An Historical Epistemology of Perception in the Use of Mobile Computers[1]

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Abstract

Recently, the interaction between humans and mobile computers, as a part of the broader problem of technology use in Human-Computer studies, has received some research attention. Researchers have explained mobile technology use in terms rhythms, negotiation, contextual influences and boundary control. However, these explanations do not exude sufficient cognitive accounts of mobile technology use. To supplement existing explanations, the use of mobile computers is explained in terms of the historical epistemology of perception. In this epistemology, perception is deemed as a mode of human action that is endowed with goal-orientation and teleological consciousness. A cognitive-based explanation of mobile technology use will enhance our understanding of the mediating role of technology representations and of how human mobility and mobile work filter these representations in mobile computing. The explanations provide guidelines for research, design and integration of mobile technologies in mobile activities.

Keywords: perception, representations, filtration, consciousness, activity, mobile technology.

1 Introduction

Many existing explanations of the use of mobile technologies confirm the idea that such technologies can be used anytime anywhere (Kleinrock 1996) but they cannot be used everytime everywhere (Wiberg and Ljungberg 2001). We seem to know quite well that mobile technology use patterns and purposes largely deviate from intentions (see, for example, Sørensen and Pica 2005, Scheepers et al. 2006). So the interesting question which has always confronted researchers has been how and why some mobile technology could or could not be used as intended in mobile activities. To this end, patterns of use of mobile technologies have been explained in terms of rhythms (Sørensen and Pica 2005), negotiation (Weilenmann 2001), contextual influences (Scheepers et al. 2006), phenomenology (Arnold 2003) and boundary control (Cousins and Robey 2005). These explanations largely focus on the physical, sociological and organizational aspects of mobile technology use, leaving the psychological or cognitive aspects unexplained.

A social-psychological explanation of mobile technology use is considered important because it will help us to understand better the role of consciousness. While not denying that consciousness considerations are implicit in non-cognitive explanations, a social-psychological analysis will explicate better the role of the user's consciousness and the technological and human factors that shape consciousness. This explanation will also proffer more nuanced analysis of various technology representations that are intended and/or

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enacted in mobile technology usage. Better explanations of consciousness and more nuanced analysis of technology representations, it is hoped, will supplement existing explanations. And therefore, I take up this challenge by drawing upon the historical epistemology of perception to analyze the use of personal digital assistants (PDAs) by a group of medical professionals for workplace learning in the British National Health Service.

An historical epistemology of perception is deemed as a suitable explanatory tool because history captures human individual and species development and associated production of tools and signs. In this capturing, human perception is not seen in terms of our physiological sense-modalities, but in terms of cultural-historical production of representations that mediate human perception. These tools and signs are representations that are consciously activated by the tools' users and that shape their perceptions. Contrarily, ahistorical theories of perception provide insights on the "sense-data" (e.g. Russell 1997) of the physical and interface design properties of technologies. Sense-data are data on tools and signs that are immediately perceptible to the human senses; that is, they are here-and-now, devoid of historical significance. Thus, mobile computing explanations built on sense-data will exclude the role of cultural-historically developed representations.

A history- and mobility-based explanation of mobile technology use is necessary for understanding the dynamics associated with mobile computing in mobile activities. This approach is useful because by tackling mobility, historical perception and the interaction between humans and portable computers, it exudes a more holistic understanding of the relationship between perception, mobility and mobile technology use.

Furthermore, this approach is useful because it provides practical guidelines for the design of mobile technologies aimed at supporting, most notably, modern professionals whose work exhibit mobility. By proceeding beyond physiological sense-modalities and their associated sense-data, this historical approach transcends conceptualization of mobile technology use based on just the material and interfacial design properties of technology towards conceptualization that accounts for the historical relationship between mobility, perception and the physical, interface and system design properties of mobile technologies.

2 Perception and Representations

Perception is necessarily a mode of human action that shares the essential characteristics of human actions such as intentionality, consciousness, historicity, goal-orientation, and as constituents of activity (Wartofsky 1979). Based on this, technological tools and their signs are understood as "representations" that mediate perceptual actions; are artificial (socio-cultural); and are produced and communicated by humans in their ontogenetic and phylogenetic means of existence. In general, both tools and signs are regarded as artifacts that consist of both "signifying" and "signified" properties (Saussure 1983). In this regard, the perception of an artifact reflects the semiotic "variation in modes of representation that perception itself comes to be related to historical changes in other forms of human practice, and in particular, to social and technological practice" (Wartofsky 1979). The signifier is the form which the artifact takes, its structure; and the signified is the concept it represents. According to Wartofsky, there are three modes of representation – genetic, reflexive and abstract.

The *genetic mode* of representation (structural) is the "fundamental activity of producing and reproducing the conditions of species existence, or survival" that is distinctively human due to our creation of artifacts. That is to say, the genetic mode of representation derives from humans' transformation of part of the environment into artificial extensions of our biological organs. Artifacts that exhibit genetic modes of representation are perceived as "primary artifacts." The *reflexive mode* of representation (functional) consists of "symbolic externalizations or objectifications of such modes of action – 'reflections' of them, according to some convention, and therefore understood as images of such forms of action – or if you like,

pictures or models of them" (Wartofsky 1979). To him, the signs that Vygotsky labels as "psychological tools" – e.g. language, theories, norms and modes of action – and that can be communicated in one or more sense-modalities are perceived as "secondary artifacts."

Vygotsky's notion of the external orientation of physical tools and the internal orientation of signs are reflected in Wartofsky's semiotic conceptualization of tools as structural representations (of "primary artifacts") and signs as functional representations (of "secondary artifacts"). In the case of "primary artifacts", their structural conceptualization is based on the idea that they are simply the environmental implements which are of interest or use in production. In the case of "secondary artifacts", their functional conceptualization is founded on their functions as preservers and transmitters of "the acquired skills or modes of action or praxes by which this production is carried out" (Wartofsky 1979).

Wartofsky conceptualized a third mode of representation based on "imaginative praxes" – "abstract." Imaginative praxes does not connote mere mental activity, although it is compatible with and sometimes derivative of it. Rather, imaginative praxes connotes actions that are detached from actual direct praxes and are exemplified in play, drama, rehearsals, enactments and modeling. The representations (of "tertiary artifacts") generated in imaginative praxes are abstractions of their use in actual praxes: they are

> "abstracted from their direct representational function … and suggest that they constitute a domain in which there is a free construction in the imagination of rules and operations different from those adopted for ordinary 'this-worldly' praxes. … That is to say, just as in dreams our imagery is derived from our ordinary perception, but transcends or violates the usual constraints, so too in imaginative praxes, the perceptual modes are derived from and related to a given historical mode of perception, but are no longer bound to it" (p.209).

Tools that exhibit abstract modes of representation are perceived as "tertiary artifacts." Through imaginative praxes, "possible worlds" are conceived and perceptual alternatives can be enacted, modeled and tested leading to their actualization. The essence of "tertiary artifacts" lies in the conscious teleology, goal-orientation and values that characterize the alternative imaginative perceptual modes behind their production and communication. It is important to note, here, that alternative imaginative perceptual modes possibly "[feed] back into actual praxes, as a representation of possibilities which go beyond present actualities" (Wartofsky 1979, p.209). This assertion mirrors Leont'ev's exposition of the transformation of representations on the mental plane: "… they are generalized, verbalized, condensed, and most important, they become capable of further development which exceeds the boundaries of the possibilities of external activity." (Leont'ev 1978).

The objective properties of technological tools symbolize shared, preserved and transmitted cultural-historical understandings that inform their users. They are material ("primary") in nature, with enabling and limiting properties into which are crystallized signs, methods and operations (Leont'ev 1978), "psychological tools," (Vygotsky 1978) or "functional representations" (Wartofsky 1979). However, in most instances, an understanding of their production and exchange suggest that they are "tertiary artifacts" reflecting the abstraction and modeling underlying their "off-line" (Wartofsky 1979) production.

The upshot of this review is that perception of an artifact is a mode of human action which is mediated by variations in modes of representations – structural, functional and abstract – and which is essentially aligned with the cultural-historical evolution of all forms of human activity.

Consequently, we will derive our understanding of the use of mobile computers from this historical epistemology of perception; that is, on the idea of perception as a mode of human action. Since these three modes of representation (structural, functional or abstract) of mobile computers always mediate perception, the epistemological basis of this paper is that the perception of an artifact is dependent on its assumption of a primary, secondary or tertiary status in an activity. The assumption of any of these statuses is also a function of the totality of those actions which the individual's perception forms a part.

3 Research Setting

This empirical example is an embodiment of the key parameters whose relationship we seek to properly understand – perception, activity-based human mobility and mobile computing. The artifact in question is the Compaq iPAQ H3970 personal digital assistant (PDA) and running a Microsoft® Windows® CE 3.0 operating system. This technology was adopted and deployed in a work-integrated learning project sanctioned by the British National Health Service (NHS), sponsored by the European Union (EU), and enforced by the EU Working Time Directive (EUWTD). The directive illegalized the 72 weekly hours spent at work by junior doctors in UK hospitals, and stipulated a maximum 48 weekly hours for these doctors. Although this legislation had been passed some years ago, the EU authorities had decided to fully enforce it in August 2004. As a result, immediate pressure mounted on the authorities of the NHS to address the looming crisis that would be caused by man-hour shortages in surgical wards. And as a means to tackle this problem, the NHS Changing Workforce Programme at the Department of Health instituted 19 pilot training projects to train new professionals to assume some of the functions that were erstwhile performed by junior doctors. One of these professionals – the Perioperative Specialist Practioner (PSP) – would be trained in peri-surgical skills which would predominantly consist of integrated care for surgical patients before and after a surgical operation.

The training was designed in such a manner that the each PSP would train as part of a resident surgical team in their hospital. The mobile nature of surgical teams' work automatically suggested that the PSPs' learning would be mobile. This was witnessed in the following statement by one of them: "my work is so MOBILE …." Furthermore, it was designed that their time spent in their hospitals was interspersed by one-week classroom based modules in the training centre in London. Thus, after every six weeks spent in the hospital, all the PSPs would travel to London and stay for a week before returning to their various hospitals.

The project was monitored, coordinated and controlled by its authorities who were based in London; and the PDAs were officially adopted and deployed to enhance the project managers' remote monitoring, coordination and controlling efforts from his location in London. Mobile computational support was built around two main schemes or applications: On the one hand, an Actions Log or database that would hold recorded details of the PSP's encounters with patients on the wards was to be developed by each PSP. They were to select items from a predefined "pick list" by tapping a stylus directly on the PDA screen. On the other hand, there was also a learning Reflective Journal which consisted of a set of templates with headings such as "thoughts and feelings" and "what worked and what didn't?" These were intentionally open-ended questions which would allow the PSPs to frame the answers as they wished. Answers to these questions were to be typed at the end of each learning day using a foldable keyboard which was also provided by the project authorities.

It was envisioned that the PDAs would provide learning support to the PSPs through the accumulation of relevant learning resources – medical literature, drug calculators and formulary – which could be available to the PSPs anytime, anywhere during their learning maneuvers. It was also envisioned that when a PDA is inscribed with theoretical medical information and used in practical learning environments, the learner could intermittently refer to this information to shape his or her sense-making from the practical clinical actions (see Figure 1).

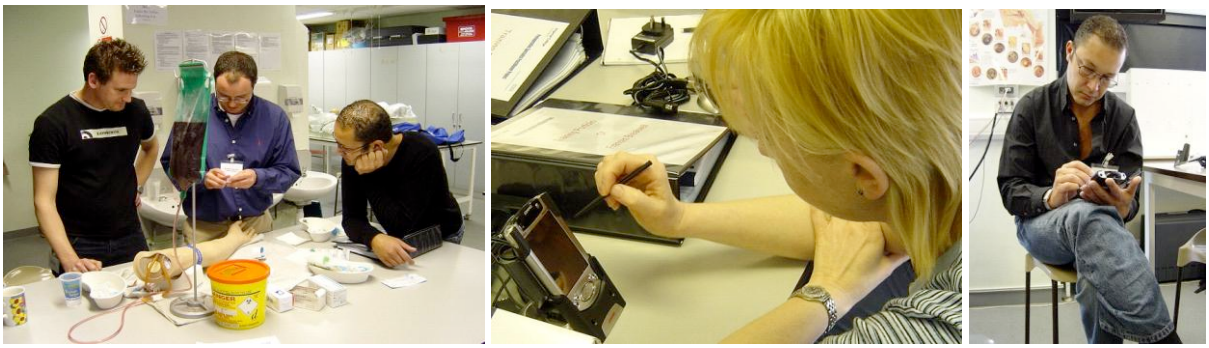

Figure 1: The left frame shows three PSPs in a simulated clinical setting. The middle frame shows a PSP documenting activities and reflections with her PDA outside the clinical setting. The right frame depicts the attention needed for mobile computing.

4 Data collection methods

Data from this project was collected through an action research strategy in which I actively collaborated with the PSPs and the authorities of the project. In addition, I was a direct observer in many of the London-based modules and led the training of the PSPs on how to use the PDAs. Furthermore, I assumed the role of a 24-hour 'helpdesk' support to them – they could call me on the phone anytime for help if they encountered any problems with the use of the PDAs during their training.

I held several meetings, conversations and interviews with the project manager and trainees throughout the project. Although, these meetings were far fewer in number compared, for example, with the number of interviews, they were a reliable and rich source of information on the motives behind the adoption and deployment of the PDAs.

In open-ended interviews, the trainees were asked questions leading to discussions of their experiences with their various hospital surgical teams. The objective was to induce and entice them to elaborate because when they did, their languages and social cues reveal attitudes, morals, beliefs, and opinions and feelings (Kendall and Kendall 1993). Furthermore, open-ended interviews were most suitable for gathering information on questions of 'how' because they are explorative in nature.

I also conducted formal interviews, both face-to-face and over the phone. During my visits to the hospitals of the trainees, the face-to-face formal interviews were largely interspersed with informal interviews or conversations as part of my problem-solving role in the project. I also held several informal conversations with them anytime they returned to London for their modules – beside the tea table, in the classroom before a session, in the canteen, and during the official three-hour "PDA session" of every module.

The project manager instituted an official "PDA session" to allow the application designers and I to interact with the trainees and solicit their problems and concerns about the PDAs use in their learning activities. I always used these opportunities to throw open questions to the PSPs for discussion. These sessions also presented an environment where their personal experiences were shared among themselves, revealing critical information that could not be discussed in a formal interview.

The project manager also instituted another three-hour session in every module called "How things went,." This session, the first of every London module, was designed to solicit feedback and experiences from the trainees in relation to their learning experiences over the previous six weeks spent in their individual hospitals. "How things went" were always very emotional and presented the PSPs with the official opportunity to pour out their feelings and frustrations. Although it was the project leader himself

who moderated the "How things went" sessions, I was always present as an observer and took notes of the proceedings.

Over the period, I also exchanged several e-mails with all members of the project. However, most of these e-mails consisted of exchanges with the trainees on the experiences with technology use. E-mailing was an option that I provided them to reach me if I could not be reached on the phone. The a-contextual nature of e-mail text, its associated asynchronous interaction, and its unobtrusive nature ensured that interaction was convenient for me and the trainee at any time.

5 Results

Each PSP was given his or her package – PDA, foldable keyboard, Microsoft® ActiveSync® software compact disc, users manual, charger and cradle – in the first module. They were given a three-hour training and induction session to familiarize with the PDA and learn to use its basic functions. Initially, when the custom applications had not yet been developed, the framework of the Reflective Journals and Actions Logging sheet were transformed from the pre-designed desktop Word® and Excel® files into a Pocket Word® and Excel® files via synchronization with ActiveSync®. The PSPs were taken through a short tutorial about the use of the files for Actions Logging and reflections documentation. Each was given a manual with explanations on how to develop the clinical activity database.

The PSPs found the standard applications very useful. They marveled and were fascinated by their usefulness, and as far as these were concerned, the PDA was a wonderful technology to them. However, it was almost impossible for them to log actions during history taking exercises with real patients. It was also nearly impractical to log observed activities during their wandering or local mobility around their hospital wards. They further complained of how irritating it was when they scrolled the Actions Logging spreadsheet left-right and up-down. They preferred to use the paper-based logging spreadsheet because of this problem.

Two and half months into the project, a new custom application – abcDB® – was developed and introduced to the PSPs. It was a database application that integrated both Actions Logs and Reflective Journals, and it was designed to help overcome the frustrations which the PSPs experienced with the pocket-based Word® and Excel® files. Unlike these files, abcDB® was seen as a better application because it contained text boxes, check boxes, radio buttons and drop-down menus that would do away with, most importantly, the left-right and up-down scrolling and facilitate actions logging and reflections writing. This application was installed on their PDAs, and they were taken through a three-hour orientation session where a step-by-step process of using the application was demonstrated by the application's developers. In addition, each of them was given a detailed user-guide as a supplement. The orientation session proceeded quite smoothly with very few questions from the PSPs. They all seemed to have understood the instructor and could navigate through the pages of the application and perform their writing and logging tasks without any perceived difficulty.

On their return to their various hospitals, however, reports of severe problems with the application began pouring in immediately.

ALL!! I rely on paper and to be honest I find it much easier and quicker. You can have it back if you
Naomi, a PSP.

-

would be -

To do each patient, I reckon it would take something like half-an-hour to input the data which would be
Ruth, a PSP.

David, a PSP.

In the end, abcDB® was virtually unusable in the mobile clinical learning setting and had become extremely problematic for two reasons. First, there was a basic design flaw in which the users had to input one patient's personal details anytime a different action was to be performed by the PSP on a patient. The PSPs' views had not been sought in the design of the application and therefore their particular practical needs were not incorporated into its design. The application's design was not reflecting the clinical reality in which the PSPs found themselves working and learning daily.

Second, there was a systemic problem with the application which manifested in its slow running. The purpose of the deployment of the PDA demanded the use of a database application that would allow an accumulation of PSP clinical actions as they were logged in daily. While the generic applications, such as contacts and calendar, responded very quickly to commands, it took an average of eight seconds for a command in abcDB® to execute on the PDA. Incidentally, this database software ran too slowly on the PDAs – and this was not detected beforehand. This also made the use of abcDB® very problematic because, again, it was too time-consuming and not practical in the clinical setting to wait for eight seconds for every command to execute. Quite simply, the use of a slowly responding application which contained too many pages was a burdensome process; disrupting the actual clinical actions of the PSPs.

These problems together made the use of the application very unwieldy and clumsy since its use was not simplified enough to stay as an action alongside the skills learning clinical actions they were performing. The magnitude of problems associated with abcDB® was alarming. The developers were informed of these reported problems but they could not fashion out an immediate solution. Feedback on the efficacy of the application was expected to be sought from the PSPs when they returned to London for the then-impending module; but the frequency of complains from the PSPs and the strength in their dismissal of the application caused its immediate abandonment by the project manager. He was immediately compelled to employ a learning technologist, approximately three weeks after the introduction of abcDB®, to develop a new and better application to replace it.

The learning technologist gathered the feedback on the PSPs' experiences with abcDB® use as an input into his new design. For this new application – HanDBase® – it was agreed by all members of the project that reflections writing would thenceforth be officially paper-based. But PSPs were still given the option to type their reflections in the earlier Pocket Word® templates if they found that more convenient. Thus, HanDBase® was an application to be developed solely for clinical actions logging purposes.

The learning technologist had to design the new application to surmount the problems which the abcDB® presented. Apart from the lengthy consultation of PSPs for their views on how the new application should look, the development process also included its beta-testing in the clinical setting by three PSPs. The feedback from the testing was encouraging: the application was easier to navigate because of its fewer pages, it was many times faster than abcDB®, and it better reflected the nature and structure of their clinical actions. To them, the redesign was much better.

However, during the beta-test, there was still the lurking problem of actions logging on-the-move or during its realistic use in the clinical setting. The testing PSPs reported that they did not have time to enter data contemporaneously. They rather logged their clinical activities at the end of the day in contravention

of the contemporaneous actions logging rule. While one of them indicated that he could potentially enter data contemporaneously in the future, the general impression was that using the application was "another thing to do" in addition to their usual clinical actions round their hospitals.

The few rough edges of the application identified by the PSPs during the testing period were dealt with and the application was ready to be rolled out to them. The first step was another three-hour orientation session that was notably facilitated by the three PSPs who had earlier undertaken the testing. Their support, in addition to the PSPs' improved familiarity with the PDAs, and the fewer pages of the new application in totality ensured that the PSPs were more properly trained to use the application for actions logging. They therefore left the training centre in London for their hospitals with the expectation that they could effectively use the PDA to log their clinical actions when they were being done.

During the evaluation of the application six weeks later, all the PSPs agreed that the new application and the installed software had caused significant improvements in their use of the PDA compared with the days of abcDB®. The application was many times faster than abcDB®, but it was still not usable contemporaneously with the performance of clinical actions and with patients' history taking. Based on this, it was decided by mutual consent that the PDA be officially abandoned for the second time. And HanDBase® was removed from all the PDAs. From that period, all information management tasks reverted to the use of pen and paper. Although the PSPs still had the option to use the initial Pocket Word® and Excel® files for reflections writing or activity logging or both, the official output of their portfolios was the huge paper-based files which were originally meant to be replaced by the PDAs.

6 Representations and Perception of the PDA

It is important to clarify, first, what is meant by designer and user in our subsequent analysis. From the PDA's production to consumption in the case, we can discern Hewlett Packard® (HP) as original designers, the project authorities led by the project manager as both designer and user, and the PSP as user (see Figure 2).

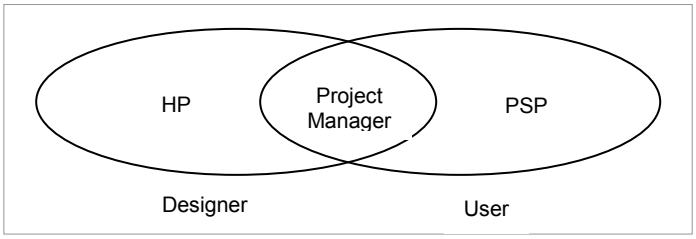

Figure 2: Conceptualisation of Designer and User

The project manager is designer because after acquiring the technology, he inscribed his rules, his controlling and coordinating functions, by sanctioning the design of the three applications. He is also user because his intention was to use the technology and his inscribed rules to control and coordinate the remote actions of the PSPs. Conceptually, when we subsequently refer to user, we will mean both project manager and the PSP. This conceptualization is grounded on the fact that the motives to monitor, control, and coordinate the PSPs' remote actions and for them to document their actions were shared by both project manager and PSPs. It was shared because the accreditation of the outcome of this learning exercise was dependent on the accreditation authorities' satisfaction that certain specific actions were performed by the PSPs during their training, and this would serve the interests of both project team and PSPs. This shared motive and outcome is the reference point for defining the functional representations conveyed by the technology. Similarly, when we refer to designer, we will mean both HP and the project manager as far as their "off-line" imaginations that premised the design of abstract representations are concerned.

However, in instances where my discussions of user exclusively refer to the PSPs, especially in analyzing the role of their mobility in shaping representations, I adopt 'PSPs' to clarify the distinction.

6.1 Representations and Filtration

The ideal PDA, at the beginning of the project, was a simple extrapolation of the ideal functionalities of desktop computers. The designer's conception and the user's expectation of the functionalities of the PDA reflect a portable prototype of a desktop computer inputted with miniature versions of desktop computer applications. In the project, these envisioned functionalities or abstract representations were reflexive of such historical modes of action as control, monitoring, coordination, personal organization, learning support, mobile computing, and support from portable artifacts. However, anecdotal evidence from technology failures suggests that such abstract representations or ideals undergo filtration during their use in certain contexts. Such pieces of evidence point out that either only a small aspect of the designer's intended use manifest or technology is appropriated and used in fashions that are not even envisioned by the designer (see Ciborra 2000). I have addressed the issue of appropriation in an earlier paper where the construct was analyzed as a function of the flexibility of mobile computing. Appropriation is intrinsically compatible with filtration in terms of process. Filtration is the process in which some or all of envisioned abstract representations that characterize an artifact manifest as or are transformed into functional representations. Filtration results in the actual functional representations seen from the user's own perspective in actual praxes; and in the context of the PSP project, they induce interest in questions like, *what were the filters, and how did they filter the abstract representations into functional representations*?

To illustrate, the filters were the "conditions" (Leont'ev 1978) or "social variables" (Bijker 2001), that is, the external factors that shaped the PSPs' actions – including perception and mobility. Note that the PDA was mediating a learning activity that consisted of several goal-oriented clinical actions and human mobility. However, the PSPs computing actions with the PDAs were conditioned by the goal-oriented clinical actions that further dictated the various modes of the PSPs' mobility – micro, local and remote (Luff and Heath 1998). In short, these other actions – mainly, clinical actions and mobility – were the filters that transformed the designer's abstract representations into the user's functional representations.

To understand *how* filtration of the abstract representations manifested, we must be mindful of the fact that the actions of a computer-mediated mobile activity are constituted by three main sub-actions – the 'true' actions, computing actions, and purposeful human mobility. 'True' actions are those that are directed towards the transformation of the object of activity, and do not necessarily require computing support for goals to be achieved. In this sense, computing actions may be deemed as 'false,' irrelevant or unwanted by the authorities who wield power and control over that activity. In the project, the clinical actions were 'true' in the sense that they did not necessarily require computations. It has to be added that these sub-actions are not mutually exclusive; they represent a mere analytical categorization, and in reality they may be intrinsically intertwined and interdependent. For example, when computing actions are mobile, they are necessarily dependent on human mobility; and the achievement of the goals of 'true' actions may be dependent on computing actions.

In the project, the clinical actions of examining patients and taking their histories, blood taking, putting up intravenous infusions, and venipuncturing all dictated the PSP's bodily movements that exemplify micro-mobility. Then the ward-to-ward movements as part of the surgical team's duties in conformity with the requirements of the training, as well as other administrative tasks dictated their local mobility or wandering around their hospitals. Lastly, their to-and-fro movements between London and their hospitals depicted their traveling or remote mobility. Since all these modes of their mobility were inherently conscious and purposeful, they translated into conditioning social variables of the concomitant mobile computing actions that also required the PSPs' consciousness and perception.

The mobile computing actions – actions logging and reflections writing, as well as those computations that used the standard applications – were envisaged to rely on the abstract representations of the PDA to be deemed successful by the user. In fact, the adoption and deployment of the PDAs by the project manager, in addition to his instructions that were inscribed (Hanseth and Monteiro 1997) via the three applications into the PDA indicated his motive to control, coordinate, monitor and scaffold (Salomom and Perkins 1998) the PSPs' learning from his remote location in London. These motives are abstract representations that were appropriated by the project manager in his imagination of the PSPs' mobile computing actions.

However, in the actual clinical praxes, all the three applications were deemed as failures not necessarily because of their poor designs, but mainly because the PDA was simply "unusable in the clinical setting." The clinical setting was dominated by the 'true' actions as well as micro-, local and remote mobility that did not enable the PSPs to perform mobile computing actions. Their micro-mobility – bodily movements during times with patients – would not allow them to log actions into the PDA. In their local mobility or wandering around the hospitals as part of surgical teams, they would not dare pull out their PDAs from their pockets to log in their actions because that was not considered by their immediate surgical authorities to be part of the 'true' clinical actions. It was only during their traveling or remote mobility that they were able to perform computing actions with the PDA, but we must remember that remote mobility was not constitutive of the clinical actions that the project manager was motivated to control, monitor, and scaffold. Ultimately, actions logging and reflections writing could only be done outside the domain of clinical actions, and this nullified the abstract representations – remote control, coordination, monitoring and scaffolding through the PDA. The PSPs could also use the PDAs comfortably for personal organization through the standard applications, but this was also not considered as crucial for the training project nor as justification for the adoption and deployment of the PDAs. In effect, the micro-mobile and locally-mobile clinical actions filtered the abstract representations by nullifying the abstract (designer's functional) representations, leaving the remnants such as personal organization, and learning support as the functional representations (Figure 3).

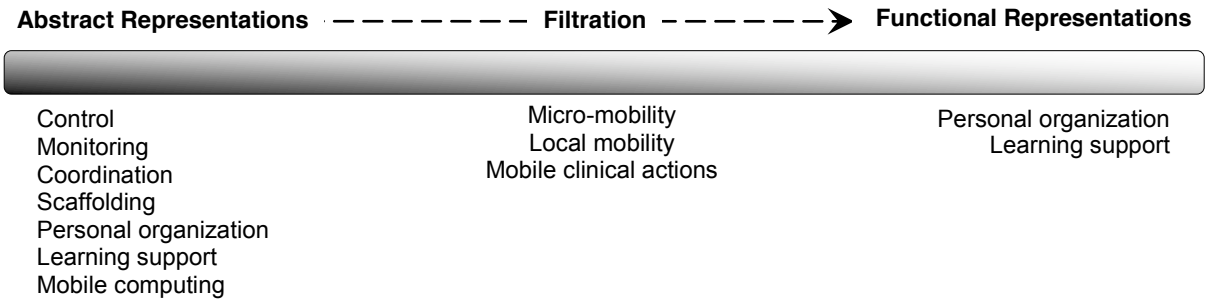

Figure 3 *esentations*

6.2 Perception of the PDA

Since "the specific feature of perception as a mode of action is that it is mediated by representation" (Wartofsky 1979), it is important to premise our examination of the user's perception of the PDA on the analysis of representations and filtration in the previous section.

To begin with, let us examine the structural representations of the artifact's promissory state. In that state, it has not yet been deployed in an activity and thus the structural representations are mere images that are internalized as sense-data through, mostly, vision, sound and feel. To Wartofsky, this form of imaging is

genetic in the sense that it conforms with essentialist theories of perception that proclaim perception as a phenomenon that relies on biological and physiological sensory-motor apparatuses – "animal perception" (Leont'ev 1978). Leont'ev labels the same idea as "image-consciousness" that refers to direct sensory-imaging of static or passive objects, in contrast with "activity-consciousness" that refers to one's interaction with those images.

"Activity-consciousness" relies on the goal-oriented interactions between the perceiver and the artifact; it translates into the *reflexive* mode of representation that is functional and reflects historical human practice. In this mode, the erstwhile images are more than mere structures; in contrast, they represent historical human praxes such as control, monitoring, coordination, learning support, personal organization and scaffolding; that is to say, they are functional. Perception therefore becomes historical rather than biological, and therefore, in the project, the user's perception of the PDA must be understood from this historical and hence functional perspective. The user's perception of the PDA was mediated by the functional representations, that is, by the historical human actions they transmitted or communicated and were perceived at the same time by him or her. Since it is filtration that engenders functional representations, perception of the PDA became dependent on the filtration of abstract representations; that is, on the PSPs' various modes of mobility and the clinical actions that conditioned their mobile computing actions. In a generic sense, therefore, if representations of a portable computer turn out to be functional, in other words, if they preserve and transmit historical human actions, then the user will perceive a secondary artifact, and mobile computing would ensure the manifestation of those historical human actions. To wit, the usefulness of portable computers lies in their functional representations that mediate users' perception of them (the computers) as secondary.

7 Discussion

The adoption of the artifact through exchange signifies that the producer's promise and the consumer's expectation have coincided; but it must be noted that, at the point of exchange, the artifact is only promissory in its utility to the consumer. In its promissory state, it is perceived as a primary artifact that is mediated by structural representations of historical human praxes. These representations are the design properties that are externalized by the producer as real objects and internalized (perceived) as sense-data by the user. Here, we are talking mainly about sense-data such as the size of the PDA (through visual and tactile senses), and Graphical User Interface items (through visual and aural senses).

From this exchange point, there is a separation in the modes of representation of the artifact; and perception becomes dependent on the perspective one adopts – designer or user. Obviously, we are interested in understanding the usefulness of the artifact and hence in the user's perspective. But this understanding will not be complete unless we fully empathize with the designer's praxes and its resulting representations (see Figure 4).

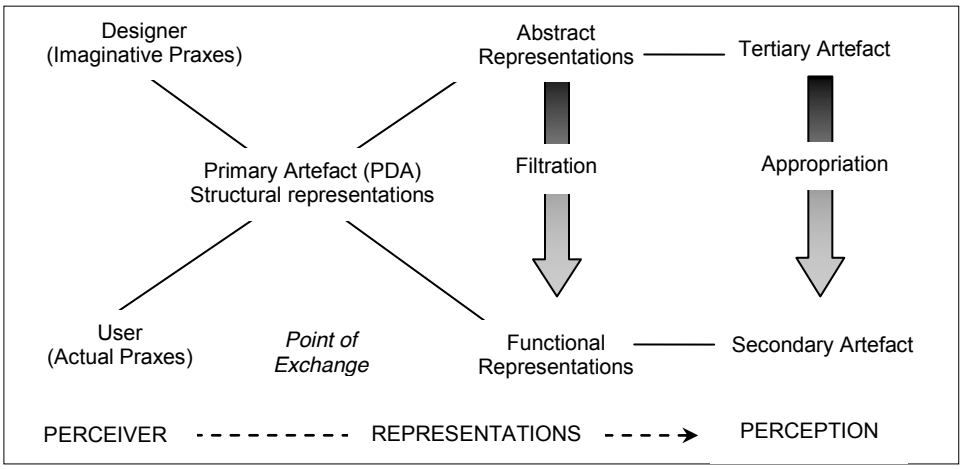

Figure 4: Representations, Perception and Filtration.

The designer's praxis is imaginative and "off-line"; that is to say, the production of technological artifacts is a mimetic re-enactment of actual historical human praxes. It relies on imagination to produce tertiary artifacts that communicate abstract representations. Such is the characterization of the PDA: it is inputted with codified operations that mimic historical forms of human actions and operations, however, this inputting relies largely on models and simulations of actual social-historical praxes but are far removed from them.

From the user's perspective, the mode of representation differs from the abstraction that characterizes the tertiary artifact of the designer's viewpoint. The user's praxis is "on-line" and active; that is, the use of a portable computer must achieve real or actual enactments of historical human praxes.

Abstract representations are resultants of the designer's imaginative construction of things that are capable of preserving and communicating historical and time-honored modes of action. This means that the designer's software and applications inputted into a portable computer, and which are reflexive of historical modes of human actions, are functional from his or her point of view. However, from the user's perspective, such 'functional' representations may be abstract beforehand, during or after the use of the artifact depending on the social variables that condition the use of the artifact and associated filtration processes.

The usefulness of a portable computer is therefore a direct function of the user's perception of it as a secondary artifact that exudes functional representations of historical human practice. Since the notion of functional representations implicitly connotes an active interaction (activity-consciousness) between the user and the portable computer, that is to say, since it connotes mobile computing, we must understand the usefulness of portable computers as non-static and non-passive, but as active and functional phenomena. Thus, mobile technology use is seen in this historical paradigm not as a constant attribute of artifacts but as a variable whose variability is tied in with the variations of functional representations that mediate the perception of portable computers. The continuous variation of perception is further seen in its shaping by functional representations and its reshaping of those representations as demanded by particular actions. Herein also lays the continuous appropriation of artifacts as their representations are conditioned by social variables – particular modes of human mobility and 'true' actions – in an activity. Therefore, the usefulness of a portable computer is defined by how social variables filter its abstract representations into functional representations to suit particular demands of emergent human praxes.

7.1 Implications

The explanations above are distinctive because they are social-psychological, complementing existing explanations of mobile technology use that are more sociological or organizational. For example, Sørensen and Pica (2005) explain "rhythms of interactions with mobile technologies" as the interplay between virtual work (mobile computing) and physical work (actual policing without mobile computing). Thus mobile computing reflects situational and institutional aspects of work. A similar epistemology is exhibited in Weilenmann's (2001) explanations in terms of negotiation of mobile phone use between "talk" and "action." Scheepers and colleagues (2006) also discuss mobile technology use in terms of contextual influences between organizational and personal contexts. Essentially, they claim that different social contexts of mobile technology use result in different social influences that affect user satisfaction. And likewise, Cousins and Robey (2005) talk about effectiveness of nomadic computing in terms of users' ability to control the boundaries between personal and business social contexts. The apparent inadequacy of social-psychological and historical explanations in existing research cannot be overemphasized. But such explanations are needed because, as developmental psychologists such as Vygotsky (1978), Leont'ev (1978) and Engeström (1987) say, most of our being, sense-making and activities are essentially cultural-historical. By elucidating the crucial roles of perception-as-action and the mediating role of filters and filtration processes in shaping the use of mobile computers, this paper brings greater understanding to an issue that is not well addressed in existing literature.

The model (Figure 4) embodies the key elements and processes useful for analyzing the utility of portable computers that are deployed to support mobile activities. My elucidation of the role of functional representations that ground our understanding of the historicity of perception has implications for how researchers should approach their analysis of mobile computing in a mobile activity, especially on the different representations associated with portable computers and their roles in shaping users' perceptions of them. This implies that to understand the usefulness of a portable computer in any mobile activity, the motives driving the activity which that portable computer is mediating should be the unit of analysis instead of the computer per se. It is in the motives driving an activity that we can understand the filters of abstract representations and filtration processes; and it is in the totality of actions constituting the activity that we can understand the filters, potential filters and the filtration processes that engender functional representations.

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