

User-Centered Design of Intelligent Environments: Requirements for Designing Successful Ambient Assisted Living Systems

Carsten Röcker

Human-Computer Interaction Center

RWTH Aachen University

Theaterplatz 14, 52056 Aachen, Germany

roecker@comm.rwth-aachen.de

Abstract. *This paper illustrates the importance of involving end users into the design process of Ambient Assisted Living applications. It especially focuses on two crucial aspects, the involvement of senior users and the home as the primary application domain. Based on this theoretical foundation, requirements for successful system design are elaborated.*

Keywords. User-Centered Design, Ambient Assisted Living, Intelligent Environments, Design Requirements.

1 Introduction

Today, the design of new homecare solutions is mainly driven by technical considerations of medical professionals and system providers [4]. Developments in this field are often demonstrations of technological possibilities [22] rather than responses to the actual needs of potential users [45][64], which is often cited as one of the main reasons for poor adoption (see, e.g., [23], [27], [33] or [65]). One reason for this problem is a lack of knowledge on the developer's side. System designers and engineers usually have very profound expertise about technical possibilities, but only very limited insight into the social context in which their products will be used [33][43][51][71][72]. Quigley and Tweed [53] even argue that “visions of what technology can do for the elderly are rarely based on any comprehensive understanding of needs and in some cases are blatant technology push”.

Despite these obvious shortcomings in the development of new technical products, user integration still does not take place in many companies [6][11][54]. Financial constraints and time pressure are the most often cited reasons for not integrating users in the design process of new technologies [30]. With respect to medical technologies this means that “many products are not

accessible to large sections of the population [as] designers instinctively design for able-bodied users and are either unaware of the needs of users with different capabilities, or do not know how to accommodate their needs into the design cycle” [10].

The importance of user-centered design approaches was demonstrated in numerous studies. For example, Ziefle and Bay [78][79] showed that age-sensitive design concepts could significantly reduce age-related handicaps and thereby enable older adults to efficiently operate new technologies. However, user-centered design does not only bring benefits to end users due to better usability of medical products, but is also likely to lead to substantial financial advantages for manufacturers and service providers as the costs of adapting technical concepts and service functionalities are considerably lower in early design stages [70]. Therefore, it is important to involve future users in explorative studies as early as possible in the design process of new products [28].

When doing this, it is vital to focus in particular on two aspect, which are often neglected in existing work: the involvement of senior users and the home as the main application domain. Both aspects will be outlined in the following sections.

2 Integration of Older Users

The vast majority of technology acceptance studies conducted in the past explored the diffusion of information and communication technologies in work environments and regarded young and middle-aged workers as their target user groups [58][61][62][59][57][60]. In contrast, Ambient Assisted Living (AAL) environments will be mainly inhabited by older users and people with mental or physical handicaps, who have different requirements than standard computer users typically investigated in technology acceptance studies [22][31][77]. Therefore, it is important to integrate elderly users in the design process and empower them to influence ongoing developments according to their personal

needs [36][56][80][81][82][83][84]. This is especially critical as older users will inevitably be lead adopters for electronically-enhanced healthcare solutions [13].

In order to define who is considered old, researchers in the field of gerontology are often using chronological thresholds [43]. However, the chronological age of an individual is often not a reliable predictor for the person's mental and physical abilities as health states of elderly people vary dramatically [75]. This is validated in several studies that found that people in average felt 10 to 15 years younger than they actually are [76]. As a result, elderly people are often clustered into groups depending on their health state instead of their age. Usually, elderly people are divided into three groups: active seniors, elderly people with declining abilities, and old people with severe disabilities (see [9] or [49] for more details).

While this might be a useful classification for general usage, such a generic classification scheme is not sufficient for the development of future homecare applications. Instead of designing for generic groups of older people, it necessary to address age-related shortcomings on an individual level. This is of particular importance as the effects of old-age illnesses and disabilities are highly individual, which results in a much higher heterogeneity of elderly people compared to younger ones [26][46][73][77]. Hence, many authors including Bierhoff et al. [7] argue that there is not such a thing as a typical older user. Instead it is necessary to design for a broad diversity of users, who are highly variable with respect to their individual physical and mental capabilities [49].

As mentioned above, the majority of existing research has focused on work and especially office environments as the main application area. While the nature of the implemented systems might be similar from a technical point of view, the social context in which they are used is completely different. Social interactions in work environments are characterized by being mostly formal, structured and goal-oriented, compared to activities in home environments, which are not only more informal and less structured, but also targeting at a more enjoying and entertaining usage experience [45].

Current design approaches are based on empirical knowledge gained in work settings and are often "grounded in the core rationalities of production, efficiency, [and] the organization of labour" [15]. When developing home technologies it is often neglected that such design rationales cannot be transferred from a work to a domestic setting as "motivations, concerns, resources and decisions [of home users] can be very different from those found within workplaces" [34]. This conceptual mismatch is especially reflected in a poor acceptance of new assistive technologies. While AAL systems can provide personalized medical assistance and thereby enable an independent lifestyle for older people, many

existing products are not fully accepted by potential users [30]. Fichten et al. [25] even estimate that nearly half of all people who need assistive technologies actually use them.

Poor or unexpected usage [1] shows that the actual needs and desires of end users are not yet met by developers. When addressing this problem it is important to be aware that technology acceptance is a highly situational phenomenon. The acceptance of new technical devices "depends on the subject of acceptance, the object of acceptance and the context of acceptance" [65]. So far, there is an extensive body of literature about the usage of information and communications technologies in work settings, but very little knowledge about the social context of technology usage in the home [33]. Hence, it is crucial to specifically study the usage of future healthcare technologies in home situations, instead of trying to transfer existing knowledge from other application domains. The design of successful medical technologies for home usage requires therefore a close collaboration with potential end users in order to fully understand the context of later usage [4].

4 Design Requirements

4.1 Medical Usefulness

Perceived medical usefulness is undoubtedly one of the most important factors for the acceptance of AAL applications (see, e.g., [29], [65] or [66]). Consequently, the medical advantages of technology-supported medical services have been proven in numerous studies. For example, Dansky et al. [16] studied the effects of tele-medical homecare on the clinical outcomes and the associated financial costs and found positive effects with respect to both factors. Hui et al. [38] studied the feasibility of using tele-medical services in a nursing home and found significant advantages of remote care provision with respect to medical and financial aspects. Comparably positive results were also found in studies exploring the efficacy of a remote blood pressure monitoring application [63] as well as the effectiveness and medical costs of a tele-care application for patients with congestive heart failure [39].

These individual results are underpinned by Hailey et al. [32], who conducted a meta-analysis of 46 existing tele-medical studies and found that over 2/3 of the studies identified benefits of tele-medical applications over classical approaches. Studies by Riegel et al. [55], Kobza and Scheurich [42], Tsang et al. [69], Whitlock et al. [74] and di Biase et al. [24] came to similar results.

So far, the majority of studies evaluated the medical and financial effectiveness of tele-medical applications. Even if some of the results might be transferable to Ambient Assisted Living systems, technical feasibility alone won't be sufficient for the large-scale diffusion of future systems (see, e.g. [65]).

Based on their ongoing research, Hirsch et al. [35] even argue that the assumption older or handicapped people “will use an assistive technology simply because they need it is misguided”. Especially in home settings, it is crucial that users accept such applications in order to voluntarily use them.

4.2 Accessible Design and Usability

Today, it gets more and more accepted that the usage of smart home care technologies depends on a variety of different and interrelated factors [7][41]. Accessible design and usability are probably the two most cited criteria in this context (see, e.g., [5], [8], [20], [21] or [30]). While these are undeniable crucial system requirements, there is a considerable number of additional design aspects, which are far less discussed in literature, but equally important for good system design. The following sections take a closer look at these aspects.

4.3 Feedback and Control

Compared to traditional desktop-based computer systems, which rely nearly completely on explicit user input, Ambient Assisted Living systems are often envisioned as autonomous helpers. Hence, it is not surprising that most early context-aware system did not address user control as a design factor. Over the last couple of years this general attitude slowly started to change. Today, many authors including Davidoff et al. [17], Poulson et al. [52] and Bierhoff et al. [7] regard user control as a key requirement for the successful design of any Ambient Assisted Living application. Contrary to a common belief of many system designers, most elderly people want to be actively involved in the usage of home technologies [12].

Providing adequate feedback and control mechanisms is vital for the acceptance of smart home applications in general [37][47][50]. When designing AAL systems, special attention should be paid to intuitive control and feedback mechanisms for enabling user-centered patient monitoring. This does not only include understandable feedback about the areas, parameters and persons being monitored, but also transparent information about the people who are able to access these data as well as easy ways to completely deactivate the monitoring process [45][47].

4.4 Integration into Daily Life

According to Alexander [3] everyday life is structured through “patterns of events” that repeat themselves over and over again. More precisely, we can say that “our lives are organized through reoccurring patterns of work, leisure, travel, relaxation, and the rest” [15]. Consequently, it is the designer's task to develop home care technologies that adapt to the user's daily

routines, instead of the other way round. In this context, it is of particular importance that new homecare services “consider ‘old’ habits of the users” [7] and by doing this minimize “the disruptive nature of new technology” [4]. Studies show that potential users of smart home technologies want future homes to be similar to their existing homes [19]. Hence, de Ruyter et al. [18] argue that the main challenge of smart homecare technology is not the physical integration of medical devices into the domestic space, but “to socially integrate the system behavior into the fabric of everyday life”.

4.5 Personalization and Natural Interaction

Results from a focus group study conducted by Lull et al. [44] show that AAL systems have to be designed such that they are flexible enough to be individually adapted to personal user needs. This is a particularly important requirement with respect to the design of user interfaces [52]. Many authors including Abowd and Mynatt [2] stress the fact that this includes a paradigm shift away from traditional desktop interfaces towards intelligent user interfaces that support implicit interactions [67].

4.6 Aesthetic Design

For a long time, aspects of aesthetics played a minor role in the field of human-computer interaction [68] and it took considerable time until the perception of aesthetic design slowly started to change. Today, an aesthetically pleasing design is widely accepted as a crucial factor determining the success of new technological products (see, e.g., [4], [40], [45] or [76]). In this context, Hirsch et al. [35] even argue that while “traditional usability factors determine whether a device can be used, aesthetic factors determine whether a device will be used”.

4.7 Avoidance of Stigmatization

However, good design does not only refer to the aesthetic qualities of a system, but also includes a visual appearance, which does not contribute to the stigmatization of its user. Authors, like e.g., Hirsch et al. [35] or Ballegaard et al. [4] argue that many existing medical support systems are stigmatizing and continuously remind users of their illness or disability, if they are not completely rejected right from the beginning. Wide-spread user adoption will only take place if future home care systems are designed such that they do not highlight the users' disabilities [7][35][76], but “support a positive self-image for the elderly persons” [12]. Consequently, Cowan and Turner-Smith [14] argue that the goal should be to develop home care systems, which are not only “attractive to own”, but provide “ability without removing status”.

5 Conclusion

Involving potential users in the design process of new applications is essential for the long-success of Ambient Assisted Living applications. When doing this, it is of particular importance to especially focus on senior users as the main target group of Ambient Assisted Living applications and the home as the primary application domain. Both aspects have been addressed in the detail in this paper.

Following a user-centered design approach also involves to take a more holistic look at relevant design criteria. Medical usefulness and technical feasibility are undoubtedly key requirements for successful system design, however, these factors alone won't guarantee that new systems are accepted by potential users. This paper discussed a number of important design requirements and illustrated how these aspects could be integrated in the design process.

References

- [1] Abowd, G D; Edwards, K; Grinter, B. Smart Homes or Homes that Smart? In: *SIGCHI Bulletin*, March/April, p. 13, 2003.
- [2] Abowd, G D; Mynatt, E D. Designing for the Human Experience in Smart Environments. In: D J Cook, S K Das (Eds.): *Smart Environments: Technology, Protocols, and Applications*. John Wiley and Sons, London, UK, pp. 153 - 174, 2004.
- [3] Alexander, C. *A Pattern Language: Towns, Buildings, Construction*. Oxford University Press, UK, 1978.
- [4] Ballegaard, S A; Hansen, T R; Kyng, M. Healthcare in Everyday Life - Designing Healthcare Services for Daily Life. In: *Proceedings of the ACM SIGCHI Conference on Human Factors in Computing Systems (CHI'08)*, ACM Press, New York, USA, pp. 1807 - 1816, 2008.
- [5] Bellazzi, R; Montani, S; Riva, A; Stefanelli, M. Web-Based Telemedicine Systems for Home-Care: Technical Issues and Experiences. In: *Computer Methods and Programs in Biomedicine*, Vol. 62, No. 3, pp. 175 - 187, 2001.
- [6] Bias, R G; Mayhew, D J. *Cost-Justifying Usability*. Morgan Kaufmann, San Francisco, CA, USA, 2005.
- [7] Bierhoff, I; van Berlo, A; Abascal, J; Allen, B; Civit, A; Fellbaum, K; Kempainen, E; Bitterman, N; Freitas, D; Kristiansson, K. Smart Home Environment. In: P R W Roe (Ed.): *Towards an Inclusive Future Impact and Wider Potential of Information and Communication Technologies*. COST, Brussels, Belgium, pp. 110 - 156, 2007.
- [8] Bjorneby, S. Smart Houses: Can they Really Benefit Older People? In: *Signpost*, Vol. 5, No. 2, pp. 36 - 38, 2000.
- [9] British Department of Health. *National Service Framework for Older People*. Department of Health, London, UK, Crown Copyright, 2001.
- [10] Clarkson, P J; Keates, S. A Practical Inclusive Design Approach. In: *Proceedings of the International Conference on Inclusive Design and Communications (INCLUDE'01)*, London, UK, pp. 72 - 73, 2001.
- [11] Cooper, R G. *Top oder Flop in der Produktentwicklung*. Wiley-VCH, Weinheim, Germany, 2002.
- [12] Corry, A V; Kramp, G; Aaløkke, S. Balancing User Control. Paper presented at the *International Workshop on Designing for Palpability, International Conference on Pervasive Computing (Pervasive'07)*, Toronto, Canada, 2007.
- [13] Coughlin, J; D'Ambrosio, L A; Reimer, B; Pratt, M R. Older Adult Perceptions of Smart Home Technologies: Implications for Research, Policy & Market Innovations in Healthcare. In: *Proceedings of IEEE Conference on Engineering in Medicine and Biology Society*, Lyon, France, pp. 1810 - 1815, 2007.
- [14] Cowan, D; Turner-Smith, A. The Role of Assistive Technology in Alternative Models of Care for Older People. In: I Sutherland (Ed.): *With Respect To Old Age: The Royal Commission for the Long Term Care of the Elderly*, Volume 2, Appendix 4, pp. 325 - 346, 1999.
- [15] Crabtree, A; Hemmings, T; Rodden, T. Pattern-Based Support for Interactive Design in Domestic Settings. In: *Proceedings of the Symposium on Designing Interactive Systems*. ACM Press, London, pp. 265 - 276, 2002.
- [16] Dansky, K H; Palmer, L; Shea, D; Bowles, K H. Cost Analysis of Telehomecare. In: *Telemedicine Journal and E-Health*, American Telemedicine Association, Vol. 7, No. 3, pp. 225 - 232, 2001.
- [17] Davidoff, S; Lee, M K; Yiu, C M; Zimmerman, J; Dey, A K. Principles of Smart Home Control.

- In: *Proceedings of the International Conference on Ubiquitous Computing (UbiComp'06)*, pp. 19 - 34, 2006.
- [18] de Ruyter, B; van de Sluis, R. Challenges for End-User Development in Intelligent Environments. In: H Lieberman, F Paterno, V Wolf (Eds.): *End User Development*. Springer, Heidelberg, Germany, pp. 243 - 250, 2006.
- [19] de Ruyter, B. 365 Days' Ambient Intelligence Research in Home Lab. In: *365 Days' Ambient Intelligence Research in Home Lab*, Philips Research, Eindhoven, The Netherlands, pp. 6 - 7, 2003.
- [20] Demiris, G; Tan, J. Rejuvenating Home Health Care and Tele-Homecare. In: J Tan (Ed.): *E-Health Care Information Systems: An Introduction for Students and Professionals*. Jossey-Bass, San Francisco, CA, USA, pp. 267 - 290, 2005.
- [21] Demiris, G; Finkelstein, S M; Speedie, S M. Considerations for the Design of a Web-Based Clinical Monitoring and Educational System for Elderly Patients. In: *Journal of the American Medical Informatics Association*, Vol. 8, No. 5, pp. 468 - 472, 2001.
- [22] Demiris, G; Parker Oliver, D; Dickey, G; Skubic, M; Rantz, M. Findings From a Participatory Evaluation of a Smart Home Application for Older Adults. In: *Technology and Health Care*, Vol. 16, No. 2, IOS Press, pp. 111 - 118, 2008.
- [23] Dewsbury, G. The Social and Psychological Aspects of Smart Home Technology within the Care Sector. In: *New Technology in the Human Services*, Vol. 14, No. 1-2, pp. 9 - 18, 2001.
- [24] di Biase, N; Napoli, A; Sabbatini, A; Borrello, E; Buongiorno, A M; Fallucca, F. Telemedicine in the Treatment of Diabetic Pregnancy. In: *Annali Dell'Istituto Superiore di Sanita*, No. 33, pp. 347 - 351, 1997.
- [25] Fichten, C; Barile, M; Asuncion, J; Fossey, M. What Government, Agencies, and Organizations Can Do to Improve Access to Computers for Postsecondary Students with Disabilities: Recommendations Based on Canadian Empirical Data. In: *International Journal of Rehabilitation Research*, Vol. 23, No. 3, pp. 191 - 199, 2000.
- [26] Fuchsberger, V. Ambient Assisted Living: Elderly People's Needs and How to Face Them. In: *Proceeding of the ACM International Workshop on Semantic Ambient Media Experiences (SAME'08)*, October 31, 2008, Vancouver, British Columbia, Canada, pp. 21-24, 2008.
- [27] Gabriel, Z; Bowling, A. Quality of Life in Old Age From the Perspectives of Older People. In: A Walker, C H Hennessy (Eds.): *Growing Older: Quality of Life in Old Age*, Open University Press, Buckingham, PA, USA, pp. 14 - 34, 2004.
- [28] Gaul, S; Ziefle, M; Arning, K; Wilkowska, W; Kasugai, K; Röcker, C; Jakobs, E-M. Technology Acceptance as an Integrative Component of Product Developments in the Medical Technology Sector. In: *Proceedings of the Third Ambient Assisted Living Conference (AAL'10)*, VDE, Berlin, Germany, CD-ROM, 2010.
- [29] Gefen, D; Straub, D. The Relative Importance of Perceived Ease of Use in IS Adoption: A Study of E-Commerce Adoption. In: *Journal of the Association for Information Systems*, Vol. 1, pp. 1 - 28, 2000.
- [30] Glende, S; Podtschaske, B; Friesdorf, W. Senior User Integration: Ein ganzheitliches Konzept zur Kooperation von Herstellern und älteren Nutzern während der Produktentwicklung. In: *Proceedings of the Second German Congress on Ambient Assisted Living*. VDE, Berlin, Germany. CD-ROM, 2009.
- [31] Gregor, P; Newell, A. Designing for Dynamic Diversity – Making Accessible Interfaces for Older People. In: *Proceedings of the EC/NSF Workshop on Universal Accessibility of Ubiquitous Computing: Providing for the Elderly (WUAUC'01)*, ACM Press, New York, USA, pp. 90 - 92, 2001.
- [32] Hailey, D; Ohinmaa, A; Roine, R. *Recent Studies on Assessment of Telemedicine: Systematic Review of Study Quality and Evidence of Benefits*. Working Paper, Institute of Health Economics, National Library Canada, 2003.
- [33] Haines, V; Mitchell, V; Cooper, C; Maguire, M. Probing User Values in the Home Environment Within a Technology Driven Smart Home Project. In: *Personal and Ubiquitous Computing*, Vol. 11, No. 5, pp. 349 - 359, 2007.
- [34] Hindus, D. The Importance of Homes in Technology Research. In: N A Streitz, J Siegel, V Hartkopf, S Konomi (Eds.): *Proceedings of the Second International Workshop on Cooperative Buildings, Integrating Information, Organization, and Architecture (CoBuild'99)*, LNCS 1670, Springer, Heidelberg, pp. 199 - 207, 1999.

- [35] Hirsch, T; Forlizzi, J; Hyder, E; Goetz, J; Stroback, J; Kurtz, C. The ELDer Project: Social, Emotional, and Environmental Factors in the Design of Eldercare Technologies. In: *Proceedings on the International Conference on Universal Usability* (CUU'00), ACM Press, pp. 72 - 79, 2000.
- [36] Holzinger, A; Ziefle, M; Röcker, C. Human-Computer Interaction and Usability Engineering for Elderly (HCI4AGING): Introduction to the Special Thematic Session. In: K Miesenberger et al. (Eds.): *ICCHP 2010, Part II, LNCS 6180*, Springer, Heidelberg, Germany, pp. 556 - 559, 2010.
- [37] Hong, J I; Landay, J A. An Architecture for Privacy-Sensitive Ubiquitous Computing. In: *Proceedings of the Second International Conference on Mobile Systems, Applications and Services* (MobiSys'04), Boston, MA, USA, ACM Press, pp. 177 - 189, 2004.
- [38] Hui, E; Woo, J; Hjelm, M; Zhang, Y T; Tsui, H T. Telemedicine: A Pilot Study in Nursing Home Residents. In: *Gerontology*, Vol. 47, No. 2, pp. 82 - 87, 2001.
- [39] Jerant, A F; Azari, R; Nesbitt, T S. Reducing the Cost of Frequent Hospital Admissions for Congestive Heart Failure: A Randomized Trial of a Home Telecare Intervention. In: *Medical Care*, Vol. 39, No. 11, pp. 1234 - 1245, 2001.
- [40] Jordan, P W. New Century Supertrends: Designing A Pleasurable Future. In: M G Helander, H M Khalid, M P Tham (Eds): *Proceedings of the International Conference on Affective Human Factors Design* (CAHD'01), ASEAN Academic Press, London, UK, pp. 3 - 8, 2001.
- [41] Klecun-Dabrowska, E; Cornford, T. Evaluation and Telehealth – An Interpretative Study. In: *Proceedings of the 34th Hawaii International Conference on System Sciences*, IEEE Pres New York, USA, 10 pages, 2001.
- [42] Kobza, L; Scheurich, A. The Impact of Telemedicine on Outcomes of Chronic Wounds in the Home Care Setting. In: *Ostomy Wound Management*, Vol. 46, No. 10, pp. 48 - 53, 2000.
- [43] Lindley, S E; Harper, R; Sellen, A. Designing for Elders: Exploring the Complexity of Relationships in Later Life. In: *Proceedings of the 22nd British HCI Group Annual Conference on HCI 2008: People and Computers XXII: Culture, Creativity, Interaction - Volume 1*, September 1 - 5, Liverpool, UK, pp. 77-86, 2008.
- [44] Lull, F; Müller, S; Santi, M. Eine Lösung für Alle? Bedarfsorientierte Gestaltung von AALKomponenten am Beispiel eines Anwendungsfalls zur Gedächtnisunterstützung. In: *Proceedings of the Second German Congress on Ambient Assisted Living*. VDE, Berlin, Germany. CD-ROM, 2009.
- [45] Meyer, S; Rakotonirainy, A. A Survey of Research on Context-Aware Homes. In: C Johnson, P Montague, C Steketee (Eds.): *Proceedings of the Workshop on Wearable, Invisible, Context-Aware, Ambient, Pervasive and Ubiquitous Computing*, Adelaide, Australia. Conferences in Research and Practice in Information Technology, Vol. 21, Australian Computer Society, pp. 159 - 168, 2003.
- [46] Meyer, S. Der Nutzer im Zentrum: Anforderungen, Wünsche, Erfahrungen der älteren Senioren. In: *Proceedings of the Second German Congress on Ambient Assisted Living*, January 27 - 28, 2009, Berlin, Germany. VDE, Berlin, Germany. CD-ROM, 2009.
- [47] Moncrieff, S; Venkatesh, S; West, G. Dynamic Privacy Assessment in a Smart House Environment Using Multi-Modal Sensing. In: *ACM Transactions on Multimedia Computing, Communications, and Applications* (TOMCCAP), Vol. 5, No. 2, Article 10, 29 pages, 2008.
- [48] Moncrieff, S; Venkatesh, S; West, G. Privacy and the Access of Information in a Smart House Environment. In: *Proceedings of the 15th international Conference on Multimedia* (Multimedia'07), ACM Press, New York, USA, pp. 671 - 680, 2007.
- [49] Newell, A; Gregor, P. Accessibility and Interfaces for Older People – A Unique, but Many Faceted Problem. In: *Proceedings of the EC/NSF Workshop on Universal Accessibility of Ubiquitous Computing: Providing for the Elderly* (WUAUC'01), ACM Press, New York, USA, 2001.
- [50] Nixon, P A; Wagealla, W; English, C; Terzis, S. Security, Privacy and Trust Issues in Smart Environments. In: D Cook, S Das (Eds.): *Smart Environments: Technology, Protocols, and Applications*. John Wiley and Sons, London, UK, pp. 249 - 270, 2004.
- [51] O'Brien, J; Rodden, T; Rouncefield, M; Hughes, J A. At Home With the Technology. In: *ACM Transactions on Computer-Human Interaction* (TOCHI), Vol. 6, No. 3, ACM Press, New York, USA, pp. 282 - 308, 2000.

- [52] Poulson, D; Nicolle, C; Galley, M. *Review of the Current Status of Research on 'Smart Homes' and Other Domestic Assistive Technologies in Support of TAHI Trials*. Ergonomics and Safety Research Institute (ESRI), Loughborough University, UK, 2002.
- [53] Quigley G; Tweed C. *Added-Value Services From the Installation of Assistive Technology for the Elderly*, Queen's University of Belfast, Research report EPSRC GR/M05171, 2000.
- [54] Reichwald, R; Ihl, C; Seifert, S. *Kundenbeteiligung an unternehmerischen Innovationsvorhaben*. Technical University of Munich, Munich, Germany, 2004.
- [55] Riegel, B; Carlson, B; Kopp, Z; LePetri, B; Glaser, D; Unger, A. Effect of a Standardized Nurse Case-Management Telephone Intervention on Resource Use in Patients with Chronic Heart Failure. In: *Archives of Internal Medicine*, Vol. 162, No. 6, pp. 705 - 712, 2002.
- [56] Röcker, C; Wilkowska, W; Ziefle, M; Kasugai, K; Klack, L; Möllering, C; Beul, S. Towards Adaptive Interfaces for Supporting Elderly Users in Technology-Enhanced Home Environments. In: *Proceedings of the 18th Biennial Conference of the International Communications Society: Culture, Communication and the Cutting Edge of Technology*, Tokyo, Japan, CD-ROM, 2010.
- [57] Röcker, C. Acceptance of Future Workplace Systems: How the Social Situation Influences the Usage Intention of Ambient Intelligence Technologies in Work Environments. In: *Proceedings of the 9th International Conference on Work With Computer Systems (WWCS'09)*, Beijing, China, 2009.
- [58] Röcker, C. Informal Communication and Awareness in Virtual Teams - Why We Need Smart Technologies to Support Distributed Teamwork. In: *Communications in Information Science and Management Engineering (CISME)*, Vol. 2, No. 5, pp.1 - 15, 2012.
- [59] Röcker, C. Information Privacy in Smart Office Environments: A Cross-Cultural Study Analyzing the Willingness of Users to Share Context Information. In: D Tanier, O Gervasi, V Murgante, E Pardede, B O Apduhan (Eds.): *Proceedings of the International Conference on Computational Science and Applications (ICCSA'10)*, LNCS Volume 6019, Springer, Heidelberg, Germany, pp. 93 - 106, 2010.
- [60] Röcker, C. Perceived Usefulness and Perceived Ease-of-Use of Ambient Intelligence Applications in Office Environments. In: M Kuroso (Ed.): *Human Centered Design*, LNCS 5619, Springer, Heidelberg, Germany, pp. 1052-1061, 2009.
- [61] Röcker, C. Social and Technological Concerns Associated with the Usage of Ubiquitous Computing Technologies. In: *Issues in Information Systems*, Vol. 11, No. 1, pp. 61 - 68, 2010.
- [62] Röcker, C. Socially Dependent Interaction in Smart Spaces: How the Social Situation Influences the Interaction Style in Computer-Enhanced Environments. In: *Proceedings of the International IEEE Conference on Mechanical and Electrical Technology (ICMET'10)*, pp. 314 - 318, 2010.
- [63] Rogers, M A; Small, D; Buchan, D A; Butch, C A; Stewart, C M; Krenzer, B E; Husovsky, H L. Home Monitoring Service Improves Mean Arterial Pressure in Patients with Essential Hypertension. A Randomized, Controlled Trial. In: *Annals of Internal Medicine*, Vol. 134, No. 11, pp. 1024 - 1032, 2001.
- [64] Saizmaa, T; Kim, H C. A Holistic Understanding of HCI Perspectives on Smart Home. In: *Proceedings of the International Conference on Networked Computing and Advanced Information Management (NCM'08)*. IEEE Press, Washington, DC, USA, pp. 59 - 65, 2008.
- [65] Scheermesser, M; Kosow, H; Rashid, A; Holtmann, C. User Acceptance of Pervasive Computing in Healthcare: Main Findings of two Case Studies. In: *Proceedings of the 2nd International Conference on Pervasive Computing for Healthcare (PervasiveHealth'08)* pp. 205 - 213, 2008.
- [66] Scheermesser, M. Akzeptanz des Bewegungsmonitorings bei chronischen Patienten. In: *Proceedings of the Second German Congress on Ambient Assisted Living*. VDE, Berlin, Germany. CD-ROM, 2009.
- [67] Streitz, N A; Magerkurth, C; Prante, T; Röcker, C. From Information Design to Experience Design: Smart Artefacts and the Disappearing Computer. In: *ACM Interactions*, Special Issue on Ambient Intelligence - New Visions of Human-Computer Interaction, Vol. 12, No. 4, pp. 21 - 25, 2005.
- [68] Tractinski, N. Aesthetics and Apparent Usability: Empirically Assessing Cultural and Methodological Issues. In: *Proceedings of the ACM SIGCHI Conference on Human Factors in*

- Computing Systems* (CHI'08), ACM Press, New York, USA, pp. 115 - 122, 1997.
- [69] Tsang, M W; Mok, M; Kam, G; Jung, M; Tang, A; Chan, U; Chu, C M; Li, I; Chan, J. Improvement in Diabetes Control with a Monitoring System Based on a Hand-Held, Touch-Screen Electronic Diary. In: *Journal of Telemedicine and Telecare*, Vol. 7, No. 1, pp. 47 - 50, 2001.
- [70] Vahs, D; Burmester, R. Innovationsmanagement: Von der Produktidee zur erfolgreichen Vermarktung. Schäffer-Poeschel, Stuttgart, Germany, 2005.
- [71] Venkatesh A; Vitalari N. Emerging Distributed Work Arrangement: An Investigation of Computer-Based Supplemental Work at Home. In: *Management Science*, Vol. 38, No. 12, pp. 1687 - 1706, 1992.
- [72] Venkatesh, A. Computers and Other Interactive Technologies for the Home. In: *Communications of the ACM*, Vol. 39, No. 12, ACM Press, New York, USA, pp. 47 - 54, 1996.
- [73] Wegge, K-P. Barrierefreie AAL Services – Nutzer mit besonderen Anforderungen. In: *Proceedings of the Second German Congress on Ambient Assisted Living*, January 27 - 28, 2009, Berlin, Germany. VDE, Berlin, Germany. CD-ROM, 2009.
- [74] Whitlock, W L; Brown, A; Moore, K; Pavliscsak, H; Dingbaum, A; Lacefield, D; Buker, K; Xenakis, S. Telemedicine Improved Diabetic Management. In: *Military Medicine*, Vol. 165, No. 8, pp. 579 - 584, 2000.
- [75] WHO. *Active Aging: A Policy Framework*. World Health Organization, Geneva, Switzerland, 2002.
- [76] Wilkes, B. Genderspezifische Produktentwicklung für AAL - Notwendigkeit oder Übertreibung. In: *Proceedings of the Second German Congress on Ambient Assisted Living*. VDE, Berlin, Germany. CD-ROM, 2009.
- [77] Zajicek, M. Interface Design for Older Adults. In: *Proceedings of the EC/NSF Workshop on Universal Accessibility of Ubiquitous Computing: Providing for the Elderly* (WUAUC'01), ACM Press, New York, USA, pp. 60 - 65, 2001.
- [78] Ziefle, M; Bay, S. How Older Adults Meet Cognitive Complexity: Aging Effects on the Usability of Different Cellular Phones. In: *Behaviour and Information Technology*, Vol. 24, No. 5, pp. 375 - 389, 2005.
- [79] Ziefle, M; Bay, S. Transgenerational Designs in Mobile Technology. In: J Lumsden (Ed.): *Handbook of Research on User Interface Design and Evaluation for Mobile Technology*, IGI Global, Hershey, PA, USA, pp. 122 - 140, 2008.
- [80] Ziefle, M; Röcker, C; Holzinger A. Medical Technology in Smart Homes: Exploring the User's Perspective on Privacy, Intimacy and Trust. In: *Proceedings of the IEEE 35th Annual Computer Software and Applications Conference Workshops* (COMPSACW'11), IEEE Press, pp. 410 - 415, 2011.
- [81] Ziefle, M; Röcker, C; Holzinger, A. Perceived Usefulness of Assistive Technologies and Electronic Services for Ambient Assisted Living. In: *Proceedings of the 5th International ICST Conference on Pervasive Computing Technologies*, Dublin, Ireland, CD-ROM, 2011.
- [82] Ziefle, M; Röcker, C; Acceptance of Pervasive Healthcare Systems: A Comparison of Different Implementation Concepts. In: *Proceedings of the 4th International ICST Conference on Pervasive Computing Technologies for Healthcare* (PervasiveHealth'10), Munich, Germany, CD-ROM, 2010.
- [83] Ziefle, M; Röcker, C; Kasugai, K; Klack, L; Jakobs, E-M; Schmitz-Rode, T; Russell, P; Borchers, J. eHealth – Enhancing Mobility with Aging. In: M Tscheligi, B de Ruyter, J Soldatos, A Meschtscherjakov, C Buiza, W Reitberger, N Streitz, T Mirlacher (Eds.): *Roots for the Future of Ambient Intelligence, Adjunct Proceedings of the Third European Conference on Ambient Intelligence* (Aml'09), November 18 - 21, 2009, Salzburg, Austria, pp. 25 - 28, 2009.
- [84] Ziefle, M; Röcker, C; Wilkowska, W; Kasugai, K; Klack, L; Möllering, C; Beul, S. A Multi-Disciplinary Approach to Ambient Assisted Living. In: C Röcker, M Ziefle, (Eds.): *E-Health, Assistive Technologies and Applications for Assisted Living: Challenges and Solutions*, IGI Global, Hershey, PA, USA, pp. 76 - 93, 2011.