-*use,* in practical contexts where people act in order to get something done. In order to develop this interpretation, I claim, it will prove to be fruitful to draw mainly from the action-oriented approach to embodiment.

Outline of the paper

The remainder of the paper is organized as follows. The second section discusses the problematic nature of cognitivism as a foundation of HCI. The third section introduces EEC. Three related lines of research are reviewed: 1) the materialist, action-oriented view (Clark, 1997, Brooks, 1991, Chiel & Beer, 1997); 2) distributed cognition (Hutchins, 1995; Kirsh and Maglio,

1994) and situated cognition (Suchman, 1987/2007) and 3) phenomenology proper (Dourish, 2001, Varela, Thompson and Rosch, 1991; Merleau-Ponty, 1962; Verbeek, 2005). The fourth section summarizes the consequences of these developments for HCI, towards an 'embodied embedded' interpretation of usability. The paper closes with a short discussion of the possibility of modeling embodied embedded interactions.

THE PROBLEMATIC FOUNDATIONS OF CLASSIC USABILITY

Usability practice is grounded in the classic, information-processing view of mind, also called 'cognitivism' (Fodor, 1983). Its focus is on identifying a set of *tasks* that the user[iv] needs to carry out while using the technology in question, in order to reach *goals* (Nielsen, 1993). Associated with each task is a set of *mental representations* of the aspects of the world relevant for carrying out the task. On the basis of perceptual input from the world the user activates the relevant mental representation. On the basis of this representation, the user creates a *plan* for action that specifies which actions should be carried out and in which order. The actual behavior itself is conceived of as the 'mere' execution of an otherwise internal cognitive process (Newell & Simon, 1972). According to the vision of Newell and Card (1985), the success of HCI would depend on how well one could formally model this human computational system, based on a thoroughly objective, quantitative measurements of its behavioral output (Newell and Card, 1985)[v]. As it turned out, all of the core concepts of this classic picture have, in one way or the other, proven to be problematic. I will discuss them in turn.

Action precedes perception

Although often implicit, cognitivist models put perception prior to action. Action is modeled as the consequence of the internal processing of a perceptual input. As Gibson (1979) and others (Merleau-Ponty, 1962) showed, perception itself emerges in the context of ones actions. A turn of my head opens up a new world for me to perceive. Running at speed creates a correlated optic flow on my retinae (Gibson 1979). Standard computer desktops provide little opportunity for creating such action-perception couplings (Keller, 2005; Wensveen, 2005). Instead, action and perception are even conceptually seperated (as *input* and *output*, respectively, or *command* and *feedback*) (Dourish, 2001; Albrechtsen, Andersen, Bødker and Pejtersen, 2001).

Knowledge is not in the head

Furthermore, the purported set of mental representations and computations that models the world quickly grows exponentially large for even the simplest of tasks, leading into problems of search and relevance: how to have access to the *relevant knowledge* at the *right* time? (Haselager, 1997; van Rooij, 2008). In contrast, as Don Norman famously showed, representations need not be in the head at all (Norman, 1988/2002). People make use of all kinds of externally represented information that is reliably embedded in the local environment. This knowledge is not stored internally: if the environment is not accessible – the knowledge is lost (Norman, 2002). We return to the embedded nature of knowledge representation when we discuss the framework of distributed cognition in the next section.

Action is prior to planning

The plan-like character of the way people carry out tasks has been attacked quite radically by Lucy Suchman, who shows that in practice, people often use ad-hoc, improvisational means to reach goals. Plans are constraining forces that emerge out of the real-time interaction itself, not preconditions for behavior (Suchman, 2007). That is, action is prior to, or at least in parallel with, planning. The procedural character of traditional models, such as in use case diagrams (Bittner, Spence and Jacobson, 2002) or Hierarchical Task Analysis (Annet, Duncan, Stammers and Gray, 1971), tend to ignore the fact that most of the actual behaviors of users are messy, improvised and thoroughly pragmatic. People use accidental opportunities that happen to be available here-and-now, which could never be foreseen in any HTA. (Suchman 2007).

Tasks are (bad) descriptions

The notion of a ‘task’ is in some way problematic, as has been discussed by others as well (Proctor and Williams, 1992). A strong focus on describing activities in terms of tasks might lead one to believe that these tasks actually represent some real underlying cause. The cognitivist model is in part responsible for this belief, since it sees behavior as the outcome of internally represented computational procedures (Newell & Simon, 1972). Research shows that the actual causes of the observed behavior often do not correspond to some observer-defined computational procedure at all. (Hutchins, 1995; Suchman; 2007; Wakkary and Maestri, 2007). As Randall, Hughes and Shapiro (1991) state:

> “... aspects of work do not come conveniently labelled as adhering to one or another task, and in practice activities will spill out promiscuously into each other and fan out into an unending succession of elements which relate more or less vaguely with ramified sets of tasks and subtasks... (Randall et al, 1991)

Randall et al conclude that ‘designing on the basis of these judgements will in the event prove disruptive rather than supportive of work activity’ (ibid). If this is true for work activity, the problematic nature of task-analysis might be even stronger for the less constrained activities such as in the home environment or in the public domain (cf. Wakkary and Maestri, 2007). Tasks might therefore best be seen as observer-dependent, normative *descriptions* of what users are doing (Blomberg, Giacomi, Mosher, Swenton-Wall, 1993).

The context issue

Cognitivism is a theory about informationally encapsulated modules that make up the brain (Fodor, 1983; van Rooij, 2008). If one assumes that a particular piece of technology interacts with only a few of such modules, then one can conveniently ignore all parts of the environment external to that isolated interactive system. Likewise, Newell and Card stated: “the human-computer interface is, in fact, a psychologically limited micro-world. Many issues of the wider world [...] do not arise” (Newell & Card, 1985). However, people tend to carve up the world into parts that were not foreseen by the designer model. The user that reads the password of a sticky note located on the monitor before manually copying it into a dialog box in a software application conceives of the physical sticky note and the digital dialog box as an integrated whole, both part of the same ‘interaction’ (cf. Jacob, Ishii, Pangaro and Patten, 2002**).** Moreover, subtle contextual elements in the global setting do in fact affect the main activity of the user in unexpected ways: context matters (Norman, 2002; cf. Lonsdale & Beale, 2004; Moran & Dourish, 2001).

The failure of cognitivist HCI

Although cognitivism has been very succesful as a theoretical foundation for most of the received methods and techniques in HCI, it turns out that the framework also brings with it several problems. These problems pertain to difficulties in separating action from perception, defining the knowledge representation, action-plans, user-tasks, and how to deal with context effects. We now turn to its main alternative: embodied embedded cognition.

EMBODIED EMBEDDED COGNITION

This section introduces several research traditions within the general EEC philosophy. It highlights those aspects of that are of direct importance to an action-oriented re-interpretation of ‘usability’ in HCI.

Basic tenets of EEC

EEC rejects the classic internalist character of cognitivism (Clark, 1997; Thelen and Smith, 1994; Keijzer, 2001). Instead, EEC holds that intelligent behavior is an emergent property arising out of situated, historically determined dynamics within a network of interrelated factors (Thelen & Smith, 1994; Kelso, 1995; Skarda & Freeman, 1987). This causal network transcends the brain, to include not only the neural processes but also the musculo-skeletal constraints of the body, homeostatic variance in the body (with strong influence on the brain’s emotional systems; cf. Damasio, 1994) and last but not least the physical- and cultural constraints present in the environment (Clark, 1997, Hutchins, 1995).

Materialist embodied cognition: inspiration from robotics

The materialist version of EEC (Clark, 1997[vi]; van Dijk, Kerkhofs, van Rooij & Haselager, 2008; Haselager, van Rooij & van Dijk, in press) draws mainly from work in robotics (Brooks, 1991; Beer, 2008; Chiel and Beer, 1997). Behavior-based robots (Brooks, 1991) show how intelligent behavior arises from the coupling between a creature's body and the physical constraints of its immediate environment. These robots need no internal knowledge representation of the task. In fact, representations only seem to 'get in the way' (Brooks, 1991). Rodney Brooks famously proposed instead to 'let the world be its own representation' (ibid). Andy Clark elaborated on this idea (Clark, 1997) showing how people go about their daily affairs mostly 'on autopilot' (van Dijk et al, 2008), guided by local dynamic couplings. Clark coined the "007-principle": 'an intelligent agent only needs to know exactly as much in order to get the job done' (Clark, 1997). If the environment provides clues for action at the right place and time, there is no need for costly computations over internal representations. Already in the 80's usability-guru Don Norman's discussed the related concept of "knowledge in the world" (Norman, 2002). Norman shows how people are often guided by external constraints, *affordances* and natural mappings, in favor of using 'knowledge in the head' (ibid).

EEC emphasizes that cognitive action arises out of a continuous and parallel flow of input and output between organism and environment (Kelso, 1995). This means that the classic metaphor of discrete *message passing* is wrong. Perception is not the passing of a message from the environment to the brain and action is not the passing of a message to the environment (Clancey, 1997). This is important for HCI since the standard metaphor has been precisely that: users are engaged in telling the computer what to do and computers are engaged in telling people what state they're in (Newell & Simon, 1972; Beale & Abowd, 1991)

Materialist EEC is concerned foremost with explaining intelligent *behavior* (Clark, 1997) and not with *experiences* as such. The ad-hoc, embedded, autopilot nature underlying the bulk of our behaviors is emphasized. The brain relies on information being locally available as we interact with the environment (Beer, 1997). Conscious, 'deep' thoughts should be seen as an additional control layer upon – and contingent on – more basic situated body-world dynamics (van Dijk et al, 2008; Haselager, Van Dijk & Van Rooij, in press; Brooks, 1991). In sum, materialist EEC tells us that much what is usually called *intelligent* behavior might in fact be based on local couplings between bodily structure and environmental constraints, not unlike the way 'lower' organisms operate (cf. Godfrey-Smith, 2002).

Distributed and situated cognition: inspiration from cultural antropology

A separate line of research originates in the social sciences (Suchman, 2007; Hutchins, 1995. See also Winograd & Flores, 1986; Clancey, 1997). Suchman's *situated cognition* has explicit phenomenological roots (Dourish, 2001). Based on careful analysis of conversations between users, while collaboratively engaged with machines, Suchman concludes that there is no such thing as an internally created ‘plan for action’ based on a mental model of the world. Like in Brooks’ robots, action is prior: through interaction with the world, plans evolve, in an ad hoc, improvised manner. This may have serious consequences for the traditional method of task analysis (see the ‘Embodied Embedded Usability’ section, below).

Hutchins’s distributed cognition (1995) is based on ethnographic analyses of behavior and talk on board of a navy ship. Activities such as making a location ‘fix’ on a chart are coordinated achievements of *systems*, consisting of the brains and bodies of several people, as well as the physical tools used. That is: cognitive processes are *distributed* processes. Hutchins, like Clark (1997) and Clancey, (1997), argues that we should not assume internal representations when this is not necessary for explaining behavior. Moreover, behavior is often not directed at carrying out some task *directly*. Rather, the user’s behavior is geared towards providing the necessary *complement* to the autonomous workings of external tools, such as charts and tables. In other words, you do not have to know ‘what the tool knows’ you only have to know how to operate the tool. This is precisely what makes tools handy: one can offload part of the cognitive load onto the environment. Likewise, David Kirsh distinguishes between pragmatic versus epistemic actions (Kirsh & Maglio, 1994; Neth, Gray, Kirlik, Kirsh & Payne, 2007). Pragmatic actions directly contribute to achieving a goal-state, whereas epistemic actions reorganize the world in such a way that further action will be less computationally burdening. Taking out a pen an paper would be an epistemic action that makes a hard calculation less difficult, because what one needs to know in order to do a calculation ‘on paper’ is less complex than what one needs to know in order to do the calculation itself (Wilson & Clark, in press). Again, we see a correspondence to the way Donald Norman shows how people not only use, but also create ‘knowledge in the world’, such as when we put stuff we shouldn’t forget in front of the door, so that we stumble upon it when leaving (Norman, 2002).

Situated and distributed cognition largely deal with the user’s intentions and (explicit) thoughts[vii]. This is understandable, since conversation analysis is based on statements in natural language, made by people about themselves and their environments. The focus is therefore somewhat different from the robot-inspired models of behavioral dynamics discussed earlier, not stressing the idea of *embodiment*. Yet, when the question concerns how intelligent behavior comes about, both lines of research are consistent in their emphasis on the *embeddedness* of cognitive processes.

Embodied experience: inspiration from phenomonology

While phenomenology is the prime philosophy of *experience*, we can nonetheless draw important lessens from it on how users and technology interact *behaviorally*. One important distinction, made by Heidegger, is between ‘*zuhanden sein’* and ‘*vorhanden sein’* (Verbeek, 2005; Dourish, 2001). Consider a piece of technology that is seamlessly integrated into ones activities, up to the point where we might say that it has become ‘transparent’ (Dourish, 2001). The user is not directed at the product itself but at something else, *through* the product. The product is said to be ‘zuhanden’ (Verbeek, 2005). The paradigmatic example concerns the blind man who feels the pavement with the tip of his cane, instead of feeling the cane with his hand (Merleau-Ponty, 1962). But sometimes the product itself comes back into ‘view’, e.g. when it breaks down or fails. For example when the cane becomes wet and slippery, the blind man becomes aware of the grip of his hand on on the cane, making the cane, and not the pavement, the focus of attention. The product is now “vorhanden” (Verbeek, 2005). Heideggers writings are dense and his claims are fundamental (‘pre-ontological’, as Dourish puts it). The conclusion I wish to draw here is that many tools work satisfactory precisely when they are *out* of view, while a product that is ‘vorhanden’ often signals a (usability) problem. In other words: fine tools operate like a good butler: discretely, though reliably present in the background, and *not* demanding explicit attention (Weiser, 1994, but see Dourish, 2001, p. 200-203)

Varela’s ‘embodied mind’ (Varela, Thompson and Rosch, 1991) is rooted in the works of Merleau-Ponty (1962). Varela’s biologically inspired work is based on the premise that the main objective of organisms is to maintain themselves. In this continuous struggle, the *niche* that the organism inhabits is not formed independently from the creature’s own behavioral and evolutionary history. Organisms ‘make a living’, based on their sensory capacities and behavioral repertoire, creating at the same time an *Umwelt* (Von Uexkull, 1934; Ziemke & Sharkey, 2001; Haselager, van Rooij & van Dijk, in press;). The organism *enacts,* not only itself, but also its world. Selecting an appropriate action is taking place in an environment with which the organism already has an intimate relationship. In line with the distributed cognition thesis, this means that it is impossible to draw a strict line between ‘user’ and ‘technology’.

EMBODIED EMBEDDED USABILITY

We are now ready to take some first steps towards describing an interpretation of 'usability' that is based on EEC, but nonetheless directed at user *behavior*, with the principle objective to improve functionality and ease-of-use.

User cognition

Contrary to the classic information-processing models, users generally do not have internal representations of the task-environment, nor do they plan their actions internally before execution. From the materialist perspective we learn that autopilot behavior often comes before deep thought and the workings of mental representations. Emergent behavior depends heavily on the available ‘knowledge in the world’ (Norman, 2002; Clark, 1997). Many tangible interaction designs (Ullmer & Ishii, 2000; Hornecker, 2006) already make use of this principle. As an illustration consider just one example, the design of a the power outlet on a video-recorder by Djajadinigrat, Wensveen, Frens and Overbeeke (2004). Figure 2 shows how a physical form, combined with the way in which the user can manipulate this form, creates an environmentally embedded representation of the state that the product is in (either on or of).

<Insert Figure 2 About here>

This information does not have to be internally represented, nor is it transferred from the system to the user in the form of an explicit message (say, as a symbol on a display). Instead, the state of the machine relies on the physical structure of the product itself and the actions this structure afford.

One of the drawbacks of a reliance on embedded structure is of course that people are quickly confused or frustrated when the necessary environmental 'background' turns out not to be present at the right time and place (Norman, 2002). One challenge for the design of computational devices is precisely to overcome that problem, and let computing power and network technology create environments where information is externally available precisely at the locations and times when it is needed by a user in that is operating in 'autopilot' mode. Current developments in mobile and context-aware systems are investigating this problem (e.g. Streefkerk, van Esch-Bussemakers & Neerinckx, 2007; Steen, van Eijk, Gunther, Hooreman & de Koning, 2005).

Interaction

EEC implies that in our everyday interactions there is no explicit message passing going from human to machine and back. People and technologies interact much more directly, in analog ways, grounded in the way their bodies interact, situated in the physical environment. Even cognitive interaction is in many ways very much like dynamically steering a bicycle (Dreyfus & Dreyfus, 1990). The appropriate metaphor is not so much 'message passing' as it is 'structural coupling' (Chiel & Beer, 1997). On this view, interaction emerges as a self-organizing process within a sets of *constraints* (Kelso, 1995). Hence, designers might be better of creating such constraints (Norman, 2002) rather than attempting to *specify* (by means of procedural models) how the interaction should unfold. Several attempts have been made at tapping into the low-level body-world couplings more directly (see e.g. Hummels & Overbeeke, 2008; Underkoffler & Ishii, 1998; Ishii, Ratti, Piper, Wang, Biderman, & Ben-Joseph; 2004). The current popularity of the commercially available *Wii controller* has given rise to interesting new strategies for interaction using the whole of the body (several intelligent examples by Johnny Lee can be found at http://www.wiimoteproject.com/).

What the user is trying to do

The classic model depicts behavior als the implementation of a task that has been formulated inside the brain of the user in the form of a plan for action. From EEC we learn that this is rarely, if ever, actually the case. Instead, people act on improvisation, guided by local, ad hoc opportunities (Suchman, 2007)[viii]. (Still users may consciously *report* to be aiming for the accomplishment of some defined task, even if this is in fact an illusion. See (Wegner, 2002)). One of the consequences of this is that abstract task definitions do not necessarily map onto the real, causal factors that determine the user's behavior *in situ* (Suchman, 2007). Users may temporarily suspend tasks or even drop certain goals altogether, if the effort needed for achieving them turns out to be outweighed by other emerging opportunities for action (Haselager, 2004). Although a rough description of a task may be very useful in defining the design problem, designers must not forget that task descriptions are ad-hoc, loose *descriptions*, in which both the desired behavior under investigation as well as elements from the observer-dependent perspective are fused (Blomberg et al, 1993). Users need to be able to act *epistemically* (Kirsh & Maglio, 1994), creating their own environmental 'scaffolds' (Clark, 1997) that in turn serve as useful external 'hook-ups' for the unfolding cognitive process. One intriguing example of this is presented in (Block, Haller, Gellersen, Gutwin, and Billinghurst, 2008), who developed the means for users to create for themselves physical interaction controls 'on the fly', to be used instantly in as interface elements to computer software. Some of these personal buttons might only serve a purpose for a particular user in a particular context. They would never have been developed on the basis of generic task analyses. Yet, such buttons can be highly functional and increase usability – i.e. for that user, in that context.

The (designed) environment

Many practical tools are ideally always *zuhanden*. Whenever my mobile phone become 'zuhanden', this is mostly when some problem occurs or in which the thing requires my explicit in order to determine how I can get the machine to do what I want it to do. That is, 'zuhanden' means *low* usability, where, in Norman's terms, the Gulf of Execution is large (Norman, 2002). Designers do not always acknowledge the user's desire for a smooth, mindless 'vorhanden' relation with their surrounding technologies, perhaps because for designers, the product is almost always *vorhanden* (it is after all their explicit focus of attention). More generally, we saw that people are not simply the passive consumers of fixed environments, they co-create these environments, 'bringing forth a world' in which to maintain themselves (Varela et al, 1991). Traditionally, the usability of a device is seen as the property of an external object people need to deal with. Using a product is like solving a problem, and if the problem too complex, usability is consequently low (Norman, 2002). Instead, following Varela (1991) we can state that technology, once it is integrated into ones life-activities (once fully 'vorhanden') has now become a genuine part *of* the user. If we conceive of artificial devices as artificial 'organs' *of* the user (Merleau-Ponty, 1962) usability becomes an issue of 'internal' harmonisation rather than something that happens 'between' two systems (i.e. user and device). In ubiquitous computing and ambient technologies we see the same reconceptualisation of what it is exactly that we mean by 'the interface' (Dey, Ljungstrand & Schmidt, 2001). In ubiquitous computing environments, the interface is both everywhere and nowhere (depending on ones perspective), distributed as it is in space and time, mediated by various kinds of physical structures in the environment that connect to all of the sensory-motor channels users have at their disposal (Dey et al, 2001, but again, see Dourish, 2001, p. 200-203).

DISCUSSION

The fact that Don Norman's "The Design of Everyday Things" (1987/2002)[ix] is still heavily quoted and used in classrooms throughout the world, already hints at the fact that several basic usability problems have not been adequately solved in the past decades, even though considerable progress has indeed been made, most notably with the advent of user-centered design (Caroll, 1997). In this paper it is claimed that some of the persisting usability issues can be traced back to the fact that mainstream HCI is ultimately grounded in a *cognitivist* conception of human computer interaction (Dourish, 2001, Winograd & Flores, 1986).

The fundamental problems facing cognitivism emerged most prominently in the area of robotics (Brooks, 1991). The theory was unable to support the creation of adaptive robots that needed to operate flexibly in real, unpredictable environments (Brooks, 1991; Clark, 1997; Beer, 2008). I've suggested that cognitivism faces quite comparable kinds of problems in supporting the design of natural, intuitive interfaces intended to function in real, messy use-contexts. The difficulties stem from issues, described in this paper, concerning the nature of knowledge representation, internal vs. external computation, planning vs. improvisation, and the role of context. I have discussed the potential virtues of the current alternative to cognitivism: embodied embedded cognition. In this I closely follow Paul Dourish, who has advocated a comparable move (Dourish, 2001). In contrast to Dourish, however, the position taken in this paper is less focussed on *phenomenological experience* and more on the ways in which people *behave* with their bodies in the physical world. With this move I hope to be able to connect insights from EEC more directly to the practical issues of *usability* that still confront us today.

One might argue that usability is simply a *part* of user-experience (Morville, 2008). If the aim is to make people 'happy' (Baekdal, 2006), basic usability issues need to be solved, in order to achieve this 'happy' experience. But a designer/engineer can only spend so much time at any project, and usability has to compete with a multitude of other important themes living under the 'eclectic' umbrella of user-experience design (cf. Sharp, Rogers and Preece, 2007). Furthermore, as discussed above, some usability issues will not (immediately) affect our conscious experience at all. In case of immediate, ongoing behavioral user-technology couplings, personal experience might just not always be the most informative concept.

All of this should not be seen as a plea against ‘experience-design’ as such, nor do I intend to downplay the usefulness of phenomenology for design. Still, this paper draws a strict boundary between on the one hand the field of user-experience design, as grounded in phenomenology of the user-experience, and on the other hand a vision of an ‘embodied usability practice’ in which the focus is on creating intuitive products that are ‘easy-to-use’, grounded foremost in the materialist behavior-based version of EEC. I have made this explicit distinction, because it might otherwise be assumed all to quickly that once HCI rejects classical cognitivism as a foundation, the only option left is to start ‘designing for experience’, abandoning ‘usability’ as a goal altogether. In contrast, ‘EEC usability’ puts its focus on untangling the various ways in which local constraints and affordances in the environment, history-of-use, epistemic actions and ad hoc plan formation influences the basic autopilot-style behavioral couplings of users and their technological surroundings.

One issue left untouched up until now is the question of whether (and if so how) it would be possible to formally *model* embodied embedded interactions between users and technologies. Computer science has a special relation to formal models because, in a way, ‘modeling’ is what defines the field. The possibility of abstract explanatory models of the observed behavior has been one of the main strengths of the information-processing account, also in HCI (Fodor; Newell and Card, 1985; Carroll 1997). Some of the EEC research described above is actually sympathetic to an information-processing interpretation, albeit one that flexibly reaches out into the environment (Hutchins, 1995; Hollan et al). However, there also have been various criticisms pertaining to the difficulty of modeling user behavior, precisely because it is embodied and embedded in nature. Consider this quote:

> “Human behavior ... is complex .. subject to a broad range of influences ... poorly defined, hard to predict and highly contingent. ... As such it is impossible to capture and represent human social behaviour formally by the kinds of quantitative methods of mainstream HCI.” (Procter & Williams, 1992)

Embodied embedded cognition seems principally at odds with the idea of formal models. As Dourish states, ‘embodiment is about engaged action, rather than disembodied cognition ... about the peculiar rather than the abstract ... practice rather than theory, directness rather than disconnection’ (Dourish, 2001, p. 189). It would seem a daunting task indeed to create a formal model of something that is in its very essence everything a model is not (i.e. models are disembodied, abstract, theoretical, disconnected). In fact, in behavior-based robotics, much research is based on simulations instead, where the robot itself *is* the ‘model’ (e.g. Brooks, 2002). We see the same case-based strategy in HCI (e.g. Ullmer & Ishii 2000). Another strategy is to describe the behavioral dynamics of the system using the vocabulary of nonlinear dynamical systems (i.e. attractor state spaces, control parameters, order parameters, initial- and boundary conditions; see

Beer, 1997). Analogously, one could conceive of HCI research in which one does not define *tasks* but rather 'task spaces': systems of task-related variables in which certain goal-directed behaviors are *likely* to emerge, in a self-organizing way. However, such precise models (e.g. Beer, 2008) are a long way of being directly relevant to HCI in any practical sense (see also Neth et al, 2007). In conclusion, taking embodiment, i.e., the grounding of user-behavior in physical structure seriously means asking the complex question of how to understand its workings, without losing 'it' at the same time. One speculative option we are currently investigating is whether the methods used in participatory *design* (Schuler & Namioka, 1993), in which users (ideally[x]) function as active ingredients in the design process, could provide a loop-hole by which abstract models could be by-passed altogether. In such a participatory design process, users, designers and design environments (prototypes, sketches, mock-ups) interact closely, on multiple iterations. The evolving product is always presented in a tangible form so as to be able to interact with it and make changes on it in an active, embodied way (Buxton, 2007). User and technology can thus be said to 'co-evolve' (Carroll, Chin, Rosson & Neale, 2000), a process that, as a design strategy, would itself be 'embodied' and 'embedded', reminiscent of Varela's 'bringing forth, or *enacting*, a world' (Varela et al, 1991)

CONCLUSION

Once we accept EEC as a theoretical foundation for HCI, some might feel that this necessesarily entails a design for *experience*. Perhaps this is partly due to the explicit coupling of HCI to a phenomenological interpretation of EEC most notably by Dourish (2001). The result is that presently user-experience designers are able to draw from the recent trends in embodied embedded cognitive science, while those interested in traditional usability are left with traditional methods and principles that are ultimately based on a problematic cognitivism. Meanwhile, many of today's interfaces are still *not* easy to use. The practical goal, then, is to improve usability. This has nothing to do with user-experience as such. The main claim of this paper is that EEC can also be seen as a theory about *behavior*, and as such it has important things to say about how to conceptualize the behavior of users that are in the process of forming structural couplings with their technological environments. It is presently an unresolved question whether it is in practice possible, or even necessary, to actually *model* such structural couplings in concrete design projects, or whether participatory design could provide an alternative strategy. In all, this paper has presented a tentative sketch for an 'embodied embedded usability', doing justice tot the embodied, embedded nature of interaction, without abandoning the original question itself: how to make technologies functional and easy-to-use in the everyday world.

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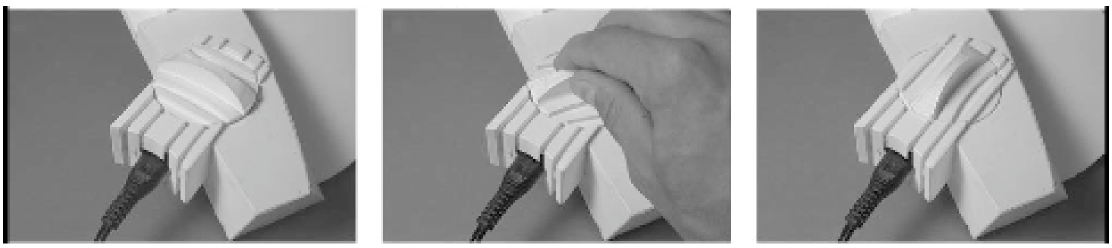
FIGURES AND CAPTIONS

Figure 1: The WIGO (Figure taken with kind permission from Bruns, Keyson, and Hummels, 2008)

Figure 2: A tangible power-outlet. From left to right: ‘off’, ‘turning it on’, ‘on’. ([permissions not arranged yet] Taken from Djajadidingrat, Wensveen, Frens and Overbeeke, 2004)



Notes

[i] See e.g. IBM's website: https://www-306.ibm.com/software/ucd/. Popular sources on 'UXD' amongst professionals are the writings of Peter Morville (http://semanticstudios.com/) and Jesse James Garrett (http://blog.jjg.net/)

[ii] Although it is agnostic to the question of the *possible* (supportive) ways in which experience can support or obstruct cognitive processes and guide user-environment interaction.

[iii] I am aware of the fact that phenomenologists like Merleau-Ponty hold that experience is a fundamental, metaphysical concept, prior to any talk of consciousness, indeed, prior to any talk of the whole of reality that surrounds us. This paper does not elaborate on the metaphysical dispute between phenomenology and scientific realism, however. The aim here is to explain how embodied embedded theory can have an important say on how to analyse *behavior*.

[iv] In the remainder of this paper I use the classic term 'user', simply because there seems to be no good alternative. There have been attempts at inventing a better suiting name to denote people during their interaction with artifacts. E.g., Philips' internal policy is to speak of 'complex human beings', instead (Slava Koslov, Philips Design, Netherlands, personal communication)

[v] Their radical thesis was attacked by Caroll (1997)

[vi] There's actually more to be said about the purported realism of embodied embedded cognition, which cannot be covered in this paper. See e.g. Chemero's (1998) response to Clark (1997).

[vii] Note that the field also explicitly discusses social and cultural embeddedness, which I leave unaddressed in this paper (see Dourish, 2001 and Clancey, 1997, for extensive accounts).

[viii] For many intriguing examples of what this amounts to in everyday life, see: Thoughtless acts? Observations on intuitive design. Jane Fulton Suri & IDEO. 2005: San Francisco: Chronicle Books. See also (Wakkary and Maestri, 2007)

[ix] But see Norman (2004).

[x] We are aware of the fact that in practice it is very difficult to really incorporate end-users in the design process itself. The term participatory design has been used for various practices in which there is either more or less actual user involvement (Steen, 2008).