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Anticipating the use of future things: Towards a framework for prospective use analysis in innovation design projects

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ABSTRACT

Anticipation of future product use is a persistent issue in User-Centered Design. In this paper, we argue that one obstacle to early integration of use analysis in innovation design is overreliance on retrospective use analysis, i.e. that which is based on clear references to existing products or activities. In contrast, innovation design projects are full of uncertainty, leading to a need for prospective analysis. After having described some limitations of prospective use analysis, we contend that creativity tools may be used to assist the anticipation of future product use, by allowing designers to approach the variability of situations of future use in a structured manner rather than by "muddling through". We illustrate the expected benefits of this approach with two case studies, and describe some prospects for future research and practice in ergonomics.

1. Introduction

User-Centred Design (UCD) refers to "*a multidisciplinary design approach based on active involvement of users to improve the understanding of user and task requirements*" (Mao et al., 2005). "Design" can be defined as a process by which *something unknown can intentionally emerge from what is known*. This implies the expansion of designers' knowledge and product concepts (Hatchuel and Weil, 2009). A "designer" may be any professional whose work involves generating these expansions, e.g. an industrial designer, an engineer, an architect, or an ergonomist. This leads us to view "use analysis" as a range of methods from various fields (ergonomics, computer science, sociology, etc.). The goal of these methods is to generate knowledge about the present or future use of a product. Theureau (2002) has noted that it is difficult to anticipate the effects of design choices on the future activity of users. This is because use analysis typically relies on the analysis of real-world situations – those situations which product design aims, precisely, to transform.

UCD, as described in the ISO 13407 standard and the more recent 9241-210 standard, solves this problem by planning design in iterative cycles (Bevan, 2001; Maguire, 2001). Each cycle leads to the production of an intermediary object of design, e.g. a mock-up or prototype. The use of this intermediary object can be analysed to test the relevance of design choices, and to gradually refine designers' understanding of the context of future use. However, in an industrial context, designers must optimize time and costs. Indeed, designers often operate with the explicit goal of "getting it right the first time" (Thomke, 1998). One of the ways to achieve this is to involve ergonomics at a prospective level. This involves anticipating future needs and activities in the early stages of the design process, rather than limiting the scope of analysis to existing activities (Robert and Brangier, 2012, Fig. 1).

In this paper, we argue that fostering creativity in the design team may help designers overcome some of the difficulties they encounter when anticipating the future use of a product. We begin by describing the main methods in use analysis. We identify two different types of analysis, named retrospective and prospective. In the third part of the paper, we describe some findings in cognitive psychology regarding biases in the anticipation of possible future events. We argue that these biases may have serious consequences for UCD, particularly in the case of innovation design projects. There is a need for tools to help designers anticipate future product use in a way that is more structured and less vulnerable to bias. In the concluding parts, we introduce creativity as a toolset to assist prospective use analysis and describe some expected benefits of this approach.

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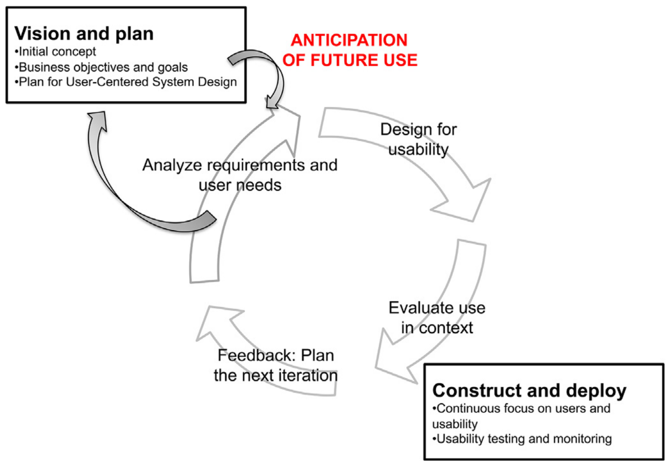

Fig. 1. Anticipation of future use and iterative user-centred design. Adapted from Gulliksen et al., 2003.

2. Use analysis in product design: a state of the art

2.1. From usability engineering to user experience design and beyond

Informing the product design process with knowledge of human activity is not a simple task. The emergence of UCD in the 1980s was partly due to the active interest of the scientific community, from World War II onwards, in modelling human activity (Card et al., 1983). This community also introduced new concepts, connecting scientific theory with design practice, such as usability (Gould and Lewis, 1985; Norman and Draper, 1986). For many years, usability was defined mainly as "quality of use" (Bevan, 1995). This concept served as a basis for the development of methods to evaluate design, and of a standardized framework for UCD (Bevan, 2001).

Dumas and Salzman (2006) identify four classes of usability assessment methods: (1) usability testing; (2) inspection methods; (3) expert surveys, interviews, and focus groups; and (4) field methods. Their review shows that one method alone cannot encompass the variability of the phenomena that make up product use. For example:

- User testing was derived from an experimental paradigm to study user behaviour. However, the acknowledgement that this behaviour was supported by mental processes led to the development and widespread use of think-aloud protocols (Ericsson and Simon, 1980). The goal of these methods is for users to generate verbal reports, from which analysts can infer descriptions of underlying mental processes;
- Laboratory experiments raise the issue of ecological validity, i.e. the generalization of findings from laboratory to real-world contexts of use. Field methods, such as observations, interviews, or remote use analysis, address this by collecting data in real-world settings. Acknowledging the crucial importance of the context of use is a central principle of Activity Theory, Situated Action Theory, and Distributed Cognition theory. All of these have found applications in both ergonomics (Daniellou and Rabardel, 2005) and Human–Computer Interaction (Diaper and Lindgaard, 2008).

In recent years, there has been growing debate about how knowledge of user activity, obtained by applying these methods, could lead to improved use value. Initially, usability described quality of use mainly in terms of "instrumental" – i.e. task-related – measures. However, the focus gradually shifted to user experience and non-instrumental aspects of the user–product relationship (Dumas and Salzman, 2006; Hassenzahl and Tractinsky, 2006). From this point of view, use value does not just stem from the concepts introduced by usability engineering, such as learnability, efficiency, or satisfaction (Nielsen, 1993). New concepts must be introduced, e.g. product aesthetics, pleasure and fun. These elements cause users to engage in a relationship with the product that can be investigated using methods similar to those quoted above. Such methods can be used for summative (product evaluation) or formative (exploratory user research) purposes. No single method can provide a comprehensive insight into future use: each method has its own focus, its own strengths, and its own weaknesses. However, there are strong commonalities between methods. The most notable of these is that designers usually produce insights into future use by analysing existing activities.

2.2. From retrospective to prospective analysis of product use

It has been said that the contribution of ergonomics to design can take one of two forms (Couix et al., 2012). First, the ergonomics practitioner's knowledge of human factors gives him/her access to resources that describe design solutions directly, e.g. ergonomic standards and guidelines. Second, ergonomists may apply methods to analyse the real-world activity of operators or users. In this case, they must begin by identifying typical situations of action that serve as a broad reference (Garrigou et al., 1995). Only after this has been done can more specific situations be selected or constructed for detailed analysis. The goal of this operation is not just to investigate existing situations that must be corrected: it is also to anticipate the effect of system transformations on future user activity.

Simulations aim to describe future situations in a more or less ecological manner. Because of this, they have been the focus of much research in ergonomics, both in the design of work systems (Daniellou, 2007) and of innovative products (Sagot et al., 2003). As Marc et al. (2007) point out, there are three main components in a simulation:

a) The simulator, i.e. the device used to simulate the situation;
b) The simulation, i.e. the implementation of a scenario within a simulator;
c) The simulated situation, i.e. the real-world situation that the simulation is intended to reproduce.

These three items exhibit great variability in simulation practices. For example, a simulator might be computational, as in the case of Virtual Reality or PC-based environments. It can also refer to a physical system, in the case of full-scale simulations with physical mock-ups or prototypes. In any case, the construction of a simulation cannot be separated from the choice of relevant *scenarios of use* (Carroll and Rosson, 1992; Bødker, 2000; Carroll, 2000; Fulton Suri and Marsh, 2000). Scenarios are stories that ensure a focus on users in a design project. They describe the product, its end users, their goals, sequences of actions and events, as well as the context of future use (Carroll, 2000). The question then becomes: *what are the resources at the ergonomist's disposal to construct scenarios of use?*

Workstation design usually poses no problem at this level, because ergonomics is usually contracted either to correct an existing system, or to assist an on-going design process (Robert and Brangier, 2012). In other words, the goal of ergonomics here is (a) either to alter an existing system where an operator's work practices can be analysed (e.g. to redesign a workstation); or (b) to materialize a system concept that company executives have already approved, based on a precedent in other companies (e.g. to build a new lean production workshop). Innovation design projects pose a more difficult challenge because they are characterized by uncertainty at two levels – technological capabilities and market characteristics (Veryzer and Borja de Mozota, 2005; Norman, 2010). Depending on the project, it may be necessary to generate new knowledge regarding technologies and/or markets. Fig. 2 illustrates this by identifying four classes of situations. We describe them below in order of increasing uncertainty.

- Situation IV (known technology, known market): This is typical of incremental innovation projects. Ergonomists can generate knowledge for UCD by analysing the use of an existing product. For example, when taking part in the design of "a safer car for elderly drivers", an ergonomist would probably examine how these drivers use existing cars. From there, it would be possible to determine how these driving practices might be considered unsafe;
- Situations II (known market, new technology) and III (new market, known technology) embody innovation processes that are more uncertain. Some references do exist to describe product use and user needs. However, the "design brief" – i.e. the earliest and most abstract expression of the product concept to be designed (Hatchuel and Weil, 2009) – is such that UCD requires a more specific investigation. Let us take two examples: designing "a multimodal virtual environment to assist research in molecular pharmacology" (Férey et al., 2009) and "a mobile phone for everyone" (Plos and Buisine, 2006). Ergonomists will probably attempt to use knowledge about activities and user populations that can be tied to the design brief, such as "researching molecular pharmacology with current tools" and "the use of a mobile phone in everyday life by different kinds of user populations". However, this will not bring the design brief to an adequate level of specification. For the first product, it is unclear how innovative technologies can transform users' activity. For the second, it is unclear what range of activities and users should be investigated;
- Situation I (new market, new technology): These situations are typical of disruptive innovation that, according to Chayutsahakij and Poggenpohl (2002) "*embodies the highest organizational uncertainty*". They happen when the design brief does not allow ergonomists to identify any clear reference in terms of future users and these users' tasks. For example, the concept "an interactive tabletop interface with multi-user, multi-touch recognition capabilities" does not include any information about who the future users of the product are, or what the future uses of the product might be.

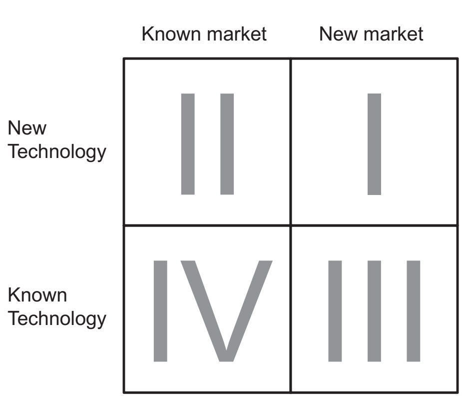

Fig. 2. Categorization of innovation design projects (adapted from Chayutsahakij and Poggenpohl (2002)).

The two projects described below serve as case studies in this paper. They belong to different categories in Fig. 2. However, the issue of "anticipating future use" is present in both cases.

2.2.1. Case study #1: innovative applications for an emerging technology

An emerging technology is defined as "*a novel computer technology with promising properties, use and significance, for which the implications for human–computer interaction are still unclear*" (Kjeldskov, 2003). Interactive tabletop interfaces are a good example of this. Much effort has been made in recent years to develop the technology that would allow groups of users to interact with a tabletop computer. The promise of such interfaces is to make it possible to combine the benefits of computational information processing with those of face-to-face interaction in a shared social setting (Shen et al., 2006). However, the market for these new technologies is mostly unknown. Such projects are often dominated by a strong technology push, with user needs often remaining a minor concern. Consequently, ergonomists often take part only in the later parts of such projects, during prototype evaluation (Anastassova et al., 2007).

Our team was recently involved in project *Digitable*, a research-industry partnership to design innovative tabletop interaction systems (Coldefy and Louis-dit-Picard, 2007). In this project, many different applications were designed in support of various activities. One application aimed to assist creative idea generation in innovation design projects (Buisine et al., 2012). The goal of this project was twofold. The first goal was to produce technological innovations allowing the design of collaborative tabletop applications with multi-user, multi-touch recognition. The second was to produce knowledge regarding the cognitive and social processes of human activity in collaborative tabletop interaction, and to better understand the strengths and limitations of this interaction paradigm.

In industrial terms, a firm with the know-how to design tabletop interfaces must constantly identify new applications of this technology that will be relevant to users before committing to a design project. However, the technology is new and the market is unknown. Designing human–computer interfaces with emerging technologies is therefore a category I situation in Fig. 2. Designers must generate, from an intentionally vague design brief, new concepts of products that are likely to lead to new sources of use value. Ergonomics is expected to take part in the design process in a prospective manner, i.e. to propose new product concepts, rather than just to assess the relevance of design decisions for UCD (Robert and Brangier, 2012). Therefore, there is a need for tools to help designers generate proposals for applications in the conceptual design stage, and to choose which concepts are worthy of further development.

2.2.2. Case study #2: validating innovative safety equipment concepts

A second project we have worked on was called *Little Mermaid*. One of the authors of this paper was part of a multidisciplinary design team with four engineers, an ergonomist, and an industrial designer. The goal of the project was to design an innovative product for use by infants, to prevent drowning accidents (Nelson et al., 2009b). Unlike in the project above, the ergonomist joined the design team only after the initial product concept had been well defined – a wearable, inflatable necklace that would activate only when the infant is immersed in water.

In this case, both the market and the technology are well defined. This is an example of a category IV situation in Fig. 2. Although the situation is different, anticipating future use is just as important as above. Because it is impossible to gather knowledge about all possible hazardous situations during the UCD process, designers must anticipate what might go wrong. In our case, over the course of our involvement in the project, we formulated and discussed scenarios of use of existing products, and future uses of this new product. This allowed us to improve the initial concept, and to propose complementary product concepts to improve infant safety and drowning prevention even further.

This ability to anticipate what might go wrong to guide design has been called *requisite imagination* by Adamski and Westrum (2003). Interestingly, these authors fail to specify what degree of imagination designers should hope to achieve. They only claim that some real-world accidents might have been prevented if the designers of the systems involved had been able to anticipate a wider range of outcomes. There is therefore a need to help designers validate product concepts by confronting them to a wide range of scenarios.

Both case studies we mentioned highlight the same point. Designers need to be able to better anticipate future use, in order to generate product concepts, to foresee how they might become sources of value, inconveniences or hazards to users, and to validate specific concepts for further development.

3. Anticipation of future use in the design of innovative products

Studies in cognitive ergonomics often view design as an activity that involves collectively solving an ill-defined problem (Visser, 2009). Several authors acknowledge that design relies on the construction and use of internal as well as external representations (Visser, 2006; Christensen and Schunn, 2008). However, few studies have focused on how designers construct and use mental models of the future users of a product, as well as models of their needs. One notable exception is a study by Darses and Wolff (2006). The authors investigated how users were mentioned in the course of design meetings. They show that, depending on the type of issues being addressed in the meeting, users were viewed in one of three ways: (1) as subsystems of the system being designed, (2) through general UCD principles, or (3) as elements of an imagined scenario, in which designers simulate users' behaviours and thoughts.

Another issue relates to how representations of users and their activities are articulated with design. Three forms of integration have been identified, related to three main approaches to design (Béguin, 2007):

- *Crystallization* rests on the idea that a model of users and of product use can guide product or system design;
- *Plasticity* claims that beyond the stable elements of activity featured in this model, design must allow for variability in the practices of individual users. This might stem, for example, from variations of characteristics within the user population, or from variations in the context of use;
- *Development* aims to foster evolutions in use, in order to counter the contradictions that emerge in user activity over time.

Rather than being separate, these three philosophies – crystallization, plasticity, and development – complement each other (Prost et al., 2007). Each philosophy requires that designers anticipate future use. What differs between them is how designers use these representations. From this point of view, "product use" is not just the result of interactions of the users with the product. It is also a product of designers' activity, since design can convey specific intents of designers with respect to use (Lockton et al., 2010). Anticipation of future use is therefore a key aspect of design.

3.1. Anticipation of future use as the control of a dynamic situation

Situations are dynamic if they are only partly controlled by a human operator, who must take into account system dynamics to reach task goals. This definition covers many work situations in the industry, such as industrial process control, air traffic control, or piloting highly automated aircraft (Hoc, 2001). These situations contrast with static situations, where the only source of variability in system behaviour is the operator's actions. In dynamic situations the operators' goal is to maintain the system's state within acceptable boundaries. Likewise, from a designer's point of view, the variability of future use needs to be taken into account in the design of a product. It can be argued that the goal is for designers to maintain product use within acceptable boundaries (Nelson et al., 2009a). For example, when designing safety systems, acceptable use implies that users are protected from hazards. More broadly, from a UCD perspective, "acceptable" situations of use can be defined as situations where users are able to derive some value from product use. In the case of consumer products, this encompasses situations where users find the product to be useful, usable, and/or to provide positive user experience.

From this point of view, any unforeseen use of a product is a source of uncertainty to designers (Redström, 2006). Unforeseen use has been studied in various fields, including ergonomics (Folcher, 2003), sociology (de Certeau, 1988) and design (Brandes et al., 2009). Depending on the authors, it is viewed either as a source of hazards to the user, system, or environment (Amalberti, 2001), or as a potential source of innovation (Fulton Suri, 2005; Von Hippel, 2005). Table 1 provides examples of how this relates to our two case studies, and how the anticipation of future use might allow designers to improve product design.

3.2. Anticipation of future use as counterfactual reasoning

Counterfactuals are "*mental representations of alternatives to past events, actions or states*" (Epstude and Roese, 2008). According to these authors, counterfactual reasoning is involved in phenomena such as regret and blame. Moreover, it plays an important part in preparing individuals for future possible events. Thinking about the future use of a product is also a way for designers to make decisions about their product. This line of thinking is at the heart of Scenario-Based Design (Carroll, 2000). Scenarios serve two distinct functions in design: a) to structure the evaluation of a product in the late

Table 1
Examples of the benefits in anticipating future use in our two case studies.

	Tabletop interface	Device for drowning prevention
Unforeseen sources of use value	• Combining the concept with unexpected contexts of use may yield original application concepts • Anticipation of future use may also yield original modes of interaction between the user and the product	• Anticipating future use may lead to formulating original product concepts for drowning prevention and/or similar safety applications.
Unforeseen hazards and inconveniences in use	• Anticipating hazards in the use of an interface (e.g. situations leading to damage and/or injury to the product, user, or use environment) will help designers design safer and more acceptable products.	• Anticipation may focus on situations where the product may malfunction or otherwise fail to achieve its goal, in order to help designers adjust the product concept.

stages of UCD, or b) to speculate about future use in the early stages of this process and convince stakeholders of the relevance of a product concept (Hanington, 2003). The idea is that by confronting this product concept to a wide range of possible futures, designers will be able to analyse more thoroughly the relationship between design features and positive or negative impacts in terms of future use. This process is also called “claims analysis” (Carroll and Rosson, 1992; Carroll, 2000).

Scenarios of use feature several elements, such as a setting, actors following goals, and a plot (Carroll, 2000). Recent work in mobile HCI design, where contexts of use may be extremely variable, suggests that this variability may be taken into account by generating values for different contextual variables and then combining them into scenarios of use (de Sá and Carriço, 2008). Such contextual variables include physical locations and environments, movements and postures in use, user tasks and activities, available technical devices, and user profiles and personas.

We agree with de Sá and Carriço (2008) that this combinatory reasoning is necessary when dealing with highly variable contexts of use, such as when designing context-sensitive mobile devices. We would also add that this is useful because the counterfactual reasoning involved in scenario generation is vulnerable to psychological biases. These biases lead to an oversimplified and restrictive view of the future that is dependent on the designer’s existing knowledge. This phenomenon is known as the *foresight bias* (MacKay and McKiernan, 2004). For example, designers may more or less consciously project themselves in the user’s place, believing that their own needs and practices are an accurate reflection of those of the users of the product (Bardini and Horvath, 1995). This phenomenon is often thought to be a negative feature in the design of innovative products, and used as an argument in favour of UCD practices (Cooper, 1999). Moreover, as MacKay and McKiernan (2004) point out, the foresight bias is a wide-ranging concept. Several interacting biases may be at work when designers anticipate future scenarios of use. Table 2 gives some examples of biases that might affect anticipation of future use in both our case studies.

4. Creative design as a paradigm to anticipate future use

4.1. Creativity sessions to structure the anticipation of future use

“Innovation-intensive capitalism” refers to an on-going trend in the capitalist economy. When designing innovative products and services, project stakeholders tend to search for patterns of value (Hatchuel et al., 2002). Creativity is seen as a key source of value, and many authors have proposed tools to improve creative performance in designers (Osborn, 1957; VanGundy, 2005). The term “creativity session” refers in this paper to an organized framework where specific tools are used to enhance creativity.

Table 2
Examples of psychological biases that may apply to anticipation of future use in our case studies.

Concept generation for an interactive tabletop interface
- Psychological inertia (Savransky, 2000): prior knowledge and/or experience in design cause designers to seek routine solutions rather than innovative solutions to inventive problems. Consequently, concept ideas are likely to be unoriginal and/or overly dependent on the designer’s own past experience.

Concept validation of a device for drowning prevention in infants (Nelson et al., 2009b)
- Hindsight bias (Fischhoff, 1975): it is an overestimation of the probability of an outcome following its occurrence. For this, as well as ethical reasons, relatives of victims of drowning and/or witnesses of accidents cannot be involved in the participatory design process as their testimony is likely to be unreliable and possibly traumatic.
- Comparative optimism (Shepperd et al., 2002), the perception that “accidents happen to other people”: representations of drowning accidents may be simplified or completely banished because of self-censorship.

Creativity is at the heart of current efforts to model the design process (Howard et al., 2008; Hatchuel and Weil, 2009). Drawing inspiration from an existing model of designer activity (Gero and Kannengiesser, 2004), Howard et al. (2008) point out that five key processes in design involve creative idea generation. This model describes the design process as an interaction between three types of variables named structure, function, and behaviour.

Behaviour variables describe the expected behaviour of the product, which is influenced by its function as well as its structure (Fig. 3, black arrows). If we consider not just the behaviour of the product, but the behaviour of the system formed by the user interacting with the product, two conclusions can be drawn. First, as several authors have pointed out, the product’s structure and functions embody a “script” written by designers, concerning the intended future behaviour of users (Akrich, 1992; Oudshoorn et al., 2004; Konrad, 2008). Second, it is users who ultimately decide what use is, and the designers’ script for future use is constantly questioned by real-world practices. As Konrad (2008) writes, “*the final shape of a technology sets a certain range for use, optimizing some uses and excluding others. It creates a realm of possibilities, some of which might not have been considered, and which are only discovered by the users themselves. Hence, scenarios of use do not determine the future users and uses, but they play an important part in delineating the realm of possibilities for users*”.

This claim echoes our own point in Section 3.1, that design involves maintaining users within a space of acceptable use. Konrad (2008) shows that generic scenarios in the early stages of a project are gradually converted to more specific scenarios, through a process that she calls “local variation”. This process draws on the knowledge and experience specific to each designer. She also writes that this local variation requires two elements: the generation of variety and the stabilization of scenarios. We agree with both these points, yet we believe that the biases highlighted in Section 3.2 above are likely to prevent designers from achieving optimal performance in scenario generation. Designers need to be able to generate and analyse scenarios of use in a more organized way. Creativity sessions appear to be an ideal tool for this, as they involve both divergent thinking – the generation of variety – and convergent thinking – the stabilization of scenarios (Cropley, 2006).

How does this relate to prospective use analysis? The description by Konrad (2008) on how designers gradually specify new scenarios of use can be seen as exploring a use frame. Flichy (2008) defines the use frame as a structure that “*describes the type of social activities proposed by technology, positioning it within a set of social practices, of everyday routines, and specifies the audience involved*” (our translation). To us, the use frame is a starting point for scenario generation: in a frame, some scenario variables are “locked”, while

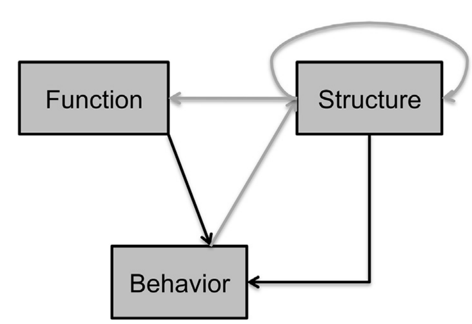

Fig. 3. Integrated model for the creative design process, adapted from Howard et al. (2008).

others remain open to local variation. One way for designers to counter the biases of anticipating future use would be to utilize a framework where scenario variables are examined separately, and then combined into use frames and refined into coherent stories (Fig. 4).

4.2. Describing a typical creativity session about future use

Creative Problem Solving (CPS) is one of the oldest models of the creative process (Osborn, 1957; Isaksen and Treffinger, 2004). Its simplicity makes it an ideal basis for creativity sessions. Based on this model, we propose a three-stage process to assist the anticipation of future use in innovative product design.

4.2.1. Problem definition and analysis

In any creative problem-solving task, the first stage is to gather all available facts and data to formulate the problem that needs to be solved. Thus, designers must collectively build and share a knowledge base. To describe future needs and activities, ergonomics can collaborate with professions that deal explicitly with present and future trends in product consumption and use. These fields might include sociology, marketing, etc. (Robert and Brangier, 2012). This collaboration is promising because these professions focus on trends in use and operate at a strategic level in the firm, whereas ergonomics deals mostly with interactions between users and the product at a more tactical level. However, collaboration is often difficult because individuals from different professional backgrounds have different views and expectations about the nature of usability and the need to anticipate future use (Hertzum, 2010). These differences need to be clarified before the promise of strategic anticipation of future use can be fulfilled. The long-term goal is to be able to coordinate knowledge about trends in future use with knowledge of the company's innovation strategy to guide conceptual design.

Considering our two case studies, this stage might focus on the following questions, in response to the design brief:

- For the interactive tabletop interface: Who are the key stakeholders in the market? Which products do they offer, and what data is available regarding the benefits and drawbacks of these products, in terms of use value? What are the current trends of technological development in this field? Can current research point us towards promising markets and future trends in use?
- For the device for drowning prevention: What systems are currently available in terms of safety equipment, to prevent drowning in infants? Are there any epidemiological studies that provide insight into the circumstances of drowning accidents? What are the reasons behind the apparent failure of existing products to prevent drowning in infants? What are the factors that promote a safety-prone relationship between users (infants and caregivers) and the product?

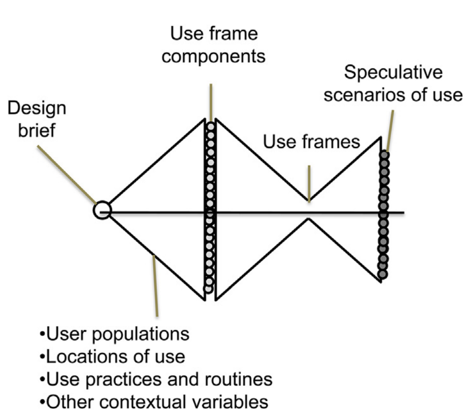

Fig. 4. Overview of a creativity session to generate speculative scenarios of future use.

4.2.2. Creative idea generation

Once this knowledge base has been constructed, the next stage is to generate creative ideas about future product use. It is essential to support divergent thinking at this point. This is the goal of tools such as brainstorming (Osborn, 1957). Brainstorming is based on four rules: criticism is ruled out, freewheeling is welcomed, quantity is wanted and combinations and improvements are sought. Osborn hoped that the principles embodied in these rules (deferment of judgement and quantity breeds quality) would improve performance in idea-generating groups. Research suggests that brainstorming can be viewed as a repeated search for ideas in associative memory (Nijstad and Stroebe, 2006). Exposure to another person's ideas may activate knowledge in one's own network of associations. Therefore, brainstorming is likely to benefit the anticipation of future use in two ways. First, exposure to other people's ideas may stimulate idea production in random and unexpected directions: this is likely to lead to more numerous and diverse ideas, about which elements could be used to construct use frames. Second, groups may also choose to focus on a more homogeneous set of ideas. This should allow a more comprehensive and in-depth exploration of specific use frames.

Brainstorming is intended to allow participants to quickly generate large numbers of ideas. However, a scenario or "story" cannot be viewed as a simple idea, as it involves several interacting elements. Idea generation may focus on single elements of the story, i.e. components of the use frame. The idea generation stage then aims to generate original ideas based on existing knowledge. New possibilities for future use can be produced in this way, to question the product concept described in the brief and expand it to new concepts. In our two case studies, designers might focus on the following questions:

- Market studies suggest that current markets for interactive tabletops lie in the gaming, educational, and public information sectors. Are there any sectors that provide market opportunities for interactive tabletops to assist work activities? Or indeed, can one propose a product or service concept at the crossroads between two or more of these sectors?
- Preliminary information suggests a particular need for a wearable, inflatable device to prevent drowning in infants using family swimming pools. However, might other populations benefit from this concept? Might the concept "an inflatable device to prevent drowning" be useful in locations other than swimming pools?

4.2.3. Idea sorting and evaluation: from use frames to scenarios of use

The goal of this stage is to produce, by combining ideas regarding elements of future use, a set of speculative scenarios of future use. These scenarios are then analysed, giving a roadmap for future design projects. In a recent paper (Nelson et al., 2012), we applied this approach to both case studies presented in the present paper. Multidisciplinary design teams used the brainwriting technique (Paulus and Yang, 2000) to generate ideas concerning a) prospective populations of future users and b) prospective locations of use of the product. From this production, participants selected the ideas that they thought were the most interesting prospects for development. The ideas were then combined within a discovery matrix, a variant of morphological analysis (Voros, 2009), to generate a set of speculative scenarios of future use of both products (the inflatable necklace and the tabletop interface). After the scenarios were constructed, they were subjected to claims analysis. This is equivalent to completing the second cycle of divergence and convergence in Fig. 4.

From our experience in the two case studies, scenario construction provides further opportunities for divergence. Each cell in the discovery matrix served as a basis for generating one or more speculative scenarios of use. For example:

- Tabletop interface: Crossing the population of “children” with the location of “an operating room” led to the team exploring four different scenarios of use for interactive tabletop interfaces that combined both features. In one case, the interface concept was educational (an interactive surgery simulator to train interns in collaborative work). In another, the concept was a skill-based game where players removed organs from a fictitious patient. However, participants also introduced new use frames leading to new product concepts, such as an interface for surgeons to demonstrate an upcoming procedure to a patient;
- Device for drowning prevention. The framework challenged teams to go beyond classical representations of future users and locations of use. Although the concept specifically targeted infants, elderly and disabled users were also mentioned in the idea generation stage. This stage also allowed designers to move from situations featuring a generic threat (“water”) to more diverse scenarios featuring concrete locations (domestic pools, public pools, paddling pools, the seaside, the bathroom, etc.), following the “local variation” mechanism described by Konrad (2008). Combining these two sources of input allowed:
  - New questions to emerge in concept validation, e.g. “Are there any situations where the device might be exposed to water without this being a hazard to the wearer? Can we revise the inflation start-up mechanism for it to occur only when the child is really in danger? What happens in the rain?”
  - New concepts to be generated in response to unusual user–location combinations, e.g. “How and why could an inflatable, water-detecting, wearable device be used by youth in a nightclub?” One designer suggested that it could serve as a playful accessory in a foam party. Another pointed out that members of the same group might use it to identify each other in a busy and low-lit environment. Thus these new use frames help designers identify possible user needs – the kind which Robertson (2001) calls “undreamt-of requirements”.

After the experiment, some participants provided us with feedback: this allowed us to better understand the role of creativity tools in anticipating future use. They pointed out that the association of brainwriting with the discovery matrix allowed them to anticipate future use more easily and in an organized manner. This, to them, was a critical need in innovation projects, especially when the design brief was very “open” – i.e. when it gave little specific information regarding future use. They enjoyed the conviviality and fluidity introduced by Osborn’s rules for idea generation.

However, some participants also pointed out the greater pressure they felt to anticipate future use, especially in the case of the drowning prevention device. As these scenarios remained ideas, they found it difficult to assess the relevance of their production. Indeed, the ultimate validation of anticipated use is actual use itself. This raises the question of how prospective use analysis might connect to retrospective analysis in innovation design projects.

5. Conclusions and future work

The method described in this paper relies on a succession of stages to generate and explore variability through speculative scenarios of future use, in the early stages of the innovation design process. Its premise is that before a product can be materialized in the design process, “product use” does not exist. Product use is an idea that can serve as a basis to defend a product concept, and to mobilize stakeholders to launch or sustain an innovation design project.

We have argued here that when producing ideas about future use, designers are confronted with various biases that contribute to a restrictive view of future use. We have proposed a multi-step approach to structure the work of designers in these situations, and have suggested that creativity tools may help designers mitigate the biases encountered in anticipating future use. This approach is a complement, not a substitute, to retrospective use analysis (Robert and Brangier, 2012). The ideas generated in the early stages of UCD are only hypothetical scenarios. This preliminary reflection on future use is useful for three purposes: to reduce the financial and time expenses in iterative UCD, to anticipate situations that are inaccessible to retrospective use analysis (e.g. on account of their rarity) and to introduce an ergonomic contribution in the early stages of the design process. Further research is needed to examine these issues in greater detail.

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