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USER EXPERIENCE AS A CHALLENGE FOR COGNITIVE PSYCHOLOGY AND ERGONOMICS

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Abstract: *Research on human–technology interaction has been concerned with assessing the experience of interacting with technology that is already in the process of being designed. However, the challenge nowadays is to help industry find out what technology should be designed. In this new context, cognitive psychology and ergonomics should be able to assist the innovation process through an analysis of the actions that constitute human life and the role that technology plays in these actions. In this paper, we present our approach to the definition of the role of cognitive psychologists and cognitive ergonomists in the innovation process. We aim to define new concepts and methodologies that would help in the process. One example, taken from a research project from a Spanish consortium of universities and industries, is described*

Keywords: *user experience, innovation, cognitive psychology, cognitive ergonomics.*

INTRODUCTION

Traditionally, usability approach research has been guided by one primary question: How well do users interact with technology? Thus, researchers have evaluated parameters such as efficiency, effectiveness, and satisfaction in order to address any problems users have had during interaction. As a result, the variables that have interested researchers were the number of errors, time to complete the task, and so on. The core issue of usability studies has been, therefore, the evaluation of interaction process and overall performance (Hassenzahl & Tractinsky, 2006; Light, 2006).

This traditional view of human–technology interaction originated from the work of cognitive psychologists in the fields of ergonomics and human factors in applied contexts, where people used the technology. In such contexts, users served as workers who had to interact with technology to perform tasks. Thus, cognitive psychology and cognitive ergonomics researchers were applying successfully their knowledge from the information processing models of human performance to predict users' efficiency, effectiveness, and satisfaction. Thus, the task and the consequent performance were the primary objects of investigation. Data were collected about

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how this task was accomplished, with cognitive economy, stress avoidance, and error reduction as the relevant goals in the interaction process. Technology was considered well designed if people could interact with it and meet their work goals in a reasonable time and with relatively low cost in terms of the cognitive resources invested.

However, researchers and industry have come to realize that when research moves out of the work context, it meets abundant situations in which the user may or may not want to use technology. Thus, even though users use technologies such as computers, trucks, diggers, airplanes, and so on, to perform their tasks on the job, they might or might not use mobile phones to talk with friends or, for instance, to play videogames. In other words, they might or might not use a mobile phone independently of how effective, efficient, and satisfactory their interaction is with it. Therefore, researchers have begun to consider the "something else" that engages users in technology when they do not need it for performing work tasks (Gaver & Martin, 2000; McCarthy & Wright, 2004).

Nowadays, especially in the academic community, a shift is taking place regarding the actual needs for evaluating interaction with technology. The focus is changing from the evaluation of user performance and technology itself to the exploration of human sense-making processes (or values, Kaasinen 2005, 2009) and positive experiences during technology use, or even before the prototype release. Although it is not possible to design experiences, technology designers have come to realize, instead, that it is possible to design for experiences, that is, for supporting and inducing them (Hassenzahl, 2011). As Norman (2011, para. 2) affirms, "Design, it has been said (Krippendorff, 1989) is creation of meaning, and … the essence of meaning to us people is our experiences." The fact that technologies work well "is a means, not an end. The end is the experiences they engender, the stories we tell, and the way that they enriched our lives" (para. 3).

Therefore, technological designers must consider human experiences. In actuality, human needs can be satisfied through products having qualities quite distinct from efficiency and effectiveness, such as beauty or novelty (Wright, McCarthy, & Meekison, 2003). These matters have been known since the early discussions involving behavioral usability versus emotional usability (Logan, Augaitis, & Renk, 1994). Where the former is more related to the traditional work of usability assessment in terms of efficiency, effectiveness, and satisfaction, the latter deals with other needs such as enjoyment, entertainment, involvement, or personal stimulation. Emotional usability evaluations assess whether a particular design solution affords a positive, exciting, and satisfying experience by considering the emotions resulting from technology interaction. Hedonic qualities of artifacts indeed play a key role in the process of interaction, especially in technologies devoted to recreation and entertainment. For example, a hedonic artifact, such as a game console, could be designed in a way that decreases the user's mistakes when interacting with it, but what is the value if such a design results in the user becoming bored while playing video games? Similarly, a design could present significant novelty to the user in the short run, but its use could decrease in the long run if the product itself does not fit in the user's form of life (Leikas, 2009). Life-based design aims at releasing technology that will be widely accepted by people because their way of living, needs, and everyday contingencies have been explored and integrated into the design process as the actual drivers of satisfactory and desirable technology interaction processes.

Thus a parallelism between the early stages of design for work technology versus hedonic technology could be established. When designing a technology for professional activities (e.g., a control panel), task analysis plays a key role in determining functional and system requirements of the final product. But when designing hedonic technology (which also could relate to home contexts, etc.), the investigation of the form of life of the potential end users is the key to successful design.

USER EXPERIENCE

For the reasons discussed so far, researchers have changed their focus of attention towards a vision of interaction in which concepts such as emotion, motivation, hedonic experiences, and so forth, are being evaluated in conjunction with effectiveness, efficiency, and satisfaction (Obrist et al., 2011). This new vision has been called user experience evaluation to mean that interaction with technology is part of the human experience when acting in life (Blythe, Overbeeke, Monk, & Wright, 2003; Blythe, Wright, McCarthy, & Bertelsen, 2006; Vermeeren et al., 2010). Therefore, we could say that user experience (UX) is an extension of the traditional usability approach to human–technology interaction research that includes the user's psychological, sociological, and cultural experiences with technology (Lai-Chong Law, 2011). The goals of a UX evaluation seem to be quite similar to those of life-based design. In fact, we think that the interest in designing appropriate technologies for positive experiences by end users is an objective shared by the two perspectives. This overlap is even clearer when designers do not have a specific technology in mind but try to envision it by preliminary studies of potential users' habits, current problems, and actual, available solutions. We will come back to this point later in the text.

Enclosing the notion of UX within a specific discipline is difficult at best. Its multidisciplinary nature has delivered to the scientific debate a collection of definitions deriving from several perspectives. UX can be considered, simultaneously, a phenomenon, a field of study for evaluating different design solutions, or a design practice (Roto, Law, Vermeeren, & Hoonhout, 2011). In this last sense, envisioning UX could represent a preliminary phase to understanding how a technology could be designed to meet specific needs, both instrumental and noninstrumental. Despite the variety of UX definitions, fruitful efforts have been realized regarding consensus on a general definition and various aspects of UX (Law et al., 2009).

However, researchers evaluating UX typically are working in situations in which they know the technology to be evaluated. Sometimes they have only a conceptual description of the technology to be designed, but other times researchers have already a prototype of the device to be evaluated (Korhonen, Arrasvuori, & Väänänen-Vainio-Mattila, 2010). In either case, they need to know exactly how this technology will fit into user actions and to evaluate it from the standpoint of usability and UX.

But if usability and UX clearly differ from each other in terms of objectives, methods, and the nature of collected data, important differences exist even among UX approaches. UX intended as the direct (or indirect) knowledge of a situation, context, or concept by means of a system (a product, service, or artifact) can include studies of both experiences deriving directly from interaction with commercial products and prototypes and surveys on imagined situations derived from early concept ideas (Obrist, Roto, & Väänänen-Vainio-Mattila, 2009). This latter case represents the challenge designers are facing nowadays, and the clearest similarity to life-based design field.

OUR APPROACH

Although research on UX during interaction is very productive, mostly due to the application of psychological, sociological, and anthropological knowledge, researchers now realize that it is necessary to move one step further. What industry and society are asking now from cognitive psychologists and ergonomists is assistance on the process of technology innovation. In such situations, researchers must start with no assumptions regarding what kind of technology people would like to enhance their lives, but rather envision what that technology could be. The valuable contributions in the methods and techniques that explore (user) experiences with technologies through UX subjectivity and an emphasis on qualitative data (as, e.g., the combination of interviews and discourse analysis, as in Light, 2006, or the use of the novel in early design phases, as in Wright & McCarthy, 2005) are welcome. However, an even greater need exists in supporting design before conceiving any specific technology in order to orientate it towards the most desirable and fitting solutions.

Of course, people should be able to use the technology that we might foresee in an efficient, effective, and satisfactory way while having a positive experience during interaction. However, one aim of this paper is to underscore that researchers must be able to foresee effectively and reliably what kind of technology design is needed in a specific use situation so that it can be evaluated for UX later.

Therefore, the challenge for cognitive psychology and cognitive ergonomics is to develop theoretical knowledge and methodologies for supporting the innovation process that precedes UX evaluation. Achieving this requires researchers to figure out the key aspects that an interaction process could undergo in an innovative redesign process. The future interactions deriving from this early phase of design will constitute the background for UX evaluations, that is, trying to capture human feelings and sense-making processes during a finite period of interaction (Hassenzahl, 2008). The challenge deals not only with new user interface (UI) design methods, but also with new theoretical knowledge and methods able to channel subsequent design choices. In this sense we emphasize the intention to design for experiences.

The research that we are conducting at the University of Granada seeks to address the new issues that technology innovation is raising. We are analyzing the foundations of cognitive psychology and cognitive ergonomics to identify the “right” questions that must be answered.

One of these questions refers to the meaning of “world experience.” If interaction with technology involves the totality of human experience, cognitive psychologists and cognitive ergonomists must start their analysis by asking what they mean by the concept of the user experiencing the world.

In our opinion, the answer to that question derives from the fact that human beings experience the world while acting in the world. Experience does not exist without acting. Even when a human dreams, she/he is acting within the dream. Therefore, we view human action as the unit of analysis. Human interaction with an artifact is a human action. In other words, we posit that the unit of analysis is never, for example, my interaction with a pencil, but rather my act of writing a letter. The pen, paper, eraser, and so on, are objects designed to be used during the act of writing. Thus, we believe that any new technology will always serve a single purpose: to help people act in the world. By extension, then, technology must help people to confront challenges in acting in the world. Without a person facing a challenge while acting in life, there is no—and no need for—innovation.

This reasoning is in line with cognitive theories of creative processes. The results of cognitive research on creativity show that people are more creative when they face conditions that impose limitations or constraints on the outcome that the people feel is appropriate for a particular situation. An example of this in the design field is the UA^2W (Universal Access Assessment Workshop) by Akoumianakis and Stephanidis (2005), in which some limitations are progressively introduced in a reference scenario in order to figure out new, alternative interactions that guarantee accessibility to special needs users. Such research findings suggest that creativity results when people find a useful object created in a category that they have not seen before. This constraint leads them to disregard the possibility of using a more conventional (and less creative) process from memory retrieval. In short, the experimental results from cognitive psychology (Finke, 1990; Ward, Smith, & Finke, 1999) indicate that a person can be forced into thinking in new and imaginative ways if researchers can prevent that individual from using his/her memory to provide a usual explanation or utility. Therefore, the focus of our work is exploring and implementing a new methodology for helping in the innovation process through imposing limits on the actions people experience in their daily lives.

A CASE STUDY: COMMTINUITY

Our research group participates in a government-funded project lead by the Telefónica Company (Proyecto mIO!) on technology innovation, together with other Spanish universities and industries. Our specific role in this project is to surface opportunities for designing new technologies by applying psychological knowledge and reasoning.

In the context of this project, a Telefónica engineering team is developing several concepts that would guide the process of innovation. One of these concepts is *continuity*,[1] expressed with the term *Commtinuity* to denote continuity within communication technologies. In the project, we posit that continuity exists whenever an activity being conducted through using a device can continue when using a different device. The project explores several interaction paradigms that involve, for instance, augmented reality and gesture interaction by the use of new devices, such as cameras, digital sensors, or multitouch displays. Therefore, work on continuity is needed, both in terms of modeling for the technological implementation of such design solutions (Faconti & Massink, 2000) and identifying the *discontinuities* that arise from the run time use of a system (Graham et al., 2000). In HTI (human–technology interaction), the concept of continuity could be interpreted as the opposite of the concept of plasticity. Borrowing the concept from science of materials, where it indicates the property of materials that expand and contract under natural constraints without breaking and preserving continuous usage, plasticity in HTI has been defined as the capacity of an interactive system to withstand variations of context of use while preserving usability (Calvary, Coutaz, & Thevenin, 2000). In a more extensive way, it could be said that plasticity is when a single artifact can be modified and adapted to a new activity (not only to a new context). For example, a device that is a phone in one context and a text editor in a different situation would have plasticity. By contrast, continuity refers to different devices that could replace each other for the user to continue with the same activity in different situations and contexts. For example, one could start to write an e-mail with a laptop and then continue with a tactile keyboard in a tablet, once electronic mail is accessed and the draft e-mail retrieved.

Figure 1 shows an example of continuity with a communication technology, as intended in the aforementioned project. When talking on the phone while walking down the street, a person is doing two things simultaneously: talking via mobile telephone technology and walking. Upon reaching his/her car, the walking action stops and the driving action starts. However, the talking action via hand-held technology may need to continue while driving. However, in many countries, this action is illegal. Therefore, some cars are now enabled to detect the Bluetooth capability in a mobile phone, and so the talking activity is immediately transferred to the car when the driver enters. Thus the talking activity is no longer mediated by the hand-held phone but through the car. In line with this type of conceptual development, one of our tasks in the project is to develop a methodology that, based on the concept of continuity, can afford the discovery of new technologies.

The methodology we are developing, in which discontinuities are identified and analyzed in terms of context, user, and platform (or system, Roto et al., 2011), consists of two parts. In the first part, researchers and participants elaborate familiar scenarios of use in which actions could be interrupted by a variety of circumstances. In the second part, researchers ask participants to imagine ways of continuing the actions beyond those interruptions. These two method parts are detailed in the next subsections.

Part I: Characterization

In this first part of the method, researchers and participants perform multiple steps. Researchers elaborate scenarios. These scenarios are not complete records, but rather brief descriptions of some activities done in the home. Participants[2] are encouraged to add information that can characterize the scenario better from their perspective.

Figure 1. An example of continuity: Talking via mobile technology does not need to end when driving a car. Photos in clockwise order, from the left: © Stuart Jenner | Dreamstime.com, © Diego Vito Cervo | Dreamstime.com, and © Pauo Resende | Dreamstime.com

1. Researchers read one scenario at a time to the participants.
2. Participants are asked to think about their daily lives and the activities and subactivities involved in that scenario. This phase represents the *task analysis* of the macroactivity proposed by the reference scenario, and it is carried out directly by participants whose proposals are strongly linked to personal, usually direct, experiences. The tasks are identified and agreed on in a group discussion. For example, in relation to the activity “watching TV,” some activities could be channel surfing (i.e., to scan channels until something interesting is found), checking out a program, purchasing a program or game via pay-per-view, and so on.
3. Participants then define a set of limits or filters that could act as agents of change by preventing continuity, leading to an interruption in/disruption to the flow of operations within the specific activity. Like the scenarios themselves, these filters are detailed by the participants in a group discussion in terms of change of people, platform, or context. For example, in the watching TV activity, a change of platform could be that the remote control does not work and another device is needed.

Part II: Exploration

In this second part of the method, each participant completes a graphic table in which the columns are the subactivities and the rows are the filters. The inner cells are left empty. The researchers ask participants to fill in the cells by answering the following question: Given this activity, and these specific subactivities (table columns), how could you solve the problem created by the specific change factor (table rows)? Table 1 provides some examples for the watching TV activity.

The participants complete their tables by imagining that the activity is interrupted by a change of user, platform, or context. They are encouraged to think freely—even fantastically—in proposing solutions that would be a possible expression of continuity, the primary goal of the activity.

When the participants have completed their suggestions, researchers plot the data gathered through this second phase into a new table. The exploration that follows the previous phases forced the participants to reflect on typical situations of interruptions and on possible technological solutions that would enhance continuity. Then, based on these results, researchers can make suggestions to the designers by helping to envision innovative solutions for the continuity of UX. In this sense, the method helps UX designers to disentangle the users’ experiences for which they will design.

One Example on How to Use These Tables

Due to the qualitative nature of the method used, data interpretation may be neither definitive nor entirely objective. Some relativism is inevitable, but this does not represent a limitation. Rather, depending on the practical needs and theoretical interests of the analysts, it is possible to selectively read the data reported in the tables. Participants’ proposals can be reworked into various relations or merged into a design scenario according to the need at hand.

Table 1. Excerpted Example of an Activity-Filters Table Derived from a Continuity Case Study.

Participant-identified subactivities		**Channel surf**	**Discuss contents**	**Mute the volume**	**Download or purchase content**	**Consult teletext**	**Radio**	**Gaming**
Type of change								
User		Customized favorite channels Camera detection system identifies the user Voice detection system identifies the user	Facebook and TV in parallel in TV screen	Mobile phone as remote control Vocal commands	Personalized download of records Facial recognition & personalized menus		Music programming according to mood Personalized contents	
Platform	**Screen**	Synchronization of PC and TV screens			Download to a central server for the household. Access from any screen.	Touch screen		All screens connect to a network. A central server controls access Viewers can access different things
	Remote control			Gesture control				
Context	**Seat**	Screen automatically orients toward user.		Seat “knows” when we fall asleep and turns off the TV	Possibility of control from any place (wi-fi)		Central audio system available throughout house	
	Room	TV program transfers to mobile phone, or iPad.				Small, portable, touch-screen tablet		
	With spouse	Simultaneous programs (2): split screen	The TV recognizes and identifies the people, and adapts content		System for parental advisory, shared by all devices	Access to favorites Split-screen		
	With family							
	With friends							

In this sense, the final tables constitute a reference frame for making suggestions to designers. Proposals made by participants come from thinking about a specific situation and its related discontinuity (introduced by the agents of change). These proposals, then, actually comprise continuity-oriented solutions. As a result, different proposals could be regrouped in the future into a single device, or alternately, a single feature could be replicated in distinct, synchronized devices.

The first implementation of the method within the mIO! project explored four reference scenarios, using four information and communication technologies: mobile phones, TV, music players, and Internet devices (laptops, tablets, etc.). Results were organized into matrices, such as in Table 1, and then analyzed.

For example, concerning the watching TV activity, the two basic aspects about which most of the technological suggestions were made were the personalization of content and person detection and recognition. These two aspects, optimally implemented, would represent a solution in terms of continuity for situations in which more than one user shares the TV unit, but not necessarily simultaneously. In such a situation, for example, one user might wish to initiate TV programming in the presence of the TV unit but then display it on another screen, such as a laptop. Examples of technologies that have emerged as suggestions on what to customize regarding the recognition of person included

- recognition by camera (facial)
- fingerprint sensors
- the mobile phone as remote control device.

Participants justified their last suggestion with several reasons. First, they noted their ease of use and familiarity with interface. Second, they pointed out that a personal phone readily allows for a sort of automatic customization, meaning automatic detection and recognition, with consequent display of personal data, records, and preferences. Finally, the simplest and most immediate needs for interactions (e.g., mute the volume) could be universal for all phones, making them able to communicate with a TV. Therefore, in reconsidering the allocation of functions of a mobile phone, its use as a remote control could be considered one outstanding result upon which to focus in the near future.

Custom profiles saved in the TV's memory (and displayed when person recognition occurs) have been a key idea for continuity in relation to several content tasks, that is, subactivities involving the search, processing, and handling of information on TV. These tasks usually have a considerable duration. Some examples are

- channel surfing
- consulting the teletext
- downloading/buying content
- listening to the radio.

Participants sometimes made suggestions not directly related to a specific task of those identified, but at a more general level. For example, an aspect of design that could sensibly contribute to enhance continuity was the synchronization of screens (e.g., PC and TV), and multiple screen vision. Such possibilities can generate new interactive processes, mediated by the TV being connected to Web 2.0 technologies.

In short, the lesson for designing devices that facilitate the continuity of UX within the activity of watching TV focuses on attending to customization options and taking into consideration the requirements of universality (i.e., mute capabilities on the mobile phone). We can therefore conclude that optimal customization of downloaded files, searches, and user profiles allow design instruments to assure continuous favorable UX with the TV or other communication technologies.

Technological platform memory for personal preferences and files, and their automatic display in presence of the user, greatly support the many situations in which users change

rapidly, without interruptions or need of manual operations. The continuity of experience gained would facilitate as well multiuser situations and interpersonal and social exchanges.
In summary, results can be analyzed and reanalyzed by using practical needs as the basis, but starting from different points of view, for example, a specific task or a situation generated by a task and an agent of change. Connections between contents can be made by means of a walkthrough of the various result matrices (see Table 1) that represent the primary source for design choices in relation to the scenarios explored.

CONCLUSIONS

After years of successful application of psychological knowledge to the evaluation of UX during interaction with technology, researchers in cognitive psychology and ergonomics are facing a new challenge. What industry and society are asking from these disciplines is help in envisioning and innovating new technologies that could enhance their lives. Beyond the traditional needs for fruitful evaluation of performance during interaction and the assessment of subjective feelings resulting from technology use, newer methods of exploration help in the early phases of design. These methods can provide insights into the contexts and behaviors upon which the innovation process should act.

In our work in the context of innovation projects, we are developing a methodology that can address that challenge. The idea behind this methodology is that innovation is a creative process that occurs when the activities of daily life meet limits or barriers. Research into the cognitive processes that underpin the creative process show that, contrary to popular belief, innovation is not facilitated by freedom of thinking, but rather by the limitations confronted when trying to reach action goals.

Because the purpose of this phase of the project was to work through insights regarding the concept of continuity in UX during interaction with communication technologies, the method proposed was a means to work on the definition of current, typical discontinuities during interaction in terms of the user, platform, and context. Once participants agreed on the tasks to be analyzed and the experience of discontinuities, the method required participants to think of continuous design solutions for the specific situation. The starting point for any suggestion made by participants was an interaction context constrained by the discontinuities previously identified by the participants themselves.

Depending on the conceptual differences existing between the identified tasks and discontinuities, participants will think about situations that are actually different. If there is conceptual overlap between tasks and between discontinuities, proposals will result in being more general and will probably apply to a number of identified subactivities and agents of change. Therefore, during the characterization phase, researchers must encourage participants to avoid focusing on tasks or discontinuities that are significantly similar, in order to cover a wider range of distinct situations.

In future implementations of the method, it is important to keep in mind the granularity of the expected data. In addition, researchers may need to moderate group discussion for the definition of tasks and discontinuities under analysis, so as to focus on explicitly distinct aspects of interaction contexts.

ENDNOTES

1. See http://www.youtube.com/watch?v=BkZyjVFw9w4 for a video demonstration of the concept of continuity.
2. The participants were 6 volunteers (3 males): 2 students, 2 administrative personnel, and 2 researchers from the Faculty of Psychology of the University of Granada. Mean age was 29 years (*SD* = 6.03). Participants knew each other somewhat, but this factor was not considered to affect final results (participants made proposals at an individual level). The implementation took place in a meeting room at the Faculty of Psychology, University of Granada, and lasted 5 hours. When scenarios were introduced for characterization, participants had to confirm they already had experiences with technologies involved, and that those activities were part of their way of living.

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