From Users' Needs to System Specifications: A Care System Supporting Older People's Independent Living

Narciso GONZÁLEZ **Anna KÄMÄRÄINEN**
AGORA Center, University of Jyväskylä, 40014 Jyväskylä, Finland
narciso.gonzalez-vega@jyu.fi **Anna.k.kamarainen@jyu.fi**

Mitja LUŠTREK **Matjaž GAMS**
Dept. of Intelligent Systems, Jožef Stefan Institute, 1000 Ljubljana, Slovenia
mitja.lustrek@ijs.si **matjaz.gams@ijs.si**

and

Igone VÉLEZ
Centro de Estudios e Investigaciones Técnicas de Guipuzkoa, 20018 Donostia – San Sebastián , Spain
ivelez@ceit.es

ABSTRACT

Following a user-centred approach, twenty-three older people participated in individual structured interviews. These aimed at identifying end-users' needs and requirements to feed the specifications of the ubiquitous care system to support older peoples' independent living, CONFIDENCE. Five types of user needs to guide the design process were obtained. Health and ageing effects are important factors to consider whilst designing care systems for all. Physical impairments affect people's ability to interact with technical systems. Use and attitudes towards technology describe the potential ability of the end-users to operate existing technologies, and whether they are willing or not to learn and utilise the system. The system should work anytime and anywhere, i.e., it should be ubiquitous. The results suggested that older people live active lives, but fears and barriers exist which might restrict them. It is important that CONFIDENCE is able to support older people whether they are at home, at the country cottage or visiting friends. We consider taking into account the point of view of the end-users to be an important step. Other important features of CONFIDENCE include: immediate operation in the case of sudden problems; and being otherwise unnoticeable.

Keywords: Care system, older people, independent living, user-centred, user needs

1. INTRODUCTION

The population of people over 60 years of age is growing faster than any other age group world wide. It has been projected that by 2050 this age group will grow to nearly two billion. People aged 80 and over are the fastest growing segment within the older group. This is expected to represent 20% of the older population by 2050. Furthermore, people in the oldest segment of the population are particularly prone to falls [1]. The subsequent effects of falls have an impact on direct and indirect costs to family, health and social systems [2]. As the number of older people increases, the number of falls and the associated expenditure are expected to increase accordingly.

The experience of falls can promote the development of fear of falling in older people. Fear of falling, in turn, can decrease quality of life and speed the decline in the ability to perform activities of daily living. Moreover, this situation might lead older people to a self-imposed isolation, refusal of mobility, and admission to institutional care [3]-[6]. Falls and fear of falling need to be minimised to enable older people to remain autonomous, live in their own homes longer, and to decrease the costs of health and social care for this age group [7].

Two main types of care systems aiming at preserving the autonomy of older people can be found on the market. The simplest is a device featuring an alarm button and a home unit which allows for the making of emergency calls through the telephone line. The pendant, or wrist worn alarm button, connects within a distance of approximately 50 meters, to the home unit through the European Social Alarm Frequency 869MHz or 169MHz. The home unit then establishes a phone connection to the service provider centre and voice communication can be exchanged through the microphone and loudspeaker of the home unit. If required personal assistance can thus be obtained [8]. The use of this type of system is restricted to the home environment or its immediate vicinity. Other systems are based on accelerometers, gyroscopes, infrared, video surveillance, or other sensors [9]-[16]. These support the autonomy of older people mainly through the possibility to activate an alarm by the user, i.e., via alarm button, or through the detection of falls

and the subsequent activation of an alarm by the system itself.

However, most of the previous care systems have important disadvantages such as high false alarm rates, lack of portability and privacy intrusion. False alarms cause distress to some users, who might be concerned about raising an alarm when it is not necessary. In order to solve these problems, the CONFIDENCE system, based on the reconstruction of the user's posture in real time by means of several radiofrequency communication channels and networked sensors, will be developed. This system will be reliable, for example in regards to low false alarm rates. It will not constrain the users' way of living, as it will be non-intrusive and will be easy to use. It will adapt to the user by learning typical and atypical behavioural patterns or events. The users will be able to control the warning and alarm protocols, and it will operate within the home environment and outdoors by means of a portable device. Older people using the system will gain confidence and independence measured by the Fall Efficacy Scale (FES). CONFIDENCE will thus contribute to prolong older people's personal autonomy and participation in society, reducing the need for institutionalization. This will significantly decrease social and health care costs.

The use of information and communication technologies is spreading rapidly, but only a minority of older people are actively engaged in their uptake. This suggests that most of the existing Internet browser-based online technologies might not be usable for older people. The development from technological innovation to commonly used household device easily takes decades, which has happened in the case of the World Wide Web, car and television. In constructing new innovative forms of interaction or systems, one of the challenges is how to get people to use the available possibilities effectively. This is a serious challenge for the ICT field, and it is also critical during the process of developing a care system for people with special needs. End-users may be interested in the emerging possibilities of care systems, but modest computing skills forestall the use of complex systems. Additionally, privacy and security are important aspects which may cause suspicions on behalf of the end-user. There is no use in developing innovations without studying end-users' desires, needs, confines and fears. Therefore, the first step in the development of this care system was to obtain information regarding end-users' needs and demands.

The aim of this was to elicit users' requirements for the design and development of CONFIDENCE. The selected methodology was a structured interview guided by a questionnaire. The aim was to gather useful inputs about end-users' needs, expectations and viewpoints. Structured questions were needed because participants in general usually do not have extensive background knowledge about care systems. In this context, it is rather difficult for people to imagine what the system can offer them and how they can benefit from the potential ICT care system. In other situations, we could have chosen questionnaires with Likert-type scaled response options. However, the goals of this study favoured a more flexible method enabling the collection of richer and more useful information from end-users.

2. METHOD

Participants

Individual structured interviews were carried out with 23 people from the city of Jyväskylä, Finland. Eleven of the participants were male and 12 female. Their mean age was 75.5 years, ranging from 48 to 92 years. All participants lived in their own homes. Twelve participants cohabited with a partner and 11 lived alone. Participants were recruited from the Central Hospital, a day centre, and the Centre for Care and Rehabilitation of War Veterans. Parallel interviews were also carried in Italy and Sweden. For the sake of space, this paper only includes the Finnish sample.

Procedure

Before commencing this research, the procedures were submitted for evaluation and subsequently approved by the Ethical Committee of the University of Jyväskylä. The researcher made individual appointments with the participants by phone. The interviews were carried out in the homes of the participants, as this was the place of their choice. During the interview meeting the researcher introduced herself to the participant and started by creating a good rapport for the interview. Then, the researcher provided information about the project as described in the information sheet. The participants read this information. When a person asked for clarification or additional information, the researcher provided answers and made sure that the information had been understood. Before initiating the interview, the participants read and signed the informed consent form created by the CONFIDENCE project in accordance with the ethical procedures for the research tasks involving human subjects. The interviews lasted approximately 1 hour. The information provided regarding the project, as well as the questionnaire and interview, were presented in the Finnish language to ensure that the participants understood the questions.

3. RESULTS

From the results, 5 types of user needs were extracted in the context of the CONFIDENCE system. These were: health and ageing effects; use and attitudes towards ICT; ubiquity and continuous operation; right to privacy; and suitability of the components. Some of the requirements were directly articulated by the interviewees and some others were extracted from their activities of daily living and the surrounding environment. These are presented below.

Health and ageing effects

Ageing causes health problems to many people. Typical ageing effects are, for example loss of hearing, memory problems, cataract and rheumatism. Thirteen participants defined their own health mostly as average or good, and seven indicated that their health condition was poor. The most frequently reported health problems were asthma, amputations, constant pain, heavy medication, rheumatism, heart problems, and reduced ability to move.

The system should be controlled in a multi-modal way. People with poor eye sight cannot use the system properly if interaction is only based on visible symbols. Voice control cannot be used by people with hearing loss. Possible ways of controlling the system can be at least visible symbols on screen, voice recognition and alarm sounds.

Use and attitudes towards ICT

Out of the 23 people interviewed, 19 demonstrated positive attitudes towards learning to use the CONFIDENCE system. Three had a negative attitude and 1 did not answer. In general, the participants would trust the technology in the case of a sudden fall (n = 20). Two respondents would trust the system depending on the situation.

The aim of the system is to increase the feeling of safety leading to better quality of life. The most important question is: are people willing to use devices and systems? Without adopting and using devices, they cannot benefit from the system. The positive attitude towards learning to use and trusting the system suggests that people are interested in the emerging possibilities of CONFIDENCE. It is a well known fact that attitude and interest increase learning. The results suggest that people are willing to use the system.

The most frequent expectation about CONFIDENCE was that it should be simple to use, e.g., that the system should not provide too many options. Other expectations included: a sufficiently cheap or affordable price; that it would be similar to other familiar technology; and that considerations will be made for perceptual and motor impairments, such as sight, hearing and rheumatism.

Most people (n = 17) reported that they do not have problems in operating remote controls, mobile phones and other portable devices. All of them can use the television, 21 can use phones and mobile phones, but only 8 reported that they can use a PC and the Internet. The interviewees acknowledged a certain gap between the capabilities of their children and their own in regard to the use of technologies, especially the newer ones. They see their descendants as more capable of learning to use new devices.

The purpose of the system is to detect abnormal events such as falls, loss of consciousness or unexpected behaviour that may be related to health problems in older people. This means that the system is in active use only in the case of trouble, and in normal daily life it is unnoticeable. On the other hand, learning and retention of information in human memory is based on consequently mapped repetitions [17]. The system should be easy to learn and use without extensive training, enabling it to be used in the case of an emergency. Factors such as intuitiveness and similarity to existing familiar technologies, increases learning efficiency and decreases errors. Intuitiveness increases safety, while the user can operate the system correctly even though, for example, he/she is in pain. The match between existing skills and familiar ways to interact with devices will ease the correct activity in the case of trouble.

Twenty of the 23 respondents reported that health care services, home health care or other public services should have the main responsibility to receive the alarms. In the case of trouble, several hopes and suggestions were made. Some mentioned the wish for a nurse to come and check on the situation, while a few preferred the automatic call for their spouse. Being continuously monitored by the CONFIDENCE system, the opinion of end-users was that the system would help them feel safer by knowing that they will get help after the system has sent an alarm.

Ubiquity and continuous usage

Many of the interviewed end-users reported that they have obstacles in their home environments including a slippery staircase, stairs outside, some slipperiness in the yard, carpets, stairs, slipperiness on the hallway floor due to snow during winter times, high bench in the sauna and slippery toilet and bathroom. Slipperiness, e.g., in the bathroom appears to be quite frequent.

Twenty-one out of 23 participants reported that they participate in social and physical activities and the majority of the participants practice some form of physical exercise regularly. The most commonly mentioned physical activities were group gymnastics, walking and Nordic walking, as well as household tasks such as snow shovelling. Only 9 of the 23 interviewees participated actively in social activities. The result probably indicates that the participants responded according to a very restricted meaning of social activities. Their participation in group gymnastics and exercises indicates that other social encounters happen more often than indicated by categorical answers. Moreover, the older people seem to have active social lives and they take care of their physical condition.

Seventeen participants reported that they have experienced dizziness, and 12 had fallen during the past six months. In this study, about 50% of the participants reported that they were afraid of falling. Only 20% were afraid of going out. Not surprisingly, the presence of another person often raises their feelings of safety. The other person can be the spouse, the partner or the

personnel of a sheltered house. The main reasons which cause insecurity are health problems, fear of falling, being alone and not being able to perform one's own activities of daily living.

The experience of falls can increase the development of the fear of falling, and furthermore, lead elderly people to a self-imposed isolation, refusal of mobility and admission to institutional care [3]-[9]. As the results suggest, older people live active lives. The aim of the CONFIDENCE system is to increase the feeling of confidence and security, thus leading to improved quality of life and longer active participation in social activities. Most of the social life and daily physical exercise takes place outside the home. Therefore, it is important that the system works everywhere, both inside and outside the home.

Privacy

The system's goal is to recognise falls and for this purpose, the user's posture needs to be monitored. For a reliable and accurate positioning, CONFIDENCE uses tags which the users wear and which are also placed inside the house. The possibility of privacy intrusion is increased by this feature.

Eighteen out of 23 end-users considered that the system violates the integrity of the user. When asked to comment on this issue, they somehow softened their answers about integrity as an abstract concept. Some of their comments manifested that the relevance of the system to the end-user might justify the use of this technology. End-users thought that the "system does not violate privacy, if the information collected is confidential", and "if getting help is reliant upon the technology, it does not violate integrity". But they also thought that constant monitoring would violate privacy.

The participants had positive attitudes towards using tags at home. Twenty respondents would use tags. Similarly, 19 out of 23 would accept the presence of tags in clothes. Surprisingly, 20 respondents answered that it would be acceptable, if the tags were visible. This is interesting because most of us members of the CONFIDENCE consortium, have argued repeatedly in favour of imperceptible tags.

Suitability

Users should carry tags in their clothes, jewellery or in other suitable places. Although in general, users are willing to accept the presence of tags, these should be transparent or hidden. Tags hidden in the clothes should be designed for both men and women.

Allergies to different metals and rubbers are common nowadays. Tags must be tested as allergy-free. The system should work in the shower as well as in the sauna, and for that purpose tags should be water and heat resistant. The system would be useless if the user could not wear the sensors (tags), nor use them, in risky environments.

Pensioners form the target group defined for the system. They do not have great purchase power. Hence, the system should be as cheap as possible. Otherwise, the potential users would not have the possibility to acquire the CONFIDENCE system.

The tags and the portable device need an electrical power supply. Power consumption should be reasonable. Battery loading should be easy and fast. In Finland, many people have summer cottages and those can be in quite unpopulated areas where telephone networks might not operate. Also, some cottages do not have electricity, yet still, the power supply for the system should be guaranteed.

4. FROM NEEDS TO SPECIFICATIONS

In this section, we present system's user requirements derived from end-user interviews. We will not deal with the technical designs as these are reported elsewhere [18].

Easy to install and set up. The system must be easy to set up by a non-technician. A technician may be needed only to calibrate the localization subsystem. The system must not require constant maintenance or updates.

Wearable tags shall be small in size and should operate on reduced power consumption. The tags should be waterproof, non-allergenic and not clearly visible as tags.

Easy to use. The system must be easy to use and designed for all. It should also be intuitive and usable in the case of an emergency.

Cost-effective. The price of the system cannot be high. The target group consists of pensioners who do not have great purchase power.

Reliability. The system must have low false alarm rates, should be secure, and accurate.

Non-intrusive. The privacy of the end-user shall be preserved. Furthermore, the end-user will keep control of the alarm protocol. Location data will only be processed with the consent of the user and for the necessary duration of the provision of a value added service.

Portability. The system will operate both indoors and outdoors.

Self-learning. The system will learn from previous situations improving its performance as it is used.

There will be one base station. There may be some sensors installed in each room, if necessary to increase

the accuracy of the system. The number of tags the end-users will wear will be kept to a minimum.

5. DISCUSSION

All systems and devices are tools that humans use to achieve goals [19] [20]. This means that systems should be seen from a goal-oriented human perspective. In the design of new types of systems and interactions, the starting point should be the understanding of the user's goals, which possible obstacles they might face, and how they could avoid these obstacles.

User requirements for alarm and security systems differ from more traditional systems due to their varying natures. Alarm and security systems should be unnoticeable in normal situations, but in the case of emergencies, systems should be in use immediately. In personal alarm systems, the aim is to provide a feeling of safety in cases of sudden trouble, opposed to the active use of the system itself. Inoperativeness and inconspicuousness lead to new forms of interaction and design problems which are not systematically studied, and there is, to date, no literature available regarding these matters.

People forget unused skills quickly if they are not automatic and people do not have time to think about the functionality of a system in emergency situations. Whilst designing alarm or security systems, the most crucial aspect is how to design a system that is so intuitive that it can be used correctly, effectively, and at random intervals without extensive training. Systems cannot rely on the skills of the user to remember functions, systems logic, or require the user to perform lengthy procedures without assistance.

Unfortunately, examples exist from situations where alarm or security systems have been in place, but the ability to use them has not been sufficient in a real emergency situation. In working environments, studies have shown that people do not learn to use the needed parts of the system randomly. The effect is called 'rare use', i.e., some important and often safety critical features are infrequently used, and consequently users' knowledge of these features is lower than it should be [21] [22].

Systems that do not meet users' needs or work in a disruptive way often become unused. In the case of alarm or security systems, users benefit from the system only when it is working properly and ready to use. Aspects that may cause unwillingness to use the system should be studied and taken into account early in the design.

In this study, we found five types of user needs to guide the design process. Health and ageing effects are important factors while designing an alarm system for all. Different impairments affect people's ability to interact with systems, and these restrictions should be considered carefully. Use and attitudes towards ICT describe: the user's potential abilities to use existing ICT technologies; what kinds of interaction styles are familiar; and how willing the users are to learn and utilise the ubiquitous care system. The system should work anytime and anywhere. As the results suggest, older people live active lives, but obstacles and fears exist. It is important that the CONFIDENCE system can support people whether they are at home, at the country cottage or visiting friends.

While monitoring people's health and gathering information of their movements, the right to privacy is the issue that must be stressed. Data cannot be misused and must be used only for specific and predetermined purposes. People should not feel that the system endangers their privacy, autonomy and dignity. If the users feel the intrusion of the care system in their personal lives, or feel it to be disruptive, they will probably not use the system.

Alarms are the core of the system. Alarms should work accurately without false alarms. False alarms will make the system disturbing and untrustworthy. Continuous false alarms cause harm to the alarm receiver and real users cannot use the system for fear of it inconveniencing the receivers of the alarms. Most people reported that a home care centre or another public alarm centre should be the main receiver of alarms. Additionally, most relatives are not willing to receive alarms. The data also suggests that multiple options are needed. It seems rational that people have several possible persons receiving the alarms depending on, for example, the time of the day.

In this paper, we have presented users' needs gathered through interviews, and have translated them into system's specifications. The aim of this user-centred approach is to design a system which is intuitive to use, fulfils the needs of the users, and can be easily adopted for use. The findings might not be an exhaustive list of all the possible requirements for CONFIDENCE, but they are a proper starting point to analyse the requirements of the system from the point of view of the end-users. The most important aspects of care and security systems are that these can be used immediately in the case of sudden problems, and that they are otherwise unnoticeable.

In accordance with the user-centred approach adopted by this project, the older people, as potential end-users of the CONFIDENCE system, will continue their involvement in other stages of the project. They will evaluate the system design and participate in usability studies. The end-users will also contribute to the validation of the resulting prototypes. Most importantly, the participation of potential end-users will facilitate the adaptation of the system to their real needs, interaction capabilities, and preferences.

Acknowledgements
The research leading to these results has received funding from the European Community's Framework Programme FP7/2007-2013 under grant agreement nº 214986.

CONFIDENCE Consortium: Centro de Estudios e Investigaciones Técnicas de Gipuzkoa (CEIT-IK4), Fraunhofer Institute for Integrated Circuits, Jozef Stefan Institute (JSI), IKERLAN-IK4, COOSS Marche, University of Jyväskylä (JYU), Umeå Municipality (UMP), eDevice, CUP 2000, and ZENON S.A. Robotics & Informatics.

The authors gratefully acknowledge the contribution of the interviewers and the participants in this research, as well as the comments on the manuscript provided by blind and non-blind reviewers.

6. REFERENCES

[1] United Nations (UN), **World Population Prospects: The 2004 Revision**, New York, USA, 2004.

[2] World Health Organization, **WHO Global Report on Falls Prevention in Older Age**. Geneva, Switzerland, WHO, 2007.

[3] D.G. Bruce, A. Devine, R.L. Prince, **"**Recreational physical activity levels in healthy older women: the importance of fear of falling". **Journal of the American Geriatrics Society**, Vol. 50, 2002, pp. 84-89.

[4] K. Delbaere, G. Crombez, G. Vanderstraeten et al., "Fear-related avoidance of activities, falls and physical frailty. A prospective community-based cohort study", **Age and Ageing**, Vol. 33, 2004, pp. 368-373.

[5] R.G. Cumming, G. Salkeld, M. Thomas, et al. "Prospective study of the impact of fear of falling on activities of daily living, SF- 36 scores, and nursing home admission", **The Journals of Gerontology A Biological Sciences and Medical Sciences**, Vol. 55, 2000, pp. 299-305.

[6] C.F. Mendes de Leon,T.E. Seeman, D.I. Baker, et al. "Self-efficacy, physical decline, and change in functioning in community living elders: a prospective study", **The Journals of Gerontology B Psychological Sciences and Social Sciences**, Vol. 51, 1996, pp. 183-190.

[7] F. Lee, L. MacKenzie, & C. James, "Perceptions of older people living in the community about their fear of falling", **Disability and Rehabilitation**, Vol. 30, 2008, pp. 1803–1811.

[8] Tunstall, **Lifeline service**, 2008, available at: http://www.tunstallonline.co.uk/service.aspx

[9] T. Degen, H. Jaeckel, M. Rufer, & S. Wyss, "SPEEDY: A Fall Detector in a WristWatch", **IEEE International Symposium on Wearable Computers**, New York, Oct. 2003.

[10] M.N. Nyan, F.E.H. Tay, M. Manimaran, & K.H.W. Seah, "Garment-based detection of falls and activities of daily living using 3-axis MEMS accelerometer", **Journal of Physics: Conference Series**, Vol. 34, 2006, pp. 1059-1067.

[11] A.K. Bourke, C.N. Scanaill, K.M. Culhane, J.V. O'Brien, & G.M. Lyons, "An optimum accelerometer configuration and simple algorithm for accurately detecting falls", **Proceedings of the 24th IASTED; International Multi-Conference Biomedical Engineering**, Feb.15-17, 2006.

[12] N. Ravi, N. Dandekar, P. Mysore, &M.L. Littman, "Activity Recognition from Accelerometer Data", **American Association for Artificial Intelligence**, 2005.

[13] G. Pérolle, P. Fraisse, M. Mavros, & I. Etxeberria, "Automatic Fall Detection and Activity Monitoring for Elderly", **MEDETEL, The International Trade Event and Conference for eHealth, Telemedicine and Health ICT**, 2006.

[14] B.P.L. Lo, J.L. Wang, & G-Z. Yang, "From imaging networks to behavior profiling ubiquitous sensing for managed homecare of the elderly", **Proceedings Of the 3rd International Conference on Pervasive Computing**, May 2005.

[15] H. Nait-Charif & S.J. McKenna, "Activity Summarisation and Fall Detection in a Supportive Home environment", **Proceeding of the 17th International Conference on Pattern Recognition**, Vol 4, pp 323-326, Aug. 2004.

[16] B.U. Töreyin, Y. Dedeoğlu, & A.E. Çetin, "HMM Based Falling Person Detection Using Both Audio and Video", **IEEE International Conference on Signal Processing and Communications Applications**, pp. 17-19, Apr. 2006.

[17] R. Shiffrin, "Attention", In R. Atkinson, J. Herrnstein, G. Lindzey & R. Luce, (Eds.), **Stevens' handbook of experimental psychology, Learning and cognition (2nd ed.)**, Oxford, England: John Wiley & Sons, pp. 739-81, 1988.

[18] C. Quemada, I. Val, M. Pietrzyk, T. von der Grün, N. González, A. Kämäräinen, & I. Vélez, "A smart care system for elderly people to support independent living: CONFIDENCE", **Proceeding of the Smart Systems Integration Conference**, Brussels, Belgium, Mar. 10-11, 2009.

[19] J.M. Carrol, **HCI Models, Theories and Frameworks: Toward a multidisciplinary science**, Morgan Kaufmann, 2003.

[20] P. Saariluoma, "Mitä on käyttäjäpsykologia?" [What is user psychology?] **Psykologia** [The Journal of the Finnish Psychological Society], Vol. 40, 2005, pp. 181-186.

[21] A. Kämäräinen, & P. Saariluoma, "User psychological problems in implementing production control system", In J. Abascal, I. Fajardo, & I. Oakley (Eds.), **Proceedings of European Conference on Cognitive Ergonomics**, pp. 174-177, 2008.

[22] N. González, **Factors affecting simulator-training effectiveness**. Jyväskylä, Finland: University of Jyväskylä, 2002.