Chapter 4
Making Sense of What Is Going on 'Around': Designing Environmental Awareness Information Displays

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4.1 Introduction

Picture this: it is 40,000 years ago, and you are an early *Homo sapiens*. You are standing on the savannah. Look around you. What do you see? No billboards, no traffic signs, no logos, and no text. You might see grassland, some trees, or a bank of clouds in the distance. You are in a kind of vast, unspoilt nature reserve. Are you feeling wonderfully relaxed yet? Don't be mistaken. Unlike the woodland parks where you sometimes go walking of a Sunday, this is not a recreational environment. This is where you live. You must survive here, and the environment is full of information that helps you to do so. An animal you are going to hunt has left tracks in the sand. Are the berries on that tree edible or poisonous? And that birdsong: Does it mean there's going to be a storm and winter is on its way? Or are the silly birds just singing for their own enjoyment? You can't be sure: you have to interpret it all. And you are good at that. So good, that you have succeeded in surviving in this environment.

Let's return to the 21st century. You are an average Western human being. You are looking at a spreadsheet or a word document on a computer screen, trying to figure out what's going on. It is said that we live in an age of information. Although it is unclear what exactly this means, many of us suffer from wrist, back, and neck pain. All of us, then, have been born into a world full of abstract technologies and systems. We are forced to adapt to them in order to survive. Berries, grassland, birds, and clouds have long since ceased to be the things we need to read in order to survive. Insofar as these elements still exist in our environment, they have taken on a recreational role. Instead, we live in a world of screens. We use these flat rectangular objects to inform ourselves about the state of our world. We use screens to check our e-mail, screens to monitor safety on the streets, and screens to follow fashion. Our scientists use screens to explore the outer limits of the universe and to descend

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into the structures of our genes. A painful truth: many of us spend more time with computer monitors than with our own friends and families.

In this chapter we discuss the design of awareness information displays. More specifically, we focus on the challenges and possibilities for the design of awareness systems that aim to seamlessly merge with the physical, social, and cultural context of everyday life in order to inform people without overburdening them. The million dollar question is: How do we integrate all those indispensable information streams into our environment? The design of Calm Technology, as formulated by Weiser and Brown (1996), forms an important 'leitmotiv' for most of the research-through-design projects presented in this chapter.

The chapter starts with an overview of related work, i.e., projects addressing the presentation of, and interaction with, awareness information in the environment. Relevant work by Dourish and Bly (1992), Strong and Gaver (1996), Hindus et al. (2001), Mynatt et al. (2001), and others, will be reviewed.

Next, based on the literature and on our own reflections of Calm Technology, we introduce a number of key concepts that, in our view, play an important role in the interaction design of environmental awareness information displays. Topics that will be addressed include the different levels of awareness that need to be supported by any awareness system interaction style and more specifically the smooth transitions between these levels. The combination of different output modalities, like, for example, sound and lighting, into effective audio–visual information renderings that integrate with the environmental characteristics is another topic of interest. A third topic concerns the esthetic qualities of the information renderings that will decorate people's habitat. In view of the tension between 'signal' and 'noise,' information decoration is not only about esthetics but can also be considered a means to make the environmental 'noise' acceptable.

The main part of the chapter will consist of the presentation and discussion of three design research projects that illustrate the practical application of the key concepts for interaction design of awareness systems.

The 'Home Radio' project was developed to support family members staying in touch with their home, extending the home experience beyond the boundaries of the physical home. This project was presented in 2003 at the Home Oriented Information Technologies (HOIT) conference, but, unfortunately, the accepted refereed paper was never properly published. We will re-use parts of this paper in this chapter.

The 'Data Fountain' and the 'Birds Whispering' projects were carried out at the Department of Industrial Design of the Eindhoven University of Technology. Both projects explore the possibilities of making use of architectural space by decorating it with awareness information. The 'Data Fountain' project uses a real-life fountain to display dynamic information structures extracted from the Internet. Within the 'Birds Whispering' project audio-only renderings of a colony of birds were designed and implemented in an actual office space. Birds can roam the office space and react to the presence and behavior of office workers.

At the end of the chapter we will go over the main lessons learned in the projects and review and generalize these findings in relation to the key concepts of interaction design of environmental awareness information displays that were introduced in the first part of the chapter. We conclude by taking a philosophical look at a future in which our information-decorated environment has become next nature. It is part of the responsibility of interaction designers of future awareness systems to ensure that people can make sense of what is going on ‘around.’

4.2 Related Work

As mentioned earlier, our vision is strongly influenced by the ubiquitous computing paradigm (Weiser, 1991). Early on, Weiser and Brown (1996), the founders of this ‘third wave’ of computing, have introduced the need for what they call Calm Technology. Most devices based on computer technology, like handhelds, mobile phones, and PCs in all sorts and sizes, currently behave in ways which makes it difficult for people to ignore their presence in daily life. As human attention already seems to have become a scarce resource today, the ubiquitous computing scenario in which computers will be everywhere in our environment could easily lead to situations that would be totally unacceptable to people. This danger was actually confirmed in earlier family studies on people’s home experience where people worried about an increasing ‘information overload’ and stated that ‘freedom from choice, i.e., freedom of not having to choose or act’ should be guaranteed in their home of the future (Eggen et al., 2003).

Weiser and Brown (1996) propose how ubiquitous computing systems should engage people’s attention: ‘Calm Technology engages both the center and the periphery of our attention, and in fact moves back and forth between the two’ (p. 3). The periphery is informing without overburdening because people can attune to information without explicitly attending to it. Weiser and Brown further state: ‘The result of calm technology is to put us at home, in a familiar place. When our periphery is functioning well we are tuned into what is happening around us, and so also to what is going to happen, and what has just happened’ (Weiser and Brown,1996, p. 3). The quality of the periphery to induce a subjective feeling of knowing what is going on ‘around’ us is served as an important source of inspiration for the projects presented here.

The importance of providing informal awareness to support casual interaction has been addressed in research on media spaces for distributed work groups. Various modalities have been used to present information that supports general awareness of the daily work environments of remote coworkers. Dourish and Bly (1992), for example, displayed periodic video snapshots of selected offices and common areas at remote sites on a person’s computer screen to support shared awareness. Greenberg and Kuzuoka (2000) and Lock et al. (2000) have used physical objects, so-called tangibles, to capture and present a remote person’s activities. Audio-only media spaces have been studied by Gaver et al. (1991) and Ackerman et al. (1997). These studies all deal with the problem of how to display information about remote site activities in such a way that the risk to distract people from their main work task is minimal. By using audio or physical objects as alternative communication channels for rendering awareness information, the visual communication channel can be relieved and remain fully allocated to primary computer screen-based office tasks.

Building on the office-related research on awareness displays, a number of studies have been reported in literature that try to apply and extend knowledge available for the workplace to awareness issues relevant for the home domain. These studies differ with respect to the user needs they aim to support. Go et al. (2000) have proposed the concept of Familyware to support the shared feeling of connection between people and their extended family including close friends. People use physical everyday objects to intentionally send simple messages to their loved ones. Mynatt et al. (2001) use a Digital Photo Frame to display qualitative information about the daily activities and well-being of elderly people providing their extended family peace of mind. Hindus et al. (2001) investigated how media spaces could be brought into homes and home life to support social communication between extended family members. Besides physical objects, they also used audio-only and multimodal awareness representations to mediate shared presence. Finally, Tollmar and Persson (2002) developed a light sculpture to support remote presence for distributed family members.

The studies mentioned above share a number of similarities. They all aim to display information at the receiver's site in an unobtrusive way to ensure that a person's ongoing activities are not interrupted. Often tangible objects are used to mediate social communication between extended family members, with the exception of Hindus et al. (2001) who, in addition, studied audio-only mediated presence. In most cases, the design of the tangible objects is inspired by the work of Ishii and his colleagues on tangible interaction (Ishii and Ullmer, 1997; Ishii et al., 1998; Dahley et al., 1998) and the esthetic objects designed by Strong and Gaver (1996) to support intimacy at a distance. Except for the Familyware tools that require a person to explicitly take initiative in sending a simple message to a loved one, all other applications feature an 'always-on' display of awareness information. But even in this case, the monitoring of remote activities has to be intentionally turned on or off. Most studies mention the importance of taking the sender's privacy into account. However, little is said about user requirements that might be important at the receiver's site. Hindus et al. (2001) report that people expect that social communication devices respect privacy and that they should not create new obligations. 'Users already feel increasingly obliged to keep in touch, and can see added communication as extra responsibilities' (Hindus et al., 2001, p. 331). Similar remarks with respect to existing and future communication devices were made by the families that participated in our investigations on the home experience (Eggen et al., 2003).

Recently, a number of commercial awareness systems have entered the market. An example of a commercially available awareness system is the Nabaztag (2007), an Internet-enabled multimodal bunny (Fig. 4.1). The bunny can adjust the light in its belly, or move its ears to communicate visually, but it can also play audio messages. Furthermore the user can move its ears to communicate with the rabbit or send a message to a paired rabbit at another location. Nabaztag can connect up

Fig. 4.1 Nabaztag, the Internet-enabled smart rabbit

to a local wireless network and can be used as an alarm clock, weather beacon, traffic, and stock news/alerts. It can also accept and notify on incoming messages via Web, e-mail, SMS, phone, and spoken messages. It can be useful, for instance, if you're waiting for an important e-mail or phone call, you can go about your business and spend some time with family instead of being glued in front of the computer. When your call or message comes in, the bunny will visually alert you. Furthermore there's the ability to create and program your own content and events. You can create your own Nabcast channels and broadcast them to other rabbits. There's an API for programming and interfacing with other applications.

Ambient Devices is a company that, based on technology developed at Ishii's 'Tangible Bits' research group at the MIT Media Lab, has launched a number of awareness products that offer consumers access to digital information (Ambient Devices, 2007). Devices like, for example, the Ambient Orb and the Ambient

Fig. 4.2 The Ambient Orb and the Ambient Umbrella of Ambient Devices

Umbrella are part of a bigger system solution that includes a service delivery infrastructure (Fig. 4.2). The Ambient Orb is a frosted-glass ball that glows different colors to display real-time stock market trends, traffic congestion, pollen forecasts, or any other ambient information channel: weather, wind speed, pollen, traffic congestion, energy pricing, and more (Ambient Devices, 2007). The handle of the Ambient Umbrella glows if rain is forecast, reminding its owner. One's actual decision to take it might be influenced by the frequency the handle pulses.

In the next section we discuss, based on the related work presented above, a number of key concepts we consider of particular interest for the design of environmental awareness displays.

4.3 Key Concepts

4.3.1 Smooth Transitions Between Levels of Awareness

In natural situations the availability of information is often very smoothly regulated. Consider the weather as an example. During the day you are more or less aware of the state of the weather. Before you go out you explicitly decide whether or not you need an umbrella. Implicitly, you already knew whether the umbrella question was relevant. Imagine that you were completely unaware of the weather and had to check a Web site to find out if you need an umbrella when you leave your house. Sounds absurd? Still, this is the model in which information is often presented to us. The Ambient Umbrella of Ambient Devices (Fig. 4.2) provides an interesting alternative to this problem although the spatial accessibility of the ambient information might be restricted depending on the physical location of the umbrella. Its location might be perfect if the umbrella (stand) cannot be perceptually missed while going away. In case the umbrella is out of sight, however, ambient information is lacking and explicit action needs to be planned to check the umbrella handle in order not to get soaked. Information designers are usually inclined to place the message at the center of our field of attention (to make sure it comes across). Did no one ever tell them it can be considered impolite to always come straight to the point? We humans have evolved precisely to attend to information at the edges of our field of attention, and when necessary transfer it to the center ourselves. Some data should be continuously available in the environment – not in the center, but rather at the border of one's attention focus. When designing ambient awareness systems it is crucial to be attentive to the different possible levels of awareness and the transitions between them.

4.3.2 Combination of Different Output Modalities

The rectangular flat screen is the default and predictable choice for an information display, while other solutions can be cheaper, more elegant, or more effective. Depending on the environmental circumstances and the required level of awareness other information displays than the ubiquitous flat screen should be designed based on alternative output modalities: (indirect) lighting, sound, gesture, touch, or even odor. Having combinations of different output modalities can support transitions between different levels of awareness. Also, different output modalities can be combined into coherent dynamic behavior patterns of tangible objects (e.g., Nabaztag). The mapping between information and modalities can be organized in a sequential or parallel way (Coutaz et al., 2005).

4.3.3 Context is Content

We believe 'context' plays an important and often underestimated role in human communication and cognition. As an example, let's consider the following situation. Suppose a man and a woman are having a love affair. They go out together, are having a nice time and after a while he uses the three words: I love you. This terse sentence touches on a truckload of associations: Shakespeare, Casanova, Titanic, and soap operas. 'What do you mean?' strictly speaking could be her only valid reply. It's amazing that she still understands what he says. She deduces his romantic intentions from the way he touches her and the look in his eyes. The place they are in and the memories of their earlier experiences. In fact: from everything except his words. For these words are so full of meaning that they've become totally meaningless. This example shows how context can determine content. Implicit information plays a bigger role then we are often aware of.

Now then, what happens if we start looking at every pattern in our environment as a possible information carrier? Look around you, wherever you are. Try to recognize all of the forms and patterns in the spacesuch as the flowered wallpaper, the humming of the air conditioning, the fish in the aquarium, and a shadow on the wall. Do you realize how few of the patterns in our environment are being used as information carriers? Information overload? What information overload? The so-called information society has barely scratched the surface of our human bandwidth. We see enormous opportunities for situated information appliances that are tightly integrated within their context. While currently information carriers are usually developed as such and randomly put inside an existing environment, we should move toward integrating them with the environmental characteristics. Our environment was previously made up of objects; now it consists of information. When architects design buildings, they will have to consider to what degree those buildings function as information carriers. (If they neglect this, they run the risk of LED screens being attached to the buildings in due course.)

4.3.4 Information Decoration

Besides the fact that we can learn a lot from old nature, where information is present in a well-integrated way, we think we can learn from the decorative world. For centuries, people have been utilizing decorative patterns, indoors and out, with the aim of improving and giving an identity to the atmosphere around them. We believe environmental information designers can learn from the world of decoration. The primary goal is not information but esthetics. Information decoration means seeking a balance between esthetic and informational quality. Of course this is not always appropriate; some messages (such as fire alarms) are too urgent to work subtly into the wallpaper and must be brought to attention unambiguously. But even in the preamble of a potential disaster is the level of urgency gradually building up over time. This increasing urgency could be 'calmly' presented in the environment in order to set optimal conditions for vigorous human action to control the damage or even prevent the accident from happening. Information decoration lends itself primarily to the kind of data we wish to have available at all times but to be able to ignore: the online status of my friends, the traffic update, the weather forecast, and the number of unread messages in my inbox.

We want to emphasize that information decoration should go further than just making data look better: it requires a genuinely different information model. Traditional information theory usually advises against things like ambiguity and repetition. In information decoration, these factors play an influential role, because ambiguity and repetition are classic esthetic means of achieving interesting images. The big advantage of information decoration is that if it's not informative, it's still decorative. That's more than you can say for most contemporary carriers. Information decoration is not only about esthetics but can also be considered a means to make the environmental 'noise' acceptable.

A simple example of information decoration is depicted in Fig. 4.3. In addition to its default explicit digital time display, this cooking timer has a 'information decoration' modus in which the passing of time is displayed implicitly through the number of blocks piled at the bottom. In this mode it resembles a sandglass with a natural 'analogue' appearance (Amadana, 2007).

Fig. 4.3 A typist's work environment

4.4 Case 1: Home Radio

> I have completely lost time while writing the paper. But over the last couple of minutes, the feeling that now it is really time to quit writing and leave for home can no longer be ignored. Subconsciously, I know dinner preparations back home are in full swing. Right on time, the changing office atmosphere, once again, has gently but effectively interrupted a satisfying flow experience. Family, here I come! Am I hungry!

The Home Radio concept was developed to support family members staying in touch with their home, extending the home experience beyond the boundaries of the physical house. The focus is on families that still live together sharing one physical house. The need to stay in touch for these families may differ from the needs of extended families, i.e., families that no longer share the same house. An ethnomethodological study on people's home experience showed, in line with Hindus et al. (2001), that family members are first of all concerned with other members of the household (Eggen et al., 2003). Together they form a small and intimate community that uses communication technology, not only to express personal intentions and emotions, but also to convey presence and concern (Tollmar et al., 2000). Communication needs with respect to the extended family can be very different. Mynatt et al.(2001), for example, developed the 'Digital Family Portrait' concept that provides awareness of the daily life of senior adults, addressing the desire of extended family members to keep their parents safe. In this section, we describe the two design cycles that led to the Home Radio concept.

4.4.1 First Design Cycle: Sound Solutions

The scope we set for the first design cycle was to find an adequate process for acoustically representing people, objects, and activities in the home, and to explore if the home feeling could be remotely experienced by using the auditory modality.

4.4.1.1 Design Rationale

Based on the earlier mentioned home studies (Eggen et al., 2003), we set the following high-level goals for the first design cycle:

- The information should be presented in the background, creating a reassuring feeling that everything at home is fine.
- The information provided should only be in the foreground when it is meaningful and appropriate. The system should not interrupt and distract attention from other activities unless there is a good reason to do so.
- The system should support smooth transitions from subliminal awareness (background) to direct interaction (foreground), to avoid messages that unnecessarily attract attention by their sudden appearance instead of their inherent priority.
- People should have control over how the system deals with privacy, both at the sender's and the receiver's site, to avoid that too much detail or a certain category of messages leads to undesired exposure or monitoring of people and their activities.

4.4.1.2 Main Findings

During the first iteration cycle of the Home Radio project, we encountered many design issues for which ready-made solutions were not available. Small-scale sound design activities and informal pilot tests were applied to explore the possibilities for using sound to design a system that supports family members to stay in touch with the emotional and intimate qualities of home life while being away from it. We gained a deeper insight into the problems that have to be dealt with when designing such a system and we were able to refine some of the requirements for future realizations of the Home Radio concept.

The main findings of the first design cycle in which we explored audio-only solutions can be summarized as follows:

- Modeling home life is complex. The first design cycle clearly established the need for a home information model that describes people, home objects and activities and their relationships. This kind of information is considered crucial for the successful development of meaningful representations of home life that can be remotely experienced by members of a household.
- Special attention is required for the level of detail that needs to be encoded in the audio stream. Preferably, different levels of representation should be supported, including an interaction model that enables people to listen to details (zoom in), or ignore details and listen to the overall situation (zoom out).
- The event-to-sound mapping should not be too explicit. Users should always be in control of the system to prevent overexposure and privacy conflicts.
- Sound is a volatile communication medium. Capturing or replaying of information to get a better overview of current or past events is not supported in an 'always-on' scenario. Multimodal information displays (including sound) could overcome this drawback.

4.4.2 Second Design Cycle: Home Radio

Based on the lessons learned in the first design cycle, we added the following goals to our original list of design goals for the second design cycle:

- The audio-only design space should be expanded by including other interaction modalities.
- The interaction environment should be taken explicitly into account in the design of the output of the system.

4.4.2.1 Exploration of the Design Space

The design space was opened up by relaxing the audio-only constraint. To systematically explore this space we decided to follow a scenario-based design approach. Initially, a total of 19 scenarios were developed covering a wide range of design solutions. These scenarios describe user−system interaction behavior in a specific context of use with a focus on communication and interaction.

The scenarios featuring the different design concepts were systematically evaluated and weighed against 25 criteria. These criteria were derived from the requirements for the Home Radio system mentioned earlier and from user, business, and research criteria used in the Home Experience study (Eggen et al., 2003). The criteria were grouped according to the following themes: integration in the cultural and physical environment, supporting personalization, design principles for intelligent environments, and feasibility. Systematic analysis of the scenarios enabled us to identify the strong aspects of the various design proposals. It also helped us to specify aspects that needed special attention during the design of the final concept.

In-depth discussions about what exactly should be communicated through these concepts and how this relates to the privacy of the members of the household led to the following line of thought. By asking people what they want to know about their home while being away from it, we realized we had been focusing on the house as a medium. By reconsidering the house as a physical structure, we realized that this structure is not static at all, but that it becomes alive when people are present in it. For example, water and gas start to flow through pipes, electricity and data streams run through cables when activities take place. These utility streams can be considered the veins of the ‘modern’ home. They partly behave autonomously, as is the case for energy consumption caused by equipment in standby mode, or by heating systems that are automatically controlled by thermostats. But in many cases, the utility streams are caused by inhabitants interacting with objects or involved in activities, for example, when taking a shower, or opening a fridge. This insight that home activities can be traced in terms of fluctuations of the utility streams and the notion that the signatures of these fluctuations can be used in defining an activity, became the guiding principle of the next phase of the project where design solutions had to be generated.

4.4.2.2 Generation of Design Solutions

Before the actual design of the final Home Radio demonstrator started, we further explored the utility streams concept through the analysis of a 'day-in-the-life-of-...' scenario. A newly written scenario featured the fictional 'Rodenburg' family and focused on different members of the household: one family member at home, creating the stream and another person at work, experiencing the stream. The story describes events such as watching television, leaving home, taking a shower, etc. Special attention was paid toward key events where communication between the home and its inhabitants was particularly valued. We also looked at the effect of these events on the utility streams.

From this exercise we concluded that utility streams indeed create patterns that people can use to extract meaningful information about home activities. The abstract representation of this information shows great promise with respect to meeting the privacy requirements that were stated for the Home Radio concept. It was also noted that the home life involves many rituals. These rituals give rise to recurrent patterns of activities. After sometime these patterns will be subconsciously perceived by the user of the system and become part of the periphery.

One of the concepts, which used moving images on a wall, and was nicknamed the 'Rotating Lantern,' seemed to best support the utility streams concept. The output of the system consists of audio and video projection. The composition of this output is determined by the number and intensity of the utility streams. Also the environment in which the output is presented is considered important for the communication and interaction.

Audio. The audio part of the interface consists of three categories. The first category consists of four characteristic sounds that each relate to a specific stream: bongo-like sounds for electricity, bell-like sounds for communication, string-like sounds for gas, and water-like sounds for water. The volume of each of these sound streams relates to the intensity of the corresponding utility stream. Interaction with the system has no effect on these sounds. The second category consists of sounds which are heard when a new activity appears in the interface. These signaling sounds are gentle chimes. Finally, the third category is a sound which acts as feedback on interaction with the system. This sound is heard as long as someone is 'zoomed' in on a specific activity. The sound resembles wood-chuck rhythms.

Video. Within the projection, activities are graphically visualized as blocks, the color relating to the nature of the stream: yellow for electricity, green for communication, red for gas, and blue for water. The size of a block relates to the intensity of the corresponding utility stream. The blocks enter and leave the canvas at certain moments in time. When blocks are entering or leaving the stage the other blocks will shrink or grow in size to find their balance. When a block enters the canvas the other blocks are pushed to the right or pushed downward. The latest additions are always situated in the top left corner of the canvas, thereby creating a time line. On top of the blocks highly transparent images are seen which gives the squares a kind of texture. The transparent image can be seen more clearly by selecting a block, thus slowly making the image less transparent. An impression of the wall projection is shown in (the background of) Fig. 4.4.

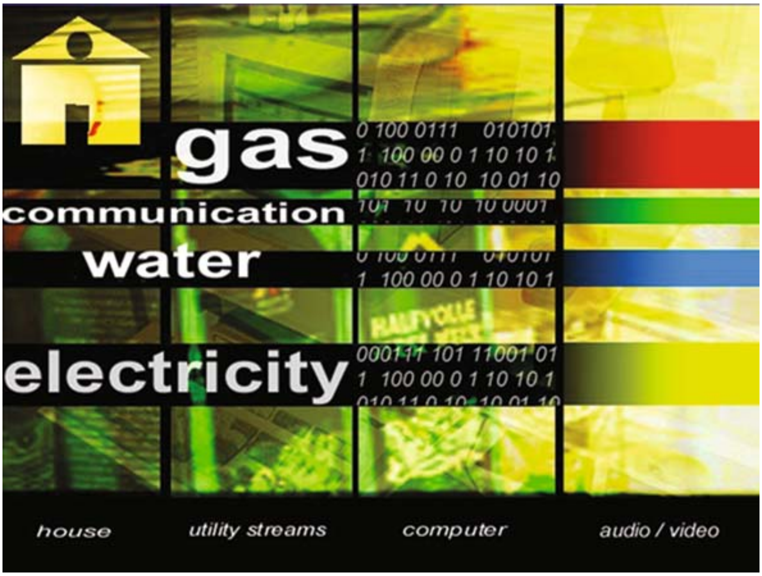

Fig. 4.4 Home Radio – video projections of utility streams

Environment. The system is projected in an architectural space. When projected on the ceiling above a desk, light reflected from the ceiling causes a 'blended' color glow on the desk and its surroundings. Together with the sound this creates an ambient information display.

Interaction. Different states are distinguished that describe the way a user interacts with the system. These states range from ambient communication/ interaction to direct communication/interaction.

1. *Ambient*. In the first state, the system is present all the time but very much in the background. The user is doing activities and the system is used to enhance the environment (context of use) in an atmospheric way (much like the way we play a CD or adjust lighting in a room). It is an ambience which surrounds us. In this state the sound and light are present but not obtrusive. It sets a scene to pleasantly work in. But this system is not just a system to create an ambience; it is also capable of sending information to the user. The user knows that this stream is related to events that happen somewhere else, and is therefore aware of meaning in the sound/light. This may be a learning process in which a person expects certain sounds/colors on certain times. She 'knows' the normal behavior of the system, and therefore also recognizes differences from the usual. The system is in its most ambient state and the user can experience this as pleasurable without wanting to know more. Feelings of the user can be that she likes the ambience and that she feels that things are happening. Her home is alive, and fluctuations are subconsciously perceived.
2. *Attentive*. The user enters a second state when she is intrigued by something that triggered her in the first state. It can also be that the user is just curious

and wants to be entertained. It should be noted that when a user is adapted to the system, information can enter the user on a subconscious level; someone just reacts without knowing why. The information presented in this state is still abstract but more structured. The activities can be distinguished from each other, and processes can be monitored more closely. If in the first state she noticed that some activity was dominant, she can now see if it was just one element, several elements, or even which activity exactly. But still there is a possibility that she does not understand the information or that she recognizes something that deviates from the 'usual' is out of proportions. Then she should be able to enter an even more specific level, namely the third state.

3. *Interactive*. The third state provides the maximum level of information the system can give about the streams. It is exact information which has lost its ambient character. This part of the system is only reached when a user has a direct interaction with the system. This interaction should be fun and natural and a user would like to do this even when she is not triggered specifically but just want to play around. The means of interaction and the specific information given have not yet been defined in the system. In the current demonstrator this is done by selecting a block with a pointing device. In future realizations, we would like to explore direct interaction through speech or gesture.

An artist impression of the three different states is shown in Fig. 4.5.

4.4.2.3 Evaluation and Main Findings

The Rodenburg scenario was re-used as an evaluative tool. A part of the scenario was refined and used to drive the demonstrator. A 'real-time' experience was simulated based on a fictional hour of activities. The demonstrator was subjected to an informal appraisal involving a small number of user interface experts. Below we discuss some of the remarks made and issues raised by the experts.

The experts thought the audio–visual representation showed great potential with respect to its ability to present information in the background. The combination of visual projections in the environment and the subtle sounds that signaled the start of new streams entering the display scored were believed to facilitate smooth transitions from background awareness to the attentive and interactive states. The experts found it difficult to assess whether the current implementation could create a reassuring feeling that everything at home is fine. To answer this question the system should not only be assessed for a longer period of time, but it should also be installed in the physical, social, and cultural context of a real home.

The utility streams idea was judged attractive and novel. In particular, this concept scored high with respect to possibilities to properly deal with privacy. Privacy of the sender seems to be guaranteed, but also at the receiver's site there seems to be a number of advantages. It is very difficult, if not impossible, for people who do not belong to the household to interpret the changing audio and visual representation. Correct interpretation can only be achieved if the patterns of home life of that family are known and learned.

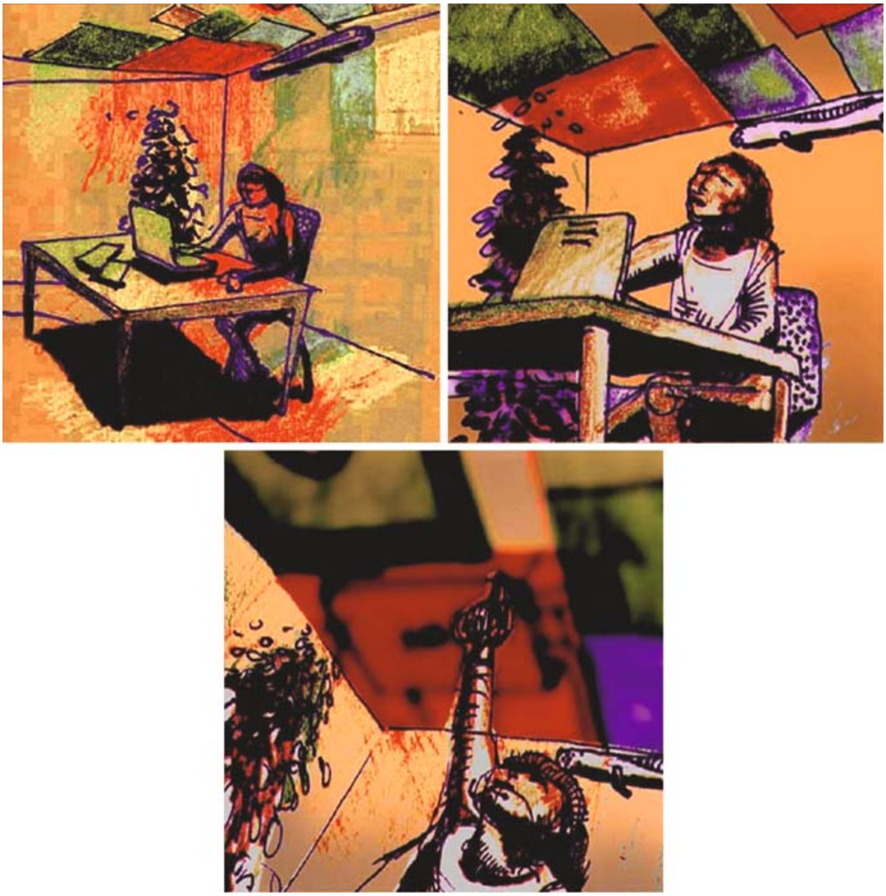

Fig. 4.5 Home Radio – interaction states: ambient (l); attentive (r); interactive (b)

People can interact with the system in an implicit or explicit way. In the current system, the implicit way of interaction has been studied. At the sender's site, the inhabitant carries out her own activities and the system taps into the traces the activities leave in the utility streams. Would people find this too much of an intrusion? Would they prefer to interact with the system in an explicit way? If this is the case then she actively interacts with the system and the issue shifts from 'privacy' to 'personal expression.'

The visualization part of the interface could have been more dynamic. In the current system all new activities start from the top left. Although this creates a time line it might look a bit boring. Other solutions can be found like surfacing from the middle and letting other blocks get pushed in all directions. The system, then, only moves when there are fade-in and fade-outs. This may not be realistic because the streams themselves are not constant but have their own fluctuations, thus having effect on the interface.

Overall, the user interface experts were positive and thought the current demonstrator complied to a large extent with the requirements that were defined at the start of the project.

4.5 Case 2: Data Fountain

> In the morning paper, I can read the weather report as well as the stock quotes. But when I look out of my window I only get a weather update and no stock exchange info. Could someone please fix this bug in my environmental system? Thanks.

Fountains are charming phenomena. You find them on squares, in gardens, or even indoors on tabletops. Usually a fountain is placed in a space for esthetic reasons. Despite of the fact that they are artificially made, people associate fountains with a sense of naturalness. We find this intriguing. A fountain is perceived as a source of quietude, not stress. People experience a fountain as a pleasant object in their environment. This quality makes it a suitable object for 'calm' technology. The goal of the Data Fountain project is to rethink fountains as information displays. Of course fountains that vary their spouting pattern already exist. The water ballet is well known. But always, an emotional value of some sort (often music) is translated into the emotional value of the fountain. The notion of displaying 'explicit' information onto the fountain is new. The esthetic value of the fountain display is a huge benefit in information design. Its presence won't bother people who are not interested in the data; information decoration instead of information push.

We equipped fountains with a control that can vary the height of the water jet (see Fig. 4.6). Through an Ethernet connection and a frequency modulator the fountain pumps are controlled. The fountain will function as a calm display. It can display the latest traffic news, remote weather conditions, train departure times, the amount of people waiting in line at a post office, etc. Or, depending on the context in which the fountain is placed, more personal data like the amount of e-mail in your inbox or the distance between yourself and your lover.

4.5.1 Mapping Money Currency Rates to Water Jets

Our Data Fountain was connected to real-time money currency rates on the Internet. It is refreshed every 5 s. This mobile fountain measures 5×4×3 meters. The relation between money and water is evident. On our Data Fountain we display the Yen, Euro, and Dollar (¥€$). Currency rates are closely interconnected; their interdependence is visible in water. The design of the casing was kept as minimal as possible. The water is the thing to look at and listen to.

It was our goal to display a general 'feeling' of the relation between the different currencies in the water jets. The currency exchange rates are available with a four digit precision (0.0000). Within this short time span, the currency rates alteration is generally very small or zero. The larger changes in the currency rates are a result

Fig. 4.6 Data Fountain, money currency rates displayed with an Internet-enabled water fountain

of many microfluctuations that happen over time. Through a short user survey we learned the perceived strength of a monetary value is derived from both the long-term relation between the currencies and daily fluctuations (see Fig. 4.7). At first we tried a linear mapping of the currency rates onto the fountain jets. Due to their smallness, the microfluctuations became invisible. The result was a fountain that changed slowly over a few days time. This didn't satisfy us, so we decided to try a more sensitive mapping. Now the microfluctuations were visible but took precedence over the long-term development. This resulted in a very noisy and seemingly randomly moving fountain. We wanted to display both the long-term development, as well as microfluctuations to control the height of the fountains. In the final design the basic level of the fountains is derived from the longer term development of the currency rates. This basic level changes slowly over time. In addition to that we exaggerate the microfluctuations with temporary 'jumps' and 'drops' of the water jets. The jumps and drops generate the lively expression of the real-time trading taking place. For instance, if the dollar rises on a certain day, the dollar jet will make many upward jumps throughout the day. This is perceived as an optimistic (rising) dollar.

4.5.2 Rethink Fountains as Information Displays

When we see a fountain in public space, we always wonder what its spraying pattern tells us. Usually fountains are just standing there being decorative. Perhaps in

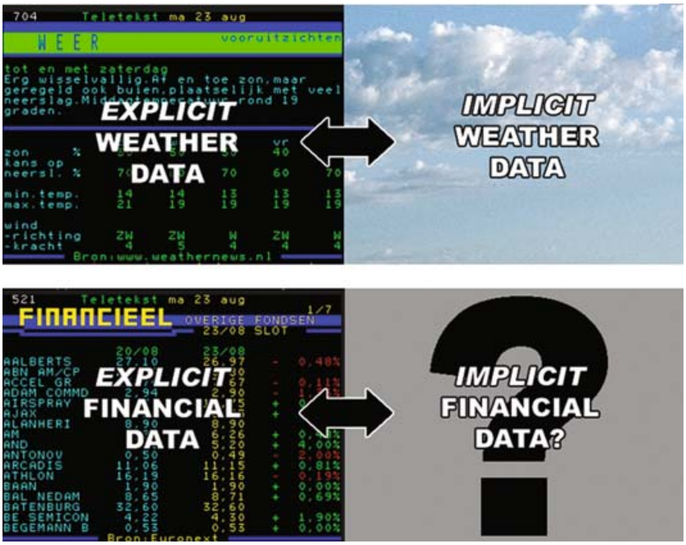

Fig. 4.7 Data with natural phenomena, like for instance the weather, usually explicit as well as implicit data are available. For abstract cultural data, like for instance financial information, the implicit data is missing!

Fig. 4.8 During the project we considered various ways to present the currency rates information, among them the data plant

the future, it will be considered rude to place a fountain in public space that has nothing to say. The information displayed on the fountain will become part of a discussion about the design of public space. The context plays an important role in the communicational value; a fountain in front of a metro station will probably means something different than a fountain in front of a stock exchange.

4.6 Case 3: Birds Whispering

> Sometimes I can hear the birds whistling in my office. Normally you don't hear them, but if you listen carefully, you do. They give me a cozy feeling that makes me want to take a break from work and go for a walk to the coffee machine. I know some of my colleges are there, because they are represented by the birds. One bird for each person. Good chance we will have some informal chitchat, down the hall.

In this project bird sounds are used to communicate information about people and places. The sounds of birds function as a calm information display that represents the presence of certain people in a certain space. When you are outdoors, in a garden or in the woods or even within cities, you continuously hear the sounds of birds whistling. To us, these bird sounds are meaningless; the information is meant for birds only. But has it been always like that? Forty thousand years ago people might have suspected hidden messages about the future, the weather of something magical within the sounds of birds. Evolution equipped us with lots of subtle sensibilities to gather information from our environment. In this project we made the birds' whispering meaningful again.

4.6.1 Representing the Presence of People Through Bird Sounds

The goal of the project was to create a subtle indoor soundscape that was pleasant to have around, but also informative in relation to the presence of people in the space. The project was conducted inside one of the office gardens at the TU/e Industrial Design faculty. The goal was to create a virtual colony of birds inside the office space that would react to the movement and activities of people in the space.

4.6.2 Noise vs. Silence

Sound has a possible (both positive and negative) influence on our function. Because we receive signals from our surroundings our level of activation increases (physiological arousal). In a space where there are no external stimuli at all, such as sound, air current, sufficient light, smells, or changes of it, we will feel stifled or musty. At this moment we become insufficiently irritated and our level of activation is low. This possible negative influences our performance level. The faster fatigue of people who are hard of hearing originates beside other factors also. Sound can irritate us also and can become an annoying experience. It will act then as a stressor.

Psychologically it is interesting that the sound of one's own drilling machine arouses less irritation than that of the neighbors even though it's louder. People are not used to silence at all; there are sounds and noise everywhere. Even when people define a specific place as silent, there will be always some background sounds such as the wind, a fan somewhere in the distance, or some other rustle.

4.6.3 Sound Design

The choice for bird sounds was made at an early stage of the project. After considering different types of more abstract soundscapes, we easily converged to the use of bird sounds. Although we were a bit concerned that the user group would perceive the bird sounds as kitsch, it turned out they appreciated them as long as they were lively and non-repetitive and kept in the background. To meet this requirement a system was build to generate dynamic and complex bird whistling from snippets of bird sounds.

We investigated different methods to generate the birds, and there are basically two approaches:

- The birdsong can be synthesized using a program like MATLAB or a regular synthesizer, or, alternatively,
- They can be sampled and filtered to remove the background noise.

The big advantage of synthesizing over sampling is that the sound is created with absolutely no noise and acoustics. The sound won't need any cleaning and sounds like it is produced inside the very speaker. A disadvantage, though, is that subtle effects which real birds can add to their sounds, like their own 'timbre,' are very difficult to reproduce with formulas and buttons. An extreme example is the sound of a crow: this is simply impossible to create without sounding at least a bit fake. We concluded that only birds that 'peep' and have basic songs can be synthesized convincingly. Exact copies of the songs of, for example, a Goldcrest are still nearly impossible to make. The birds we synthesized turned out more like imaginary birds, based on real ones. This is no problem though, as they still sound like the real thing; people didn't notice that a particular birdsong that is being generated does not really exist as long as it sounds convincing.

With only birds that peep and make simple songs, the soundscape becomes very monotonous. So 'back up' our synthesized birds, we wanted to add some really familiar birds in the form of samples. We also added sampled songbirds to increase the variety of sounds. We noticed that although a sample can sound a bit unclean when carefully auditioned, the samples really don't sound bad when they are put into the composition of birds. And because there was no other way to add more complex birds, we decided to use both synthesized and sampled sounds in our soundscape.

Especially for the songbirds, we had to make some sort of algorithm that plays the different sounds the bird can make, but doesn't sound like it's constantly repeating.

The way we did it was by breaking up the birdsong or sound into small segments in such a way that they could all be played in random order. Say you have a birdsong with four segments. If you just play it you will have one variation. If you split it up and randomize the order of the segments every time it is played, you suddenly have 24!

The birds that we chose all live in the Netherlands. We didn't want the workspace to turn into a rainforest or any exotic habitat: the birds should all be familiar so that they conform to our everyday experience of being outside.

4.6.4 Scenarios

Another important design decision dealt with the relation between the birds and the people. Various scenarios were considered. In an early scenario, which was not implemented, the idea was to have the bird sounds represent absent people. The main function of this concept is that the emptiness created by an absent colleague will be filled up, so that a team of coworkers always is 'complete.' Every person has got his own sound, and if that sound is played then the rest of the team will know who's absent in the group because they will recognize the type of the bird. In this concept every person would have a sound which represents his character. Absent colleagues would be able to communicate through the birds, for instance when working at home. A possible disadvantage of this system is that the bird sounds can irritate the present persons in the group. The team members do know whether someone is absent or not, so they probably don't need sounds to hear that. But on the other hand, the sounds might be a nice way to fill the silence.

A second concept was the 'Utility Bird' scenario, in which the soundscape is used to convey information about the tools, appliances, and resources relevant for the workspace: the printer, meeting rooms, coffee machine, elevator, and toilets. This system is very functional, and therefore the information is relevant because it provides information about your workspace. If you understand the system and it doesn't matter in which state of understanding you are, you can get a lot of information out of it; you are able to know if it had sense to go to a meeting room because you are able to hear if it is occupied or not. The same for the printer; it is useless to print a file if you know that there are 100 pages of printing in line with you. What is very important is to understand that the information is definitely not in the foreground, and so it will never force itself. We think it positive that this 'Utility Bird' scenario has a learning curve. If you work on a place for a longer while, you will probably just know where all the bird songs are coming from, without anybody telling you: 'if you hear a swallow singing, the lift is being used.' We don't want to tell people what the birds are telling, they would have to find out by themselves. The exciting thing about this concept is that one bonds with the system because everyday it is better understood.

A third concept, which we fully implemented, was the idea of the bird colony as an autonomous entity, with a natural tendency to move to the quiet places in

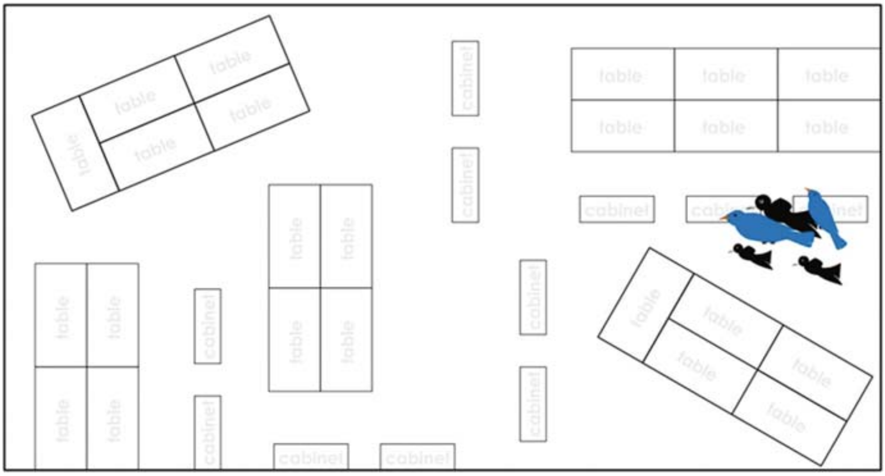

Fig. 4.9a The birds are just flying around in the workspace

the office space. This was realized with a system consisting of eight speakers and eight microphones. Using Max MSP the sound levels of the eight locations in the room were continuously measured. The virtual birds could move between speakers and did so depending on the sound volume measured at the location of the speaker. Once people would move into an area and started conversations or made other kinds of sounds, the birds would find their way into a quieter area of the office space. The final result was a subtle soundscape of bird sounds that emphasized quiet locations in the office space to the inhabitants (Figs. 4.9a, b and c).

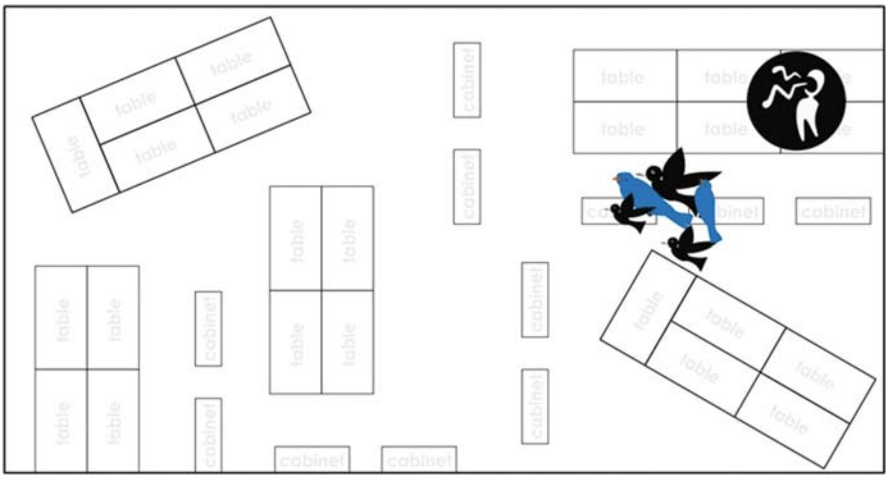

Fig. 4.9b . . . until they get disturbed. When people are talking loudly, they will fly away to a place where it is quieter

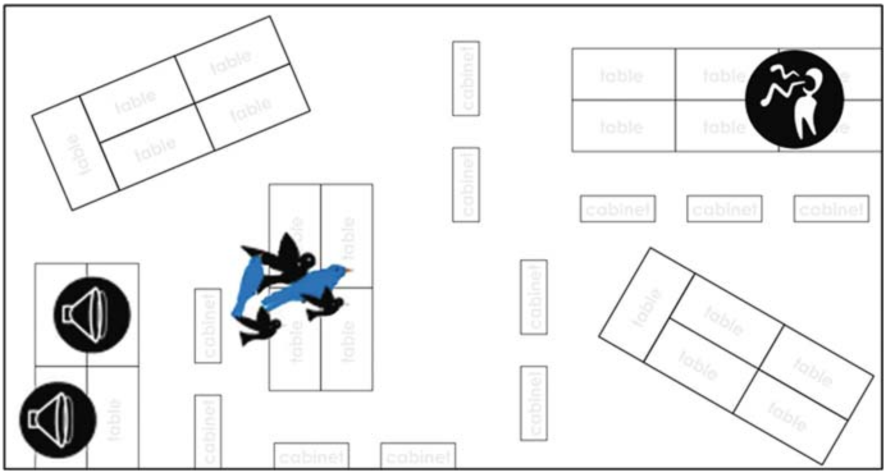

Fig. 4.9c And if someone turns on music this place, the birds will search for another place. The birds will always fly to the quietest place

4.7 Discussion and Conclusions

It is said that we live in an information age; that is, we face big challenges concerning information management. Evidently, the manner in which information is made available is not optimally matched to human perception, or more precisely, human bandwidth. Today, duplication of data has become extraordinarily simple; it is high time we adjust its presentation to suit human beings' needs, abilities, and desires.

In this chapter we explored alternative ways of designing environmental awareness information displays. We introduced a number of key concepts that play a role in the design of environmental awareness information displays:

- the different levels of awareness that need to be supported by any awareness system interaction style and more specifically the smooth transitions between these levels,
- the combination of different output modalities, like, for example, sound and lighting, into effective audio–visual information renderings that integrate with the environmental characteristics, and
- the esthetic qualities of the information renderings that will decorate people's habitat.

Different levels of awareness and smooth transitions between these levels were explicitly addressed and designed in the Home Radio project. The combination of different output modalities into effective audio–visual information renderings that integrate with the environmental characteristics were realized in the Home Radio (sound and lighting) and the Data Fountain (visual and auditory information) projects. A focus on esthetic qualities steered the design of the information renderings of the Data Fountain and Birds Whispering projects. Also, in these projects, the characteristics of the real-world environment in which the designed artifacts are ultimately supposed to come into existence determined the final information renderings to a large extent. In these projects we explicitly faced the challenge to design a balance between pure information and esthetics. Where traditional information theory usually advises against ambiguity and repetition (redundancy), we learned these factors play an influential role in information decoration. This finding is in line with what is known in the arts where ambiguity and repetition are classic esthetic means of achieving interesting images.

Today, we still live in a world of screens. They were originally found only in offices, but nowadays the screen virus has spread to shops, squares, and railway stations – more or less all public space is filled with them. According to Dutch government guidelines, a screen worker may spend a maximum of 6 hours a day working at a monitor. It is unclear to what degree they took into account exposure to garish LED screens on the street when this rule was formulated. Personally, it gives us a dreadful feeling when after a long day of computer work, on our way home or during a night out, we are once again forced to look at a screen hanging randomly in public space. The really brutal thing about screens is that they seldom enter into a relationship with their environment. Some new TVs, though, might form an exception, as they have ambient lights (for instance, on the back of the screen) controlled by the image on the screen (Diederiks et al., 2004). In general, however, screens are isolated, draining elements that do nothing but try to seize our undivided attention and turn our environment into a Swiss cheese of realities (screens are even more obtrusive than, say, posters, which stand still and have a light intensity linked to their environment). Perhaps you would expect us to start arguing now for screen-free environment. But that is not what we set out to do. Despite our criticism on the contemporary ‘screen virus,’ the merging of virtual and physical spaces is an inevitable development, and we should welcome it. After all, remaining seated in front of the computer, stiff from RSI, is no alternative. If we are charitable, we can look at the contemporary screen virus as a transitional phase – a growing pain, if you will, of the information age. Tiling our environment with screens is an extremely literal, and on top of that rather unimaginative, way to introduce virtuality into the physical world: simply piling it on where seamless integration was what was wanted.

Although they are made to inform us, all too often the busy flickering noisy screens are also a source of distraction. They demand our attention, thus creating a nervous and restless environment. Is this the future of our environment as an information carrier – feeling as if you’re being pounced on by a lion at every street corner? No thank you. ‘Attention’ is the scarcest resource in the information age. We like to sustain the claim by Weiser and Brown (1996) that the periphery can and should be used to calmly inform us without overburdening. There is still sufficient space at the edges of our field of attention; let us utilize our human bandwidth sensibly.

Before human cultural progress went in full swing, the environment was our interface and evolution equipped us with the capability to read our environment for vital information. Today, the phenomena of old nature – clouds, wind, trees, birds, etc. – are no longer crucial for our survival. We've long left the savannah and have become dependent on abstract and complex data that is habitually presented to us in ways that force us to adjust to the world of systems. Technology is getting so omnipresent up to the level that it is becoming our next nature (Mensvoort, 2006). As a result of ambient intelligence, our environment becomes the interface, again. It is part of the responsibility of interaction designers of future awareness systems to make sure that in this next nature people can make sense of what is going on 'around' them. In old nature the availability of information is often very smoothly regulated. We believe this can be a source of inspiration in designing these systems, but wish to stress this should specifically be searched in the pragmatic functioning of the older natural phenomena (just mimicking the first appearance will only lead to the frustration of the fake, the less powerful derivative). In our design research we have experimented with different materializations. We conclude that being inspired by old nature does not necessarily mean that the new design will have the same appearance as the source of inspiration. No plastic flowers please! We want new wallpaper. We want new furniture. We want a houseplant that has something to say. New media may lead to new types of perceptions that did not exist before, but nonetheless feel natural. Paving stones that show us the way. Trains that blush before they take off. When autumn comes, the street will be littered with flyers.

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