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3 Optimal Experience in Ambient Intelligence

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Abstract. Ambient Intelligence (AmI) will radically change how people interact with technology. In AmI, people will be surrounded by a multitude of interconnected embedded systems. These devices will be able to locate and recognize objects and people, as well as people's intentions. The term "intelligence" in this regard refers to the fact that the digital environment is able to analyze the context, adapt itself to the people and objects that reside in it, learn from their behavior, and eventually recognize as well as express emotion. According to this vision, people will not just use technology: they will live with it. This system requires a clear understanding of user's experience and of the methods to be used for its evaluation. However, the concept of subjective experience is a complex one. In the current chapter, we present a framework to evaluate user's experience in AmI systems that stresses the role of attention in actively selecting information from the digital environment. Since individuals effectively perceive only a small part of the available information, a process of psychological selection unfolds throughout life. This process is prominently guided by the pursuit of a positive, complex and rewarding state of consciousness, called flow, or optimal experience. Starting from these premises, in the second part of the chapter we explain how optimal experience may be assessed during the use of AmI systems. In particular, we describe the Experience Sampling Method, a procedure that has been effectively used in various applied research domains.

Contents

3.1 Introduction

Evolution is a knowledge process
K. Popper

Ambient Intelligence (AmI) refers to digital environments that are sensitive and responsive to the presence of people. The vision of AmI is characterized by two key features: intelligence and embedding. The feature of "intelligence" refers to the fact that the digital environment is able to analyze the context, adapt itself to the people and objects that reside in it, learn from their behavior, and eventually recognize as well as express emotion. The feature of "embedding" means that miniaturized devices will increasingly become part of the invisible background of peoples' activities, and that social interaction and functionality will move to the foreground [1]. Therefore, according to the AmI vision, people will not just *use* technology: they will *live* with it. This requires a clear understanding of user experience. Why is experience so important for the successful development of AmI? The answer is provided by Pine and Gilmore in their authoritative book "the Experience Economy" [2]. They suggested that the economy would increasingly become oriented toward offering activities for entertainment, education, escapism, and aesthetic pleasure, that provide engaging and rewarding experiences. According to Pine and Gilmore:

"*Experiences have always been at the heart of entertainment, from plays and concerts to movies and TV shows. Over the past few decades, however, the number of entertainment options has exploded. Today, the universe has expanded to encompass a vast array of new kinds of experiences, as new technologies encourage whole new genres of experience, such as interactive games, World Wide Web sites, motion-based simulators, 3D movies and virtual reality. The end result? Just as the service economy commoditised goods, so the emerging experience economy is rapidly commoditising services*" [3]

Furthermore, the authors speculate that once experience economy proceeds, the "transformation economy" will take over. That is, in this future age of business, companies will help customers to learn, take action and change themselves in order to achieve aspirations and goals:

"*The individual buyer of the transformation essentially says, 'Change me'. The company's economic offering isn't the materials it uses, nor the physical things it makes. It's not the processes it executes, nor the encounters it orchestrates. When a company guides transformations, the offering is the individual. Once the experience economy has run its course, the transformation economy will take over. Then, the basis of success will be in understanding the aspirations of individual consumers and businesses, and guiding them to fully realising those aspirations*" [3]

According to this vision, the value of the experience from the user perspective determines the worth of the offering and the business work. However, the conceptualization of subjective experience in AmI systems presents a challenge for human-computer interaction (HCI) researchers, because it requires a theoretical regrounding and innovative methods of evaluation [4]. Traditional HCI approaches aim at achieving an objective, generalized understanding of users and systems in order to develop design practices that provide empirically reproducible results. For example, in a typical HCI experiment, a user has to complete a set of defined tasks using a specific device; usability is seen as the interaction between the device and the user. Therefore, the evaluation of such

HCI activity is mainly guided by criteria of effectiveness and performance optimization, while the cognitive, affective, and motivational components of user's subjective experience are largely overlooked [5].

3.2 Subjective experience

What is subjective experience, and how can it be evaluated? These issues have been debated by many scholars from the very beginning of psychological investigation. As early as in 1902 William James [6] noted that,

"*The world of our experience consists at all times of two parts, an objective and a subjective part… The objective part is the sum total of whatsoever at any given time we may be thinking of, the subjective part is the inner 'state' in which the thinking comes to pass*" (p. 402).

Moreover, experience, in James's view, is the result of focusing attention on the content and sequence of conscious events [7]:

"*… Millions of items in the outward order are present to my senses which never properly enter into my experience. Why? Because they have no interest for me. My experience is what I agree to attend to. Only those items which I notice shape my mind – without selective interest, experience is utter chaos*" (p. 499).

More recently, other authors have claimed the primacy of attention as a crucial process that regulates the states of consciousness. According to Csikszentmihalyi [8],

"*ideas, feelings, wishes or sensations can appear in consciousness and therefore become 'real' to the person only when attention is turned to them*" (p. 337).

Starting from these premises, we present a framework to evaluate a user's experience in AmI systems that stresses the role of attention in actively selecting information from the digital environment. Since individuals effectively perceive only a small part of the available information, a process of psychological selection unfolds throughout life. This process is prominently guided by the pursuit of a positive, complex and rewarding state of consciousness, called *flow*, or *optimal experience*. In the second part of the chapter we explain how to assess user's optimal experience in AmI systems. In particular, we describe the *Experience Sampling Method*, a procedure that has been effectively used in various applied research domains.

3.3 Attention and optimal experience

A growing number of studies analyze human beings as open living systems, exchanging information with the environment throughout their lives [9]. Day by day, individuals select and differentially replicate a subset of biological and cultural information, in terms of activities, interests, and values. This selective process, called *psychological selection of bio-cultural information*, is based on the differential investment of attention and psychic resources [10]. Being a limited resource, attention forces the individual to focus on a restricted number of environmental or internal stimuli per time unit. Therefore, each

individual effectively perceives only a small part of the available information, subsequently processing and organizing it for future use and transmission. According to Csikszentmihalyi and Massimini, psychological selection is driven by the quality of experience subjectively perceived in the interaction with the environment [10]. In particular, among the different state of consciousness arising during daily life, individuals preferentially engage in opportunities for action associated with a positive, complex**,** and rewarding state of consciousness, called flow, or optimal experience [12]. In this state, an activity is perceived as enjoyable and intrinsically worth doing for its own sake [12]. Other features of this experience are: the perception of high challenges in the task at hand, personal skills adequately high to face those challenges, high concentration, involvement, enjoyment, absorption in the task, unselfconsciousness, control, clear feedback on the course of the activity [12, 13]. Athletes call flow experience being in the "zone" - an optimal psychological condition for peak performance. Brazilian soccer player Pele has described this experience as:

"*a strange calmness I hadn't experienced in any of the other games. It was a type of euphoria; I felt I could run all day without tiring, that I could dribble through any of their teams or all of them, that I could almost pass through them physically. I felt I could not be hurt*" [14]

A large number of research studies have shown the occurrence of flow in the life of people belonging to most varied age, groups, and occupational categories [13]. People associate flow with various daily domains, such as work, family, leisure activities. Flow activities require focused attention and allow to progressively raise the level of challenge as performance improves. Moreover, they offer clear feedback and goals. The association of specific activities with optimal experience leads to the preferential cultivation of individual skills [15]. As the latter improve, the person will subsequently search for increasingly complex opportunities for action:

"*When both challenges and skills are high, the person is not only enjoying the moment, but is also stretching his or her capabilities with the likelihood of learning new skills and increasing self-esteem and personal complexity*" [16]

By virtue of this dynamic process of skills cultivation and challenge increase, optimal experience shapes the development of a life theme, namely the set of goals and interests a person preferentially pursues and cultivates in his/her life [15].

3.4 Optimal experience in AmI

AmI interface designers and engineers are becoming aware of the fact that user attention is a limited resource that must be conserved [17]. This is also the core thesis of "Attention Economy", another influential business model recently developed by Davenport and Beck [18]. The model is based on a simple reasoning: Economy is by definition about the allocation of scarce resources; and thanks to the exponential growth of human knowledge, information is not only abundant, but overflowing**,** especially on the Net. Attention, thus, is the scarce resource in today's economy. According to Davenport and Beck,

"*Attention is at a premium partly because information has becoming less expensive for many, many years. By one analysis, in a single edition of the Sunday New York Time has*

more facts than anyone in the world could have commanded in, say, the 15th century. In 1472, for example, the best university library in the world, at Queen's College in Cambridge, had 199 books. Today more than 300,000 new books spew out of worldwide presses every year. The web includes well over two billion pages, a large chunk of which can't be found even with the best search engine" [19]

Following this view, AmI researchers are beginning to design computing devices that adapt the volume and timing of their communications to the cognitive needs of user. Such systems with a deep understanding of user attention have been referred to as *Attentive User Interfaces* [20]. In AmI spaces these systems will proactively undertake speculative or anticipatory actions to hide the overall system complexity, by delivering to the users only information which is rich with meanings and contexts and provide stable functionality whenever requested [21].

However, as noted earlier, preserving user's attention is not the most important requirement to foster optimal user's experience. Actually, flow is determined by focused attention and deep involvement in the activity. Data gathered among over 4,500 individuals highlighted that repetitive, easy, and low-information activities are never associated with optimal experience, while complex tasks requiring focused attention are widely reported [22]. The condition of boredom disrupts concentration: attention must then shift to more complex challenges in order to replicate optimal experience [20, 21]. Moreover, optimal experience is a dynamic process that depends on the perceived balanced ratio between high environmental challenges and high individual's skills. These observations suggest that the interaction with AmI systems must be challenging enough to require an active engagement of the user and to promote satisfaction in the use of personal skills. As noted by Riva,

"*an effective AmI system is able to induce a feeling of presence in the activity it is supporting: The less is the level of presence,(…) the less is the quality of experience of the AmI system*" (p. 28, in this book).

For example, in the context of Web navigation, presence is shown to be an important predictor of online consumers' flow experience, contributing to increased participation, exploration and positive attitude in navigating a website and resulting in enhanced learning [23]. But how can these subjective aspects be assessed in a real-world AmI application?

3.5 The Experience Sampling Method

AmI systems can be viewed as environments in which people will increasingly live their lives. Ubiquitous AmI technologies and systems like personal digital assistants, wearable sensors, mobile phones, etc. challenge traditional usability evaluation methods, because use context can be difficult to recreate in a laboratory setting. This view suggests that the evaluation of user's experience with AmI systems should take place in realistic contexts, such the workplace, the home, etc. Another issue has to do with the *content* of the evaluation. Performance-based approaches are not suitable for AmI systems, because it is difficult to specify tasks that capture the complexity of real world activities. Moreover, experience is idiosyncratic, in that it is related to the specific bio-cultural configuration of the each individual, and it can undergo changes throughout individual life and daily situations [13]. The Experience Sampling Method (ESM) [24, 25] offers a new perspective in the analysis of these issues. ESM is based on the online repeated assessment of individual behavior and experience in the daily context. Participants describe themselves

and their environment while interacting with it. They carry with them for one week an electronic beeper and a booklet of self-report forms. Whenever they receive an acoustic signal, they are expected to fill out a form. The form contains open-ended questions about situational variables such as place, activities carried out, social context, and subjective variables such as the content of thought, perceived goals, and physical conditions. The form also contains 0-12 Likert-type scales investigating the quality of experience in its various components: affect, motivation, activation, and cognitive efficiency. Two additional scales investigate participants' perceived levels of challenges and skills in the activity carried out when beeped. Participants receive five to eight signals a day during waking hours. Thanks to repeated sampling, after a standard ESM session 35 sheets are collected from each participant on average, thus providing a rich databank on the quality of daily experience of each individual. In order to assess the influence of perceived challenges and skills on the global quality of experience, the Experience Fluctuation Model was developed for the analysis of ESM data [26, 27]. The model is built on the Cartesian plane, with challenges on the Y-axis and skills on the X-axis (Figure 1), and it comprises eight 45° sectors, called channels. Each channel represents a defined range of ratios between challenges and skills. Given the repeated assessment, values of challenges and skills are standardized (M = 0, SD = 1). Thus, the centre of the model - that is the origin of the axes - is zero and corresponds to the aggregated subjective mean. Specific experiential states, determined through the standardized values of all the ESM variables, have been associated with the four main channels: In Channel 2, characterized by an above-average balance between challenges and skills, optimal experience is reported. In channel 4, skills are higher and challenges lower than subjective mean: The associated experience is relaxation. Channel 6, characterized by below-average values of challenges and skills, is associated with apathy. In channel 8, skills are lower and challenges higher than subjective mean: The associated experience has been labelled anxiety. The remaining channels represent intermediate experiential states, and are referred to as transition channels [22].

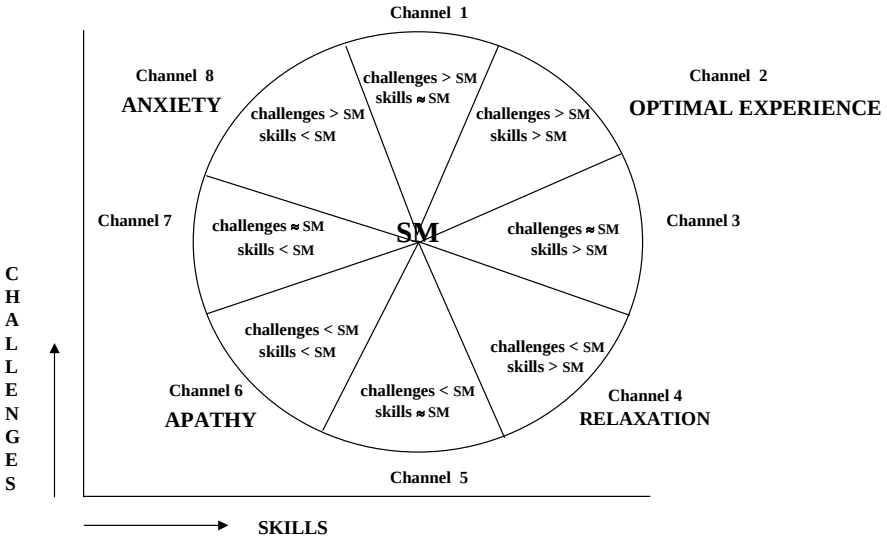

Figure 3.1 The Experience Fluctuation Model (SM = Subjective mean)

Several ESM studies have been carried out to evaluate the quality of experience associated with the use of information and communication technologies, primarily television [28-31] and, more recently, the Internet [32] and Virtual Reality [33, 34]. In

studies assessing quality of experience and AmI systems, Intille and colleagues at MIT have recently developed a Personal Digital Assistant-based version of the ESM which can be used for user-interface development and assessment of ubiquitous computing applications [35]. This approach, called *Context-Aware Experience Sampling*, includes the possibility to assess user's experience not only through the standard time-based protocol, but also according to the participant's location, by means of information provided by a GPS plug-in. Thus, researchers can design experiments collecting self-reports only when the participant is near a location of interest. Moreover, users can answers via audio recording or by taking a picture with a camera [35].

3.6 Conclusion

A constant challenge faced by designers and human factors specialists is how to apply theory when designing and evaluating interactive technologies. A theoretical model can provide rigor, coherence, and instruments for analyzing and evaluating products [36]. What does our framework provide to AmI researchers? In our opinion, it offers a clearer understanding of two features - attention and optimal experience - which are considered important to the development of successful products. Whenever companies underestimate the importance of these constructs, they will find it increasingly difficult to win new customers and to retain old ones. In the long run, this overlooking might negatively affect their businesses. We suggest that AmI systems should be able to support optimal experience, by recruiting the attention of the user and promoting his/her satisfaction in the use of personal skills. To achieve this goal, designers, developers, and evaluators must collect qualitative and quantitative data that reflect the idiosyncratic features of each person and his/her subjective experience of reality.

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