Experience Research: a Methodology for Developing Human-centered Interfaces

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1 Introduction

At the turn of the century, a distinguished group of researchers identified the potential devastating effects of rapid technological developments, as described by the generalized Moore's law, for the balanced relationship between humans and technology (Aarts et al., 2001). Whilst not ignoring the threads and risks of so called technology push, the Ambient Intelligence (AmI) vision was introduced to emphasize the positive contribution these technologies could bring to our daily lives. Within the AmI vision human needs are positioned centrally and technology is seen as a means to enrich our life. In course terms Ambient Intelligence refers to *the embedding of technologies into electronic environments that are sensitive and responsive to the presence of people*.

In Ambient Intelligence, the term **ambience** refers to technology being embedded on a large scale in such a way that it becomes unobtrusively integrated into everyday life and environments. Hence, the ambient characteristic of AmI has both a physical and social meaning. The challenge for ambient technologies is to become invisible while still providing meaningful functionality to these end users (Weiser, 1991). Such challenge is not trivial to address and requires radical different approaches to human – system interaction (De Ruyter et al., 2005).

The term **intelligence** reflects the situation in which the digital surroundings exhibit specific forms of cognition, i.e. the environments should be able to recognize the people that inhabit them, personalize according to individual preferences, adapt themselves to the users, learn from their behavior and possibly act upon their behalf.

In AmI we distinguish between several levels of **system intelligence**: *context aware*, *personalized*, *adaptive* and *anticipatory* system intelligence:

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- *Context aware*. The environment can deter-mine the context in which certain activities take place, where context relates meaningful information about persons and the environment, such as positioning and identification.
- *Personalized*. The environment can be tailored to the individual needs of users. It can recognize users and adjust its appearance to maximally support them. Automatic user profiling can capture individual user profiles through which personalized settings and in-formation filtering can be accommodated.
- *Adaptive*. The environment can change in response to the users' needs. It can learn from recurring situations and changing needs, and adjust accordingly.
- *Anticipatory*. The environment can act upon the user's behalf without conscious mediation. It can extrapolate behavioral characteristics and generate pro-active responses.

The user benefits of the AmI paradigm are aimed at improving the quality of people's lives by creating the desired atmosphere and functionality via system intelligence and interconnected systems and services. Several futuristic scenarios have illustrated how technology can become supportive in people's daily lives (ISTAG, 2001). By mid 2006, a consortium of five European partners grouped under the name SWAMI , focused further on some potential threats and vulnerabilities of AmI scenarios. Although these scenarios are built around the same technological developments as those AmI was responding to, the scenarios are particular in their focus on addressing human needs. With these "dark side" scenarios, the SWAMI consortium emphasized that positioning human needs in the centre of technology development is not enough to ensure that the balance between humans and technology will be safeguarded. Although scenarios have been written and books have been published, the potential solution for this problem has not been provided other than suggestions for more technology (e.g. security related algorithms) development.

As technology and society are changing, the vision of AmI has also changed over the years. New requirements for the enabling technologies that relate to ethics, new methodologies for empirical research to better understand the context in which these applications will be positioned, a shift from system intelligence to social intelligence, are just some examples of challenges that call for a paradigm shift in Ambient Intelligence research. Next we discuss some important trends that influence not only the definition of Ambient Intelligence but also its research approach.

1.1 From Entertaining to Caring

Whereas Ambient Intelligence research has traditionally been focusing on user experiences in more entertainment oriented scenarios, there is a recent move towards the deployment of Ambient Intelligence technologies for *Wellbeing* and *Care* related application scenarios. Wellbeing and Care applications cut across the domains of Lifestyle (e.g. persuasive fitness applications) and Healthcare (e.g. remote patient monitoring systems for chronic care patients). It should be clear that the development of applications related to our wellbeing and care will demand for some important shifts in the Ambient Intelligence research paradigm. For a more detailed discussion on the possible ambient assisted living applications as well as future challenges for AmI research are discussed in De Ruyter and Pelgrim (2007).

1.2 From System Intelligence to Social Intelligence

As AmI technologies are becoming more part of our daily life and are taking the role of coaching and caring solutions, there is are increased expectations of AmI technologies to adapt and fit into social contexts. With this we observe that the levels of *system intelligence* in the AmI paradigm require complementing with *social intelligence*. The earliest definition of Social Intelligence was coined by Thorndike (1920) and described as: "*the ability to understand and manage other people and to engage in adaptive social interactions*". To adhere to and behave in a social intelligent manner is clearly a new challenge for AmI environments for which new destinations have been identified in the area of wellbeing and care.

When we consider human-human social interactions, we see that there are several characteristics that make certain individuals stand out and more liked by others, or which convey an air of trustworthiness, competence and dependability (Ford & Tisak, 1983). This list of social intelligent characteristics is large and includes attributes like "*being nice and pleasant to interact with*" and "*being sensitive to other people's needs and desires*". In its broadest definitions social intelligence is "*...a person's ability to get along with people in general, social technique or ease in society, knowledge of social matters, susceptibility to stimuli from other members of a group, as well as insight into the temporary moods of underlying personality traits of strangers*" (Vernon, 1933). So the socially intelligent person has a better than average ability to judge other people's feelings, thoughts, attitudes and opinions, intentions, or the psychological traits that may determine their behavior. This judgment creates expectations on the observer's part about the likely behavior of the observed person. This in turn leads to adjustments of one's own behavior accordingly and appropriately. However, that appropriateness can only be judged when the social context is taken into account. In this sense, social intelligence is not merely something that goes on between two people in isolation, but contextual factors also come into play. The complexity and challenges for designing social intelligent systems is further discussed in Green and De Ruyter (2008).

Social intelligence in AmI environments can take the form of a socialized, empathic or conscious system (see Figure 1).

Socialized

AmI environments that are socialized are compliant to social conventions. For example, in a sensing environment some form of system intelligence can be context aware and thus know that a person is in a private situation. A personalized system

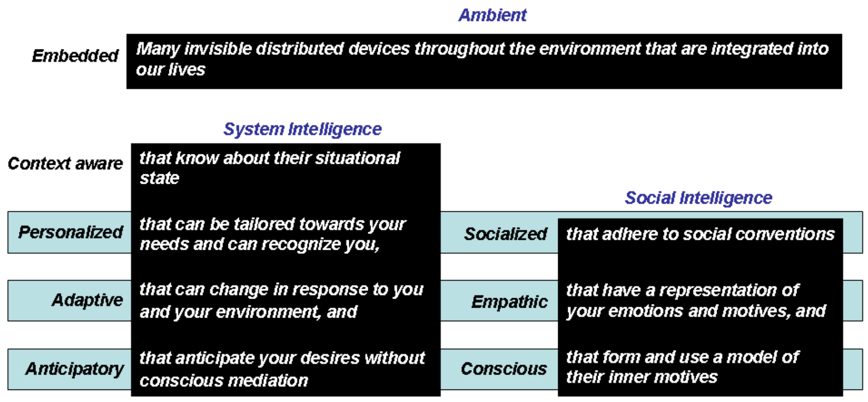

Fig. 1 The extended AmI model

would know that it is the user's preference not to be disturbed in such situation. An intelligent system that is socialized would use common sense knowledge to not allow disturbing the person in such a context. From this simple example it should also be clear that although we make a distinction between system and social intelligence at conceptual level, that at implementation level both forms of intelligence need to come together.

Empathic

An empathic system is able to take into account the inner state of emotions and motives a person has and adapt to this state. Empathy is described as the intellectual or imaginative apprehension of another's condition or state of mind without actually experiencing that person's feelings (Hogan, 1969). For example, a form of system intelligence could infer that a person is getting frustrated while the social intelligent system with empathic capabilities would trigger the AmI environment to demonstrate understanding and helpful behavior towards the person.

Conscious

Ultimately, a conscious system would not only be aware of the inner state of the person but also about its own inner state. With such level of social intelligence, the conscious system could anticipate the effect a person is trying to get onto the system. With this level of social intelligence it will be possible to develop rich and human like interactions in AmI environments.

Discussion

Ambient Intelligence is a vision on the development of technology applications with an emphasis on creating end user experiences that highlight user benefits of new technology applications. Throughout the years of its existence, the vision had undergone several changes and the basic model of Ambient Intelligence has been extended with the notion of social intelligence.

It is clear that the Ambient Intelligence paradigm has a strong impact on the methodologies and instruments that are used for application driven research. This impact is further discussed in the next section.

2 Experience Research

The design of Ambient intelligent environments differs markedly from the design of classical single device systems. AmI environments introduce new options for services and applications, by focusing on the desired functionality, rather than on the devices traditionally needed for each individual function. The fact that the technology will be integrated in these environments introduces the need for novel interaction concepts that allow the user to communicate with their electronic environment in a natural way. When aiming at user experiences, requirements engineering for AmI environments has to take a step beyond the development of scenarios and the translation of use cases into system requirements. For this we propose an iterative empirical research cycle that consists of three phases: studies in *context*, *laboratory* and *field* (see Figure 2).

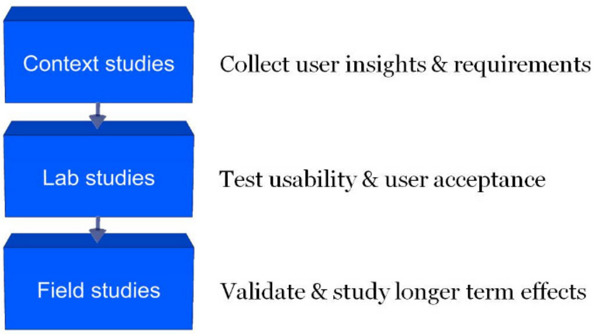

Fig. 2 The Experience Research cycle

Although the presentation of the three phases might assume a sequential approach, it should be noted that its implementation is iterative. From traditional User Centered Design cycles it is known that each phase in the research cycle will provide new insights but might also require the researcher to go back into one of the previous phases (De Ruyter, 2003).

The iterative Experience Research cycle consists thus of three phases: studies in (i) **context**, in (ii) the **laboratory** and in (iii) the **field**. Whereas the context studies focus on collecting initial user requirements without introducing any new technology applications, the laboratory studies and field studies focus on the evaluation of new propositions in a controlled and real life setting respectively. Whilst some studies reported very limited added value of conducting both laboratory and field studies (Kaikkonen et al., 2005), others have highlighted the added value of conducting field studies (McDonald et al., 2006). Although Tory and Staub-French (2008) classify empirical studies in laboratory versus field settings as quantitative versus qualitative studies, we believe that such classification is an over simplification. Both types of studies will highlight different aspects related to the user – system interaction and both types of studies allow for the collection of qualitative as well as quantitative data. The different phases are now further discussed.

2.1 Context Studies

In context studies the focus is on today's reality without introducing any new technology applications. By using ethnographic techniques[1] (such as observations, in-situ interviews and diary studies), users are studied in their natural environment (Beyer & Holzblatt, 1998). Context studies can be seen as a way to understand the context in which future technology applications will be positioned. Although what is suggested as an approach is not participatory design, in which the end-user is not only the object of study but also the co-designer of new technology applications (Moss & Hunt, 1927), such participatory design sessions can be conducted as a follow-up for applying the results of the context study in the design of new technology applications. As a technique for collecting contextual data, the context mapping approach (Sleeswijk Visser et al., 2005) has demonstrated to be very successful in gaining insight into the context of use for future technology applications. Also within the user – system interaction research context Rose, Shneiderman and Plaisant (1995) has demonstrated the added value of applying ethnographic techniques in context studies provide both qualitative and quantitative insights for improving interactive systems.

Once these studies have been completed, there is usually an overload of rich contextual data and the challenge is to abstract meaningful but not trivial insights without losing valuable information. It goes without saying that this is a difficult and cumbersome trajectory. All too often ethnographers complain that the step from the rich contextual data towards abstracted user insights is problematic due to in-

[1] While ethnographic techniques are not restricted to context studies, it is important to note that in our positioning of context studies the aim is to study end users in their natural environments without interfering by for example introducing new technology applications. The latter studies will be part of field studies.

formation loss. Nevertheless, one needs to make such transition as the contextual data is too extensive to work with. One approach that has proven to be useful is to compile some very high level insights from the contextual data and then to return to the rich contextual data to further understands these insights. This approach is very consistent with the approach to working with rich ethnographic data as suggested by Iqbal et al. (2005).

For example (see Figure 3), when studying the role of social networks in real life settings, one can conclude that people need to receive appreciation from their social network. At first one might argue that such high level statement is rather obvious and that such insight was known even before conducting the contextual study. Or to quote Beyer & Holzblatt: "*The complexity of work is overwhelming, so people oversimplify*". However, this is not where the analysis of the rich contextual stops but rather where it begins: in the next step one will go back to the rich contextual data and explore the exact instances that have led to the generation of the high level statement. In this example, one would go back into the rich data to understand how people experience and express appreciation through their social network. With this second step it will be possible to go beyond the obvious of the high level insights formulated during the first exploration of the rich contextual data.

Using this two step approach of abstracting and detailing it becomes possible to formulate valuable insights from the rich contextual data.

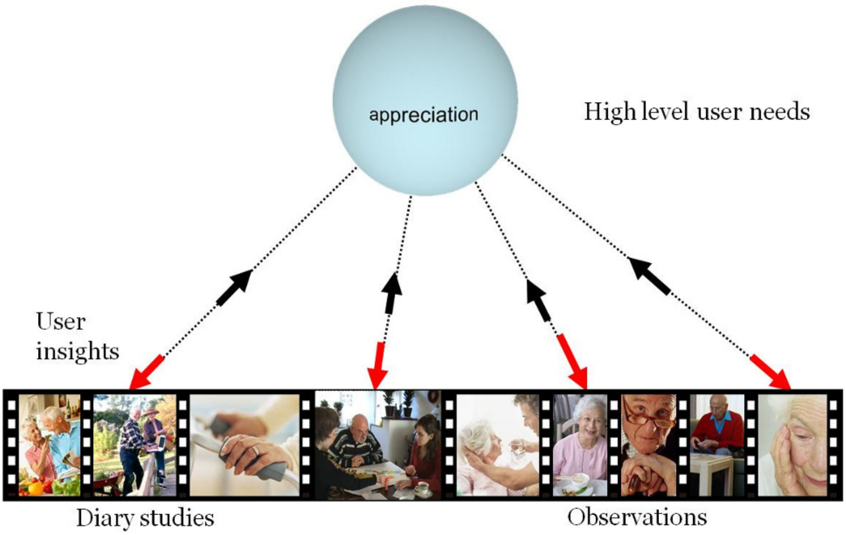

Fig. 3 From rich context mapping data towards user insights

2.2 Lab Studies

System functionalities that generate true user experiences can be studied in a reliable way by exposing users to feasible prototypes that provide proofs of concept. These are called experience prototypes, and they can be developed by means of a user-centered design approach that applies both feasibility and usability studies in order to develop a mature interaction concept. For this laboratories are needed that contain infrastructures supporting fast prototyping of novel interaction concepts in environments that simulate realistic contexts of use. Moreover, these experience prototyping centers should also be equipped with an observation infrastructure that can capture and analyze the behavior of people who interact with the experience prototypes. Philips' ExperienceLab is an example of such an experience and application research facility. It combines the opportunity for both feasibility and usability research into user-centric innovation, leading to a better understanding of (latent) user needs and the technologies that really matter from a user perspective. The use of the ExperienceLab is discussed in more detail further in this chapter.

Since the opening of ExperienceLab in 2001, there are several lessons learned with respect to the use of the ExperienceLab: (De Ruyter et al., 2005)

1. *Real-time observation* is less important, off-line scoring is preferred. When equipping the ExperienceLab with observation tools, it was assumed that researchers would code observations in real-time. However, over the years we have learned that off-line scoring after the experiments is preferred. This has a consequence for the way data is collected and made available for scoring since now researchers need portable solutions and export the observational data from the ExperienceLab system.
2. Developing good *coding schemes* is as much effort as developing a questionnaire. Coding schemes provide an extensive classification of potential observable behavior. This coding scheme is used to code the recorded behavior. Developing good coding schemes takes time and reuse of these coding schemes (like for questionnaires) is desired.
3. New *methods and instruments* to measure the subjective user experience in an objective way are needed. Although the user experience is by nature subjective, there is a need to capture and analyze user experiences by means of objective methods.
4. ExperienceLab is a *catalyst* for improving technology transfer into the business. Traditionally, research results are communicated through scientific publications and presentations. Over the years ExperienceLab has proven to be a very effective communication tool within a large corporate environment. Although the original goal of the ExperienceLab was to support usability and feasibility research, there is a need to reserve capacity for demonstration and dissemination events.
5. Having a *support team* is essential when operating an ExperienceLab. Since the opening of the ExperienceLab there has been a permanent software engineering team available for technology integration and maintenance of the infrastructure.

Similarly, there is a need for a team of behavioral scientists to guide the empirical research in ExperienceLab.

2.3 Field Studies

Although studies in controlled laboratory settings can provide lots of valuable insights, the research findings are limited in terms of their ecological validity (Dix et al., 2004). With field studies the emphasis is on introducing new technology applications into realistic settings and studying the usage or behavioral change that might follow. In field studies end-users will be less enthusiastic about new technology applications and they will demand that these applications fit into their daily life by providing functionality that is meaningful to people. Additional, in field studies end-users will have the option to use these technology applications over longer periods of time.

There are no clear guidelines on the optimal duration of a field study. Some researchers (Neustaedter et al., 2007) have used pilot studies to estimate the needed duration of their field study in order to observe for example behavioral change. Others (Breazeal and Scassellati, 2000) have used the term field studies to indicate both contextual studies (in which no new technology applications are introduced) and field studies in which technology applications have been introduced.

Although, in contrast to laboratory studies, there seems to be very little methodological guidance in conducting field studies, one can postulate the following guidelines:

1. Field studies are often limited to the deployment of focused prototypes (rather than complete environments). This is both from a practical (i.e. installation & stability issues) and control perspective desirable.
2. Field studies (although very much depending on the type of behavior that is being studied) will often spread from 4 to 8 weeks.
3. Field studies will often be preceded by a period in which the users are not confronted with new technology applications. These periods serve as baseline for understanding the effect of the introduced technology applications. Often these periods will end with some data collection in the form of questionnaires. These questionnaires will be repeated at the end of the actual field test.
4. Field studies rely for data collection mostly on logging data and in-situ interviews or questionnaires sampled over time. Although influenced by the complexity of the introduced technology application, it is found to be very useful to revisit and interview the user after an initial period of 3 days. After such initial period the end-users have experienced most of the application's functionality and have found the major obstacles in using the application. Interviews at the end of the field study will often not reveal these issues since end-users will have forgotten about them.

3 ExperienceLab Infrastructure

Given the high importance of controlled experiments in a realistic environment, the ExperienceLab is presented in more detail. By developing and integrating advanced technologies in the area of Ambient Intelligence, ExperienceLab, currently consisting of a Home, Shop and Apartment environment, is an innovation center for the development of novel consumer products and services.

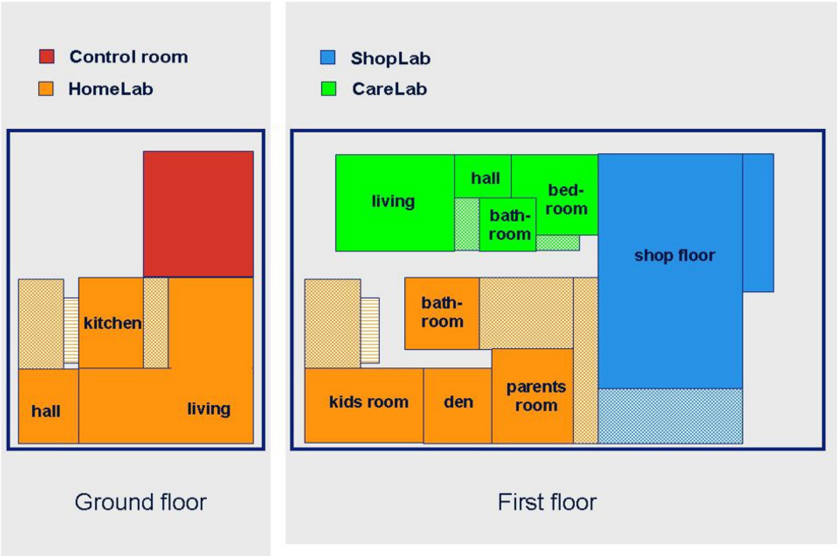

Fig. 4 The ExperienceLab floorplan

3.1 HomeLab: the Home Environment

The HomeLab is built as a two-stock house with a living, a kitchen, two bedrooms, a bathroom and a study. At a first glance, the home does not show anything special, but a closer look reveals the black domes at the ceilings that are hiding cameras and microphones. Equipped with 34 cameras throughout the home, HomeLab provides behavioral researchers a perfect instrument for studying human behavior inside HomeLab. Adjacent to the Home there is an observation room.

When HomeLab was opened in 2001, one way mirrors were placed between the living and observation room. The idea was to have a direct view into the living. But time learned that observers preferred the camera images. The different viewing angels and possibility to zoom into details were reasons to abandon the mirrors. The observation room is equipped with four observation stations. Each station has a large high resolution flat screen showing a collection of six different images from the cameras in the house. The observer is free to choose which cameras he wants to use and what the pan, tilt and zoom position of every individual camera has to be. And he can route two of the roughly 30 available microphones to the left and right channel of his headphones. Each observer has an application running to feed the behavioral data to the storage system, synchronized to the video data. In the early days of HomeLab this setup was used in the real time situation. Four observers had a hard time to follow the progress of the experiment. Nowadays it is more common to first have the video data stored on the capture stations and do the behavioral data collection afterwards. Also events and sensor data are time-stamped and appended to the video data. This way of working is much more efficient and a single observer can collect all the relevant data.


Fig. 5 HomeLab: user centered design environment for advanced studies in multimedia concepts for the home

Broadband Internet facilities enable various ways to connect parts of the HomeLab infrastructure to the Philips High Tech Campus network or even to the outside world. A wireless Local-Area Network (LAN) offers the possibility to connect people in HomeLab without running cables. However, if cables are required, double floors and double ceilings provide nice hiding places. Corridors, adjacent to the rooms in HomeLab, accommodate the equipment that researchers and developers need to realize and control their systems and to process and render audio and video signals for the large flat screens in HomeLab. Light control systems (LON and amBX) can be accessed by the researchers and offer their prototypes the possibility to affect the light settings in the rooms.

3.2 ShopLab: the Retail Environment

The ShopLab research program builds on the insight, that shopping itself has become an important leisure activity for many people, and that flexible atmospheres are needed to enhance shopping experiences. On the other hand many retail chains want to maintain a clear house style for branding reasons.

This introduces the challenge of combining these two major aspects. One approach to this, studied in ShopLab, is that one atmosphere design will be sent to all stores and slightly adapted there to meet local conditions. With the introduction of solid state (LED) lighting, a wide range of new options to create such atmospheres using color and dynamic effects is becoming available. However, tuning these atmospheres requires controlling several hundred lamp settings, introducing a complex overall control challenge. Another approach studied to enhance the shopping experience is the introduction of interactivity, in the form of interactive shop windows, interactive signage and reactive spots. Adaptation of these shop atmospheres also requires input from smart environments that detect people's presence and product interests while they are in or near a shop.

Fig. 6 ShopLab: augmented environment with advanced vision and lighting concepts for retail studies

The ShopLab is used extensively to perform user studies, both with retailers and with end-users (shoppers). By involving these users in all phases of the design process, including the evaluation of the experience prototypes, important insights in the actual experiences of users are obtained early on in the development process.

3.3 CareLab: the Assisted Living Environment

This CareLab resembles a one-bedroom apartment for seniors and is equipped with a rich sensor network to study the contextual settings in which people will use the health and wellness applications.

The sensor information is processed and combined to extract higher-order behavioral patterns that can be related to activities and states, such as the presence of people, the state of the home infrastructure, etc. With the CareLab it is possible to explore at an early stage the user's acceptance for these solutions and to assess the interactive and functional qualities of these solutions before deploying these into field settings. Results will be used to improve applications of innovative technologies, to eliminate imperfections and to explore new applications.

Fig. 7 CareLab: realistic aware environment with advanced sensing and reasoning capabilities to study consumer health and wellness propositions in a home context

4 The ExperienceLab as an Assessment Instrument

As described, the ExperienceLab consists of realistic environments offering an advanced instrument for studying Ambient Intelligence solutions. Such laboratory environment should facilitate data collection without influencing the data itself. However, throughout the use of the ExperienceLab it has also been observed that test participants are impressed by the environments and expect to encounter high tech systems during their stay in the ExperienceLab. Murray & Barnes (1998) describe this so-called 'wow'-effect as "initial enthusiasm". Such 'wow'-effect could bring on a highly satisfied feeling towards Philips HomeLab, which could positively influence participants' responses collected during an experimental session. This type of response bias is also often described as a *halo effect*.

Response bias can be describes as *any systematic tendency of a respondent to manifest particular response behavior for an extraneous reason which is not part of the experimental manipulation*. In the past, various researchers (Donovan & Rossiter, 1982; Mehrabian & Russell, 1974; Kotler, 1974) demonstrated the influence of specific facets of environment on consumer behavior. To measure the impact of the ExperienceLab as instrument, a controlled experiment was conducted. This experiment involved the replication of a traditional usability test (of an experimental system for video editing) in both the ExperienceLab and a traditional laboratory environment. The experiment and its findings are now briefly discussed[2].

[2] A more detailed report of this study is found in De Ruyter et al, 2009.

4.1 Method

A total of 40 participants, who were unfamiliar with the ExperienceLab, were recruited for this study. The experiment was designed as a within subject design consisting of two experimental sessions separated by a time interval of one week. It was suggested to the participants that there would be an improvement of the system's usability between the sessions (see Figure 8) based on the general results of session 1. In reality, only minor changes (e.g. user interface colors) were made to the system in order to be able to compare the findings from both sessions. In both sessions we conducted a typical usability test of the same interactive system.

	Session 1		Session 2
Group 1	ExperienceLab	→	ExperienceLab
Group 2	ExperienceLab	→	Laboratory
Group 3	Laboratory	→	ExperienceLab
Group 4	Laboratory	→	Laboratory

Fig. 8 The methodological design of the ExperienceLab experiment

4.2 Procedure

Setup as a typical usability test, the ease of use of a video editing system was assessed in both the ExperienceLab and in a traditional laboratory. The laboratory environment is less attractive and realistic compared to the ExperienceLab environment. The most importance difference between both environments is the embedding and presentation of the experimental system as part of a home like environment.

A set of questionnaires was preceded by a short introductory text that differed depending on the experimental setting the participant was about to enter. In the introduction the participants were told they were participating in a research on the usability on a recently developed video editing system. Consequently, the participants were given some information on the system to make it possible certain expectations could be evoked. Next, the participants were told the usability test had been divided in two sessions with one week in between in which the video editing system would be adjusted on the basis of first session's results. During the second session the participants had to evaluate the system again.

4.3 Materials

The experimental system deployed in the usability test is a TV-based video editing system that is able to automatically convert a home video into an edited version, which is basically a ‘summary’ of the raw footage. By means of a remote control, the user can edit and modify this automatically created summary by, during the viewing of the summary, pausing the desired shot and subsequently selecting one of the editing functions (e.g. adding music, adding effects). During the usability test, participants are requested to complete a given set of tasks with this system. Several usability and contextual measures are collected during the experiment. The instruments used for this data collection are briefly discussed.

Brief Mood Introspection Scale (BMIS)

In order to measure participants’ mood, the Brief Mood Introspection Scale (BMIS) by Mayer & Gaschke (1988) was applied. The BMIS consists of 16 adjectives which are based on eight mood states: (1) happy, (2) loving, (3) calm, (4) energetic, (5) fearful/anxious, (6) angry, (7) tired and (8) sad.

Software Usability Measurement Inventory (SUMI)

The software’s usability was measured with the Software Usability Measurement Inventory (Kirakowski, 1993). The SUMI consists of 50 statements and three item Likert scales on which the participants have to indicate whether they agree, are undecided or disagree with the statement. The SUMI contains statements like “*I enjoy my sessions with this prototype*”, “*It is obvious that user needs have been fully taken into consideration*” and “*The prototype has a very attractive presentation*”.

Pleasure, Dominance and Arousal scale (PDA)

In order to measure the degree to which participants are satisfied with the two different environments, the semantic differential Pleasure, Dominance and Arousal scale was used. Mehrabian & Russell (1974) designed this widely used instrument to investigate how consumer behaviors are influenced by atmospheres (Foxall, 1997). This instrument is based on three dimensions to describe an individuals’ emotional responses to an environment: *pleasure*, *arousal* and *dominance*. These dimensions have been subdivided into six opposing states of mind each. Each opposing pair is rated along a seven point Likert scale.

NASA Task Load Index (TLX)

The task load evoked by the performance of the assignments is measured by means of the NASA Task Load Index (Hart & Staveland, 1988). In order to measure mental workload, the TLX uses six bipolar scales to assess task load on six dimensions: *mental demand*, *physical demand*, *temporal demand*, *performance*, *effort* and *frustration* (Rubido, Díaz, Martín & Puente, 2004). The mean task load value represents how demanding the participants experienced the execution of the tasks.

(Dis)confirmation of Expectations

In order to measure the (dis)confirmation of expectations a commonly applied seven-point semantic differential scale is used (Aiello, Czepiel & Rosenberg, 1977; Linda & Oliver, 1979; Oliver, 1977; Swan & Trawick, 1980; Westbrook, 1980). The scale ranges from “The experimental system was worse than expected” to “better than expected”. In order to measure participant’s expectation level Churchill & Surprenant’s (1982) seven-point semantic differential scale was used. The range of this scale goes from “My expectations about the experimental system were too high: it was poorer than I thought” to “My expectations about the experimental system were too low: it was better than I thought”.

4.4 Results

The results of the statistical analysis of the collected measures are now presented. Note that in order to process data of ordinal level as interval level data, all values were normalized to Z-scores preliminary to statistical processing.

Brief Mood Introspection Scale (BMIS)

4.4 shows the mean scores on mood state for each group preliminary to the first session.

Table 1 Mean group scores on mood state corresponding to session 1 (score is at least 1 and at most 7; $N_{group} = 10$)

	Group 1	**Group 2**	**Group 3**	**Group 4**
Session 1	3.62 (0.38)	3.64 (0.38)	3.80 (0.36)	3.68 (0.47)

The results of a One-Way ANOVA show that there was no significant difference between the four groups on the mean mood state scores concerning session

1 ($F(3,36) = 1.60$, $p = .21$). In 4.4 the mean scores on mood state for each group preliminary to the second session are presented.

Table 2 Mean group scores on mood state corresponding to session 2 (score is at least 1 and at most 7; $N_{group} = 10$)

	Group 1	Group 2	Group 3	Group 4
Session 2	3.67 (0.25)	3.79 (0.45)	3.84 (0.32)	3.76 (0.63)

Again, a One-Way ANOVA was conducted. The results show that, concerning the second session, the four groups did not differ significantly from each other on the mean mood state scores ($F(3,36) < 1$, $p = .91$).

Subsequently, in order to check whether there was a significant difference between the scores of session 1 and session 2, for each group an Independent Samples t-test was conducted. There was no significant difference found for group 1 ($t(18) = 1.96$, $p = .07$) just as for group 2 ($t(18) = 1.34$, $p = .20$), group 3 ($t(18) < 1$, $p = .95$) and group 4 ($t(18) < 1$, $p = .89$).

Software Usability Measurement Inventory (SUMI)

The group mean scores for satisfaction as measured by the SUMI in session 1 are presented in 4.4.

Table 3 Mean scores on *satisfaction*(based on SUMI) corresponding to session 1 (score is at least 1 and at most 3; $N_{group} = 10$)

	Group 1	Group 2	Group 3	Group 4
Session 1	2.45 (0.26)	2.41 (0.23)	2.40 (0.15)	2.55 (0.17)

The results of a One-Way ANOVA show that, regarding session 1, the groups did not differ significantly from each other concerning mean satisfaction scores ($F(3,36) < 1$, $p = .57$). 4.4 shows the groups' mean scores on satisfaction for session 2.

Table 4 Mean scores on *satisfaction* (based on SUMI) corresponding to session 2 (score is at least 1 and at most 3; $N_{group} = 10$)

	Group 1	Group 2	Group 3	Group 4
Session 2	2.47 (0.20)	2.40 (0.14)	2.40 (0.25)	2.50 (0.27)

Again, a One-Way ANOVA was conducted to check for significant differences in mean satisfaction scores between the groups. The results show, once more, that there was no significant difference between the groups ($F(3,36) < 1$, $p = .57$).

Finally, an Independent samples t-test was conducted to check for significant differences in mean satisfaction scores within each group between session 1 and session 2. The results show that neither for group 1 (t(18) < 1, p = .36) nor group 2 (t(18) < 1, p = .92), group 3 (t(18) = 1.06, p = .31) and group 4 (t(18) < 1, p = .93) were there significant differences between both mean scores.

Pleasure, Dominance and Arousal scale (PDA)

In 4.4, for each group the mean scores on the PDA-scale corresponding to session 1 are presented.

Table 5 Mean scores on *feeling evoked by environment* corresponding to session 1 (value is at least 1 and at most 7; $N_{group} = 10$)

	Group 1	**Group 2**	**Group 3**	**Group 4**
Session 1	4.44 (0.59)	4.55 (0.45)	4.34 (0.73)	3.99 (0.52)

The result of an One-Way ANOVA indicated that the four groups did not differ significantly from each other concerning session 1 (F(3,36) = < 1, p = .42). 4.4 shows for each group the mean scores on the PDA-scale corresponding to session 2.

Table 6 Mean scores on *feeling evoked by environment* corresponding to session 2 (value is at least 1 and at most 7; $N_{group} = 10$)

	Group 1	**Group 2**	**Group 3**	**Group 4**
Session 2	4.42 (0.57)	4.28 (0.65)	4.55 (0.70)	3.59 (0.49)

Again, a One-Way ANOVA was conducted to check whether the mean scores differed within session 2. Just like in session 1, there was no significant difference between the mean scores concerning session 2 (F(3,36) = < 1, p = .44). Finally, an Independent samples t-test was carried out in order to find out whether there was a matter of significant difference within the mean group scores between session 1 and session 2. However, the results show that within group 1 (t(17) < 1, p = .89), group 2 (t(17) < 1 p = .41), group 3 (t(18) < 1, p = .63) and group 4 (t(17) < 1, p = .35) there were no significant differences between the sessions.

NASA Task Load Index (TLX)

In 4.4, for each group the mean values on task load corresponding to session 1 are presented.

A One-Way ANOVA showed that the first session's results of the groups did not differ significantly from each other (F(3,36) = 1.37, p = .27). Secondly, within the

Table 7 Mean task load values corresponding to session 1
(value is at least 5 and at most 100; $N_{group} = 10$)

	Group 1	Group 2	Group 3	Group 4
Session 1	26.67(13.56)	31.08(9.92)	33.58(11.08)	26.67(12.90)

first session the mean scores of group 1 and group 4 and group 2 and group 3 were also compared. However, neither between group 1 and 4 ($F(1,18) = 1.49$, $p = .24$) nor group 2 and 3 ($F(1,18) < 1$, $p = .42$) any significant differences were found. 4.4 shows for each group the total mean value on task load corresponding to session 2.

Table 8 Mean task load values corresponding to session 2
(value is at least 5 and at most 100; $N_{group} = 10$)

	Group 1	Group 2	Group 3	Group 4
Session 2	18.47(5.64)	31.50(9.52)	27.33(9.33)	26.17(11.62)

A One-Way ANOVA was conducted to check whether the second session's results differed significantly between the groups. The results show that there was again no significant difference between mean values ($F(3,36) < 1$, $p = .55$). The results of a One-Way ANOVA show that group 1 and 4 ($F(1,18) = 1.73$, $p = .24$) and group 2 and 3 ($F(1,18) < 1$, $p = .49$) did not differ significantly from each other with regard to session 2.

Furthermore, to find out whether there was a matter of significant difference between the group's mean scores between session 1 and session 2, an Independent samples t-test was carried out. The results show that there was only a significant difference between the mean scores for group 1 ($t(18) = 2.35$, $p < .05$, explained variance = 18.4 percent) and not for group 2 ($t(18) < 1$, $p = .63$), group 3 ($t(18) < 1$, $p = .64$) and group 4 ($t(18) < 1$, $p = .88$).

(Dis)confirmation of expectations

In 4.4, for each group the mean scores on (dis)confirmation of expectations towards the experimental system measured in session 1 are presented.

Table 9 Mean scores on *disconfirmation of expectations* measured in session 1
(value is at least 1 and at most 7; $N_{group} = 10$)

	Group 1	Group 2	Group 3	Group 4
Session 1	4.40 (1.17)	4.80 (1.09)	4.45 (1.09)	5.05 (0.93)

The results of a One-Way ANOVA show that the mean scores of the groups did not differ significantly from each other (F(3,36) = < 1, p = .49). The mean scores of each group corresponding to the second session are presented in 4.4.

Table 10 Mean scores on *disconfirmation of expectations* measured in session 2 (value is at least 1 and at most 7; $N_{group} = 10$)

	Group 1	Group 2	Group 3	Group 4
Session 2	3.90 (0.91)	5.15 (1.31)	4.20 (0.95)	4.35 (1.11)

Once more, the results of a One-Way ANOVA show that there was no significant difference in mean scores between the four groups (F(3,36) = 2.44, p = .08). An Independent samples t-test was conducted to check if there were significant differences in mean scores between session 1 and session 2. However, there was no significant difference found for group 1 (t(18) = 1.07, p = .30) just as for group 2 (t(18) < 1, p = .52), group 3 (t(18) < 1, p = .59) and group 4 (t(18) = 1.53, p = .14).

4.5 Discussions

The main finding of this study is that there is no statistical significant difference between the usability measures obtained in the ExperienceLab and those obtained in a traditional usability laboratory. On the basis of this study one can assume that conducting an usability study in the ExperienceLab environment does not result in a more positive system evaluation as compared to evaluating the same system in a traditional laboratory environment.

During the debriefing at the end of the second session, several participants explained that because of performing the video editing tasks and filling in questionnaires they had paid hardly any attention to the environment. On the basis of this explanation it could be possible that the occurrence of response bias due to the ExperienceLab environment is much more system related. That is: systems that are very much part of the environment will draw more attention to the testing environment. Consider for example the evaluation of voice controlled environments in which there is no single point of interaction but in which the user will interact with or through the environment as a whole. In such situations the presence of response bias due to the testing environment, needs to be re-assessed.

However, the present study leads us to the conclusion that the evaluation results of an interactive system, in which this system is the main locus of attention, will not be biased by the testing environment. As such, the present study provides us with an important argument towards the validity and reliability of empirical research in environments such as the ExperienceLab.

5 Case Study of the Experience Research Approach

In this section, a brief [3] case study of applying the Experience Research cycle is presented. The application domain for this case study is found in the domain of *Ambient Assisted Living* solutions for the ageing population. The target group for this case study is characterized by elderly who have recently retired and who have an active social network. For this study the main focus was not identifying problematic situations (e.g. social isolation) but to better understand well functioning social networks of people who experience a major change in their life (i.e. retirement). Equipped with these insights research could conceptualize potential technology applications for elderly that are at risk of experiencing a reduced active social network and for which it is important to support them in re-activating their social network.

5.1 Context-Mapping Study

Following the context mapping methodology (Sleeswijk et al., 2005) a study was designed to gain more insights into social world of elderly. The context-mapping process generally comprises three parts: (1) eliciting information about the context, (2) structuring the contextual information and communicating the information to the development team, and (3) incorporating the contextual information in concept development activities. In this method, a key element is having users create expressive artifacts (in so-called *generative sessions*) and discussing them in individual interviews or group sessions.

After recruiting and introducing 11 elderly for the context mapping study, a probe package was provided to these participants. This purpose of this package is to sensitize the participants by making them conscious of their social network. More specific, the participants were requested to complete a poster that represents their social network (Kang and Ridgway, 1996). The participants were not instructed to pay attention to any specific aspect of their social network but rather to keep a diary of this social network by working on the poster on a daily basis.

The participants are thus asked to work on the small assignments each day for approximately 10 minutes during one week by describing and annotating their social interactions on this poster. At the end of this first week, the participants were interviewed and the poster was discussed with them. During the interview it was agreed that the participants would involve a companion (a person that plays an important role in their social network) in completing together another poster representing activities and interactions within the social network (see Figure 9). This second activity was again setup as a collection of daily assignments spread over one week. At the end of the second week, both the participant and the companion would be

[3] The case study description is brief and intended merely to illustrate the different steps of the Experience Research cycle. A more detailed report of this case study is found in De Ruyter & Leegwater, 2009.

Fig. 9 Context mapping participants detailing their social network on a poster

interviewed to better understand the poster they have created together. At this occasion there would also be a small interview on the use of today's technologies (e.g. phone, email, postal mail) within the context of staying in touch with their social network.

In the next step of the context-mapping study, the findings of the context-mapping study are clustered and analyzed (see Figure 10). The richness of this material requires making high level abstractions that represent the high level needs of the participants. These are summarized as:

- There is a strong need for recognition from the actors in the social network.
- The elderly have a need for being independent from the social network.
- The elderly have a need to experience general satisfaction about their social world.

For example, the *need for recognition* was further detailed by specific behaviors and situations that were highlighted during the context-mapping study:

- *Being useful*. There is a strong need to make one's self useful; after retirement the mentioned group of elderly still feels responsible to add something to society to a certain degree.
- *Being included*. People want to be become member of an association or want to be invited at someone's birthday party. In other words, they feel the need of belonging.
- *Confirmation of status*. People show what they are capable by comparing themselves with others with respect to condition, expertise or skills, or by challenging each other in a competitive way.
- *Mutual appreciation*. Recognition is expressed for other people's skills and expertise by giving each other compliments. Also the elderly show mutual interest in each other by exchanging news and ask for each other's situation. A lot of mutual help and support takes place as well: help each other with small jobs, cook for each other, and helping someone to his destination.

Although many of these findings are already confirmed in literature (Bauwmeister and Leary, 1995), the present study provided more insights into *how* these fundamental human needs are addressed with today's solutions. In a second level of the

Fig. 10 The classification and analysis of the context mapping findings

data analysis, it became clear how their social networks are formed, how the participants maintained and expanded these networks and what made these networks satisfying and rewarding.

5.2 Laboratory Study

As a further research direction, the topic of *social recognition* and *appreciation* was explored. It is noted that the context-mapping data is rich enough for investigating many other aspects of the participant's social network.

Building on literature (Bauwmeister and Leary, 1995), the following requirements for an application concept were put forward:

- Social networks consisting of few close friendships are preferred over large networks with less intimate friendships (Caldwell and Peplau, 1982)
- Satisfying social networks involve two criteria: (i) frequent and affectively pleasant interactions and (ii) these interactions must express an affective concern between the network's members (Bauwmeister and Leary, 1995)
- The social interaction should allow for small talk over trivial matters (Gerstel and Gross, 1982)

While these requirements are general and well documented in literature, the context-mapping study results supported understanding the context in which any technological solution would be introduced and additional requirements for the concept were established.

After a further literature study and an exploration of existing technological solutions for supporting social networks, a concept creation step was started. The concept developed in this case study is that of an interactive television channel for a closed community (see Figure 11). With this TV channel, the members of the social network can post short messages and pictures that are meaningful to their network[4]. More important was that the members of the community could rate the posted materials by attributing flowers to the postings (see Figure 12). This was done in order to provide the network's members with an explicit means to show appreciation for each other's postings. The interactive channel would only allow a limited number of postings to be shared at the same time. As soon as new materials were introduced the older postings would be removed.

Fig. 11 The concept of an interactive community channel

Although the TV is a well known device, it also introduced a major challenge for the concept's usability since all interaction would be done using a simple remote control. After consulting existing design guidelines (e.g. readability of text on TV displays) a first prototype of the concept was built and tested in the laboratory environment in terms of its usability and initial acceptance. The usability test was based on a comparison of actual usage logging and a pre-defined task model for the developed concept. Post experimental interviews revealed some of the participant's attitudes towards this concept.

Fig. 12 Viewing postings and expressing appreciation

[4] Note: the actual posting is done using a PC with an internet connection while the consumption and sharing of the postings is limited to the TV channel.

The laboratory study highlighted several usability issues with respect to the use of the remote control, the transitions between the messages and the readability of the posted messaged. The concept was adapted and prepared as a robust prototype that could be deployed in a field setting.

5.3 Field Study

The prototype (implemented as a set-top box that connects to any standard TV) was installed in six homes and was available for the users for a period of 8 days. After explaining the basic functionality and use of the system, the end users could start using the prototype. The participants in this study were member of a small social network that organized frequent walking trips. The channel was used to share pictures and small messages related to their trips.

Fig. 13 Installation of the prototype in end-user's home

Since the prototype was implemented as a networked application, detailed loggings were made of the daily use of the system. Throughout the field test, the participants were requested to complete a daily questionnaire measuring the perceived appreciation they experience from their social network (Adler and Fagley, 2005).

The results of the field test provided more insights into the use of the concept in real life settings. Additional, it enabled researchers to investigate some specific mechanisms that enable and create strong social networks. Additional, the results of the field study highlighted some unexpected behaviors. For example, one of the members of the social network was very negative towards the system due to its simplicity. After discussing the issue further it became clear that the person raising this issue was recognized in the social network as an expert when it comes to using ICT solutions such as the PC. However, due to the concept's simplicity any member of the social network could post and retrieve messages and pictures. As a consequence, the specific user lost his status as expert since his support was no longer needed.

6 Discussion

It goes without saying that the AmI vision holds the promise of becoming a truly disruptive paradigm. It calls for a far-reaching multi-disciplinary and integrative approach that extends far beyond the levels of system innovation that mankind has been dealing with so far. This requirement is a challenge and a threat at the same time. The threat lies in the fact that the complexity of AmI environments may not be tractable and that the implementation of the vision therefore will be infeasible. On the other hand the requirement may stimulate the search for innovative solutions to this complexity problem resulting into now insights that eventually will lead to the realization of true Ambient Intelligence.

Although the experience research cycle case study is only reported in brief, it should make clear that each phase of this cycle will provide its own specific insights into the interaction between users and technology applications. The contextual study enabled the research team to better understand and instantiate some of the general findings from literature that relate to the development and maintenance of social networks. Within the laboratory setting it was possible to study how end users could use the experimental prototype. Finally, the field study gave more insight into actual use and affective responses people have when using the proposed technology applications. It should be clear that this process (although not presented this way) is iterative and that findings of each phase might require the researcher to step back to a previous phase of the experience research cycle.

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