AI & Soc (2009) 24:115–122
DOI 10.1007/s00146-009-0194-5

ORIGINAL ARTICLE

Awareness systems and the role of social intelligence

Panos Markopoulos

Received: 15 January 2008 / Accepted: 19 December 2008 / Published online: 24 February 2009

Abstract This paper discusses awareness systems for supporting informal social relationships, focusing on some of they key concerns for designers and researchers. The discussion is general, but examples highlight the design issues discussed and summarize related empirical results. The paper argues in favor of automated capture of awareness information and suggests that social intelligence is relevant (a) as a design and evaluation criterion for such systems and (b) as a mechanism for supporting users in managing the information sharing by means of awareness systems.

1 Introduction

This paper discusses the design of awareness systems for supporting informal social communication. The term 'awareness system' here carries a broad meaning; it encompasses all communication systems that help individuals to maintain a mental model of the activities and status of others. A common ambition for such systems is that such a mental model is constructed and maintained with low effort, in such a way that it does not hinder primary activities of the individuals concerned.

The discussion here focuses on connecting individuals related with primary social relationships and especially family ties. It focuses on systems supporting awareness over sustained periods rather than moment to moment awareness that is necessary for the performance of collaborative tasks in some shared workspace—which for example is the focus of Gutwin and Greenberg (2002).

Dourish and Bellotti (1992) consider that awareness provides an understanding of others and their activities that provides a context for one's own actions. Extending their classical definition beyond the concerns of the workplace, one can consider awareness as providing also a context for understanding and interpreting one's own experiences, actions and social interactions.

To understand the nature of awareness systems it helps to contrast them to systems supporting focused communication as a primary task, like the phone or video conferencing. While awareness can be obtained by using such media we are interested here in the feasibility of a continual 'trickle' or eventually 'flow' of information between actors that does not require focused effort or even contemporaneous engagement by actors who, in this way, can engage fully in other primary activities.

On the display side, it is often assumed that awareness information is displayed peripherally and can be attended to sporadically. Perceiving it should require minimal effort, often requiring just pre-attentive cognitive processes of the users. A popular example, are buddy lists of instant messaging systems also support awareness by displaying information on the status of one's online social network at a glance.

Researchers have proposed a great number of concepts for supporting awareness between social relations and family. These may be devices for the home or mobile device. An example of a wearable awareness appliance is WatchMe (Marmasse et al. 2004) that aimed to connect friends round the clock, allowing them to share information automatically regarding location and movement, as well as supporting more explicit and intentional forms of communication.

P. Markopoulos (✉)
Department of Industrial Design,
Eindhoven University of Technology,
Den Dolech 2, 5612 AZ Eindhoven,
The Netherlands
e-mail: P.Markopoulos@tue.nl

WatchMe and other systems of this kind were introduced as demonstration prototypes and have not been deployed and tested in actual use. Currently the state of the art in this research field is shifting towards more robust prototypes that can support sustained field deployment and testing. For example, the recent Whereabouts clock by Brown et al. (2007) displays coarse grained information regarding the location of household members during the day: at home, at school, at work and which has been used to explore the uses and interpretations families develop for such awareness information.

In the remainder of the paper, we discuss a few recurring issues and themes surrounding the design of awareness systems, drawing from our own experiences with designing and evaluating such systems to support intra-family communication.

First, the question is raised whether awareness systems represent a technology push or whether they address actual user needs. The argument is developed further by discussing affective costs and benefits experienced by their use. Moving on to design issues, the paper describes the trade-offs pertaining to the automated input of awareness information, the precision and accuracy of awareness information and finally methodological issues surrounding the evaluation of these systems. The paper concludes with reflections on the role of social intelligence in awareness systems.

2 Is there a genuine need for awareness systems?

To an extent the emerging interest in awareness systems can be seen as a by-product of the increased availability of bandwidth, connectivity and computing, which makes it possible to establish semi-automated and permanent links to connect individual or groups. Technology developments bring along a steady increase in the frequency and the amount of information transferred between communicating individuals as well as the frequency and amount of time that individuals communicate to each other. Compared to current messaging and communication technologies awareness systems represent the next step in this progression; however, they can only succeed as such if they provide genuine value to their users.

Awareness of others can support people at work or leisure, as they engage in any type of activity in pursuit of very fundamental human needs. This however can happen only if:

- They move beyond communicating data to providing information: awareness information that is meaningful in the context of some joint activity or social relationship.
- Users are able to consume, recruit and utilize awareness information in the course of other activities they engage in.

In the context of supporting social communication the latter implies that people should be able to embed awareness systems in their daily social interactions and requires them to derive meaning and emotional benefits from the information obtained through these systems.

For example, consider the case of providing awareness of the location or activity of family members during the day on some awareness display at home. This popular scenario requires system designers to question on what basis this can become a valuable proposition for users. Based on the conception of awareness discussed here, an awareness display decorating some part of the home will provide little more that an irrelevant piece of information, unless family members start consulting it, referring to it and even adapting their routines and interactions to the information they receive through such a system. Evaluations therefore need to examine whether such assimilation takes place, what meanings are assigned to the awareness display and what uses and rituals are built around it.

To conclude, designers need to be explicit about the value they wish to provide to their users and for them to evaluate design proposals regarding these benefits. In the absence of such an explicit account of benefits provided, eventually accompanied by empirical evidence, design research in this field runs the risk of degenerating into a self-referential reproduction of ideas that favors the grotesque and the surprising over one that fits the life and needs of people. The research discussed in the remainder of this paper assumes this value-centred perspective.

3 Costs and benefits of awareness systems for intra-family communication

In the most common cases, families and friends already possess some degree of awareness regarding each other. This awareness is multi-faceted. It may concern the location of each other, their momentary activities but also a deeper level concerning their pursuits, tribulations, achievements or disappointments, or even how they reflect on their relationship with each other. Awareness needs pertain to each of these levels and concern activities spanning different periods and different aspects of each individual's life.

This diversity of needs motivates a wealth of research works. Examples are sharing information on waking up/going to sleep through networked alarm clocks (Schmidt 2006), daily commotion into and out of the home (Markopoulos et al. 2006).

ASTRA (Romero et al. 2007) supports sharing of impressions and accounts regarding small daily experiences as well as conveying the simple message of thinking and valuing each other. The latter is the sole purpose of well-known design concepts, e.g., see Strong and Gaver (1998). Other examples, aim to strengthen emotional ties by awareness even if they serve no explicit and prior need for sharing information. For example, Aura (Bitton and Mhóráin 2004) is one of several published designs that were conceived to support intimacy through awareness. Aura helps friends share information describing their quality of sleep as a predictor of mood.

The examples mentioned are indicative of the ambition of designers and researchers to provide affective benefits through awareness. Considering the abundance of related design proposals there is little (though growing) evidence regarding the affective benefits experienced by connected parties and confirming that such systems are indeed valued and needed by their users.

A demonstration of the affective benefits concerned the scenario of friends having peripheral awareness of each other through a home media space while watching the same broadcast event. The experiment reported by Markopoulos et al. (2005) showed how this awareness can increase group ties and, more specifically, the group attraction experienced by members of the group.

The scenario above concerns only a brief period (roughly a couple of hours) and a very specific activity. However, the impact of awareness on group attraction was documented also with the field evaluation of ASTRA where participants used the system for 1 week, see Romero et al. (2007).

The evaluation of ASTRA not only documented and measured affective benefits but also the costs of awareness.

Benefits resulting from awareness pertain to:

- Connected individuals knowing more about each other.
- Increased awareness regarding whereabouts, status, activity of each other.
- Feeling connected and in touch with each other.
- Individuals feeling that they manage to share experiences with each other.
- Understand, recognize and empathize with each other.
- Form a cohesive group, to which they feel attracted.

Use of the awareness system can also bring about affective costs that pertain to:

- One's feeling that connected others have more information about oneself than desired and vice versa.
- The extent to which one feels that the system creates social obligations, e.g., to return a call, to take a call at a difficult moment.
- The extent to which one's expectations that others will engage in communication/interaction or will respond to or reciprocate one's own actions.
- The physical or cognitive effort required to operate the communication system, e.g., setting up the system, logging in, etc.

These costs and benefits can be evaluated using the Affective Benefits and Costs of communication questionnaire (Van Baren et al. 2004). During evaluation one can issue this questionnaire to assess communication in the absence of the system evaluated and also while using the system evaluated. Its application during the deployment and evaluation of the ASTRA system mentioned earlier (Romero et al. 2007) found that users of ASTRA did not report increased affective costs compared to their regular means of communication while they did experience increased benefits.

Typically, evaluations of awareness systems are more qualitative in nature and do not always relay on quantitative measures like the ABC questionnaire. Related work in this research field is gradually piecing together evidence documenting the uses and value of awareness systems and providing an understanding of the corresponding design space. The remainder of this paper discusses dimensions of this design space and related trade-offs relating to affective benefits and costs of communication for users.

4 Intentional versus incidental input of awareness information

The ASTRA system mentioned earlier relied on actors creating content 'manually' by taking pictures, making notes and supplying their social network with information about their daily activities and experiences. While ASTRA succeeded in lowering the threshold of capturing and consuming fleeting experiences during the day, manual input of all awareness information does not scale up in time or with regards to the number of people connected.

In practice, sharing awareness information will need to rely, at least in part, upon the automated capture of awareness information and its dissemination to connect others. For the persons concerned this capture and dispatch of information can become incidental and a side effect of their daily activities.

This approach was implemented in the Diarist system (Metaxas et al. 2007). Diarist was designed for seniors living alone, informing their adult children about selected aspects of their daily life activities in the home; the aim was to achieve connectedness and peace of mind for both. A sensor-based network at their home helped collect and interpret sensor readings and construct a record of the

whereabouts of elderly. This record was displayed at the home of their adult children using a Philips iPronto device (a smart TV remote control, featuring a touch screen and which is able to display interfaces as HTML pages). Information was displayed at different levels of granularity:

- A large icon showing one of the following regarding the home occupant: at home, away, with friends, in the kitchen or in bed.
- A log of the whereabouts for the last 24 h displayed as a list of blocks sowing duration, and a fitting description, e.g., home, or away. This is visible when one walks up to or holds the device.
- A detailed narrative (see Fig. 1), showing a detailed account of the information collected that lets the user inspect the premises of this reasoning (e.g., that his/her father got out of bed twice tonight, lets the system infer that he slept somewhat calmly).

Let us consider the trade-offs related to choosing between explicit and implicit input of awareness information. Explicit input (e.g., setting your status e.g., at home or not, sending a message, or updating a blog), lets users control which information to share and to adjust their presentation to the intended audience and context.

People are extremely skilled at doing this, and a mediating system can go very wrong when it attempts to substitute user explicit input and to pre-empt user intentions. Subtleties of language are hard to reproduce, timing, accuracy of information, precision, empathy with the audience; each of these aspects becomes one way in which people demonstrate their social skills, when communicating unaided by an awareness system. Social skills of this kind are an essential component of human social intelligence and one that intelligent systems are far from being able to emulate at this moment.

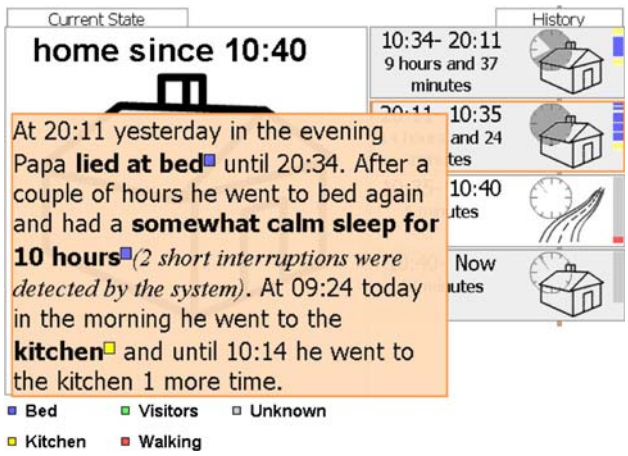

Fig. 1 Close up view of the Diarist (Metaxas et al. 2007), with the narrative explanation for the block of time 20:11–10:35 popped up

A limitation of explicit input of awareness information is that actors may forget to update it, or may make mistakes while entering it. Automated systems offer the possibility of scaling up; they can capture information that can be tedious for humans to capture or that only makes sense if there is some reliable technology, e.g., for health monitoring an indication that someone's heart rate is within safe bounds or not, or for a dementia patients whose location is tracked by the system.

A less obvious trade-off regarding the automated capture of awareness information is how meaning and intention is attached to it. Here are some points to consider:

4.1 Quality of information

A system like Diarist mentioned above or systems monitoring health parameters can only provide reassurance and peace of mind when users can assume that the information presented is accurate and up to date.

This may not be the case for at least two reasons. The person concerned might prevent the system from sharing specific information, e.g., an elderly not wishing to disclose that he does not feel well to stop others from worrying unnecessarily. In this case, the intentions and priorities of the user compete with the function of the system that provides little added value to those who rely on its information.

Another reason may be that the interpretation of user activity and status presented by the system are flawed or technical errors are obscured. System failures or erroneous assumptions about human behavior implemented in a system like Diarist can cancel out all its potential benefits. For example, during the field trial of Diarist (Metaxas et al. 2007) a battery failure caused an erroneous reading that the elderly father was out all night making his daughter to be unnecessarily concerned. The intended benefits for peace of mind were thus reversed.

4.2 Intentionality

The very act of explicitly sending information is meaningful and potentially valued by connected individuals. Sending a regular and automated log of activities of one's holidays will be less appreciated than a personally addressed and well-timed message (see e.g., Romero et al. 2007). To give an example from a different domain, sending an invitation for coffee to a colleague will be less warm and inviting than an automatically generated announcement that you are having a break. Intentionality can be expressed in the content, the timing of the message and also, by considering the context in which it will be displayed. Such an adaptation requires considerable knowledge and reasoning abilities regarding social context, situations and audiences that is still an elusive target for current computing systems.

4.3 Control

Connected actors may feel their privacy is under threat and may thus need flexible and powerful controls for disclosing information or making themselves available for interaction with others. Being able to manually choose when to declare your presence at home or your availability for direct communication gives more control over one's privacy borders allowing users to exercise social skills that are not present in devices that automate this process.

5 Precision and accuracy of awareness information

We can distinguish awareness information by (at least) the dimensions of precision and accuracy. Figure 2 illustrates how awareness information regarding children at school was presented to parents on their PC at home and at work during a recent investigation, cf. Khan et al. (2007). Awareness information consisted of two parts: presence and activity. In this study children carried a Bluetooth headset which was detected by the PC computer at their class. This device helped obtain real time information regarding their presence in the classroom: when the Bluetooth headset is in range of the classroom computer a colorful icon is shown on the desktop of the remote parent. A gray icon indicates the child is out of range. The text line below the image showed the scheduled (but not necessarily actual) activity of the child according to the school's weekly schedule. Below, we use this example to explain the concepts introduced in this section.

5.1 Precision

Precision can be understood in terms of the granularity of the awareness information. For example, in Fig. 2, the icon indicating whether the child is in the class or not conveys 1 bit of awareness information (close to the classroom computer or not). The Whereabouts clock by Brown et al. (2007) conveys 2 bits of information relying on the cell network to distinguish between four location indicators: home, work, school and other. In the Diarist system discussed above, the top level view represented a choice of six locations, while the blog and the narrative represented increasing levels of detail. In media spaces, a blurred image offers less precision over the full video image.

Precision as discussed here pertains partly to the notions of information capacity and that of representational fidelity introduced by Pousman and Stasko (2006) in their taxonomy of ambient information displays. Focusing mostly on graphical representations they distinguished three levels of fidelity: symbolic, iconic and indexical displays (going from the most abstract to the most concrete levels of presentation).

Designers often opt for low precision to protect the privacy of their users. On the other hand, it is often the case that more precise information is required. In the evaluation of the awareness system of Fig. 2 parents required more information, e.g., whether their child is alone, or who the child interacts with, etc. In this case, they required higher precision. Other parents who preferred to know whether the child was out of bounds of the school, required lower location precision, as this was more relevant to their concerns. Going out of bounds would be a reason for concern. In a flexible system users may prefer to vary the precision of the information as a means for managing their awareness and privacy needs.

5.2 Accuracy

The scheduled activities of the children in Fig. 2 can be reasonably precise and rich descriptions but they are the ones scheduled for the school a week in advance. As such, they may not be accurate, e.g., because some activity runs late, or a teacher falls ill, etc. As has been argued by Price et al. (2005), users may also wish to vary the accuracy of the awareness information in order to protect their privacy. Further, as discussed already, erroneous system operation can reduce accuracy of the awareness information displayed.

As is often the case, there is a tension between the needs for accuracy and precision. The Diarist system discussed above attempted a rich and precise description of user activity for which accuracy is a significant technical challenge. Users will face a similar trade off—faced with increased precision of awareness information they may prefer the ability to modify it, reducing its accuracy to protect their privacy (see Price et al. 2005).

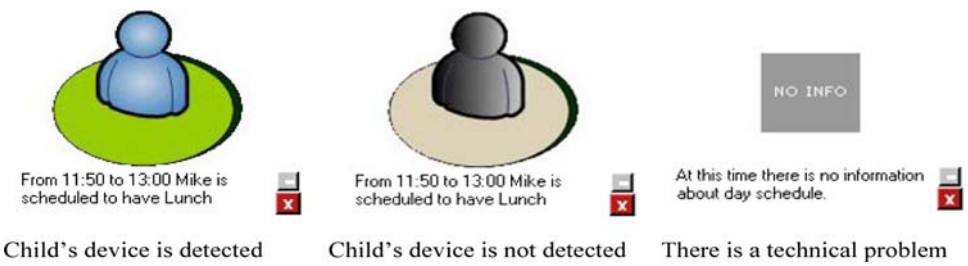

Fig. 2 Awareness of children at school for their parents (adapted from Khan and Markopoulos et al., in press). Three states of graphical widget showing whether a child is in the class and the scheduled activity of the child at a given time

In every day life, people are very fluent in managing the right level of accuracy and precision for the information they disclose about themselves or they try to obtain regarding others. This social skill is important for how individuals present themselves or let others present themselves, allowing for protecting their privacy and for equivocation. Designers need to resist the temptation to convey as much awareness as is technically possible and should look for ways to enable people to exercise their extant social skills for sharing information about each other.

Abstraction is a way to reduce the precision of the information presented (assuming it is available for the system in the first place) is abstraction through the use of symbols or mapping awareness information to graphical illustrations.

Figure 2 combines a symbolic display (the icon representing presence of the child in the class) and a literal presentation of this information, listing the child's activity in text. Literal displays tend to be more precise. If there is little need for precision, designers may often opt for a more decorative presentation of awareness information, by some abstract pattern or a picture that is a symbolic visualization of awareness data, e.g., the Info Canvas (Miller and Stasko 2001). Apart from their function as decoration, abstract and symbolic displays can be differently understandable to their owners and others, offering in this way some privacy guards. For example, after long term exposure users may gradually learn how to interpret abstract displays (e.g., light patterns), that are at first sight meaningless to others.

In our studies concerning family communication, informants have consistently indicated preference towards literal and directly accessible displays. It is noted though that none of these studies compared the use of otherwise equivalent versions awareness systems, so it could still be that more impressionistic presentations of awareness information are valuable in some contexts.

6 Research and evaluation methodology

A point of consensus in the research community is that the evaluation of awareness systems should involve field deployment and testing over a sustained period of time examining realistic social interactions between individuals. Evaluations of systems in the lab may be a good first step, where a design team can aim to:

- Establish the smooth operation of the system and increase its reliability.
- Find out and correct usability defects that might hamper evaluation in the field.

Early works in this field did not include evaluation or included a minimal evaluation with interviews or focus groups based upon scenarios, non-functional prototypes or demonstrations of system concepts. More recently, evaluations have started to focus on working systems used for sustained periods, even going up to 6 months; e.g., see Brown et al. (2007) and Oulasvirta et al. (2007).

The general outcomes from such evaluation studies seem very upbeat regarding the acceptance of awareness systems, providing evidence that people find uses for awareness systems, fit them in their daily life, appropriate them and develop their own conventions for their use.

Some caution has to be exercised in reading these results. Evaluations have typically concerned small proportions of one's social network, and in most cases do not compare use against non-use. Participants could be positive in their subjective assessments to please the creators of the systems or even are very likely to change their behavior as a result of being under study more than because of using the system in question.

There are some measures that one is advised to take to avoid this problem:

- Extend the evaluation period, if participants are excited about participating in a study, this should fade off with time.
- Evaluate a period of use, with a period of non-use, prior to and after the exposure to the system; see for example Oulasvirta et al. (2007) or Romero et al. (2007).
- Include explicit checks regarding the possibility of actors adapting their behavior regarding information disclosure or trust because of the research context, van Garde and Markopoulos et al. (2007).

Our own studies have focused on the application of psychometric techniques for the evaluation of these systems, using the ABC questionnaire as above or other questionnaires for evaluating subjective experiences from users. This can give rise to problems during field testing; one cannot keep asking participants to complete the same long questionnaire time and again during a long period of time. The quality of the answers and compliance should deteriorate. What is needed at the moment is improved research methods and instrumentation for evaluating awareness systems during such sustained studies, e.g., using semi-automated diary techniques or experience sampling (Kubey et al. 1996).

7 The role of social intelligence

By their conception awareness systems are intended as intermediaries in our social interactions. They will be embedded in daily social encounters and depending on how well they are designed they might empower or hinder people in their social conduct. How much a system lets

someone be perceived as socially intelligent or the opposite is a plausible empirical measure for evaluating awareness systems. This type of evaluation becomes very relevant when an awareness system is partly automated, thus reducing users' flexibility and control regarding how they interact with other individuals.

An obvious corollary of this argument is that social intelligence can and should be built into awareness systems that involve some degree of automation. This social intelligence though does not refer to manifesting human-like expressions or movements, but to the very understanding of the social implications of the information exchange that an awareness system implements.

There are two main areas where (artificial) social intelligence can support the operation of an awareness system:

- *Capture and presentation of awareness information*. An example is the Diarist system which supported interpretation of sensor data and the generation of narrative descriptions in natural language to describe the lower level data in a comprehensible format. People apply a considerable amount of social knowledge for how to interpret what they observe, extracting social cues and interpreting social contexts. Current experimental awareness systems lack such perceptive and reasoning abilities even at a very basic level.
- *Disclosure of information*. At one extreme, an awareness system could manage the flow of information autonomously, e.g., by attempting to match content to recipients. This can be a hard problem as a system would have to reason regarding the inferences that connected others can draw from information presented to them. For example, when the user's preference for disclosure includes activity but not location, disclosing to others that the user is watching television, studying or cooking may allow them to make inferences regarding their location as well.

The second option above represents a major challenge for our ability to reason about social interactions between individuals. A much more likely scenario is that users set their preferences regarding disclosure through an appropriate 'programmable' interface. This will be no minor feat; attempts to automate reachability management or interruption handling have shown in practice to be too rigid and were circumvented during actual use.

Matching respective preferences regarding the sharing of information needs to rely on a model of such information and of the inferences a human or other recipient could draw from this model; some first steps in this direction are described in Metaxas and Markopoulos (2008). To enable such a possibility a prerequisite is to construct appropriate languages (e.g., XML based) for describing awareness information and for describing the implication relations that connect different types of awareness information (as for example, noted above regarding activity and location). This is the topic of our current investigation in awareness systems and one that could empower users, allowing them to use awareness systems for longer and for facilitating a larger proportion of mediated social interactions.

8 Conclusions

In order to ensure the acceptance of awareness systems by their users, designers must be deliberate regarding the value that these systems can provide and must ensure appropriate assessment of related affective costs and benefits. There is by now ample evidence that such benefits are attainable and that awareness systems serve actual user needs and can be effective in supporting social interactions.

In this context, awareness systems should not hinder people in applying their social skills. Consequently, designers need to balance the need for automation and control, and to choose an appropriate level of precision and fidelity in capturing, disclosing and presenting awareness information.

Finding this balance is the central challenge for designers of awareness systems. A major research challenge emerges which is to emulate in such systems some of the abilities human have for perceiving and managing social situations. Achieving even a limited degree of social intelligence might be a major challenge for current technology, but may be the only way to achieve the increase in connectivity and sharing of information about our daily activities that is entailed by awareness systems. The challenge then for the field of social intelligence design is to explore social intelligence beyond implementing human-like physical and expressive behaviors, and onto reasoning that is associated with handling social situations in our daily communication activities.

Acknowledgments The author wish to thank B. de Ruyter, W.A. IJsselsteijn, N.A. Romero, J.V Khan and G. Metaxas for their work in several of the research studies cited. This research is supported by Senter IOP MMI (project "Ambient Awareness") and the FET IST programme (project ASTRA, IST 29266).

References

Bitton J, Mhóráin AN (2004) Human connectedness, Atopia J 4.33:87–92

Brown B, Taylor AS, Izadi S, Sellen A, Kaye JJ, Eardley R (2007) Locating family values: a field trial of the whereabouts clock. Lecture notes in computer science. vol 4717. Springer, Berlin, pp 354–371

Dourish P, Bellotti V (1992) Awareness and coordination in shared workspaces. Computer supported cooperative work. ACM press, New York, pp 107–114

Gutwin C, Greenberg S (2002) A descriptive framework of workspace awareness for real-time groupware. Comput Support Coop Work 11(3):411–446

Khan V-J, Markopoulos P, Eggen B (2007) On the role of awareness systems for supporting parent involvement in young children's schooling. In: Proceedings of the home oriented informatics technology, HOIT 2007

Kubey R, Larson R, Csikszentmihalyi M (1996) Experience sampling method applications to communication research questions. J Commun 46(2):99–120

Markopoulos P, Bongers B, Van Alphen E, Dekker J, Van Dijk W, Messemaker S, Van Poppel J, Van der Vlist B, Volman D, Van Wanrooij G (2006) The PhotoMirror appliance: affective awareness in the hallway. Personal Ubiquitous Comput 10(2–3):128–135

Marmasse N, Schmandt C, Spectre D (2004) WatchMe: communication and awareness between members of a closely-knit group. In: Proceedings of the Ubicomp 2004. Lecture notes in computer science, vol 2875. Springer, Berlin, pp 214–231

Metaxas G, Markopoulos P (2008) Aware of what? A formal model of Awareness Systems that extends the focus-nimbus model. In: Proceedings of the EHCI. Lecture notes in computer science, Springer, Berlin

Metaxas G, Metin B, Schneider J, Markopoulos P, De Ruyter B (2007) Daily Activities Diarist: supporting aging in place with semantically enriched narratives. In: INTERACT 2007. Lecture notes in computer science, vol 4663. Springer, Berlin, pp 390–403

Miller T, Stasko J (2001) The InfoCanvas: information conveyance through personalized, expressive art. CHI '01 Extended abstracts. ACM Press, New York, pp 305–306

Oulasvirta A, Petit R, Raento Tiita S (2007) Interpreting and acting upon mobile awareness cues. Hum Comput Interact 22(1–2):97–135

Pousman Z, Stasko J (2006) A taxonomy of ambient information systems: four patterns of design. AVI '06. ACM Press, New York, pp 67–74

Price A, Adam K, Nuseibeh B (2005) Keeping ubiquitous computing to yourself: a practical model for user control of privacy. Int J Hum Comput Stud 63(1–2):228–253

Romero N, Markopoulos P, van Baren J, de Ruyter B, IJsselsteijn W, Farshchian B (2007) Connecting the family with awareness systems. Pers Ubiquitous Comput 11(4):299–312

Schmidt A (2006) Network alarm. Pers Ubiquitous Comput 10(2):191–192

Strong R, Gaver WW (1998) Feather, scent, and shaker: supporting simple intimacy. In: Proceedings of the CSCW '98. ACM Press, New York, pp 169–178

Van Baren J, IJsselsteijn WA, Markopoulos P, Romero N, de Ruyter B (2004) Measuring affective benefits and costs of awareness systems supporting intimate social networks. In: Nijholt A, Nishida T (eds) Proceedings of the 3rd workshop on social intelligence design, pp 13–19

Van De Garde-Perik E, Markopoulos P, De Ruyter B, Eggen B, Ijsselsteijn W (2008) Investigating privacy attitudes and behavior in relation to personalization. Soc Sci Comput Rev 26(1):20–43