Technology and Disability 14 (2002) 1–9 TAD132
IOS Press

Designing acceptable 'smart' home technology to support people in the home

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Abstract. This paper considers the main aspects and questions that are required to be asked by any designer of residences that include technology designed to support the lives of disabled people. It seeks to reframe the design process to extend the concepts of 'inclusive' and 'universal' design within the social context of designing for people with a wide range of disabilities. Designing 'smart homes' or homes that contain elements of 'smart home' technology for disabled or older people is not different from designing the home for people without any form of impairment on the one hand. On the other hand, there is a perceptual shift that is required in order to ensure needs are met from all stakeholders. There is a need to determine the needs of the occupant(s) and reflect these needs within the overall design. This paper addresses the main questions that arise from the design process as well as discuss the role of cultural probes in enhancing the design.

Keywords: Cultural probes, design, dependability, disability, assistive technology, 'smart homes', inclusive design, universal design, design criteria

1. Introduction

This paper is derived from the work of three projects, namely CUSTODIAN and the ongoing EQUATOR and DIRC projects (URLS at end of paper). Designing 'smart' homes that meet the needs of older or disabled people is not as straightforward as might first appear, especially when technology is likely to be performing a central role in the finished design and the user will rely on the technology at all times to work appropriately. This paper unpacks the main considerations and questions that are significant to the design process. The paper is based on the authors' experiences of the designing acceptable technology residences for older and disables people throughout the UK. Four main areas of significance are covered within the paper. The paper initial considers the primary design considerations, and then enquires about the general design of the building and internal spaces. The authors then direct attention to the main residential structures before considering the technology that might be appropriate. The paper concludes with design and methodological considerations that might be of use to people who design assistive or smart home technology to support people in residential spaces. Although the paper is based on the authors' experiences of designing over 30 'smart' residential spaces in the UK, there is transferability of many of the ideas within the paper that can assist good design.

A methodological underpinning to the design process has stemmed from Manderville [18] who demonstrates that technology and disability are interrelated. Through this interrelation, technology can be disabling if it is not used effectively and cautiously. Technological solutions are required to be tailored to the individuals' needs and those of the other stakeholders.

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ISSN 1055-4181/03/$8.00

"Smart homes can be useful; enhancing the quality of life for people whose life is limited by their domestic environment. The design process is something that requires needs to be considered within a framework of barrier free design. However, technology for technology's sake like inappropriate design can be debilitating and dis-empowering". [10]

2. Primary design considerations

2.1. Stakeholder identification

Designing homes that are responsive to the needs of residents and carers (both formal and informal) is the primary consideration in any specification. However, these two groups are only a fraction of other *stakeholders*, who may include, members of family, care staff, care managers, social work, housing and health authorities, funding bodies, building societies, advocates, emergency services etc. The first task is to identify all the relevant stakeholders for the particular case. There is no definitive list of stakeholders, as these will vary from case to case. In order to identify the relevant stakeholders in any given case the following guidelines are suggested based on experience designing home technology that meets needs and budgets:

- Listen to the stories that people relate, the narrative texts and subtexts provide considerable information including who might be potential or discrete stakeholders. Understanding everyday activities and peoples experience with technology is crucial.
- Ask people who they consider will have an interest in the resident(s) and residence.

It is worth taking the trouble to find out whom all the stakeholders are as early as possible within the project as it can avoid having to repeat extensive consultations and design work or even totally abandoned the project, as a key and influential stakeholder had not been identified during the very early stages.

Often the stakeholders and funders will identify these key people. Sometimes, this will not be possible, as the information the designer would require is not "*allowed*" to be given out, due to its sensitive nature. Should this situation occur, it is useful to ensure that the designer's approach is open and that the reservations about the qualified design are acknowledged. The initial considerations for any design should to consider the needs of carers, residents, and other stakeholders within the same view and not as separate entities and this will be mediated by the cost/budget of the project.

Locating needs	Some basic questions
Carers' needs	Who is paying?
Residents' needs	For what are they paying?
Stakeholders needs	What is being paid for in the design?
Costs/budgets	What budgetary constraints are there?

2.2. Budgetary constraints

Having determined the needs of residents and carers and stakeholders through ethnographic investigations; it is necessary to consider budgetary constraints on the project. In the current climate, within the UK, health and social care related packages are subject to budgetary constraints and technological solutions may not be a feasible, practical or appropriate solution. Nevertheless, it is still essential that the design of the building be considered from the viewpoint of all stakeholders. Ancillary augmentative technology such as community alarms, fire detection and alarm systems will most likely still be required and budgeted for. This allows the possibility of adding some minimal assistive or smart technology into the design by an appropriate choice of these systems.

3. General design of building/internal spaces

3.1. Accessibility

There is little point in putting the latest racing engine into an old car; the breaking system and other components of the cars make up would not be able to cope with the demands made of it (see [9]). Similarly, there is little point in putting the latest technology into a home where the resident(s) or carer(s) will not be able to benefit from it because the design of the house itself is not appropriate. Design solutions are required to be empowering to all users and potential users. A minimum number of questions need to be addressed concerning the internal spaces:

Are they accessible?
Are they comfortable, convenient, easy to use and enjoy?
Are they meeting the needs of the residents for privacy/independence/rehabilitation?
Does the technology fit aesthetically with the users views of the living spaces?
Do they meet the needs of the carers: privacy, security?

3.2. External spaces

Having determined the accessibility and issues relating to the internal spaces it is necessary that the designer be concerned with activity that is to occur in the external spaces, outwith the four walls of the residence.

– If there is external spaces/garden?

Is this space secure and safe?
Is space accessible?
Is it attractive?
Is it maintainable?
Does the user occupy this space?

Accessibility to external spaces can be as important as accessibility within internal spaces. If a resident feels trapped, or the carers are limited to caring for a person within the internal spaces itself this will limit the rehabilitative nature of the design.

This raises the common issue that has been noted from our research, that professionals tend to focus on either the internal or external spaces as mutual exclusives. There tends to be a belief that people are either inside the house where they undertake X, Y and Z or outside where they do D, E and F. There is little realisation that these spaces are not separate in many people's minds and therefore should be considered of equal importance in the initial design stages. The evidence suggests that rehabilitation is not just something that occurs within internal spaces.

The design of the building and its immediate surroundings must be responsive to the needs of the carers and residents but must also be designed for the other users such as domestic staff, catering staff professionals and other visitors as well as friends and family. Therefore, the designer must consider the following:

– Is the building accessible from all entry points /access points?

– Which areas are required to be secure?

Accessibility	Visitability	Usability

3.3. Time and contacts

The designer must also consider and make a note of the contacts that they are required to make and maintain during the design process. It is also necessary to determine the level of interaction that can be expected with each of these contacts not only to ensure that the designer does not get over committed, but also because the number and duration of meetings and time spent in interacting with these contact should be reflected in the costs of the design.

– Who do you need to make contact with and interact with?
– What level of interaction is required and can this be reflected in the total cost of the project?

4. The residential structure

Often the first thought of the designer is the residence's physical attributes. This paper contends that although this is a crucial aspect of the design its importance is less than the social aspects of the design. However, as can be seen from the preceding considerations, the physical aspects will interplay with some of the aforementioned concerns such as budgets etc. Notwithstanding, the structural aspects of the residence are of importance for a number of reasons; the designer needs to determine the feasibility of applying suitable technology and determine it there are any impediments that are likely to inhibit the process.

Where possible, considerations of flexibility are important – occupant's requirements may change – for better or worse. The building should be designed to accommodate change, as should the technology. For example, a frame structure, with non-load bearing walls might have advantages over a traditional load bearing masonry home.

Some basic considerations in Smart House design are:

Type of residence:
House or flat or multi occupancy dwelling?
How many rooms/levels/floors accessible by resident(s)?
How many floors/levels are there?
What are the routines and activity patterns of the residents?
Does home meet accessibility criteria?

The secondary aspects are related more to the buildings physical nature as follows:

What is the construction of the building?	
Are there fire prevention or other safety aspects that emanate from the buildings construction and usage that need attention?	Does the cabling and plumbing need replacing?
Is the building a new build or retrofit?	If retrofit Is the cabling and plumbing accessible?

Will the structure of the building withstand the alterations?	How much will the permission cost?
Is permission required for any of the potential alterations	If so, how long will it take to obtain?

The problems associate with designing retrofit installations have been detailed significantly [1,12,14,25]. Retrofitting is not a cheap option since it will often involve expenses, such as redecorating, new piping and ducting work or rewiring. If retrofitting is to be undertaken, the designer should require that the house should still meet barrier free design criteria (See [13,16,19, 23], for examples of barrier free design). Currently technologies such as X10 and wireless networking allow designers to avoid the necessity of large-scale alterations that might have been necessary through retrofits of the past.

5. Technology system specification

The social and physical requirements of the occupiers, the functions, form and structure and technology all need to be considered and manipulated simultaneously to achieve the best outcome for all. Design is not a linear process. It is a number of parallel processes with coupling between them and feedback loops [7,9,11,20, 21]. The designer needs to thoroughly understand what the possibilities and implications of smart systems at the start of the design. In this way it should be possible to ensure that there is no conflict or problems result and that unnecessary and expensive redundancy is avoided. Technology for the sake of technology is not acceptable.

> "*What can technology do to help?" is almost always the wrong question.* [21]

Technology should be considered as an augmentation to the overall design. Although technology can be empowering it can also be dis-empowering to the user if it is not suitable, not reliable, or does not perform the functions it was intended to perform.

Currently there are no technological assessments that are designed to embrace smart home technology and therefore the designer is required to translate the determined need into a smart home system or subsystem. This is carried out by the use-case strategy [10, 25], whereby the designer maps the needs to the design and systematically works through different options and configurations to ensure that the system does not produce unexpected consequences. By undertaking use-cases, the designer might avoid completely redesigning the system in order to meet the differing and conflicting needs that the stakeholders place on the environment.

Are alternative non high-tech solutions more appropriate?	What systems can enable the carer and residents and which are definitely not suitable for consideration?
Is there to be one major system and manufacturer to be used throughout the design or a number of different ones?	How is the system going to benefit the carer(s) and resident(s)?
Where are the electrical points [switches and sockets] to be placed?	Are they at the appropriate height and easily accessible?
Where are the control units to be placed?	How many different systems are needed to be combined together in the overall design?
Are there any special considerations that are required within individual designs?	How much are these likely to cost?
Are they feasible?	Can they interface with the main system design?

Having determined the systems basic architecture, the designer should consider the usability characteristics of the system and how the system is to become interactive, and provide a safe and secure environment for the residents and carers.

What form of alerting system is required (sound, visual, tactile etc)?	What prioritisation do each of the potential alerts require?
Who is to access and act on the alerts?	What safety features are required (such as back ups)?
What support systems are required?	Are the user interfaces clear and easy to use?
What rehabilitative systems are required?	Does the user interface provide meaningful feedback to the user so that it is understandable?
Does the system augment the residents and staff/carers?	Are the systems not likely to add to confusion?
Is the system easy to learn?	Is the system self-evident?
Can the system be upgraded?	
Are automated tasks doing what they should do and measuring what they should measure?	Will the system do what everyone expects the system to do, no more and no less? False conceptions of what the technology offers is poor design.

Most systems that are designed will involve some form of alert system, which is required to provide additional security to the resident. It is important that the users and stakeholders are aware that a system with security features is unlikely to stop physical harm from external parties, but should, if well designed, alert others if this situation occurs.

6. Meeting need through appropriate technology

Meeting the need of the user and stakeholder requires the designer to consider a number of factors. Initially the budget will determine the level of support that the person will obtain through the design. A small budget will mean that the technology that is used is likely to be either be unreliable or made up of only a few key items with fixed modality. Currently, at most hardware stores there are a range of off the shelf devices that can perform useful functions to provide the user with a potentially safer home such as burglar alarms, pressure pads, magnetic reed switches etc, but many of these are reliant on mains borne activity and therefore are potentially dangerous should a power put occur. Moreover most of these devices are not reliable as there is no means to determine if they are working appropriately unless a simulation condition is used to test them.

Ideally when designing technology to meet the needs of disabled or older people it is important that the technology is reconfigurable, easy to learn how to use, usable by the user, easily maintainable, does what the user thinks it will do, supports the everyday activities and routines of the individual and is aesthetically pleasing for the person to live with. The last of these is highly important when designing for people with cognitive impairments who might become confused by parts of the system appearing in their home.

6.1. Types of 'smart' home technology

There are a number of differing technologies available each of which has their pros and cons. Powerline systems, as previously stated are liable to be knocked out in situations where a power cut occurs, and they might not be easily reset. Busline systems are useful in new build homes as they offer more stability, but are far more expensive and often limited in what operations they can do. Moreover, busline systems often rely on interfacing with devices that are not busline protocolled and this can lead to instability in the system and difficulty in programming devices in the manner that is desired.

The authors have had experience of designing homes using both of the above systems, but are now using extensively radio frequency devices (RF) throughout the installation. Although RF devices are still new and can be problematic as they can suffer from interference and other anomalies, they are useful as they can be easily changed, easily removed and replaced somewhere different. They do not require that the home be structurally tampered with, and there are a number of manufacturers and companies providing the equipment to make it a competitive venture for them and supply enough choice for the designer. RF tends to be cheaper than busline systems, and even at time cheaper than Powerline system. If RF devices are being used in the design it is important that the designer ensures that they all meet the same specification as 802.11a and 802.11b specifications are incompatible as they operate in different frequency ranges 2.4 GHz (802.11b) and 5 GHz (802.11a). The speed rate that they transfer data is different; 802.11a up to 54Mbps compared to 802.11b 11Mbps. A major consideration for the appropriate use of RF devices is the thickness of walls, as the density of the walls could impede the signal.

7. Ways of determining need

> *Technologies can be understood as materials whose stability relies upon the continuous reproduction of their meaning and usefulness in practice* [24].

Although lip service is often paid to the 'adding the user into the design' an essential feature of good design is to know as much as possible about the person(s) for whom the design is being done. In the case of older or disabled people, the easiest option is to talk with the appointed or informal carers to find out what they might consider the needs of the person(s) to be. Clearly this might yield some useful data but the disabled or older person(s) should always be the primary target. Their views combined with the views of other carers and stakeholders should provide a useful platform from which the design can be launched [26].

7.1. 'Cultural probes'

Methodologically there are a number of problems with finding the most appropriate form of obtaining the views of the relevant parties. Standard interviewing will yield a certain amount of information; focus groups might also provide a useful information source in the short term. The Computing Department at Lancaster University in conjunction with the Psychology Department at the University of York are currently looking at issues of dependability within the DIRC (*Dependability Interdisciplinary Research Collaboration*) Project Activity (PA7) entitled 'Dependable Ubiquitous Computing In The Home'. DIRC is a UK project that is considering the role of dependability in systems (in the broadest sense) and is specifically looking at issues relating

to assistive technology within the home. It considers how systems failures occur, what is a fault and what is an error; how systems can be made more reliable and safer; how issues of timeliness, structure, responsibility, diversity, risk and maintainability are addressed within the areas of advanced home technologies. The Digital Care project, which is part of EQUATOR also considers the role of appropriate technology to enhance people's lives.

One way in which we have attempted to increase the repertoire of available techniques is through the employment and adaption of 'cultural probes' in which a number of common items are given to older people to provoke inspirational and diverse responses. 'Cultural Probes' [15] originating in the traditions of artist¤Cdesigners rather than science and engineering, and deployed in a number of innovative design projects (e.g. the Presence project) may prove a way of supplementing ethnographic investigations. We use 'cultural probes' (cameras, diaries, maps, Dictaphones, photoalbums, postcards, qualitative questionnaire etc) in the project, as a way of uncovering information from people that are difficult to research by other means and as a way of prompting responses to users emotional, aesthetic, and social values and habits [5]. The probes furthermore provide an engaging and effective way to open an interesting dialogue with users [17]. Through the use of the probes an understanding of how older people relate to technology can be uncovered. The cultural probes being used in the study are specially chosen items that can be used by the older people.

Disability or impairment or care or old age is considered in relation to how individuals practically perceive and understand it, and how it practically effects their everyday life, not in terms of some explanatory or prescriptive model. We suggest that when it comes to mundane technological intervention in everyday lives what is needed is an alternate position that attends to members' perspectives, replacing political rhetoric with recommendations for design. In the DIRC and Digital Care projects we explore some of the methodological options open to those working in the domestic domain. In addition we highlight some of the moral and ethical components of the design enterprise. Technology can present dramatic compromises in social activities, role definition, and identity. Consequently, the challenge for the project is to provide support for individuals, rather than create new, technological, forms of dependence. Embodying a philosophy of care into design requires an ethical awareness and recognition of the various ways that technology can impinge on individual care pathways and a sensitivity towards the social implications of any technological intervention.

We use 'cultural probes' as a way of uncovering mundane information from a group that is difficult to research by other means and as a way of prompting responses to users emotional, aesthetic, and social values and habits. The probes furthermore provide an engaging and effective way to open an interesting dialogue with users. The probes have been provocative in eliciting some informative responses; enabling us to overcome some of the 'distance' between researchers and users, presenting us with a rich set of materials that grounds our designs in the detailed textures of everyday life. Probes are about understanding people in situ, uniquely not abstractly en masse, and the results of the probe exercise are highly individual, emotive, idiosyncratic and revealing of participant's personal lives as these "fragmentary glimpses" of people's home lives are transformed into "semi-factual narratives" informing design.

The probes have elicited a wide variety of responses but have enabled the research team to determine some of the most common areas of design failures within the respondents' homes [4]. For example, a number of respondents use the telephone as their only means of communication and a significant number rely on a landline-dedicated phone situated in the living room. This would normally suffice, yet, when a person is living alone or as the main carer of another person who might be severely infirm then the necessity to have a telephone upstairs becomes a real issue.

We have also noted temporal logistics that can affect design outcomes, such as the traditional washday. Traditionally, we consider standard tasks such as undertaking the weekly wash as a simple exercise which can be done at our convenience, yet for older people this is not the case as this task (as with most other tasks) there is a necessity to schedule this event into the week as the whole day could be taken up doing it. The scenario in some houses is: get the washing together upstairs . . . rest . . . move washing to top of stairs . . . rest . . . move washing down the stairs . . . rest . . . move washing to sitting room or washing machine . . . rest . . . programme washing machine and start it . . . rest . . . rest . . . rest . . . rest . . . put washing on line . . . rest . . . collect dry washing together . . . rest . . . move dry washing to bottom of stairs . . . rest etc. Hence simple tasks become complex adventures.

Through the use of cultural probes the situated activities and organised events through which technology

interfaces with the person can be truly explored. The probes act to inform us of how people relate to technology, use technology, worry about technology as well as highlighting areas of difficulty experienced within the person's life. The probes also allow us to find out about life patterns such as who visits the person, what would the most like to be able to do etc. Taken as a whole, the material gathered provides a clear snapshot of a person's life that can be complimented by interview material and other data gathering techniques. Our fieldwork studies and the probes have indicated some major preoccupations in our different research settings such as an understandable preoccupation with safety and security. Amongst the older residents concerns about safety and travel outside the home are reflected in diary entries and are manifested in reduced social contact. These unfortunate circumstances pose fascinating, if distressing, problems for the design of appropriate and acceptable technologies, through highlighting the importance of connections between the home environment and the outside world.

7.2. From method to design

Translating the results of the cultural probes into technology recommendations is also straightforward as the recommendations are already given through the work with the probes [3]. Already, the probes have alerted the team to the differing levels of expectation that people have about technology as well as the differing dependency that people have on technology. The team has also been acutely aware of the lack of understanding and utility of much of the technology that people have in their own homes. Few of the respondents were able to programme their videos, apart from switching on record as they left the house and recording the whole evenings programmes. Many respondents were happy with technology that they couldn't work or wouldn't use, based on the assumption that it was supposed to be good for them.

The eclectic approach adopted by this project attempts to meet some of the ethical and moral dilemmas through careful involvement and acknowledgement of users in the design process. One particular technical concern, perhaps a dominant if unusual concern for a research project, is that of dependability and associated issues of diversity, responsibility and timeliness. Given the domestic setting it is imperative that technologies designed for the setting are reliable and dependable. Björneby [2] notes that the reliability of the technology is essential. Just as technology can enable it can equally be the cause of disablement and low self-concept. In amongst the technical challenges are other issues concerning the location of the interface, the generalisability of design solutions, the transfer of skills to real world situations, and support for independent living in the community. These challenges highlight some of the moral and ethical components of the design enterprise, in particular the need to carefully think through and balance issues of 'empowerment' and 'dependence'.

8. Reflections

This paper describes the elements that are required within the design process when specifying technological solutions for people with disabilities. It has explored the elements of the design process, based on the authors experience in the field. Clearly, negotiations and mediations take up the majority of time in any design. This is because it is critical to obtain the real views of what the perceived and actual needs are in order to reflect these in the specification. The deciphering and investigative skills of the designers are also essential in eliciting accurate needs appraisals.

The designer needs to thoroughly understand what the possibilities and implications of smart systems are, at the onset of the design. In this way it should be possible to ensure that there is no conflict or problems and that unnecessary and expensive redundancy is avoided. Also where possible, considerations of flexibility are important – occupant's requirements may change – for better or worse. The building should be designed to accommodate change.

The paper identifies the main steps that are undertaken in the design process, which fall into four outlined logical categories. The paper also has argued that these procedures form an iterative process, which should lead to a reduction of errors and omissions by the designer and a robust design specification.

Any design is a reflection of the inner essence of the designer, just as any design will effect the quality of life and self perception of the resident that occupies the designed space. The designer, therefore, has a moral and ethical responsibility to ensure that the needs of stakeholders, residents and carers are reflected as accurately as possible in the overall specification.

Finally the paper suggests that a method that can be employed effectively to determine needs is through the use of "cultural probes" which enable users to convey elements of they life to the designer.

Acknowledgements

This work is funded by the UK Engineering and Physical Sciences Research Council (EPSRC), EQUATOR and Dependability (DIRC) Interdisciplinary Research Collaborations.

For more information see

DIRC related sites

http://www.dirc.org.uk/research/activities/P7-description.htm
http://www.comp.lancs.ac.uk/computing/research/cseg/projects/dirc/pa7.htm

EQUATOR

http://www.equator.ac.uk
http://www.equator.ac.uk/projects/digitalcare/
http://www.equator.ac.uk/projects/domus/index.htm

9. CUSTODIAN

http://www2.rgu.ac.uk/subj/search/research/sustainablehousing/custodian/home.html
http://www.smartthinking.ukideas/custindex.html
Information on all of the projects can be found here:
http://www.smartthinking.ukideas.com

References

[1] Ad van Berlo, ed., Design Guidelines on Smart Homes: A COST 219 bis Guidebook, Inclusion of Disabled and Elderly people in Telematics, 1999, http://www.stakes.fi/cost219/smarthousing.htm# Distributed%20intelligence.
[2] S. Björneby, *Signpost: Smart Houses: Can they really benefit Older People?* **5**(2) (October, 2000).
[3] K. Cheverst, K. Clarke, G. Dewsbury, T. Hemmings, J. Hughes and M. Rouncefield, Design With Care: Technology, Disability And The Home, in: *Inside The Smart Home, Springer-Verlag*, R. Harper, ed., London Ltd, 2003.
[4] G. Dewsbury, K. Clarke, J. Hughes, M. Rouncefield and I. Sommerville, *Designing Dependable Digital Domestic Environments*, In Proceedings of HOIT 2003, The Networked Home and the Home of the Future, April 6–8, 2003, in Irvine, California.
[5] G. Dewsbury, K. Clarke, J. Hughes, M. Rouncefield and I. Sommerville, Growing Older Digitally: Designing Technology For Older People, In Proceedings of INCLUDE 2003, inclusive design for society and business, *Helen Hamlyn Research Centre, Royal College of Art* (25–28 March 2003), 57–64.
[6] G. Dewsbury and M. Edge, Designing The Home To Meet The Needs Of Tomorrow, *Open House International* **26**(2) (2001), 33–42,
[7] G. Dewsbury, The Social And Psychological Aspects of Smart Home Technology within the Care Sector, *New Technology In The Human Services* **14**(1–2) (2001), 9–18.
[8] G. Dewsbury, K. Clarke, M. Rouncefield and I. Sommerville, *Home Technology Systems, Housing Care and Support Journal*, Pavilion, October, 2002.
[9] G. Dewsbury, B. Taylor and M. Edge, Designing Safe Smart Home Systems for Vulnerable People, in: *Dependability in Healthcare Informatics*, R. Proctor and M. Rouncefield, eds, Proceedings of the First Dependability IRC Workshop, Edinburgh March 22–23rd, 2001, Lancaster University.
[10] G. Dewsbury, B. Taylor and M. Edge, *The Process of Designing Appropriate Smart Homes: Including the user in the design*, A paper presented to the Workshop on Ubiquitous Computing in Domestic Environments, Nottingham University, 13–14th September 2001.
[11] G. Dewsbury, B. Taylor and M. Edge, Designing Dependable Assistive Technology Systems For Vulnerable People, *Health Informatics Journal* **8**(2) (June 2002), 104–110.
[12] M. Edge, B. Taylor, G. Dewsbury and M. Groves, The Potential For Smart Home Systems In Meeting The Care Needs Of Older Persons And People With Disabilities, *Seniors Housing Update* **10**(1) (August 2000).
[13] H.M. Edge, G.A. Slaven and G. Deveci, *The Adaptive House in Rural Social Housing Policy: Removing Barriers through Design Participation and Flexibility*, European Network for Housing Research Conference, Cardiff, September, 1998.
[14] D. Gann, J. Barlow and T. Venables, Digital Futures: Making Homes Smarter, Chartered Institute of Housing/Joseph Rowntree, 1999.
[15] B. Gaver, T. Dunne and Pacenti, *Cultural Probes*, Interactions, 6,1, Jan–Feb 1999, 21–29.
[16] G. Kane, G. Heaney and S. McGreal, Resident participation in the evaluation of external accessibility requirements in housing estates, *Facilities* **18**(1/2) (2000), 45–55, MCB University Press.
[17] S. Kember, K. Cheverst, K. Clarke, G. Dewsbury, T. Hemmings, T. Rodden and M. Rouncefield, Keep Taking The Medication: Assistive Technologies For Medication Regimes in Care Settings, in: *Universal Access and Assistive Technology* S. Keates, P. Langdon, P.J. Clarkson and P. Robinson, eds, Springer-Verlag, London Ltd, 2002, pp. 285–294.
[18] L. Manderville, *Towards The SUPERHOME: Bringing Home the IT Revolution*, England, RMDP, 1995.
[19] F. Martin, *Every Home You'll Ever Need*, Edinvar, Edinburgh, 1992.
[20] J. Neislon, *Usability Engineering*, Academic Press Inc, 1993.
[21] D.A. Norman, *Things that make us smart: Defending human attributes in the age of the machine*, Reading, MA: Addison-Wesley, 1993.
[22] J. Porteus and S.J. Brownsell, *Exploring Technologies for Independent Living for Older People*, A report on the Anchor Trust/BT Telecare Research Project, Anchor Trust, 2000.
[23] Scottish Homes, The Design of Barrier-Free Housing, Scottish Homes, Edinburgh, 1995.
[24] L. Suchman, Working relations of technology production and use, in: *The Social Shaping Of Technology*, D. Mackenzie and J. Wajcman, Open University Press, UK and USA, 2002.
[25] B.J. Taylor, *The Frankenstein Home, would you want to live in one?* New Technology in Human Services, Sept. 2001.

[26] A. Venkatesh and S. Mazumdar, New Information Technologies in the Home: A Study of Uses, Impacts, and Design Strategies, in: *The Power of Imagination*, T. Mann, ed., Environmental Design Research Association (EDRA), pp. 216–220.