HAL
open science

Assisting Designers in the Anticipation of Future Product Use

Julien Nelson, Stéphanie Buisine, Améziane Aoussat

To cite this version:

Julien Nelson, Stéphanie Buisine, Améziane Aoussat. Assisting Designers in the Anticipation of Future Product Use. Assisting Designers in the Anticipation of Future Product Use, 2009, vol 2 n° 3 pp 25-39. hal-00787618

HAL Id: hal-00787618

https://hal.science/hal-00787618v1

Submitted on 25 Feb 2013

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Assisting Designers in the Anticipation of Future Product Use

Nelson J.
Arts et Metiers ParisTech, LCPI, 151 boulevard de l'Hôpital – 75013 Paris - France
E-mail: Julien.nelson@paris.ensam.fr

Buisine S.
Arts et Metiers ParisTech, LCPI, 151 boulevard de l'Hôpital – 75013 Paris - France
E-mail: stephanie.buisine@paris.ensam.fr

Aoussat A.
Arts et Metiers ParisTech, LCPI, 151 boulevard de l'Hôpital – 75013 Paris - France
E-mail:ameziane.aoussat@paris.ensam.fr

Abstract
In this paper, we present some theories sover past decades describing interactions between designers and users, and a state of the art of methods and tools to support these interactions in user-centred design. We discuss related methodological issues as a first step toward the introduction of new methods to assist user-centred design, to avoid uses of the product which might have undesirable consequences, while leaving margins allowing users to adapt to the situation and potentially introduce further innovations within the product. Lastly, we discuss the concept of unforeseen use and introduce creativity methods to help designers anticipate these uses.

Keywords*: User-centred design, user-designer interactions, prospective ergonomics, creativity.*

1 Introduction

User involvement in the design process aims to gather knowledge of existing needs and practices to design products that are better suited to them. Several authors have contended that the end product "crystallizes" designers' representations of users and of the uses they make of the product [1, 2]. Real-world use can be thought of as a test of these assumptions. Although the appearance of unforeseen uses was originally thought to be a mark of poor workmanship on the part of designers, "design-in-use" posits that design continues into the stages of product use through users' "tailoring" of the product, or as Folcher puts it, "operators' development of their own instruments to serve their individual activities"[3].

One difficulty is that unforeseen user behaviour often stems from adaptation to specific, unforeseen situations, and is mostly judged according to its consequences. These can be beneficial or catastrophic, according to the context. In the field of industrial systems, for example, Reason [4] points out that many major accidents (e.g. the Chernobyl meltdown, the Tenerife crash, etc.) have resulted from operators disconnecting automatic control mechanisms to better cope with an impending accident, ultimately failing to do so because of an imperfect knowledge of the situation. On the other hand if automatic safeguards are not efficient in a specific situation of use, human intervention is often the only means to maintain or restore safety [5]. Our goal is to propose a conceptual framework for the design of a tool whose aim would be to elicit consequences of unanticipated use beforehand, in order to improve user-centred design. This leads us to relationship.

Regarding this relationship, one view in the field is that user-designer interactions support a *mutual learning process* [6, 7]. In this paper, we contend that this process can further be described as the co-construction of an abstract space defining which uses of a product are acceptable. The second part of the paper lists theories put forth in recent years to describe user-designer interactions, specifically those concerned with defining this space. The third offers a brief state of the art of existing methods used in such interactions. In the fourth part, this analysis leads us to make a first step toward a transactional model of user-designer interactions, aiming to help explain the emergence of unanticipated uses of a product and control its consequences. In the fifth and final part, we discuss the concept of unforeseen use and how designers should and could integrate these new uses in the scope of their work. Finally, we introduce creativity as a potential tool to help designers achieve this.

2 Product use as the result of designer-user interactions

2.1 *Use as a balance between compliance and appropriation*

Several authors describe use as a double-sided process involving, on the one hand compliance to prescriptions in use and on the other hand redefinition of these constraints according to personal and situational factors [8-10].

Design with Intent (DwI) [11] summarizes a large number of concepts proposed in recent years to help designers define and convey specific uses of a product as being "preferable". These include Norman's discussion of "affordances" [12] as directly perceptible mappings between artefact characteristics and potential uses. One example of this is the use of specific shapes for door handles to aid in the perception that the door can be pushed or pulled. Later, several authors advocated the use of various "barriers" [13] to guard against unwanted uses, be they physical (e.g. an object blocking the entrance to a forbidden area), symbolic (e.g. a warning sign), functional or otherwise. As Lockton *et al.* [11] point out, DwI to date has focused less on methods to convey intent and more on the underlying ethical issues. For example, when designing urban environments, what are the ethical questions raised by the use of chairs with central armrests to enforce a policy discouraging the homeless from sleeping in the open? The question seems to be: how, when and why should one convey specific uses as being acceptable, and deem others unacceptable?

The response put forward by the French-speaking tradition of ergonomics [14] is to define variability as a fundamental element of human activity. Task-related constraints are managed with a user-driven process of adaptation. Thus, although user behaviour can be broadly characterized, interactions between the user and situations-of-use preclude complete and accurate anticipation of user behaviour. In other fields, this has led to broadening the spectrum of analysis and viewing use as a social phenomenon.

2.2 *Use as social fact: communal acceptance and rejection of products and prescriptions of use*

Regarding the social aspects of product use, two strands of research can be described which mirror the "compliance vs. appropriation" divide mentioned above. A first strand focuses on the social mechanics of acquisition and transmission of use patterns in product use. Bourdieu's concept of *habitus* [15] exemplifies this, since it defines social class as a unit for the dissemination of practices in the use of a product. According to this, users belonging to the same class also tend to exhibit similar tastes, and therefore potentially use similar products in broadly similar and consistent ways (e.g. swinging a golf club). This first strand is therefore concerned with use as a result of social determinism.

A second strand is concerned with the mechanics of product appropriation by social communities [16]. It stresses social acceptance of a technology as instrumental to the diffusion of innovative products and practices. Product functionality is only partly responsible for such acceptance. Proulx [17] describes cases of "civil disobedience" within user communities, characterized by the enforcement of codes of conduct and values, which may be opposed to existing laws and social boundaries e.g. in hacker communities.

2.3 *Synthesis: use as a "trial" of the product*

Use can be viewed as a balance between prescription of use and user appropriation on two levels, that of individuals and of social groups. To quote Jouët [18] : "Appropriation is a trial. It is the act of composing one's self" (our translation). We agree with this, in that product use involves an evaluation on the user's part of the product's capability to respond to specific needs. Noticing a discrepancy between these needs

 © King Mongkut's University of Technology North Bangkok Press, Bangkok, Thailand

and capabilities triggers either product rejection, or transformation of its uses and/or structure. In this we subscribe to Simondon's view of technology as evolving in Lamarckian-type adaptation to user needs [19]. Only successful solutions, regarding both new products and new uses of existing products, are kept and shared with the community.

This points directly to von Hippel's discussion of user innovation processes [20]. According to his work, relevant transformations of a product may be shared within a community, by members he calls "lead users", who combine knowledge of specific personal needs with technical know-how which allows them to propose and implement solutions, notably in the case of designing customized sporting equipment to improve performance. For example, he cites a study of user innovations in a canyoning community, which developed a way to cut a trapped rope loose using a chemical agent. Such innovations can then be produced and sold by manufacturers in the field. In most cases however, knowledge of technical solutions and of user needs is distributed. The emergence of unsatisfied needs triggers an examination of existing resources for innovation. Such resources can be self-centric in the case of lead users, but may also stem from user-manufacturer collaboration. Repeated exposure to specific user needs thus allows manufacturers to select transformations deemed most relevant to users, leading to what von Hippel calls "manufacturer-centric innovations".

However, he further points out that user-manufacturer collaboration is fundamentally different from user innovation. Indeed, in the latter case, users can freely share innovations within communities. This totally changes the balance of use prescription vs. product appropriation for several reasons:

- Social values associated to product appropriation are very different. Appropriation is viewed in a positive light since it can give rise to innovation. Indeed, in some communities, contributing to the effort may be seen as almost contractual, since unreciprocated profit from use can lead to effects of social branding. For example, "leeching" refers to the practice of downloading the productions of online communities without contributing to the community in return;
- Values associated to use prescription are also different. In the case of open source software design, for example, prescription is superseded by overall contractual principles, e.g. total access to software code in exchange for crediting original authors [21, 22]. Likewise, recent initiatives such as the freecycling movement provide a basis for product reuse, both in social (a social contract that states that unused goods can and should be exchanged with other freecyclers) and material terms (e.g. communities to help freecyclers contact each other to arrange such exchanges).
- The user-designer loop is tightened by the fact that the terms "user" and "designer" can refer to the same people. Spaces for exchanges regarding existing needs or future uses function according to communal rules (e.g. meetings, forums, emailing, etc.) which differ from the user-designer or user-manufacturer relationship which is contractual [22].

As we will see in the third part, one problem of existing methods for use analysis is the asymmetry they introduce between designers on the one hand and users on the other hand.

3 Methods for use analysis: some forms of collaboration between designers and users

User centred design has fostered a varied set of methods for the analysis of product use. In this part, we provide a short state of the art of these methods. Following the distinction made in the first part of the paper, we examine existing methods according to two levels of dichotomy. The first level concerns whether methods are geared toward *prospective* or *retrospective* analysis of product use. The second level concerns whether the unit of analysis is the *individual* user or *groups* of users.

3.1 *Prospective vs. retrospective use analysis*

Original models of user-centred design such as the one put forth by the International Standards Organization [23] advocated retrospective evaluation of the usability of design solutions against user requirements. Such methods are classically divided in three categories:

- User testing, which examines user behaviour with the product in the context of typical tasks, e.g. based on performance measurement or think-aloud protocols.
- Inspection, which requires a usability specialist to examine the product and apply domain-specific knowledge, e.g. through heuristic evaluation or cognitive walkthroughs
- Survey methods, presented in the next part.

Two main elements stick out from this classic framework of usability engineering. The first concerns the gradual broadening of the spectrum of analysis from usability to the wider realm of "user experience" [24]. The second concerns the use of analysis results and extrapolation of the results to future situations.

An increasingly large toolbox

Usability, defined as "the effectiveness, efficiency and satisfaction with which specified users achieve specified goals in particular environments" [25] was long considered as a yardstick by which a product's quality could be measured. It originally included three classic components: effectiveness, i.e. "the accuracy and completeness with which specified users can achieve specified goals in particular environments"; efficiency, i.e. "the resources expended in relation to the accuracy and completeness of goals achieved"; and satisfaction i.e. "the comfort and acceptability of the work system to its users and other people affected by its use".

More recent developments gradually came to consider many more aspects of "user experience" as measures of quality of use, e.g. beauty, affective, hedonic or experiential aspects, which call for new conceptual (models of human experience) or methodological tools. Methods used in the evaluation of these "non-instrumental" aspects can be based on various methods. Following Theureau's work on the "Course of Action" research programme, one can identify several key requirements in constructing an appropriate set of methods and tools to study human activity [26]:

- An epistemological framework which defines what are the specific objects of interest in the realm of "product use" and the basic rules underlying their study
- A set of methods, borrowed from various scientific fields, with specific rules for their application
- A set of rules regarding to what this "observatory" tells us, what are its potential and limitations for the generation of data and hypotheses regarding product use.

Thus, broadening interest to "user experience" led to the widespread use of methods from social sciences. Overall, the epistemological framework of "use analysis" can be seen as fundamentally heterogeneous, and a practitioner (or indeed, several practitioners) might rely on various combined methods depending on their specific expertise.

Foreseeing future use

One reason for the inability of designers to integrate use-related knowledge early on in the design process is that the introduction of new elements within human activity is likely to cause in-depth changes of habits in use. For example, Folcher's [3] study of the use of a proble

m-solving database by telephone hotline operators shows that the contents of the database were reorganized by users according to the type of problems they solved in their everyday activity. Cerf and Meynard [30], while studying the activity of agricultural counsellors, found that a system intended to be used as a parasite trap for single plants was used in a wider context as a detector to help decide when to start anti-parasitic treatment on entire fields. Both these examples illustrate strong "design-for-use assumptions", i.e. the construction of internal models of what Guérin *et al* [31] term "characteristic situations of action" in the use of existing products, as well as potential situations of future use.

Extrapolation from one to the other can be viewed as a form of counterfactual reasoning. As Roese and Olson point out, construction of counterfactual scenarios stem from localized changes in specific variables of existing scenarios [32]. For example, one might start out with information regarding the use of a product by middle-aged adults and attempt to extrapolate product use by the elderly. Therefore, methods for prospective use analysis, i.e. projection into simulations of "what might happen", always depend on models of existing situations. Existing methods depend on various postulates:

- Prior occurrence in other, similar situations can serve as a starting point for users to simulate what would happen with a different product. For example, Flanagan's critical incident technique may be used to identify problematic situations and likely causes of the problem, as levers to construct new scenarios and examine users' counterfactual behaviour [33];
- Users can rely on existing problem-solving strategies. For example, information-on-demand and Wizard-of-Oz type techniques help elicit user needs in terms of information and expected system behaviour in solving such problems.
- In short, prospective analysis is usually based on fostering the construction and use of mental simulations. One last point we would like to make is that several media may be used for this.

 © King Mongkut's University of Technology North Bangkok Press, Bangkok, Thailand

- Storyboards describe the key elements of a situation on a series of panels. A storyboard is a partial representation in both senses of the term: time-wise, it only shows part of the story and leaves the user to "fill the gaps"; content-wise, it shows a fixed point of view on the situation, which is chosen by designers. Film-based techniques are richer with information but have the same limitations. One key difference, however, is freedom regarding content. One can only film situations that are observed or acted out, but can sketch any kind of situation;
- Interactive simulations insert the user in a scripted situation, while offering possibilities for interaction. These limitations, which mostly stem from interface characteristics, are counterbalanced by the expected benefits of interactivity. Although simulations can rely on various media such as role playing or CAD simulations, Virtual Reality (VR) has been the subject of much interest, since its capacity to immerse the user in a potentially realistic environment, easily gather use-related data and afford a sense of "presence" have been hailed as the next gateway toward prospective use analysis.

However, as several authors point out [34-36], physical realism of simulations is not paramount to obtain reliable data regarding future use. The goal is what Burkhardt [35], in the area of VR use for training, terms "psychological realism" i.e. to place the user in a situation where his behaviour can be reliably said to be an accurate description of future use behaviour. This involves a shift in points of view from the present to the future situation. As long as psychological realism is ensured, one can think of several other methods for prospective anticipation of future use, e.g. roleplaying or storytelling-based, which offer a greater degree of freedom. However, this "shift" also entails overcoming pervasive obstacles described below.

3.2 *Use analysis from individual vs. social points of view*

User collaboration in use analysis practices

When one examines the ways in which designers and users interact beyond the stages of product design, most situations of interaction involve problem-solving services, such as using a technical hotline. Although these involve a specific form of collaboration aimed toward diagnosis and problem solving [41], the following remarks can be made concerning the characteristics of such interactions:

- Speed: Feedback is generally fast and has a single, clearly defined objective;
- Expectancy: Users can reasonably expect that their call will lead to the problem being solved and the situation returning to normal within a short time.

Technological breakthroughs, mostly regarding online tools, have allowed these service-based interactions to evolve considerably in terms of both content and structure. For example, computer maintenance can now rely on remote tools for both diagnostic (e.g. log files, which can record various kinds of commands and parameters) and intervention (e.g. remote desktop services, in which the maintenance operator physically takes control of user-interface interaction) purposes.

In contrast, design projects have less clearly defined objectives. The key difference is that a problem solving service can be thought of as a corollary to the act of purchase, whereas users providing feedback existing and future possible uses of a product are not bound by the same relationship. However, in line with recent work in this field [42], we posit that this relationship is still service-bound, although it doesn't necessarily rest on the same framework, since benefits expected from user participation are not necessarily viewed as immediate.

Complex phenomena may be at work when users are asked to participate, in some form or another, in the product design process. Walker and Prytherch [43], for example, point out that user motivation can have profound effects on the user's perceptive, cognitive and evaluative processes, thereby impacting any analysis results. Likewise, Morie [44] shows that motivation has an effect on the user's ability to reach a state of immersion in a Virtual Environment. Similarly, several studies in social sciences gave shown that user participation to investigations experiments requires personal investment on the part of users, in terms of:

- Investment in the traditional sense, e.g. time, which is usually the object of some form of compensation;
- Investment in terms of internal resources, related in particular to the construction of a mindset prone to yielding relevant results.

Lack of investment in this second area can lead users to question the usefulness of investigations, e.g. ask themselves questions such as "What am I doing

here?" Thus, experimentations relying on simplified tasks or simplified versions of the product require some form of "suspension of disbelief" on the user's part in order to provide interesting results. Participant observation, which aims to reach a close and intimate level of familiarity with a given group of individuals, also requires investment on the part of users [45]. Likewise, the reliance on data mining methods, which rely on machines rather than humans to collect use-related data for extended periods of time, can lead to protocols being abandoned because the expected benefit of submitting continuously to automatic "surveillance" is not necessarily clear to users.

4 Toward a transactional model of user-designer interactions

4.1 *Principle and overall view*

One main problem of user centred design today is foreseeing future use, for which several methods exist. Some consist in projecting users or designers within a mindset in which counterfactual reasoning is sufficiently close to factual reasoning that information gathered might be seen as a useful resource for design. Others rely on anticipating use through analysis of the behaviour of user groups. We introduced the idea that user participation to such investigations might be viewed as a specific form of service relationship, whose failures might in part be due to the terms and benefits of this service being unclear.

One approach to use anticipation relies on introducing rules of use, which users can either comply to or reject the latter leading to either rejection of the product altogether, or to the emergence of unanticipated uses. In this part, we contend that such an approach may also imply service relationships, albeit relationships with similar difficulties but very different dynamics.

One difficulty is pointed out by Rabardel and Béguin [9], whose view on accidents in unanticipated use rests on the idea of asymmetry of information between designers and users. For example, the user might stray from use prescriptions (e.g. prolonged use of a sunbed) because of a misrepresentation in risks associated to such use and lacking knowledge of key facts (e.g. minimal exposure time before the probability of developing skin cancer rises significantly). Mutual learning between users and designers may help even out these effects of asymmetry. However, we contend that the complexity of real world use may prove to be "too much" to be circumscribed by even regular exchanges aiming to help mutual learning. Instead, we propose to view use as a process of negotiation between users and designers. Use can then be characterized as a sequence of acts of compliance and defiance regarding use prescription.

Designers' inability to predict all possible forms of user defiance, as well as the fact that some of these acts may give birth to further innovation, are responsible for the fact that such situations can be viewed as "tolerated violations" to prescriptions of use, in Amalberti's sense [46]. This model, represented in fig. 1, underlines that use practices may stray from the usual space of operations into an area of violations and deviances. This space of usual forms of use is defined simultaneously by technological pressures (e.g. product functionalities), individual concerns (use appropriation by users) and safety procedures (i.e. prescriptions in use).

This model is concerned with the drift into accidents seen in major industrial systems. To generalize, one should point out that safety is not the sole criterion involved in expected product use, but that it is examined jointly with other criteria such as social acceptability and collective, rather than individual, concerns. However, a recurrent theme is the complexity of factors involved in "crossing the border" and engaging in unforeseen uses. Some authors call these the system's "Borderline Tolerated Conditions of Use" [47], whereas others use the term "catachresis" to describe "the use of a tool for another function than one planned by the designer of the tool" [48]. Both these concepts, although belonging to different traditions of scientific research, highlight the idea that unforeseen use might stem from a strain between design solutions and user expectations, which we, in turn, choose to view as a process of negotiation.

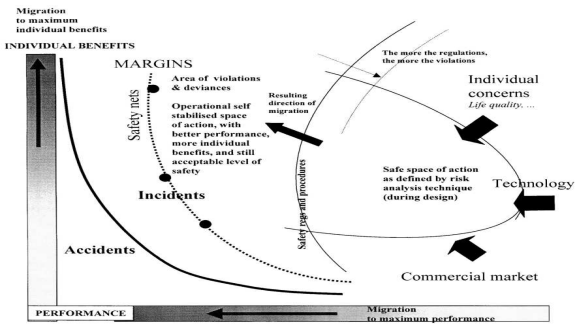

Figure 1: the traps of overregulation, from Amalberti [44]

4.2 *Negotiating future use as an alternative to comprehensive anticipation*

Introducing such a basis for user-designer relationship, highlighting not mutual learning but negotiation processes, involves modelling this relationship in order to control it. As a first step, we introduce the concept of "pact of use" which relates to what Joule *et al* [49] call the "free will compliance paradigm". These authors describe a number of techniques to allow persuasive communication. These techniques mostly rest on the fact that users tend to carry out actions in line with set attitudes, rather than commit inconsistent actions. Furthermore, they describe a number of factors which tend to foster strong commitment on the part of subjects, such as repetition, perception of the irrevocability of the action, or explicitly describing an action's consequences. One should note that several such attitude-shaping elements are at play, for example, when designing "barriers" [13] against unintended use of software.

However, we posit that just confronting the user with the consequences of actions located outside of the domain of expected use is not enough. User interactions with the product may also be viewed within the scope of a service relationship, involving a human presence outside of the user-product pairing. For example, the use of "lifeline" bracelets for the elderly needs to be strictly controlled to be reliable. Anomalies in product use (e.g. accidental activation) are followed up by check-up calls on the telephone, to ensure that the wearer is not in any immediate danger. This service is a normal part of product use, but such initiatives are still fairly underdeveloped.

Obviously, our suggestion is not that product use should be tracked and interfered with every step of the way. Besides the logistical nightmare this would entail, constant involvement of designers might be perceived as just another constraint, and likely impeded (e.g. through deactivation of surveillance or assistance functions). Rather, since the basic problem of unanticipated use seems to be understanding user motivation to stray from anticipated use, we propose to include sensors within products to identify when the product is being placed outside of the usual scope of operation. Rather than immediately prescribing a corrective action, a service would then allow collecting information regarding the rationale for this unexpected use.

4.3 *A sample application: a negotiating agent to avoid overload in domestic vehicles*

In designing motor vehicles for transporting goods, one risk relates to overload. Some forms of prescription have been proposed to avert this type of risk. For example, professional truck drivers undergo specific training to help them handle their vehicle based on various types of information (e.g. driving context, truck specifications, etc.). However, in the context of everyday domestic use, such information is not often made explicit, which causes drivers to frequently overload their vehicle, often out of necessity.

Placing a sensor within the loading compartment would allow the system to sense when it is being led outside the conditions of anticipated use, and trigger a sequence of events described in fig. 2. Sensor activation might first trigger a warning, not in terms of an immediate corrective action, but in terms of a knowledge-providing service focused on the vehicle, e.g. "You are currently driving with an overload of [x] kg based on your car's specifications." Then, rather than just presenting the driver with a warning, the system would also provide contextual information about vehicle design, clearly describing the expected consequences of this unusual use, for example; "This may cause support elements to break." Finally, in order to avert automatic processing (and ignoring) of such alarms, the system should explicitly present the user with the choice to pursue under current conditions of use, and require a specific response from him.

Some authors have stressed the importance of presenting the user with a simulation of the foreseeable consequences of his actions, e.g. when training to operate complex systems such as cranes [50], but this work is only concerned with *acquiring* the set of skills and concepts necessary for product use. In everyday operation, others have pointed out that decision-making required the user to constantly update his mental model of the situation, identifying specific cues of the system's state given its current use [51, 52]. For example, hearing a car creak, or feeling it lag, are both indicators of overload, but the decision to stop and unload the car is not systematic or compulsory. Klein [51] points out, in fact, that *sensemaking*, i.e. "the deliberate effort to understand events" requires continuous cycles of gathering and interpreting new data.

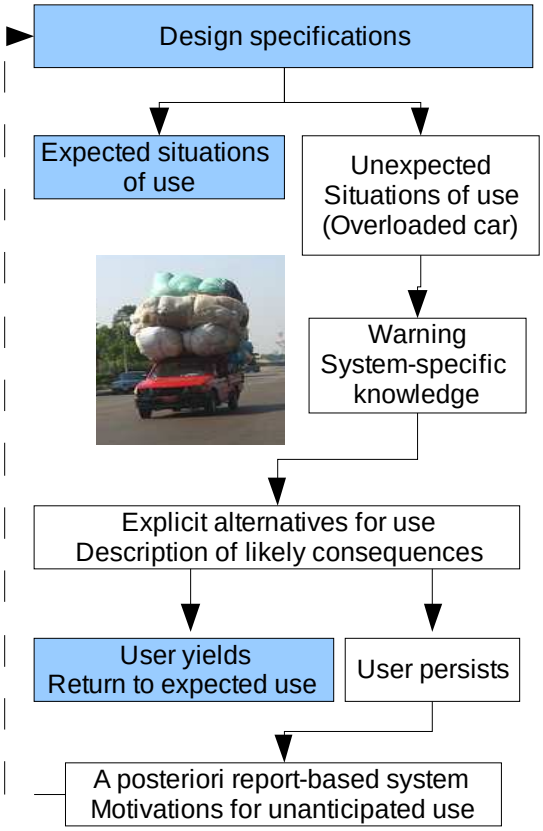

Figure 2: a view of the process for managing unanticipated product use

This entails two types of risks: the first is failing to identify relevant cues, e.g. not understanding the meaning of an alarm; the second is failing to gather enough cues for efficient action, e.g. waiting to see "how the car will behave". This second level poses specific difficulties, since uncertainty regarding the risks in current use behavior is outweighed by certainty regarding task objectives [46]. Beyond providing the user with contextual information, it is therefore essential to specifically request an action on his part, since such requests allow the user to better manage time-critical tasks, as well as to enforce accountability and ensure commitment to following consistent use strategies [53].

Furthermore, this system may also provide a basis to understand the occurrence of unforeseen uses, through the use of a reporting system. For such a system to be truly functional, it should be used following (rather than during) driving episodes, in a debriefing stage, and provide the user with information to help remember the circumstances which led to the product being used outside of its intended scope of use.

This approach provides explicit information regarding the margins of expected product use, thus confronting the user with a choice: comply with prescriptions regarding product use, or persist in current strategies. Conversely, when unanticipated use is described *a posterior* in a positive light, user responses could be collected automatically to help guide future innovation

5 From unforeseen to undesirable use: building upon a negotiation-based approach

In the example described above, we defined "overloading the car" as an unforeseen use, i.e. one that is outside of the spectrum of uses catered for by the product. One could point out that this situation, which is critical to the product, in fact refers to a variety of situations of use since there are many reasons and situations where one might be led to overload a car, e.g. when moving house, going on a long journey, transporting bulky items, etc. What links these situations together is the resulting effect on the product, which can be detected and signalled to users. In this part, we examine the consequences of this claim on the design of use-negotiating agents, and the potential to broaden this concept.

5.1 *Unforeseen use, a polymorphous concept*

Scenario-based design [54, 55] is a staple philosophy of user-cantered design, relying on the use of evocative stories told in various formats (textual, graphical, film-based, etc.) to maintain orientation to people and their needs when making design decisions. Scenarios may focus on several elements of a situation but are invariably concerned with a single situation. By nature, scenarios are meant to elicit discussion between designers, particularly regarding the scope of situations of use that have been catered for in a given project. For example, designing a safety product to prevent drowning in infants may incur a lengthy discussion of accident scenarios, i.e. the situations which the product is meant to guard against [56]; but, since it is impossible to process each possible contingency individually, scenarios are more often viewed as representing classes of situations, rather than single courses of events, the goal being to make *claims*, i.e. guide design towards relevant trade-offs based on their representations of future use [57, 58]. This

 © King Mongkut's University of Technology North Bangkok Press, Bangkok, Thailand

concept of "trade-off" echoes Simon's theory of "bounded rationality, whereby decisions are made not by examining the full spectrum of possible scenarios, but settling for the most "*satisficing*" one [59]. This means that however much effort is put into generating and discussing scenarios of use, there will always be a set of unanticipated situations which the user might "stumble into" in the use stage of the product lifecycle.

Within this spectrum of "unanticipated use", however, a review of the literature leads us to consider the point of view of the user, more specifically distinguishing whether entering this "grey area" is an intentional process, or not. Thus, Brands *et al.'s* recent survey of non-intentional design, or NID, processes [60] ("non-intentional" refers here to *designer* intentions) – shows that diverting objects from their original intended use can be a conscious, or even political, action, just as it can be a semi-conscious act of "making the best with what you have". Similarly, Fulton Suri's [61] choice to describe some types of diversions as "thoughtless acts" – such as using a pencil as a hairpin – clearly shows that user intention is an important variable in characterizing diversions of use.

A second important variable is the consequences of specific use strategies. In our process model (fig. 2), relying on a binary persist/ yield alternative to describe use choices implies that in a given situation where user and designer are at odds with choosing appropriate behaviour of use, one of the two is right and one is wrong. But within the realm of human error, several authors [4, 62] suggest taxonomies based on the distinction between what the user intended to do and what action is actually carried out (e.g. fig. 3).

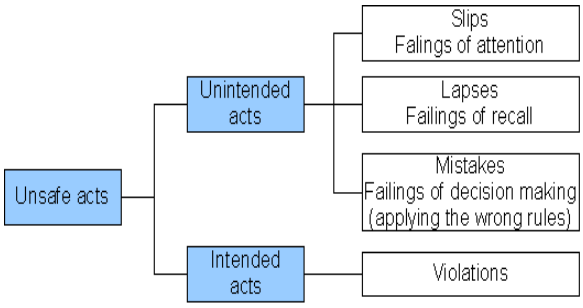

Figure 3: Taxonomy of unsafe acts, from Reason [4]

Like Amalberti's model (fig. 1) the model in fig. 3 emphasizes safety as a dominant criterion in design. However, as Daniellou [27] points out, design decisions can rest on other criteria, such as efficiency (success in carrying out a task, of which safety is one element), fairness (conformity to the legal system), authenticity (conformity to the designer's personal values), etc. Therefore the concept of "consequences of unforeseen use" should be extended to include these various criteria, and one could substitute the term "unsafe acts" in fig. 3 with the term "undesirable acts".

In short, "unforeseen use" is an extremely polymorphous concept, and one should think about which subset of situations is of most interest to user-centred design if one is to expand the concepts put forth in this paper (fig.4). In particular, we will set apart 2 types of unanticipated uses:

- *Misappropriation*, which refers to intentional drifts from designer anticipations in product use;
- *Misuse*, which refers to unintentional drifts.

Both these strategies are clearly outside of the space of acceptable use as defined by designer intentions (area 1), but it is possible for designers to anticipate at least some of these practices, either to prevent them from spreading or to alleviate their consequences (area 2). However, only some of these unintended uses can be anticipated, and others may develop unexpectedly, forming a set of unforeseen uses (area 3). Therefore, misappropriation and misuse both straddle areas 2 and 3 of our model.

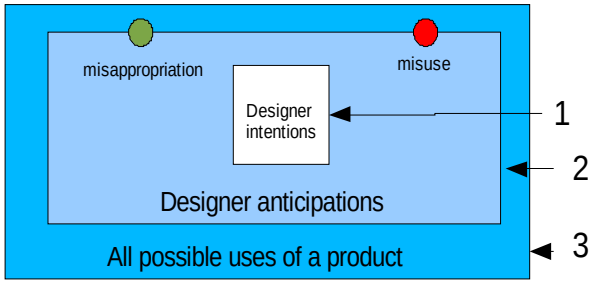

Figure 4: Types of unforeseen use. Green denotes intentional actions on the part of the user, red to unintentional ones.

5.2 *Augmenting designer capacity for prospective use analysis*

Anticipating both misuse and misappropriation is of great interest to designers, but one should point out that most strategies deployed by designers rely on anticipating contingencies. Most "barriers" used by designers to keep users in a domain of acceptable use

(e.g. an instructions manual, a "foolproof mechanism", use procedures supported by "wizards", etc.) seem built on the premise, not that "the designer knows best", but that design has entailed enough effort to claim that unexpected use is automatically undesirable.

The originality of the "negotiating agent" approach is that it acknowledges that design assumptions may be wrong, and lets the user decide whether to follow through on his initial intentions; in Vicente's words, "letting the user finish the design" of the system [63]. This makes the agent potentially useful in countering both misuse and misappropriation, but for two different reasons:

- In the first case, it allows the user to ascertain that he is outside of the scope of intended use, thus addressing the risk of skips, lapses or mistakes;
- In the second, it encourages negotiation by allowing the user to turn back on a violation or justify it, giving material for further design iterations.

However, the remaining issue is that this system relies on prior definition and formalization of the anticipated set of situations of use. How can one program such an agent to ensure efficient prior detection of all undesirable uses?

Bødker [64] found that users confronted with a variety of design projects were able, through the construction of open-ended scenarios and reflection thereon, to support creativity in design. The methods she describes (e.g. creating and acting out further scenarios; playing the devil's advocate, building ideal scenarios, etc.) emphasize the fact that scenarios are merely an entry point to access a wider variety of situations, and that creativity focuses just as much on finding solutions as it does on identifying situations to test them. However, the potential of these methods to widen the scope of use anticipation is reduced because they are used in a seemingly haphazard way.

This is a recurrent concern in literature. For example, in a study carried out as part of the design of a new process control interface in a chemical plant, Béguin [65] used simulations in a participatory design framework to build up designer expectations of future use. This allowed him to prospectively identify the appropriation of a heat-sensitive alarm by plant operators, who used it as a thermometer. To put a stop to this undesirable practice, designers fitted a separate heat sensor in the plant. One wonders, given these results, if it might be possible to guide this process further to allow more rapid and efficient expansion of designer knowledge of future use.

5.3 *Creativity as a tool for prospective use analysis*

In the example mentioned above, the involvement of a qualified agronomists is the driving force for expanding designer knowledge of future use. The initial diagnosis allows identification of "characteristic work situations" which are then subjected to a more in-depth analysis leading to prescriptions for design [31]. The intervention itself therefore serves as a tool to describe existing situations of use (e.g. of a work tool), clarify stakeholder intentions, and anticipate future evolutions. However, as Robert and Brangier [66] point out, this model refers to corrective practice, which focuses on existing products, rather than prospective practice, which refers to "the anticipation of human needs and activities".

In line with our earlier remarks, these authors note the need for collaboration between various fields (sociology, marketing, ethnography, etc.) to anticipate future use. Since prospective analysis aims to widen the scope of anticipated use based on interactions between people of different backgrounds (including, in the case of participatory design, users), we feel it is even more necessary to rely on a framework to structure this process of exploration and definition of product uses.

We contend that creativity may be a suitable candidate for this. Creativity has been the subject of a very abundant and varied body of research in the social sciences aiming to discover its sources and mechanisms; at the same time, several pragmatic methods and practices have been developed to attempt to boost creativity, such as brainstorming [67] or TRIZ [68]. Although, as some authors point out, the theoretical basis is still in its early stages [69, 70], one trend in the field is to define creativity as a practice allowing *divergence* from a set of existing ideas to extend this set, and *convergence* for these ideas to be developed. Literature in this field broadly defines four main tasks in the creative process, which can be combined linearly in a "creativity session".

5.4 *Creativity sessions to foresee future use*

Creativity is generally viewed as a key element in the design of innovative products [71]. Increasingly, designers aim to manage their own creativity through the use of structured methods and processes as well

as dedicated tools. However, it should be pointed out that the incentive in harnessing creativity lies, following the seminal work of Guilford [72], in the promise of new and improved solutions for solving design problems. Typically, for example, creativity might be used to generate a product concept to address a particular problem or user need. Alternately, later stages of the design process, creativity may be used in the definition of product specifications. In short, creativity is usually viewed as a resource to decide upon product characteristics whereas it is rarely used when reflecting upon the product's future use. The originality of our work lies in this novel application of creativity enhancement methods.

Referring to the initial example of the car overload, problem definition might focus on the various possible situations in which a user might want to load a car, with special emphasis on user role in the overload and motivation to indulge in it. Feedback from negotiating agents in the field, but also from users themselves (e.g. in simulations [73] or focus groups [74]) may provide material for this initial exploration. Combining the two, e.g. using allo-confrontation [75] is likely to provide designers with further insight.

Once initial knowledge about means and motivations for car overload has been gathered, collective examination of existing solutions used to reduce unwanted consequences for the car, e.g. through a "brain purge" [76]. This examination should be two-directional, i.e. focus both:

- On widening the space of acceptable use and improving the vehicle's load-bearing capabilities (e.g. roof racks, suspensions, trailers);
- On strategies for use prescription and "architectures of control" [77], in order to remove the incentive for overload (e.g. driving instruction, safety campaigns, removal services, etc.)

In our case, the creative production stage aims to identify the reasons for which these existing strategies are ineffective, as well as to find more effective alternatives. For example, if roof racks are overloaded, why is this so, and what are the possible consequences? Classical methods of creativity that can be used here include brainstorming [67] or problem-solving matrices [78]. For example, a problem-solving matrix may focus on crossing the solutions discovered in the problem analysis stage on the one hand, with the situations of car overload mentioned in the problem definition stage, in order to generate scenarios where available solutions are ineffective in preventing car overload.

Since our review of the literature emphasizes that product appropriation is a developmental process, these scenarios may infer on events and activities that occurred before the loading or driving tasks, the goal being to achieve consistent scenarios [64] For example, one scenario might involve the user having to "stuff everything in the back seat" because a roof-rack strap has been damaged in a previous outing.

The final stage of idea sorting and evaluation aims to critically examine the scenarios generated in order to improve on the design of the negotiating agent or other safety systems. The KJ method [79], for example, might uncover commonalities in the scenarios generated in the creative production stage, allowing designers to identify usable parameters for the detection of unwanted situations of use. "Backseat loading" is a good example of such a category: integration of load sensors in the back seat or floor of the car may be a viable solution.

Alternately, creative production may, in defining these unwanted scenarios, uncover consequences of overload going beyond initial design expectations of vehicle damage, e.g. reduced visibility, leading to further opportunities for the development of innovative products, e.g. a visibility sensor that would improve upon the classical practice of checking in the rear-view mirror. This last example shows that creativity is an overarching and continuously essential element of design [80].

6 Conclusion

In this paper, we have laid the groundwork for a model describing product use as a double-sided process of use prescription *vs*. appropriation. According to this view, most methods of use analysis appear to have a retrospective point of view, i.e. rely on collecting data about existing situations in order to optimize an existing product. In contrast, product use may be seen as a possible source of innovation. This entails letting users "take over" the product to let new uses emerge, which can be spread in social groups to give rise to "trends of use. However, some existing technologies (e.g. P2P networks) are known to have disseminated uncontrollably in this way. In this case, unanticipated uses can also have unexpected consequences for the product, for the user, or even in some cases for society as a whole. For all these reasons, freedom of use is often counterbalanced by

forms of prescription in so-called “standard” or “tolerated” conditions of use.

Studies of use prescription have shown that particularly conflicting relationships can exist between designers and some user groups, e.g. hackers [17], resulting in uncontrolled dissemination of specific use practices. However, no form of prescription is absolutely reliable, and as our review of the literature suggests, neither should it be. This complex relationship calls for new forms of communication between users and designers. Modelling underlying social and cognitive processes should yield interesting results for the design of tools and structures to help users and designers interact around and during product use, and foresee consequences of specific forms of product use. We hope, in line with the proponents of “design-in-use”, that continued user involvement in the process may improve user centred design. Finally, we put forth a methodological suggestion approach to circumvent the “paradox of design ergonomics" [81], i.e. designers’ inability to finely predict a product’s future use from the initial stages of design, where such information would be most useful. A creative design paradigm, based on applying existing creativity enhancement methods to the original field of *defining frames of product use*, constitutes an original step forward to reach this longstanding goal.

References

[1] Béguin P., 2007. Taking activity into account during the design process, *@ctivités*, 4(2): 115-121

[2] Visser W., 2006. Designing as construction of representations: A dynamic viewpoint in cognitive design research, *Human Computer Interaction*, 21(1): 103-152.

[3] Folcher V., 2003. Appropriating artifacts as instruments : when design-for-use meets design-in-use. *Interacting With Computers*, 15(5): 647-663.

[4] Reason J., 1990. *Human error*, Cambridge, MA: MIT Press.

[5] Woods D.D. and E. Hollnagel., 2006. *Resilience Engineering concepts, E. Hollnagel, D.D. Woods, and N. Leveson, Editors*, Ashgate: Aldershot.

[6] Béguin P., 2003. Design as a mutual learning process between users and designers. *Interacting with Computers*, 15(5): 709-730.

[7] Vallette T., 2005. *Recherche d'un cadre conceptuel d'aide à la conception collective innovante par l'usage: proposition de l'outil "Glocal" pour la conception d'outils à main et des équipements de travail, in Génie industriel*, ENSAM: Paris.

[8] Nardi B.A., 1996. *Studying context: a comparison of Activity Theory, Situated Action models, and Distributed Cognition, in Context and Consciousness: Activity Theory and Human-computer Interaction, B.A. Nardi, Editor*, Cambridge University Press: New York, NY: 35-52.

[9] Rabardel P. and P. Béguin., 2005. Instrument mediated activity: From subject development to anthropocentric design. *Theoretical Issues” in Ergonomics Science*, 6(5): 429-461.

[10] Suchman, L., 1987. *Plans and Situated Actions: The Problem of Human Machine Communication*, New York, NY: Cambridge University Press.

[11] Lockton D., D.J. Harrison. and N.A. Stanton., 2008. *Design With Intent: Persuasive Technology in a Wider Context. in Persuasive 2008*.

[12] Norman D.A., 1988. *Design of everyday things*, New York, NY: Basic Books.

[13] Hollnagel E., 2004. *Barriers and accident prevention*, Aldershot: Ashgate.

[14] Daniellou F., 2005. The French-speaking ergonomists’ approach to work activity: cross-influences of field intervention and conceptual models. *Theoretical Issues in Ergonomics Science*, 6(5): 409-427.

[15] Bourdieu P., 2005. *Habitus, in Habitus: a sense of place, J. Hillier and E. Rooksby, Editors*, Ashgate: Aldershot, UK.

[16] Akrich M., 1992. *Beyond Social Construction of Technology: the Shaping of People and Things in the Innovation Process, in New Technology at the Outset : Social Forces in the Shaping of Technological Innovations, M. Dierkes and U. Hoffmann, Editors*, Campus: Frankfurt.

[17] Proulx S., 2005. *Penser les usages des technologies de l'information et de la communication aujourd'hui : enjeux – modèles – tendances [Conceptualizing current-day use of IT: stakes, models and trends], in Enjeux et usages des TIC : aspects sociaux et culturels,, L. Vieira and N. Pinède, Editors*, Presses universitaires de Bordeaux, Bordeaux: 7-20.

[18] Jouët J., 2000. *Retour critique sur la sociologie des usages [A critical review of sociology of use]*. Réseaux, 100: 488-521.

[19] Simondon G., 1958/1980. *On the Mode of Existence of Technical Objects*, London: University of Western Ontario.

[20] Von Hippel E., 2005. *Democratizing innovation*, Cambridge, MA: MIT Press.

[21] Elliott M.S. and W. Scacchi, Mobilization of Software Developers: The Free Software Movement, *Information Technology and People, 2008*. 21(1): 4-33.

[22] Stewart K.J. and S. Gosain, 2006. The Impact of Ideology on Effectiveness in Open Source Software Development Teams, *MIS Quarterly*, 30(2): 291-314.

[23] Organization I.S., 1990. *ISO 13407 : Human-centred design processes for interactive systems.*

[24] Hassenzahl M. and N. Tractinsky., 2006. User experience - a research agenda, *Behaviour & Information Technology*, 25(2): 91-97.

[25] ISO, 1998. *ISO 9241 - Ergonomic requirements for office work with visual display terminals (VDT)s*, ISO/IEC.

[26] Theureau J., 2006. *Le cours d'action: méthode développée [Course of Action: developed method]*, Toulouse: Octarès.

[27] Daniellou F., 1992/1999. *Le statut de la pratique et des connaissances dans l'intervention ergonomique de conception [The status of practice and knowledge within ergonomic interventions in design], in Ergonomie*, Université le Mirail: Toulouse.

[28] Bach C. and D.L. Scapin., 2003. *Ergonomic criteria adapted to human virtual environment interaction*. in *15th French-speaking conference on human-computer interaction*, Caen, France.

[29] Kujala S., 2003. User involvement: a review of the benefits and challenges, *Behaviour & Information Technology*, 22(1): 1-16.

[30] Cerf M. and J.M. Meynard., 2006. Diversité d'usages des outils d'aide à la décision en conduite de cultures : quels enseignements pour une création conjointe des outils et de leurs usages ? [Diversity of uses of tools for decision-making assistance in crop management : what does it teach us for the joint design of tools and their uses ?], *Natures Sciences*, Sociétés, 14: 19-29.

[31] Guérin F., Laville A., Daniellou F. and Duraffourg J., 2007. *Understanding and transforming work*, Lyon: ANACT.

[32] Roese N. and J.M. Olson., 1993. The structure of counterfactual thought, *Personality and social psychology bulletin*, 19: 312-319.

[33] Flanagan J.C., 1954. The Critical Incident Technique, *Psychological Bulletin*, 51(4): 327-359.

[34] Patrick J., 1992. *Training, research and practice*, London: Academic Press.

[35] Burkhardt J.M., B. Bardy. and D. Lourdeaux., Immersion, réalisme et présence dans la conception et l'évaluation des environnements virtuels [Immersion, realism and presence in the evaluation of Virtual Environments], *Psychologie Française*, 48: 35-52.

[36] Nyssen A.S., 2005. *Simulateurs dans le domaine de l'anesthésie. Etudes et réflexions sur les notions de validité et de fidélité, in Apprendre par la simulation - De l'analyse du travail aux apprentissages professionnels, P. Pastré, Editor*, Octarès: Toulouse.

[37] Darses F. and M. Wolff., 2007. How do designers represent to themselves the users needs?, *Applied Ergonomics*, 37: 757-764.

[38] Oudshoorn N., E. Rommes. and M. Stienstra., 2004. Configuring the user as everybody: gender and design cultures in information and communication technologies, *Science Technology & Human Values*, 29(1): 30-63.

[39] Hyysalo S., 2003. Some Problems in the Traditional Approaches to Predicting the Use of a Technology-driven Invention Innovation, *The European Journal of Social Science Research*, 16(2): 117-137.

[40] Darses F. and F. Reuzeau., 2004. *Participation des utilisateurs à la conception des systèmes et dispositifs de travail [User participation to the design of work systems and devices], in Ergonomie, P. Falzon, Editor*, PUF: Paris : 405-420.

[41] Falzon P., 1994. Dialogues fonctionnels et activité collective [Functional dialogues and collective activity], *Le Travail Humain*, 57(4): 299-312.

[42] Cerf M. and P. Falzon. eds., 2005. *Situations de service : travailler dans l'interaction [Service situations: working within interactions]*, Octarès: Toulouse.

[43] Walker S. and D. Prytherch., 2008. How is it for you? A case for recognising user motivation in the design process, in Affect and Emotion in Human-Computer Interaction : From theory to applications, C. Peter and R. Beale, Editors, *Springer*, New York, NY.: 130-141.

[44] Morie J.F., 2006 *Virtual reality, immersion and the unforgettable experience*, in *Stereoscopic Displays and Virtual Reality Systems XIII*, A.J. Woods, et al., Editors.

[45] Jorgensen D.L., 1989. *Participant observation: a methodology for human studies*, Newbury Park, CA: Sage.

[46] Amalberti R., 2001. The paradoxes of almost totally safe transportation systems, *Safety science*, 37: 109-126.

[47] Pollet P., Vanderhaegen F. and Amalberti R., 2003. Modelling border-line tolerated conditions of use (BTCU) and associated risks, *Safety Science*, 41(2-3): 111-136.

[48] Lefort B., 2005. The tool, the thought and action, in French and other perspectives in praxiology, V. Alexandre and W. Gasparski, Editors, *Transaction publishers*, New Brunswick, NJ.: 99-116.

[49] Joule R.V., Girandola F. and Bernard F., 2007. How can people be induced to willingly change their behavior? The path from persuasive communication to binding communication, *Social and Personality Psychology Compass*, 1(1): 493-505.

[50] Boucheix J.M., 2003. Simulation et compréhension de documents techniques : le cas de la formation des grutiers [Simulation and comprehension of technical documents : the case of training crane operators], *Le Travail Humain*, 66(3): 253-282.

[51] Klein G., 2007. Corruption and recovery of sensemaking during navigation, in Decision making in complex environments, *M. Cook, J.M. Noyes, and Y. Masakowski, Editors*, Ashgate, Aldershot, UK: 13-30.

[52] Samurçay R., 1995. Conceptual models for training, in Expertise and technology, *J.M. Hoc, P.C. Cacciabue, and E. Hollnagel, Editors*, Lawrence Erlbaum Associates: Mahwah, NJ.: 107-124.

[53] Landgren J., 2006. *Making action visible in time-critical work. in CHI2006*, Montreal, Quebec.

[54] Rosson M.B. and Carroll J.M., 2002. *Scenario-Based Design*, in *The Human-Computer Interaction Handbook: Fundamentals, Evolving Technologies and Emerging Applications, J.A. Jacko and A. Sears, Editors*, Lawrence Erlbaum Associates.: 1032-1050.

[55] Go K., 2009. What properties make scenarios useful in design for usability?, in Human Centered Design, *Springer*, Berlin: 193-201.

[56] Nelson J., Buisine S., Aousst A. and Duchamp R., 2009. *Elaboration of safety equipment concepts for infants. in 17th International Conference in Engineering Design*, Stanford, CA.

[57] Carroll J.M. and Rosson M.B., 1992. Getting around the task-artifact cycle: how to make claims and design by scenario, *ACM transactions on information systems*, 10(2): 181-212.

[58] Sutcliffe A.G. and Carroll J.M., 1999. Designing claims for reuse in interactive systems design. *International Journal of Human Computer Studies*, 50(3): 213-241.

[59] Simon H.A., 1957. *A Behavioral Model of Rational Choice, in Models of Man, Social and Rational: Mathematical Essays on Rational Human Behavior in a Social Setting*, Wiley: New York, NY.

[60] Brandes, U., S. Stich, and M. Wender., 2009. *Design by use: the everyday metamorphosis of things*, Basel: Birkhäuser.

[61] Fulton Suri J., 2005. *Thoughtless acts ? Observations on intuitive design*, Chronicle books.

[62] Norman D.A., 1981. Categorization of action slips, *Psychological review*, 88(1): 1-15.

[63] Vicente K.J., 1999. *Cognitive work analysis: towards safe, productive and healthy computer-based work, Mahwah*, NJ: Lawrence Erlbaum Associates.

[64] Bødker S., 2000. Scenarios for user-centred design: setting the stage for reflection and action, *Interacting With Computers*, 13(1): 61-75.

[65] Béguin P., 2009. When users and designers meet each other in the design process, in Risky work environments, *C. Owen, P. Béguin, and F. Wackers, Editors*, Ashgate: Aldershot, UK.: 153-170.

[66] Robert J.M. and Brangier E., 2009. What is prospective ergonomics? A reflection and a position on the future of ergonomics, in Universal Access in HCI Part I, *Springer-Verlag*, San Diego, CA.: 162-169.

[67] Osborn A.F., 1953. *Applied imagination: Principles and procedures of creative problem solving*, New York, NY: Scribner.

[68] Orloff M.A., 2006. *Inventive thinking through TRIZ: a practical guide, Berlin, Springer Verlag*.

[69] Sternberg R.J. and Lubart T., 1999. *The concepts of creativity: prospects and paradigms, in Handbook of creativity, R.J. Sternberg, Editor*, Cambridge University Press: New York, NY.: 3-15.

[70] Sweller J., 2009. *Cognitive bases of human creativity*. Educational Psychology Review, 21: 11-19.

[71] Von Stamm B., 2008. What are innovation, creativity and design ?, in Managing innovation, *Design and creativity*, John Wiley: New York, NY.: 1-25.

[72] Guilford J.P., 1964. Creative thinking and problem solving. *Education Digest*, 29: 21-31.

[73] Daniellou F., 2007. Simulating future work activity is not only a way of improving workstation design, 4(2): 84-90.

[74] Bruseberg A. and D. McDonagh-Philip., 2002. Focus groups to support the industrial/product designer: a review based on current literature and designers' feedback, *Applied Ergonomics*, 33: 27-38.

[75] Mollo V. and Falzon P., 2004. Auto- and allo-confrontation as tools for reflective activities, *Applied Ergonomics*, 35(6): 531-540.

[76] VanGundy A., 2005. *101 activities for teaching creativity and problem solving*, San Francisco, CA: John Wiley.

[77] Lockton D., Harrison D., Holley T. and Stanton A.N., 2009. *Influencing interaction: development of the Design with Intent method. in Persuasive 2009.* Claremont, CA.

[78] Schwartz S.H. and Fataleh D.L., 1973. Representation in deductive problem solving: the matrix, *Journal of experimental psychology*, 95: 343-358.

[79] Scupin R., 1997. The KJ method: a technique for analyzing data derived from Japanese ethnology, *Human Organization*, 56(2): 233-237.

[80] Dorst K. and Cross N., 2001. Creativity in the design process: co-evolution of problem–solution, *Design Studies*, 22(5): 425-437.

[81] Theureau J., 2003. *Course-of-Action analysis and Course-of-Action centered design, in Handbook of cognitive task design, E. Hollnagel, Editor*, Lawrence Erlbaum Associates: Mahwah, NJ.: 55-81.