19

Experience Design

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"Design explorations take the next step of considering how computation is to be manifest when it moves into the physical environment, and recognizing that this move makes the physicality of computation central."

Paul Dourish 2002

19.1 Introduction

One way of looking to the future is to take the past as a point of departure and in passing by the present-day extrapolate to things to come. Actual practice has demonstrated that this type of forecast can be highly accurate when it comes to the advancement of core AmI technologies. For decades Moore's law has correctly predicted the exponential growth of computer processing power. And in its generalized form it is also properly indicating performance improvements in the areas of wireless connectivity, storage capacity, and power battery technology. But despite the evident empirical observations on which this law is based, uncertainty will inevitably creep into the equation the further we look ahead in time. Taking a point of reference that is predominantly monodisciplinary in nature might cause other restrictions of "extrapolated" visions of the future. For example, by focusing primarily on technological developments danger exists that complementary disciplines in the arts and sciences will remain underexposed. This situation seems undesirable, especially as true innovations seem to happen on the borderlines between different scientific disciplines.

Alternatively, current trends can be ignored in order to freely, i.e., without any restrictions emanating from the past, think about the future. Realists call this way of looking to the future "dreaming" and attribute little predictive power to the resulting visions of the future. Visionaries, on the other hand, argue that the intrinsic needs and desires of people, but also the physical, mental, and social capabilities of people, only very slowly change over time. A change that is much slower, in fact, than the time scale typically used to forecast trends. These so-called normative visions of the future put the focus of attention on people's everyday life and top down inspire different disciplines to bring about new insights through collaboration.

In practice, both ways of looking to the future, extrapolated and normative, are hardly ever encountered in their purest form. It is the continuous exchange of these two directions of view, "*past* → present" and "present ← *future*," respectively, that should characterize and determine successful strategies for exploring the future of electronically enriched living environments. In fact, the intertwining of both approaches naturally puts the spotlight on the present. And it is precisely the *present* the authors of this chapter want to focus on when it comes to the "*true* visions" theme of this book.

To fully appreciate why the present is put in the center of interest, it is important to know that, from the early days on, the authors have been approaching the area of Ambient Intelligence from an *Industrial Design* perspective. In short, this means that the main objective of our design research efforts has been to explore the possibilities of Ambient Intelligence through concrete experience prototypes. The concept generation processes that underlay these prototypes were always grounded in sound technological, societal and cultural trend analyses, and the actual realizations often made use of just-beyond-the-state-of-the-art technologies only available in a laboratory setting. In addition to this, potential end-users were systematically involved to evaluate their experiences while interacting with the prototypical implementations of future intelligent products and systems. In our view, the real-time and physical characteristics of these interactions are indispensable for the creation of true points of contact between extrapolated future technological possibilities and normative long-term psychological and sociological human capabilities.

Although true encounters can only happen in the present, they can be captured in time, and further analyzed and generalized into knowledge relevant for the design of future intelligent products and systems. In this chapter, we will review some insights we consider relevant for designers of AmI environments. These insights originate from the numerous encounters between people and the experience prototypes that were created by our co-workers and us over the last couple of years. In the remainder of this chapter, we will first briefly review relevant technological developments and expectations. Next, we will summarize the design relevant knowledge we acquired from the experience design research activities we conducted within the area of Ambient Intelligence. Finally, we discuss new directions in design research that we consider crucial to truly realize the exciting possibilities offered by the AmI vision (Aarts et al. 2001; Aarts and Marzano 2003).

19.2 Looking to the Future

19.2.1 Disappearing Technology

In 1991, Mark Weiser and his colleague's at Xerox Palo Alto Research Center (PARC) concluded that technologies that have the greatest impact on people's everyday life are those that in the end perceptually disappear in the

Fig. 19.1. GB Microdrive technology "hidden" in everyday objects (© 2004 Hitachi Global Storage Technologies)

environment (Weiser 1991). They stated that the same would hold for information and communication technology, which eventually will only come out well when it fully merges into people's everyday life. One way to become invisible is to literally, i.e., physically, disappear out of sight of the end-user. Recent developments in the area of miniaturization have reached a point where we can actually start to "hide" electronics in the environment; see for instance Fig. 19.1.

Another way for information technology to disappear is to become transparent. In this case, the user is no longer aware that he or she is operating technical equipment, but attention is fully allocated to the experience of the interaction itself; technology does no longer put up barriers.

Making information technology transparent for people poses new challenges to design research that clearly go beyond pure technical specifications. Transparency characterizes the interface between the information processing system and its users, or, when the system has physically disappeared into the environment, between the environment and the user; see for instance Fig. 19.2. In practice, this means that in addition to knowledge on advanced interaction technologies, knowledge about the user and his or her environment is vital to guarantee transparent interaction. We believe that system intelligence is a key enabler for transparency. After all, when the system is aware of its context, the user of the system no longer has to feed the system with explicit information about the environment. Reducing explicit input not only increases interaction speed, but it also reduces the cognitive workload of the user and the chance of making mistakes (Lieberman and Selker 2000). At the output side, context awareness enables the system to decide about the best moment in time and place to present the information to the user in a way that optimizes information transfer while minimizing information overload. In summary, a context aware system that shows meaningful and appropriate adaptive behavior enables users to primarily focus on the basic intention that in first instance triggered the user–system interaction.

Fig. 19.2. Transparency in Ambient Intelligence – communicating with distant family members objects (© Philips Research)

Future scenarios are frequently used to systematically explore the possibilities of these kinds of intelligent environments. In 2001, the Information Society Technologies Advisory Group (ISTAG) of the European Community published four scenarios that describe in detail how people's everyday life in 2010 would look like assuming Ambient Intelligence has pervaded the living environment by that time (ISTAG 2001). The next excerpt summarizes a part of the ISTAG "Dimitrios" and the "Digital Me" (D-Me) scenario, which puts the emphasis on system-mediated communicative acts supporting human relationships:

> *Dimitrios is wearing, embedded in his clothes (or in his own body), a voice activated "gateway" or digital avatar of himself, familiarly known as 'D-Me' or 'Digital Me'. At 4:10 p.m., following many other calls of secondary importance – answered formally but smoothly in corresponding languages by Dimitrios' D-Me with a nice reproduction of Dimitrios' voice and typical accent, a call from his wife is further analyzed by his D-Me. In a first attempt, Dimitrios' 'avatar-like' voice runs a brief conversation with his wife, with the intention of negotiating a delay while explaining his current environment. [... time goes by in which Dimitrios gets entangled in other activities ...]. Meanwhile, his wife's call is now interpreted by his D-Me as sufficiently pressing to mobilize Dimitrios.*

The ISTAG scenarios do not only aim at sketching a provoking view on a possible future, but they are also especially intended to systematically map developments in the area of information and communication technology, and to get a discussion going on related economic, social, and public factors. The scenarios are called "human centered" by their creators, because people, the individual is put in the center of our future information society. Also in the

Dimitrios scenario, human relationships play a central role. However, after reading the scenario, the question easily arises whether you and I would positively judge the way in which these relationships are maintained and supported by technology. Despite the fact that the advanced speech and language technologies and the artificial intelligence needed to realize these scenarios are impressive, at the same time, these technologies to a large extent give color to the personality of D-Me. It is literally impossible for Dimitrios' wife to get round D-Me. What does she think of the way D-Me behaves? And how do these situations influence her relationship with the real Dimitrios? In case these questions will be answered negatively, will it be possible in the long run for Dimitrios to identify himself with his Digital Me, or is D-Me urged to disappear from Dimitrios' sight once and for all?

In a more recent publication the ISTAG working group "Experience and Application Research" has concluded that a new approach is needed to ensure the successful application of research and development efforts in the area of Ambient Intelligence (ISTAG 2004). This new approach should be based on an extensive involvement of those people who will be confronted with the advantages and disadvantages of Ambient Intelligence. In the next section, we will elaborate on the role of end-users in the design of intelligent products and services.

19.2.2 The Future Seen from a People's Point of View

As indicated before, it is considered of utmost importance that a designer of future intelligent systems integrates technical knowledge with knowledge of the user and the environment into innovative solutions for relevant problems. User involvement in the design process is a crucial element for a number of reasons. Firstly, interactions with end-users can be employed to define and validate the design problem from the viewpoint of the individual, his or her social context, or the public interest. At the same time, user involvement can be instrumental in mapping out the characteristics of the target group that will use the system, the context in which the system will be used and the suitability of available technology. This leads to a set of design requirements the intelligent system should comply with. After solutions have been generated and implemented, people can once again be brought into action to evaluate to what extent the design meets the requirements.

Over the last decade, we have been actively involved in the set up and execution of numerous *user-centered* design research projects within the AmI programs of Philips Research and Philips Design; for an overview see, for example Aarts and Aarts and Marzano (2003). More recently, this collaboration was continued in the context of the AmI research program carried out at the department of Industrial Design of the Eindhoven University of Technology (TU/e) (Lundqvist 2004). The vision of Ambient Intelligence always formed the basis of the considerable efforts in design research carried out in these projects. In the majority of projects, experience prototypes were built which created *true* points of contact between people and future technological possibilities.

19.3 The Home Experience

To better understand the physical, social, and cultural context in which AmI technology will be used and its implications on daily life, early on in the research program we conducted a user study on people's home experience. To acquire this knowledge, we left our laboratory and went out to talk to consumers. We visited ten carefully selected Dutch families at their typically Dutch homes as shown in Fig. 19.3 (Eggen et al. 2003).

During interactive family sessions, various techniques, such as telling, drawing, writing, taking pictures, free association, and family members interviewing one another were employed to stimulate the families to express their experiences in the present home. We also learned about their attitudes towards so-called "Smart Homes" and towards their Dream Home of the future. Although a Smart Home is a future concept, it should be noted that people's ideal Dream Home is not necessarily smart. The main findings of our study can be summarized as follows.

– 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.
– People have mixed feelings about a Smart Home. The families see a Smart Home as a home where technology is applied to make life easy and to save time that can be used to do things one really likes to do. It provides comfort and luxury, and overcomes the drawbacks of the current home by taking over the unwanted tasks. When talking about a Smart Home, people start to talk about fears and worries they have regarding this Smart Home. They fear a cold and emotionless place where boredom and laziness will take over. So, besides positive effects, people explicitly discuss negative aspects. Some people do not even believe in a Smart Home at all. They

Fig. 19.3. Family studies – the home experience (© Eindhoven University of Technology)

think it will never be possible: “people are smart; a home will never be smart.”. Given the anticipated disadvantages and dangers of the Smart Home, people start to formulate requirements: “If you build a smart home, make sure I can trust it. It should be easy to use and integrated. I want to be in control.”

– The Dream Home equals home as it is now, but better. In the future the feeling of home should remain the same; the core values of the home must remain untouched. What people would like to have are the benefits of the Smart Home, and the positive experiences and values of the current home. People’s expectations of the benefits of the Smart Home are limited to what they think will be technically feasible. Because they sometimes underestimate what is possible, potentially interesting options are not mentioned. This is why we asked the families to imagine that anything is possible and to tell us what they would like. In general, the role of a future home would be one of an assistant. It would give advice, create the right conditions, and support the family in their activities and with the things that have to be done.

In the remainder of this section, we generalize some of the lessons we learned from these interactions with people into a number of insights. These insights are not only based on the family studies mentioned above, but also stem from many additional user-centered studies carried out in the AmI research programs at Philips and the Eindhoven University of Technology.

19.4 Design Insights of AmI Systems

For the purpose of this paper we only selected insights that we consider most relevant for the design of future intelligent products and systems. Although many projects were carried out in the context of the home environment, additional projects were done in the office, public, automotive, and medical domains. We therefore like to stress that the relevance of the insights described below definitely go beyond the home domain and hold for other domains too.

Insight 1. Intelligent Products Should Not Offer Predefined Experiences to People, But Only Create the Right Conditions to Enable and Support a Personal or Social Experience

From a business perspective, quality is no longer the only differentiator between competitive products. In their book “The Experience Economy,” Pine and Gilmore have convincingly argued that the “user experience” offers new ways to create competitive advantage (Pine and Gilmore 1999). The user experience can be realized by making the interaction between the user and the product unique and personal. Consumers are willing to pay for this experience. It is the task of the designer of intelligent products to uncover such unique and personal aspects, and take them as the starting point for the design of new products or systems. In many of the projects carried out by the authors and their co-workers, end-users have repeatedly indicated which product-interaction aspects they really valued. An illustrative example is provided by the "Phenom" project shown in Fig. 19.4 in which we developed a system to support the recollection of memories in the context of an AmI living room (van den Hoven and Eggen 2003). Initially, the project focused on fast and efficient retrieval of photos stored in a digital home archive. The photos were considered digital representations of memories. Interactions of users with early prototypes 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 the 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 change of direction led to many new technological challenges concerning the localization and tracking of objects and persons in the environment, the synchronization of decentralized digital databases, the development of intelligent algorithms, and the application of advanced network, display, and user–system interaction technologies.

Insight 2. The Behavior of Intelligent Products or Systems Should Fit the Rhythms and Patterns of Everyday Life

During the many interactions we had with people, time after time, it turned out that the use of electronic systems should be seamlessly integrated in everyday activities that at closer inspection seem to be driven by hidden personal and social user needs. The primary task or activity the product was originally

Fig. 19.4. Phenom – an intelligent living environment supporting the recollection of memories (© Philips Research)

designed for is carried out subconsciously focusing the "true" user experience on the underlying user needs. Family members, for example, indicated that daily household tasks like vacuum cleaning or ironing are often considered boring, but that, 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. 2003). People realize such moments are of great importance for their personal well-being and explicitly question what the personal and social consequences will be when the future Smart Home will "relieve" them from these daily household chores.

The designer of future intelligent systems should be aware of possible interferences between the use of the system and the rhythms and patterns of everyday life. Recent investigations, for example by O'Brien (1999), have shown that in case of interference, the user will not accept the new system and the system is doomed to fail.

Insight 3. Intelligent Products Should Only Explicitly Attract People's Attention When This is Meaningful and Appropriate

Based on the present situation, many people tend to worry about a future in which the number of "smart" products is said to grow exponentially. People indicated that, already now, they often feel overloaded with information that is inadvertently pushed onto them. People demand from intelligent systems that this problem is solved, or at least that it is severely reduced in order to restore a situation in which they could experience a certain degree of "freedom from choice" again. In such a situation people will only read, listen, look, choose, and act when meaningful information is presented in an appropriate manner and at a suitable moment in time.

According to Weiser and Brown (1996), *Calm Technology* that makes better use of the periphery of the human perceptual and cognitive system needs to be developed. People are only subconsciously aware of what happens in the periphery of the perceived situation, but when desired or necessary this information can immediately be put in the center of attention. Calm technology prevents overloading people with information by presenting this information in the periphery. At the same time this peripheral information gives people the feeling that they know what is happening around them and that they are fully in control when it comes to decide whether or not and when they should act. Within the "Home Radio" project this approach was investigated in more detail. A system was built that supports family members to stay in touch with each other and their home (Eggen et al. 2003). The nature of this contact can be characterized by three modes of interaction which seamlessly can change into one another: in the "ambient" mode audiovisual means are used to unobtrusively display information in the environment to create an ambience informing the user that everything at home is fine, in the "attention" mode the user consciously pays attention to the audiovisual information display, and in the "interaction" mode the user performs explicit actions to

Fig. 19.5. Home Radio – ambient awareness (© 2003 Philips Research)

extract additional information from the system about the home and/or its occupants. Experiences gained within projects such as the Home Radio project, shown in Fig. 19.5, underscore the importance of the development of calm technologies within the context of Ambient Intelligence. Designing calm interaction styles implies the integration of knowledge of information modeling and multimodal input and output technologies with psychological knowledge about cognitive processes that regulate human attention management.

Insight 4. Intelligent Systems Should be Trustworthy

People acknowledge the fact that systems can only behave intelligently when they know something about their environment. However, only a small portion of this knowledge can be preprogrammed in the system when it is bought. The greater part of the necessary knowledge has to be learned from the user, from the environment in which the system is supposed to operate, and from the actual use. People indicate they are willing to invest in this training process only when the use of the resulting intelligent system is guaranteed for long-term use. Negative experiences with computer crashes and "upgrades" to new operating systems, in particular, seem to worry people most in this respect. The user should also be able to trust the system that privacy sensitive information is in good hands. This means, for example, that personal information needs to be protected against "hackers,", commercial and/or government institutions. In the Home Radio project it turned out that at the sender site there not only was a need to secure privacy sensitive information from unwanted disclosure to close relatives, but it was also found that the receiver of personal information should be able to indicate the kind of information that he or she considers appropriate to receive. Unwanted disclosure of privacy sensitive information might negatively influence the receiver's peace of mind or, in some cases, might even burden the receiver's sense of responsibility. In general, people indicate they want to have full control over the kind of information a system is allowed to know about them and which part of this information can be shared with other people and other systems. These requirements put new challenges to designers of intelligent systems to develop tools that enable users to effectively manage their stored personal profiles.

Insight 5. People Should Always Stay in Control of Intelligent Systems

In many projects people have indicated that if needed or wanted they should be able to regain system control. This requirement has always played an important role and been a determining factor in the design rationale for favoring semiautomatic design solutions over fully automatic ones (Van de Sluis et al. 2001).

Insight 6. Building and Testing Experience Prototypes in a Realistic Setting Represents a Crucial and Necessary Phase in the Design of Intelligent Systems

In most design research projects from which the "lessons learned" described above were derived, big efforts were spent on the implementation of design concepts into working prototypes. Although these demonstrators clearly did go beyond supporting tasks, they also had their limitations. We have learned that one should go to considerable length in allowing end-users to realistically interact with and experience an application in the proper context of use. It turned out this is of particular importance for the multimodal and adaptive interaction components of the intelligent user interface. Multimodal interfaces aim to improve the naturalness of user–system interaction. True naturalness can only be achieved in the actual physical, social, and cultural context of use. We also learned that valid evaluations of adaptive systems (from a user point of view) should be performed in a realistic "everyday life" setting where adaptation of the system to the user (and vice versa) is done under "real" space and time conditions. Finally, it was found that the investigation of smooth transitions from background to foreground activity, in particular, requires believable and realistic environmental conditions.

Not only to fulfill these experimental research conditions, but also to better support investigations into the feasibility and integration of advanced technologies and to study the practical, psychological, and social implications of Ambient Intelligence, the HomeLab was built (Eggen and Aarts 2002); see also Fig. 19.6. HomeLab is a research laboratory comprising a fully furnished modern one-family home, complete with living, sleeping, and kitchen facilities. HomeLab is equipped with a distributed embedded infrastructure in which Ambient Intelligence can be developed and investigated.

Fig. 19.6. HomeLab – a peek at the living room taken from the observation cameras mounted on the ceiling (© 2003 Philips Research)

The insight that experience prototyping should be a necessary phase in any design process of intelligent products and systems concludes this section in which lessons learned were presented that are considered of crucial importance for the design of future intelligent systems. These understandings help us to set out new directions for future design research. In the following section, four different research directions are discussed that will deliver us more detailed and specific knowledge necessary to take the next concrete steps towards real-world AmI applications.

19.5 New Directions

19.5.1 Multimodal Interaction

One of the goals of multimodal interaction research is to increase the bandwidth of the communication channel available for the interaction between people and systems. By integrating multiple sensory modalities, not only when processing user-generated input, but also when generating system output, multimodal interaction better fits the human communication capabilities. This increases the naturalness of human–system interaction; see, for example Bongers et al. (1998). We believe multimodal interaction will only become more important in the context of the design of intelligent systems. Seen from the viewpoint of the system, a rich interaction with the environment is a first and necessary requirement to be able to show intelligent behavior. Multimodal-interaction technologies enable the system to extract more relevant information from the environment and to subsequently, based on explicit knowledge of the context-of-use (who is where, is doing what, with whom, etc.), take appropriate action. We are currently working on multimodal interfaces that enable systems to better identify when somebody is directing explicit attention to the system. In contrast to the often-studied "single user–single system" scenario, we investigate situations where the presence of multiple people is highly likely and the interaction with the system is interleaved with interaction between people. In such more realistic scenarios it turns out that besides the use of verbal cues (e.g., explicitly addressing the system or fitting the incoming utterance to a language model) nonverbal cues like the eye gaze of both the speaker and the listener can improve the identification of the intended addressee in mixed human–human and human–computer interaction (Van Turnhout et al. 2005)

In future AmI environments where many intelligent objects will be present, it seems inevitable that the various objects have to communicate to people what functionality they offer or what interaction possibilities they support. As mentioned above (Insight 3), this "information push" should preferably only be instantiated by the objects if it will be judged meaningful and appropriate by people. From a system's perspective this dilemma poses a complex problem that seems extremely difficult to solve by means of computational intelligence. Multimodal approaches to calm technology in which various output modalities are combined offer alternative ways to address this problem. Unused sensory channels can be allocated in parallel to the modality supporting the primary activity. These complementary modalities can be used to communicate background information that people subconsciously perceive but that can be easily put in the foreground when necessary. We are currently exploring the possibilities of haptic devices for enhancing person-to-person interaction over the Internet. More specifically, we are investigating the usability and fun of foot interaction enabled by real-time haptic signals; see Fig. 19.7. First experiments in which the Foot IO devices were used in an Instant Messaging application showed that users abundantly used "hapticons" and experienced the addition of haptics to the IM application as "more fun" (Rovers and Van Essen 2004; Van Essen and Rovers 2005).

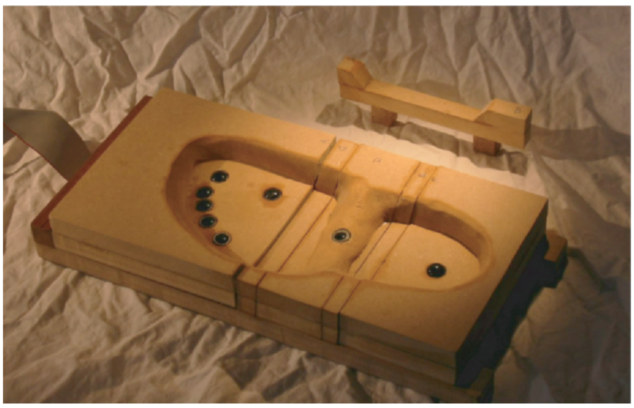

Fig. 19.7. Foot IO prototype (© Eindhoven University of Technology)

19.5.2 Interaction with Intelligent Tangible Objects

Today's electronic devices to a large extent integrate similar basic functional building blocks: audiovisual displays to present system feedback, storage capacity and processor power to store, process and generate information, and user interface components to enable users to directly interact with the system. New developments in the area of wired and wireless network technology have allowed these functional components to separate and migrate into the environment. Audiovisual displays, for example, can be integrated in tables, walls, windows, and even in clothing and storage capacity and processing power can disappear out of people's sight by being hidden in the environment. And, although, sensors, cameras and microphones, in principle, provide system designers the means to replace physical interaction elements with a perceptive environment, we strongly believe that also in the future tangible interaction objects will remain important. In the recent past, in many Ambient Intelligent projects it has been demonstrated that people like to grab and use physical interaction objects and that tangible interfaces can be very effective in supporting people to fully immerse in the creation of valued experiences (Insight 5). Examples of projects include the WWICE project in which physical tokens were designed and used to move multimedia activities in the social context of the home environment (Van de Sluis et al. 2001) and the Phenom project in which souvenirs were used to support the recollection of autobiographical memories (van den Hoven and Eggen 2003). Recent work by Fels has shown that the actions performed on an object and the resulting system behavior should subjectively match in order to guarantee that the emotional content of a message is effectively transmitted (Fels 2000). When this subjective match is sufficiently strong the object will be experienced as an extension to the human body instead of being treated as a "separated" interaction tool; the interaction has become "embodied" (Dourish 2002). When embodied interaction happens, it is the interaction itself that satisfies the user and no longer the achievement of the final goal only. Further research is needed to uncover the design requirements that tangible interaction objects need to meet in order to bring about embodied interaction.

A second line of research currently being explored concerns making tangible objects "smart" by empowering them with built in sensors and actuators, processing power, and communication possibilities. Within the department of Industrial Design of the Eindhoven University of Technology we recently started investigations into ways objects can express basic emotions through movement (Kyffin et al. 2005); see also the emotional walnut of Fig. 19.8. To explore options for adding behavioral expressions to existing movement possibilities of objects and to study the mediation of behavior a new approach called 4D sketching was developed. This method includes sketching in 3D space with the active behavior adding a fourth, temporal dimension. Easy-to-use materials for spatial sketching like foam and cardboard are used in addition to microprocessors, servomotors, and sensors to sketch the active

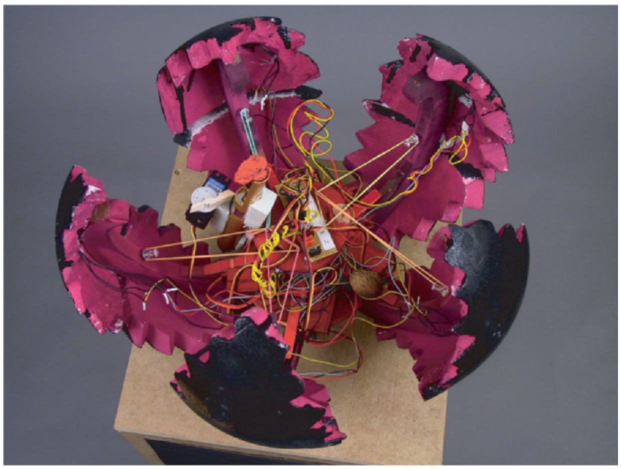

Fig. 19.8. Crack, the angry walnut machine (open) (© Eindhoven University of Technology)

behavior. Early results show that objects indeed can express at least basic emotions through movement, but also that it is particularly hard to separate form, color, motion and sound, and that an integrated multimodal design approach is needed.

19.5.3 Ambient Culture

Connectivity is one of the core functionalities of future electronic systems and offers new opportunities to connect many simple smart objects through a network. These objects can then collaborate resulting in emergent group behavior that fulfills a specific user need or supports a desired user experience. Watching television could, for example, become a total new experience when different electronic systems in the living room like lighting, sunblinds, central heating, telephone, electronic agenda, furniture, and audiovisual consumer products become equipped with "eyes and ears" and rules that define how signals in the environment should be interpreted, and the resulting behavior of the individual systems should be adjusted accordingly (Diederiks et al. 2002). It is important to realize that this collaboration does not necessarily result from explicit planning, but emerge from the relative simple interactions between the individual devices without one of them taking the central "lead." We have successfully applied such a "decentralized systems" approach in the software domain to automatically select audio tracks from a music database to generate "playlists" that fit particular moods like exciting music for a party or more relaxed music for a romantic dinner (Pauws and Eggen 2003). We are currently investigating the possibilities to embed these software agents in physical objects that can collaborate in an intelligent way with people to support the co-creation of desired user experiences (Insight 1). In general, we are interested in the ecology, the *Ambient Culture*, which will arise from the interactions between people and these smart objects and from the interactions between the objects themselves. See Chap. 3. Such communicative acts eventually will lead to a dynamic set of shared attitudes, values and goals defining the quality of the relationship of people, and their smart environment.

19.5.4 User-Centered Design

Over the years and throughout this paper we have advocated and demonstrated the involvement of end-users in the design process of intelligent systems. This so-called *User-Centered Design* approach was recently sustained by the working group "Experience and Application Research" of the ISTAG of the European Community (ISTAG 2004). We believe successful introduction and acceptation of intelligent products and systems in daily life will be strongly influenced by the way in which these products will enable people to shape and enhance their everyday social and cultural experiences. This calls for a continuous effort into the development of new design and evaluation methods that explicitly addresses these social and cultural aspects of intelligent product environments. Below we will elaborate four different lines of research.

We again want to stress the importance to better know and understand people's daily routines. People have indicated these routines greatly influence their personal well-being; see for example Eggen et al. (2003). It should be noted that, although the designers could not create the routines themselves, the electronic products they design and that take part in these routines could. Of course, any product should in first instance just offer well the functionality it is supposed to deliver. But, in addition, the designer should explore new dimensions of the user experience that enable the user to seamlessly integrate the product in existing or new routines (Insight 2). Ethnomethodology represents a direction within social psychology investigating commonsense routines people apply to manage and organize everyday life (Dourish 2002). We are currently developing new design methods based on and inspired by ethnomethodology that will be used to uncover commonsense routines that are of importance for the area of health and well-being.

The design of decentralized intelligent systems deserves special attention. As explained before, the overall behavior of a group of connected devices emerges from the interactions between the individual devices. The designer of this kind of system faces the difficult challenge to design the situational behavior of the individual product, while, at the same time, keeping an eye on the group behavior of the community of products. Currently, we are developing user-centered design methods that involve people to solve this complex design problem; see Fig. 19.9. In a "Wizard-of-Oz"-like experimental setting, persons temporarily put themselves in the position of the smart devices. In an iterative "playing–reflection" process the local roles for each "human-as-

Fig. 19.9. User-centered design – "gaming" focus group with children (© Eindhoven University of Technology)

device" are defined leading to emergent solutions that solve the decentralized design problem.

The issues of privacy deserve special attention (Insight 4). Personalization will become a key characteristic of the interaction of people with future intelligent systems. In practice, this means a system has to build up a user profile over time. The use of such a profile is especially critical when it comes to applications that support social relations between people as well as in situations in which the profile autonomously carries out actions on behalf of the user. In these situations the user should be able to trust the profile. Trust in the system needs to be building up over time on the basis of experiences obtained in daily interactions of the user with the system. Also, the way in which the user is involved in the actual building, the manipulation, the reconstruction, and the application of the distributed user profile determines the level of trust the user is willing to attribute to the system. Within the faculty of Industrial Design, we are currently conducting research on cost–benefit aspects of the disclosure of privacy sensitive information (Perik et al. 2004).

So far, the stakeholders directly involved in the development process of AmI applications mainly belonged to the design and research departments of our organizations. The next stage of design research calls for a more collaborative and interdisciplinary approach than ever before including business development. This is compounded, on the one hand, by the need to innovate more rapidly in a dynamic and shifting market, and on the other hand, by the need to differentiate in a saturated market by more fully incorporating end-user insights and providing true value. Within this context, we propose that the envisioning, designing, and development of innovative solutions require a multiple "creative process" which encompasses all the contributory issues, from people insights and context to software and platforms, simultaneously. Within Philips we have applied this approach in 2004 for the first time through the establishment of a mutual agreement among various business, design and research groups to work in partnership towards a joint vision demonstrator. This collaboration has led to its first result, the Intuitive Connected Home II demonstrator targeted at aspects of lifestyle, healthcare and well-being in the home and on the move. In the future, this approach may be adapted to enhance the way the company works with external partners to the benefits of all (Andrews et al. 2005).

19.6 Conclusion

In our work described in this paper we have always taken experience design as a vehicle to create true points of contact between people and future technological possibilities. The many AmI applications that were implemented throughout the work served as true encounters of the invisible future from which we were able to derive a number of key insights that are of prime importance for the design of intelligent products and systems. These validated insights helped us to focus our research efforts into new directions that eventually will deliver the missing detailed design relevant knowledge that we need to build the next generation of successful real-world AmI applications.