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# Human-Centered Design and Smart Homes: How to Study and Design for the Home Experience?

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## Abstract

The focus of this chapter is on designing for smart homes. The perspective will be user-driven design research. The chapter starts with a context analysis of the home environment. This analysis shows that, from a user perspective, home is about emotions and not about the physical house with all its smart applications. It is this “home experience” designers have to design for. The core of the chapter consists of the description of three big challenges that modern designers (need to) face when designing or studying smart home environments. These challenges are linked to existing and future design paradigms. The following challenges are addressed: (1) What makes a worthwhile user experience? (2) How to design for user experience? (3) How to design for user experiences that can be seamlessly integrated in everyday life? The chapter concludes with a summary of the main insights that emerge from current design research practice facing these challenges.

## Keywords

User Experience; Human-Centered Design; Interaction Design; Home Experience; Design for Everyday Life

## Introduction

“*Homes are not smart, people are smart.*”<sup>1</sup> In the end, it will be the inhabitants of houses that give their verdict whether or not their homes behave in an appropriate and meaningful way; they will decide whether or not the predicate “smart” should be attached to the behavior of their home. This insight has led designers of intelligent systems, products, and related services to actively involve end users in all stages of their design process. User-centered design methods have been developed over time, influenced by general theories and ideas within the design discipline on the creation of value both from people’s and business perspective. Brand and Rocchi (2011) describe the change from a focus on product ownership (industrial economy) toward the current focus on user experiences enabled by product-service systems (experience economy) and the trends toward self-actualization (knowledge economy) and meaningful living (transformation economy). In this chapter, we focus on designing for the *home experience*.

Over the last decades, “traditional” homelife has been under heavy attack of ever faster developing information and communication technologies (ICT). In particular, the digitization of media and

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<sup>1</sup>A statement made by participants of a study on the home experience by Eggen et al. (2003a).

the possibilities to connect people and devices with powerful embedded ICT capabilities through the Internet have changed the home environment. Whereas the digitization of physical media, in first instance, was used to make media like music, pictures, movies, games, newspapers, and books available outside the home on an anytime-anywhere basis, we now see the digitization backfire at home; physical instantiations of media or media collections disappear, and new physical interaction devices like smartphones and tablets enter the home domain to enable experiencing the digital media. The same is happening for “analog” communication. A more recent trend concerns the generation of (personalized) media streams by all kinds of sensors embedded in stationary, portable, and wearable devices in- and outside the home.

It is clear that these recent and ongoing developments are changing and will continue to change homelife for better or for worse. According to Turkle (2011), these developments negatively affect the emotional qualities of life. People’s accommodation to changes in perceived sociopsychological constructs like privacy, community, intimacy, and solitude, as explained by Turkle, might impact homelife in particular, as these constructs are core to many home-based user experiences (Eggen et al. 2003a). On the positive side, the advancement of technology has opened up opportunities for designers to create product-service systems that enhance existing and support new home experiences. In this chapter, we take the second perspective and describe three big challenges that modern designers (need to) face when designing or studying smart home environments.

It is important to note that, at the moment of this writing, there is no single definition of what a *user experience* is. Recently, however, a group of more than 30 leading user experience (UX) experts made an inventory of the UX phenomenon and how it is approached in current design practice (Roto et al. 2011). This overview provides valuable insights that can inform the design for home experiences. The experts point out that the true challenge of UX design is to focus on a number of important dimensions that go beyond the “traditional” principles of human-centered design (HCD) for interactive systems (ISO 9241–210 2010). The basic principles of HCD entail the central and participative role the user should take in an iterative design process as well as the identification of user-specific factors to guide and assess the design. Whereas traditionally there has been a strong focus on functionality and usability factors, “new UX factors relate to affect, interpretation, and meaning (Roto et al. 2011).” To identify which factors define a worthwhile user experience is one of the big challenges for the designer of interactive systems. This challenge will be addressed in the next section as “[Challenge 1](#).” But also, how to assess designs on the basis of selected UX factors that, for example, relate to social, emotional, and/or aesthetic issues remains a challenge, as, currently, there exists no single overall measure for UX. A related challenge concerns the creation of effective representations of UX concepts and designs to communicate with end users and other stakeholders in the design process. The last two challenges will be combined in “[Challenge 2](#)” that addresses the more general question how to design for user experience. Within the special multiuser setting of the home, where highly personal and intimate experiences have to seamlessly fit the daily rhythms, patterns, and routines of family life, we introduce and discuss a third and final challenge: How to design for user experiences that can be seamlessly integrated in everyday life?

## **Challenge 1: What Makes a Worthwhile User Experience?**

For a long time, the functionality of a product or system has been the main focus and starting point for designers. What does the user need, i.e., what should be the intended outcome of the interaction with the product (the end), and what functionality should the product offer to the user to enable him/her to fulfill this need (the means)? But once this “need for functionality” has been fulfilled, the

focus of design naturally shifts toward the interaction itself. More specifically, the quality of interaction design, then, is defined and evaluated in terms of the usability of the system. Usability, as defined by the ISO standard, refers to the “extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use” (ISO 9241–11 1998). But what user needs arise when the design meets the set usability goals? According to Jordan (2000), the next level in the hierarchy of consumer needs is the need for pleasurable products. Jordan defines two different types of pleasures: need pleasures and pleasures of appreciation. Need pleasures move a user from a state of discontentment to a state of contentment, i.e., they help to eliminate negative feelings like discomfort. Pleasures of appreciation are pleasurable in and of themselves and help to facilitate positively joyful feelings and experiences. Jordan distinguishes the following pleasures: *physio*-pleasures that have to do with the body and the senses, *psycho*-pleasure that have to do with the mind and emotions, *socio*-pleasures that have to do with relationships and status, and *ideo*-pleasures that have to do with beliefs and values. Within the pleasure framework of Jordan (2000), the need pleasures relate to usability goals, whereas the pleasures of appreciation are characterized as being cognitively more challenging and emotionally gripping or exciting (Jordan 2000).

In moving up the hierarchy from user needs related to functionality to user needs related to usability and pleasure, respectively, the model of the user as a human being is becoming more complete. A user brings more to the interaction with systems than physical and cognitive abilities and limitations only; a person’s values, goals, needs, and pleasures should also be taken into consideration in the design of systems. But still, the overall picture of human-system interaction that emerges up till now remains rather instrumental: the functionality, the look and feel, and the interface offered by the system enable the human user to interact and satisfy his/her needs in a certain context. Experience design, however, takes a more holistic view on the situation, by not only focusing on the what (functionality) and the how (usability, pleasure) but by explicitly putting the why as the leading question to be uncovered, understood, and addressed in interaction design (Hassenzahl 2011). According to Hassenzahl (2011), *form*, i.e., how the system looks and interacts, and *function*, i.e., what the system can do, should follow from *insight*, i.e., why the system can help to satisfy the users’ needs. And by doing so, the focus shifts from specific user needs to more general human needs. Within this context, the ten psychological needs that according to Sheldon et al. (2001) make events satisfying, for example, offer a powerful framework to address the basic human needs that make user experiences worthwhile to live, remember, and communicate to others. The needs described by Sheldon et al. (2001) are introduced by Hassenzahl (2010) to guide and inspire experience design. The Sheldon et al. framework includes needs like autonomy (“I can do what I want, the way I want it”), competence (“I am good at what I do”), and relatedness (“I feel close to the people I care about”).

A study on the home experience by Eggen et al. (2003a) showed that the use of intelligent systems and products should be seamlessly integrated in everyday activities. At closer inspection, these mundane activities seem to be driven by hidden, but basic, personal and social human needs. Whereas the primary task or activity the product was originally designed for is carried out subconsciously, as a means to an end, the “true” user experience relates to the deeper basic human needs. Family members, for example, indicated that daily household chores like vacuum cleaning or ironing are often considered boring, but, on the other hand, the nature of these activities enables them to create precious moments in time where they can daydream and reflect on or escape from their daily worries (Eggen et al. 2003a). Another example concerns the “Phenom” project in which a system to support the recollection of memories was designed (van den Hoven and Eggen 2008). Initially, the project focused on fast and efficient retrieval of photos that were considered digital

representations of memories. Interactions of users with early prototypes, however, showed that the photos only act as a trigger to start the recollection process. The real memories emerge and become tangible in the form of stories told by users. This insight caused the project to shift its focus from “information retrieval” to “storytelling” and the role various artifacts like souvenirs, photo albums, and physical aspects of the environment play in the experience of recollecting. This user experience is closely related to basic human needs like relatedness, self-actualization meaning, and self-esteem.

## Challenge 2: How to Design for User Experience?

User experiences are unique and personal and, as we have seen, get their positive meaning from the fulfillment of basic needs. But it is important to also realize that the user experiences people have when using a system might also be influenced by earlier experiences they (or others) had with the system or simply by expectations they have about the system. Besides this psychological state of mind of the user, the social and cultural context of use also determines the UX. For designers it is of crucial importance to be able to communicate with the user and other stakeholders involved in the design process about anticipated, i.e., new user experiences, or about earlier related experiences. This communication process forms the basis for envisioning, representing, evaluating, and creating the design that enables the user experience (Roto et al. 2011). In particular, stories told by users about their experiences with interactive systems are considered informative and a powerful communication medium to get to grips with the intangible nature of the UX phenomenon. The importance of stories is distinguished in the definition of user experience by Hassenzahl (2011) who considers an experience “as story that emerges from the dialogue of a person with his or her world through action.” In this view, a designer cannot design experiences (stories) as such; a designer can only design for experiences, i.e., creates artifacts or environments that enable the emergence of stories. As a consequence, the value of interactive systems lies in their ability to support and mediate user experiences rather than in the underlying technology or the physical artifacts as such.

In this chapter, we put *focus* on the involvement of the user in the design process to understand his/her characteristics, capabilities, and needs. But to design for future experiences, a designer also needs to take the *perspective* of the user to learn about his/her feelings, emotions, thoughts, and dreams. Over the last decades, many methods have been developed that focus on human-centered interaction design; see, for example, Rogers et al. (2011) for an excellent state-of-the-art overview. The shifting focus from usability to experience design has led to the development of many new methods, which have been mapped by Sanders (2008). Sanders (2008) uses two dimensions to differentiate and position the “new” HCD methods. The first dimension captures the contrast between methods that consider users as subjects, or “reactive informers” that inform the “expert” design researcher [expert mindset], and methods that consider users as partners, or “active co-creators” in the design process [participatory mindset]. The interconnecting dimension captures the contrast between [research-led] and [design-led] methods (Sanders 2008). The map nicely shows that the UX methods, more recently developed, are in the [participatory mindset]-[design-led] quadrant.

As we stated before, for the UX designer, it is not only important to make the context of use of the user-system interaction as concrete as possible but also to empathize with the user. For the first design activity, sound methods are readily available, like, for example, the PACT framework proposed by Benyon et al. (2005) to analyze design situations. This analysis is based on the principle that “*People use Technologies to undertake Activities in Contexts*” (Benyon et al. 2005). Empathy can be defined as the capacity to think and feel oneself into the others’ “emotional state” (de Waal

2008), the others' "thoughts and feelings" (Baron-Cohen 2003), and the others' "values and motivations, knowledge, skills, and meanings" (Schwartz 2002). Various methods have been developed to create and involve empathy with users through ethnography (e.g., through contextual interviews and observations), the imagined other (e.g., through role play), and narratives. As stories and storytelling are intricately linked to user experiences, we now briefly describe three methods that center on narratives.

The scenario-based design approach described by Carroll (2000) uses scenarios and stories as narratives to capture and communicate the essence of the interaction design. These informal stories can be used by designers as an "empathic" tool as they represent a holistic view of a situation in which one or more actors with personal motivations, knowledge, and capabilities interact with various tools and objects. Good scenarios present concrete situations, are open-ended, and are action-based. Visser et al. (2005) described the context-mapping method, which aims to identify latent user needs, i.e., needs that people are not yet aware of and that can become realized in the future. As this method intensively involves users in creating an understanding of the context of human-system interaction, it belongs to the [participatory mindset]-[design-led] category of methods that treat users as the real domain experts of the user experience to design for. Design probes, like disposable cameras, workbooks with exercises, postcard prompts, etc., are used to facilitate the creation of content awareness by eliciting (emotional) responses from the participants. Once these probes have done their work in sensitizing the individual participants, generative or projective techniques are used in a group setting to tap participants' tacit knowledge, i.e., knowledge that people can act upon but cannot readily express in words, to create views that reveal possible future user experiences based on existing and latent user needs (Visser et al. 2005). As a last example, the co-constructing stories method by Ozcelik and Terken (2012) also contains a sensitization and an envisioning phase. This method aims to elicit in-depth user feedback on early design concepts to help designers to investigate if their concept is the right concept and how it should be further developed. A sensitizing story enables the designer to set the stage for dialogue and triggers participants to recollect and tell stories about the past. In the second phase of the method, the new, early design concept is staged in a story about an envisioned future. This visionary story elicits prospective stories from the participant about needs, dreams, and aspirations. These stories inform the designer about the "why" reasons that should be addressed by the design concept; they allow creating empathy with the users, and they contain suggestions to inspire and inform further concept development (Ozcelik and Terken 2012).

The co-constructing stories method of Ozcelik and Terken (2012) exemplifies one of many possible methods that can support designers to design for user experience. A recent study by Offermans et al. (2014) in the area of intelligent lighting systems can serve as an example of how these methods, the context-mapping method in this case, are used in actual design research practice. With the advancement of new lighting technologies, new dimensions capturing functional, emotional, physiological, social, and cultural aspects of the interaction with light are opening up for the design of new interaction paradigms. Offermans et al. (2014) conducted a context-mapping study to better understand people's motivation to interact with light. They uncovered that the needs for lighting are layered and that (1) these layers are highly dependent on the context and (2) the different layers require control at different levels. They found that the context and the lighting needs had a large influence on people's motivation to adjust the lighting in their environment (functional and UX factors). But also, vice versa, it was found that the interaction qualities of the lighting interface itself had a large effect on people's motivation to control the light (functionality and usability needs).



### **Challenge 3: How to Design for User Experiences that Can be Seamlessly Integrated in Everyday Life?**

Designing for user experiences that are part of or actually make up the social fabric of everyday life is a true challenge (Eggen and Kyffin 2006). But designing for the home environment might bring even greater challenges, as user experiences in this context are not only highly personal, they also intimately contribute to and are influenced by the social dynamics of the family life, i.e., the other family members and the family as a unit. Quoting Dutch families (Eggen et al. 2003a, p. 6): “*Home is a feeling. It is a cozy, trusted, and safe place, a place to return to; where you can be yourself and do what you want; where your own things are; where you meet the people you love and like.*” And “*Together with your family and friends. Family members take care of each other and create the opportunity for others to be themselves and to do what they want. However, this freedom is limited by the fact that living together brings responsibilities. This is accepted as a part of home, albeit with mixed feelings.*”

Interactive systems that are tailored to serve the needs of individual family members do not necessarily work in the multiuser setting that is so characteristic for the home. For example, the personal recommendations a media system offers are bound to fail if there are no accommodations made to cater for social settings where media are shared. Currently, this is often not happening, as designers seem to be ignorant of the delicate balance between basic needs such as pleasure stimulation (“I experience new activities”) and relatedness (“I feel close to the people I care about”) (Sheldon et al. 2001). If designers do not base their design concepts on a deeper understanding of the complex and dynamic nature of the anticipated user experience, their product-service systems will fail, and, worse, they might even threaten family life as family members get isolated from one another and start to “live alone together” (Turkle 2011). On the positive side, future concepts that are the result of sound user experience design will seemingly fit the rhythms, patterns, and cycles of everyday family life and, as a consequence, will support and enhance the well-being of people.

Future smart homes are supposed to become populated by many smart devices that are sensitive to the presence of people and that can adapt their behavior to serve the members of the household. We should realize, however, that intelligent systems can only behave intelligently, i.e., autonomously, appropriate, and meaningful, if they actively communicate and interact with their environment (just like intelligent people need to do). These basic system needs might easily lead to “nightmare” scenarios once the number of smart devices starts to grow significantly. A smart home scenario in which smart systems will compete for people’s attention will automatically lead to situations that are unacceptable to people. To prevent such situations from happening, Weiser and Brown (1997) proposed to develop “Calm Technology” that makes better use of the periphery of the human perceptual and cognitive system. As suggested by Weiser and Brown (1997) and based on human attention theory (Bakker et al. 2012), interaction designers can present information in such a way that people are only subconsciously aware of what happens in the periphery of the perceived situation. However, when desired or necessary, this information can immediately be put in the center of attention. A “peripheral design” approach toward the design of smart home environments could be instrumental in preventing future scenarios in which people are overloaded with information. However, to be able to successfully apply such an approach, designers should not only have to acquire a deeper understanding of the latest psychological theories on human attention management, they should also develop new ways to apply the acquired knowledge into concrete design actions (Bakker et al. 2012).

Within the “Home Radio” project, a peripheral design concept was developed, which addresses the basic human need of “relatedness” expressed by family members as the need to “stay in touch” with each other and their home (Eggen et al. 2003b). Home Radio allows family members to tune in to their home from a distant location, e.g., their office at work, to see, to hear, and to interact with the other household members, home events, activities, and information. Home activities, for example, are coded by the corresponding utility streams they generate (gas, electricity, water, communication, and information). This coded information is streamed on the Internet and family members can tune in to this stream. At the receiver end (e.g., your office), the coded information is rendered and presented in the environment by audiovisual means. The design of the presentation of the auditory and visual information streams in the office space was matched to the perceptual and cognitive requirements for peripheral display. The “Home Radio” project exemplifies a design research effort that tries to serve the everyday needs of individual family members by applying psychological knowledge into concrete design actions.

## Conclusions

In this chapter, we have looked at the question of how to study and design for the home experience. We have addressed three challenges the modern designer of smart home environments is confronted with. The first challenge is to fully understand and appreciate the user experience (UX) paradigm. Designing for user experiences calls for a holistic approach in which system components like functionality, interface, and look and feel enable basic human needs. Basic needs such as autonomy, competence, relatedness, and self-actualization are the target to design for once the “lower” needs concerning functionality (means to an end) and usability (effectiveness, efficiency, and satisfaction) are met. The second challenge concerns methods to identify, understand, and come to grips with UX factors that capture the user experience and how to use stories and storytelling to communicate about the user experience during the design process. These design-led and participatory methods focus on user involvement in the various phases of the human-centered design process and facilitate taking the users’ perspective by empathizing with the user through narrative. The third challenge is about designing for user experiences that become a natural part of the complex and dynamic social structures of everyday life. But also, it is about how to design for user-system interactions that take place in the periphery of human attention and only draw attention when wanted or needed. Through a deep understanding of basic human needs in context and through the application of state-of-the-art psychological theories on human processes, UX designers will be able to design for user experiences that enhance everyday life and improve the well-being of people.

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