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Inclusion of service robots in the daily lives of frail older users: A step-by-step definition procedure on users' requirements

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ABSTRACT

The implications for the inclusion of robots in the daily lives of frail older adults, especially in relation to these population needs, have not been extensively studied. The "Multi-Role Shadow Robotic System for Independent Living" (SRS) project has developed a remotely-controlled, semi-autonomous robotic system to be used in domestic environments. The objective of this paper is to document the iterative procedure used to identify, select and prioritize user requirements. Seventy-four requirements were identified by means of focus groups, individual interviews and scenario-based interviews. The list of user requirements, ordered according to impact, number and transnational criteria, revealed a high number of requirements related to basic and instrumental activities of daily living, cognitive and social support and monitorization, and also involving privacy, safety and adaptation issues. Analysing and understanding older users' perceptions and needs when interacting with technological devices adds value to assistive technology and ensures that the systems address currently unmet needs.

1. Introduction

Robotics is getting greater attention nowadays as a promising field to support older adults with a range of different activities and to address the challenges associated with ageing, enabling them to live independently in their homes (Mitzner, Chen, Kemp, & Rogers, 2014; Smarr et al., 2014). Robots fulfil a growing number of roles in today's society, ranging from factory automation and service applications to medical care and entertainment (Feil-Seifer & Mataric, 2009). The development of service robots has been divided into two sectors: (a) non-manufacturing productive sectors such as agriculture, the boating industry, the mining industry, or medicine; and (b) the personal service sector, including personal assistance, cleaning, monitoring, education, entertainment, etc. (Aracil, Balaguer, & Armada, 2008).

Prototype robots have been developed to support independent living, in order to help older adults who try to live in their homes for as long as possible, even when the user is functionally disabled. Several personal service robots have been developed, including Aibo (Fujita, 2001), Care-O-bot (Graf, Han, & Schraft 2004; Graf, Reiser, Hägele, Mauz, & Klein, 2012), Pearl (Pollack et al., 2002), iCat (van Breemen, Yan, & Meerbeek, 2005), Robocare (Cesta et al., 2007), Robot-Era robots (Cavallo et al., 2014), or Hobbit (Fischinger et al., 2016). In addition, the robots Huggable (Stiehl et al., 2006), Paro (Wada, Shibata, Musha, & Kimure, 2005), Companionable (Badii et al., 2009), Giraff (Coradeschi et al., 2011) and GiraffPlus (Coradeschi et al., 2014), amongst others, have been developed to provide emotional support and other companion functions. Under this context, some studies have considered the optimal companionship that robots could provide (Taggart, Turkle, & Kidd, 2005; Wada, Shibata, Saito, & Tanie, 2003). However, the implications of the inclusion of robots in the daily lives of frail older adults (in terms of these frail older adults' needs and requirements, and the relationship between ethical implications and technical possibilities of such inclusion) have not been as widely studied until recently (Sharkey, 2013; Smarr et al., 2014; Sorell & Draper, 2014).

It is well known that people aged 65 and over represent the fastest growing age-group worldwide. In the United States and in Europe, high proportions of adults over 65 years old (58.7% and 66%, respectively)

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have chronic illness or health problems that prevent them from living autonomously (European Commission, 2014, 2015). Whilst there is no causal relation between ageing and disability, age can be a key risk variable related with several health problems and frailty (Mitnitski et al., 2015). Frailty is characterized by the concurrent loss of several capabilities. Older adults commonly become frail in a general sense that includes unstable health conditions, reduced reserve capacity for dealing with stressors and increased socio-economic difficulties (Avila-Funes et al., 2009; Jung et al., 2010; Rockwood, Fox, Stolee, Robertson, & Beattie, 1994; Schuurmans, Steverink, Lindenberg, Frieswijk, & Slaets, 2004). Furthermore, older adults usually experience deficits sequentially or concurrently, thus becoming frailer in a general sense (Clegg, Young, Lliffe, Rikkert, & Rockwood, 2013; Schuurmans et al., 2004).

In order to fill the gap between inclusion of robots in the daily lives of frail older adults, and to provide support to frail older populations, a project entitled "Multi-Role Shadow Robotic System for Independent Living (SRS)" focused on developing and prototyping of remotely-controlled, semi-autonomous robotic solutions in domestic environments. The system developed comprises an automatic task planner that produces proactive robotic behaviours based on updated semantic knowledge and executive control for coordinating activities at the level of sensing and action (Qiu et al., 2012). The robot was a wheeled mobile platform equipped with a robotic arm, capable to be operated through remote control to perform several tasks (such as grabbing objects, carrying objects and using adapted electric devices) for supporting older adults in a frail condition to cope with problematic homeostasis and vulnerability to stressors, and ultimately to improve their health condition. The systems can help with daily living activities such as reaching, fetching and carrying objects that are heavy or out of reach (Pigini, Facal, Garcia, Burmester, & Andrich, 2012).

Development of the SRS project was user-centric and iterative. The aim of the present study is to define in detail the step-by-step procedure used to identify and prioritize a set of user requirements. Taking into account the large amount of documentation generated in the project covering the assessments procedure (Mast et al., 2012; Pigini, Facal, Blasi, & Andrich, 2012), our main research question was: what type and which are the frail older user requirements' to accept the integration of robotic solutions in their daily lives and homes? The current study presents the whole procedure for gathering the requirements throughout the SRS project instead of going deep into exhaustive descriptions of the actions and materials (for this purpose, several supplementary documents have been included as Supplementary materials).

2. Design and method

2.1. Participants

215 participants were recruited through different SRS procedural phases for identifying user requirements (Table 1). All the participants took part in the study voluntarily and signed an informed consent in which their participation, rights and use of the data was described.

Focus groups were attended by 67 participants. A total of 22 frail older adults (77% female), with a mean age of 80 years-old (range: 65–90 y.o.) participated in 4 focus groups in all the three countries. Seventeen relatives of older adults (88% female) with a mean age of 55 years-old (range: 46–64 y.o.) participated in 3 focus groups in Germany and Spain. Twenty health professionals (80% female) with a mean age of 46 years-old (range: 30–61y.o.) and 8 professional caregivers (5 women, 3 men) with a mean age of 51 years-old (range: 27–60 y.o.), participated in 4 focus groups in all the three countries.

Individual interviews were held with 129 individuals comprising 64 frail older adults (47 females, 17 males; 65–92 years old), 19 family caregivers (17 females, 2 males; 28–69 years old), 22 professional caregivers (21 females, 1 male; 29–62 years old), and 24 health professionals (17 females, 7 males; 27–57 years old). In the first and second phases, frail older adults were recruited (in Germany, Italy and Spain) from among non-institutionalized people experiencing initial difficulties in activities of daily living (ADL), usually classified as frail older individuals.

Table 1
Different assessment methods used.

N = 230		Frail older adults	Primary caregivers	Professional caregivers	Health professionals
Phase 1	Focus groups	5 M, 17F	2 M, 15F	2 M, 14F	5 M, 8F
Phase 2	Individual interviews	17 M, 47F	2 M, 17F	1 M, 21F	7 M, 17F
Phase 3	Ethnographic study	4 M, 14F			
	Total number	104 (26 M, 78F)	36(4 M, 32F)	38 (3 M, 35F)	37 (12 M, 25)

M = Male; F = Female.

Frail participants were identified in each country by means of being categorized as frail by the different services involved in each country having heterogeneous conditions: hip, wrist or leg fractures, pain, mobility problems and other comorbidities.

Family caregivers (in Germany and Spain) were individuals with personal experience in caring for a relative or friend and who performed these duties *pro bono*.

Professional caregivers (recruited in Germany and Italy) were caregivers paid to perform a variety of professional skills in older adults' care: some had nursing and first aid qualifications, and others worked as home helpers or personal assistants. All of them had more than 5 years of experience.

Health professionals (in Italy and Spain) were professionals involved in health attention both directly (medical doctors, occupational therapists, physiotherapists, etc.) and/or indirectly (health service administrators, advisors).

In a final round, 18 frail older participants (10 in Italy and 8 in Spain) took part in the ethnographic study (14 females, 4 males; 75–93 years old).

2.2. Materials

There are several procedures available within the social sciences methodology that can be applied to design. The present study was carried out in line with other similar methodologies used within the UCD, such as USERfit (Poulson, 1996) and the RESPECT User Requirements Framework (Maguire, Kirakowski, & Vereker, 1998). We selected three different procedures in order to meet the users' needs from different perspectives: (1) focus groups for gathering a broad point of view on their interests and opinion about our foreseen solutions; (2) interviews for qualitative and quantitative definition of users' characteristics and needs, including Likert-type closed questions, but also "why" and "how" questions open questions; and, (3) an ethnographic procedure, based in a home visit, for having a qualitative daily life understanding of users' needs and behaviour.

In each phase of the study, the materials comprised, respectively, a focus group script, a semi-structured interview and an ethnographic interview. In the focus group approach, the planned script was designed to elicit the users' needs and pragmatic scenarios of use from the perspective of different users and beneficiaries. Group discussions were directed through questions on specific topics to discover participants' feelings, attitudes, and ideas about these topics. The following topics were included throughout the discussion: 1) basic ADLs (BADLs) and instrumental ADLs (IADLs) (i.e.: difficulties in carrying out daily tasks); 2) assistive technology (technology currently in use and future