Addressing Maslow's deficiency needs in smart homes

Michiel Brink MSc[a]
E: m.brink@tue.nl
Johanna E.M.H. van Bronswijk PhD[a]
E: j.e.m.h.v.bronswijk@tue.nl

[a]Group PEBE, Department of the Built Environment, Eindhoven University of Technology, The Netherlands

M. Brink, J.E.M.H. van Bronswijk. Addressing Maslow's deficiency needs in smart homes. Gerontechnology 2013;10(3):445-451; doi:10.4017/gt.2013.11.3.008.00 Modern smart homes contain elements from different technical disciplines, such as home automation, robotics, and tele-heath. We investigated to which extent smart-home systems address the different levels of deficiency needs of Maslow, and the corresponding level of integration of smart-home systems. Reports published between 1993 and 2010 concerned 28 prototypes or concepts, which have been analyzed. Functionalities that are supported by these smart-home systems are not equally distributed over the deficiency-needs levels of Maslow. The focus is on the two lower levels (physiology and safety), while preventing end-users to install and adapt the system (an esteem-related deficiency). Among the minority of fully integrated smart-home systems the highest level of deficiency needs (self-actualization) was addressed in 4 projects, with half of them also allowing the end-user to be master of installation and adaptation to changing needs in time. Fully integrated smart-home systems have so far not made it onto the market. The Maslow hierarchy of deficiency needs may act as a guide to developers and marketers to make sure that relevant needs are addressed effectively, and no new deficiencies are introduced.

Keywords: smart home, user needs, Maslow, aging-in-place

In their review of the different elements of smart homes, Franchimon & Brink[1] state that matching of existing technologies of home automation, robotics, assistance, tele-health (including geriatric telecare and telemedicine) is required to assure an optimal quality of life in our aging society. However, the roll-out of smart homes leaves much to be desired. Besides technology issues to be solved, business models are lacking to remove vendor locks, and to combine with other types of business (health care, entertainment, security, etc.)[2–4].

Even more important is the discrepancy between user needs and offered functionalities[5]. Earlier, Maslow's[6] hierarchy of deficiency needs was proposed as a framework for catching user values in design and development of technologies for a longer vital life[7].

Maslow[6] identified consecutive layers of deficiencies in needs of human subjects: (i) physiological, (ii) safety related, (iii) concerning a sense of love and belonging, (iv) esteem related, and (v) room for self-fulfillment or self-actualization. The more basic physiological needs (such as breathing, eating, walking) have to be fulfilled before the higher deficiencies (such as social and safety needs) start to matter.

Smart home elements may not only address the needs of daily life directly, they may also become sources of new need deficiencies, such as loss of mastery over one's own situation (esteem related). Since older adults generally do not wish to have technologies in their homes before they need them, the smart-home systems must have a large degree of adaptability with different functionalities activated at different times[8].

Although all levels of needs are neither age- nor culture dependent, their diversity increases with age and varies among cultures[8,9]. In addition, the variation in individual demands broadens as one goes from the basic to the higher deficiencies to be supported[7]. Both progressed age and support of higher-level deficiencies call for a broadening of the range of ICT (Information and Communication Technology) supports to guarantee well-being.

Smart-home initiatives, such as related to Ambient Assisted Living (AAL), specifically aim at improving the well-being of older people by using relevant ICT-innovations. Aim of this study is to elucidate the coverage of end-user needs by published complete smart-home systems in development.

Methodology

Project selection

Our sample of running smart-home projects to be analyzed, originates from reports published between 1990 and 2010. We used 'home automation' and 'smart home' as keywords in Web-of-Knowledge[10], Science Direct[11], Google Scholar[12], and the database of European Research Projects[13]. Initially this resulted in 900 publications. The following inclusion criteria were applied in a second step of selection: (i) the system had been implemented; (ii) it contained system-integration software (for instance, middleware), and (iii) it was described in detail. A total of 28 smart-home prototypes or concepts, described between 1993 and 2010, remained, and were described in 39 publications originating from Asia, Europe, North America, and Oceania.

User-needs analysis

For each selected project, we extracted included functionalities and classified them by Maslow's hierarchy of deficiency needs. Functionalities that serve a physiological aim like tele-care, physical health (monitoring), or food preparation, are categorized in the lowest, physiological layer of deficiency needs.

The second layer (safety) includes functionalities to improve safety or security, such as fall detection and activity monitoring. Although 'weather forecast' does also have an entertainment component we chose to consider it as a form of safety, since weather conditions may be unsafe for older persons[14].

The third layer (social) covers functionalities that support social activities or interactions.

Cognitive training and energy saving are both included in the fourth layer (esteem). Although these functionalities, especially energy saving[15], also relate to other layers, the main intended result of both is a higher level of self-esteem. In addition, being master over the system is esteem-related. Two aspects of this mastery could be found in the descriptions of the systems: end-user installation and end-user adaptation.

Entertainment and multimedia are both leisure activities and for that reason mapped to the highest level of needs[7].

System-integration analysis

Four levels of system integration were recognized[16]:

(i) Stand-alone: a system with a functionality that does not communicate with the outside world or other applications in the home (for instance, a motion sensor wired to a local alarm);

(ii) Tele-devices: systems that communicate with the outside world but do not require additional devices (for instance, a panic button);

(iii) Interconnected: the system has multiple functionalities; applications that provide these functionalities require additional applications for optimal performance of the system as a whole (for instance, a home automation system that controls both heating and lighting); and

(iv) Fully integrated: a system that includes all functionalities in the home (prototypes using a universal platform).

Results

All levels of deficiency needs are addressed in smart-home prototypes and concepts, but emphasis lies on the lower levels of deficiency needs, with 21 applications pertaining to physiological needs, 17 concerning safety and security, 11 addressing social relations, 2 related to esteem, and only 1 covering self-actualization (*Table 1*).

Looking at individual smart-home projects reveals that about half (15 of 28) are restricted to the lower deficiency needs dictated by physiology and safety. Among them are projects on all levels of system integration. Only in one case (Smart House Osaka) is the end-user master over the adaptation of the system (*Table 2*).

Interconnected smart home systems are most common in our sample of prototypes and concepts (15 of 28). They are dominant in the support of the lower levels of deficiency needs (9 of 15), but also support social relations (5 of 15), esteem related issues (2, but with no or doubtful support of end-user installation or adaptation), and self-actualization needs (2, but without support of end-user installation or adaptation) (*Table 2*).

One of the interconnected systems, MPOWER that allows for support of the four lower Maslow levels, claims easy installation and adaptability by the end-user. However, this could not be supported by the specifications of the system architecture[24,25].

None of the 28 prototypes or concepts allows for supportive functionalities on all levels of deficiency needs, but all of them include some physiological and safety needs. When the highest and most complicated level (self-actualization) is included (6 cases), the majority (4 cases) are fully integrated systems. Only in case of fully integrated systems is the end-user master over the system and may install or adapt it at will (*Table 2*).

Table 1. End-user needs addressed by published multifunctional ICT-systems for aging-in-place, as sorted by need-deficiency level according to Maslow[6]

Need deficiency level	Specific needs addressed
Physiology	Activity coach[17,18] Activity level monitoring[17,19–34] Blinds, curtain and window control[19,21,30,32,35–37] Blood glucose, oxygenation, and pressure monitoring[18,21,26,38,39] Body movement, temperature and weight monitoring[17,24–26,34,38–40] Food supply monitoring[41] HVAC control[17,35,36,42–44] Heart rate monitoring[17,26,34,39,45–47] Kitchen use, meal reminding[19–21,29,32,33,45,48] Medication use and reminding[19,21–23,27–32,40,48] Nutrition advisor[17,27,28] Personal hygiene assistant[40] Remote access to monitored data[19,24,25,32] Remote (snail)mailbox checker[40] Remote rehabilitation[22,23,27,28] Respiration rate monitoring[39,45] Shopping assistant[27,28] Sleeping pattern[19,22,23,32,40] Sweating monitoring[39] Tele-care[18,49] Toilet use monitoring[48]
Safety	Activity detection[17,20–23,26–31,33,34,37,39,43–47,50,51] Alarms (burglary, fire, smoke, community)[19–21,26,29–31,33,39–41,46,47,49,52,53] Automatic lighting, lighting control[17,19,21,32,35–37,42,43,52–54] Bath and cooker monitoring[21,54] Control of oven, microwave, washing machine[40,41] Door camera[42] Fall detection[17,21,27,28,30,31,39,49] Flooding detection[24,25,29,40,41] Home-access control[21–23,27,28,40,49] Memory support, including item localization[26,54] Panic button[22,23,27,28,30,31,43,49] Person identification[39] Pressure sensors (bed, chairs, floor)[30,31,34,39,45–48] Room occupancy monitoring[19,21,24,25,32,39,44,48] Room temperature monitoring[20,24,25,30,31,33,38,39,46,47,50,51] Security cameras[19,32] Weather forecast[21]
Social relations	Activity reminder[19,26,32,35,36] Distant dining[40] Group cooking[21] Internet access[21–23,30,31,49–51] Message service[24,25] Photo viewer[42] Reminding services[21–25,27,28,35,36,40–43] Social media[17,21,26] Tele-consulting[27,28] Videophone[21,27,28] VoIP calls[38]
Esteem related	Cognitive training[17,24,25,40] Energy saving[35,36,52,53]
Self-actualization	Entertainment, including multimedia[21–23,35,36,38,40,52,53]

Table 2. Addressed levels of Maslow's need deficiencies[6], and system integration of smart-home prototypes and concepts published between 1990 and 2010, sorted by year of publication; x=at least one item addressed in the stated category; ±=presumably; ?=data missing

Need deficiency level					End-user maintenance option		System integration	Reference
Physiology	Safety	Social relations	Esteem related	Self-actualization	Install	Adapt		
x					No	No	Inter-connected	1994:Monitoring House[50,51]
x	x				No	No	Stand alone	1995:PROSAVE[44]
x	x				No	No	Inter-connected	1995:SmartBo[37]
x	x				±No	No	Inter-connected	1998:CareNet[39]
x	x				?	Yes	Fully integrated	1999:Smart House Osaka[34]
x	x				No	No	Inter-connected	2000:ADL/IADL House[48]
x	x				No	No	Tele-device	2000:Intelligent Monitoring[20,33]
	x				No	No	Inter-connected	2001:Gloucester's Smart House[54]
x	x	x			±No	No	Inter-connected	2001:Elite CARE (2001)[43]
x	x	x			±No	No	Inter-connected	2001:Millennium Home[30,31]
x	x				No	No	Inter-connected	2003:TigerPlace[45]
x	x				No	No	Fully integrated	2003:ExperTel[49]
x	x				No	No	Fully integrated	2003:ILSA[19,32]
	x		x	x	Yes	Yes	Fully integrated	2004:eHOME[52,53]
x	x	x		x	No	Yes	Fully integrated	2005:Gator Tech Smart House[40]
x	x	x			No	No	Inter-connected	2006:I-Living[26]
x	x		x	x	No	No	Inter-connected	2006:MavHome[35,36]
x	x	x		x	Yes	Yes	Fully integrated	2006:MONAMI[21]
x					±No	No	Tele-device	2007:SENSACTION-AAL[18]
x	x				?	No	Inter-connected	2007:EASY-LINE+[41]
x	x	x			Yes	Yes	Fully integrated	2007:PERSONA[27,28]
x	x				No	No	Inter-connected	2008:AlarmNet[46,47]
x	x	x			±No	±No	Inter-connected	2008:I2HOME[42]
x	x	x	x		±Yes	±Yes	Inter-connected	2008:MPOWER[24,25]
x	x	x	x		±Yes	Yes	Fully integrated	2008:OASIS[17]
x		x		x	No	No	Inter-connected	2008:OLDES[38]
x	x				No	No	Inter-connected	2009:AT EASE[29]
x	x	x		x	No	No	Fully integrated	2009:SOPRANO[22,23]

Discussion

Our results show that all deficiency-need classes of Maslow may be addressed by modern smart home elements, but none of the smart-home systems analyzed extend over all classes of personal and environmental deficiencies. Most systems in our sample introduce additional esteem-related problems by not allowing the end-user to easily install or adapt the system.

The 'e-Home' system and 'Gloucester's Smart-House' support higher levels of needs, but leaves out the most basic ones (*Table 2*). We expect that these omissions will hamper a massive roll-out of smart homes that aim to support aging-in-place. But still, most smart-home applications focus on the lower levels of deficiency needs. This has to be expected since these lower levels have to be fulfilled before the higher levels start to matter.

For a full support of aging-in-place the higher levels have to be included. This, however, is more complex. For example, a virtual dress-couch that helps you to choose your clothes might improve your confidence (self-esteem), but needs an extensive database and sensor system of life style, mood, weather conditions, and requirements for the occasion. In addition, the variation in personal needs among adults tends to increase with age[7].

In our sample of 28 smart-home prototypes and concepts it was not possible to assess operational reliability (safety level), easy maintenance (esteem level), and affordability[2]. Future research on smart-home systems should include tests and reports on these technology-related barriers. Another weak point of our analysis is the general nature of Maslow's classification. The actual acceptance of a specific technology depends on the support of specific needs by specific characteristics of the technology, rather than the support of needs in general[55]. Maslow's hierarchy remains, however, useful as a first global assessment. It can be considered as a guide to make sure that no group of needs is forgotten and no new deficiencies in needs are introduced.

Systems adapted to the highest deficiency-need classes generally show the highest level of system integration. They commonly allow the end-user to install and adapt his or her smart home without the intervention of a technician. This way the user may freely choose and change the functionality of the system by implementing or removing certain applications, as soon as new needs arise or old ones loose value. Apparently a high level of system integration is not only needed from a technological point of view[1], but also to strengthen the user value of smart-home systems.

Although fully integrated systems could have the best performance in theory, there are a number of challenges to overcome. Most research projects result in proof-of-concept, but these concepts are rarely developed further or entered the market[2].

The domain of smart homes develops fast. The universAAL project and AALOA (Ambient Assisted Living Open Association), two initiatives supported by the European commission and started after 2010, have taken promising steps by aiming to design, develop, evaluate, standardize, and maintain a common service platform for Ambient Assisted Living[56,57], but the implementation of support at all levels of human deficiency needs has not been included in these initiatives. In addition, a recent review stresses the understanding of end-user needs to develop effective and efficient smart-homes, but does not propose a tool or theory to implement this in design and development[3].

The Maslow hierarchy may act as a guide to developers and marketeers to address all levels of human deficiency needs. The resulting total user value may ease integration and market introduction of smart homes for aging in place.

Acknowledgements
We are grateful to BAM Techniek and the PIT Foundation (Stichting Promotie Installatie Techniek) for financial support.

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