Design for Adapted Devices: An Evaluation Tool of Smart Things for Seniors

Javier Barcenilla[1], Charles Tijus[2], Djamel Aissaoui[1], and Eric Brangier[1]

[1] Université de Lorraine - Metz, PErSEUs, Ux Lab. Île du Saulcy, 57045 Metz, France
[2] CHArt-LUTIN, Cité des Sciences et de l'Industrie - 30 Avenue Corentin Cariou, 75019 Paris, France
{Javier.Barcenilla,Djamel.Aissaoui,
Eric.Brangier}@univ-lorraine.fr,
tijus@lutin-userlab.fr

Abstract. In addition to usual Information and Communication Technology (ICT) devices, things such as clothes and homes are becoming smart and can be used for specific aging needs. However, because there is a diversity of senior impairments, one must diagnose needs, expectations or skills of seniors in order to provide the best adapted functions and usages. This study is about how to choose the best care method for seniors by providing a diagnosis based on a tool called "Design for Adapted Devices" (DAD). DAD tries to develop adaptable systems based on the comprehensive diagnosis of human deficits and needs of future users, taking into account the aspects of the individual's activity. DAD takes into account several dimensions of user diversity like skills and abilities (motor, cognitive skills, etc.) and measures deficits that modulate users' performances (social support, experience, etc.). Applied to seniors, DAD gives prospective data to define future smart things.

Keywords: Universal design, senior needs, smart things, impairments diagnosis.

1 Introduction

As pointed by O'Connel [1], the range of issues that impact design for an aging population is broad-ranging. The scope of this paper includes the first phase of conception: knowing seniors as possible end-users, how to diagnose deficits, impairments, and needs, as well as abilities and skills, in order to establish the corresponding profiles that might help design the adapted ICT devices and services. "Design for Adapted Devices" (DAD) is a proposed method, which provides a set of possible ergonomic and technological solutions depending on needs and diagnosed deficits. "Seniors" includes active people, retired people, seniors with disabilities, seniors living alone or with their family, seniors living in a retirement home; all of them having specific abilities, capacities and needs.

The ICT industry has ignored in most cases requirements of groups like elderly or disabled people (usability of perceptual and motor skills, cognitive stimulation,

C. Stephanidis and M. Antona (Eds.): UAHCI/HCII 2013, Part III, LNCS 8011, pp. 3–11, 2013.

cognitive remediation…). Reasons for this are diverse: economic issues, lack of knowledge about human center design, stereotypes concerning older people, and especially lack of information about the special needs of the elderly and disabled users [2].

In 2000, roughly 600 million citizens were over the age of 60. By 2050, that number will rise to over 2 billion. In addition to the growing proportion of seniors, there will be more and more devices and technology in demand to meet the needs of the elderly in terms of habitat management, ergonomics objects, use of services, etc. All of these devices will have to be properly adapted to the progressive decline of physical, perceptive, and cognitive capacities of aging people in order to be what we call "smart things for seniors."

Thus, the rapid development of ICT is a problem in terms of inability to access new devices for people with sensory or cognitive deficits, which is often the case with the elderly. As a primary solution, many ICT innovations, not specifically designed for the elderly, are marketed as such, with the further subsequent evaluation of how much they are appropriate to elderly: identifying usability difficulties in order to make recommendations for design in the future. This is, for instance, the method used by Vandi, Rico-Duarte, Thibault, Rougeaux, and Tijus [3] to provide design recommendations for interactive tablets intended for seniors.

Conversely, some researchers [4] have pointed out shortcomings and limits of the first (reactive) approach to conception for seniors and promote for more proactive approaches: "*it is important that the needs of the broadest possible end-users population are taken into account in the early design phases of new products and services*" (p. 2-7). Others authors advocates also on designing for people with specific needs: accessible design [5], assistive technology [6], barrier-free design [7] transgenerational design [8], universal design, etc. All of them agree to include people with physical or cognitive deficits in the first step of the design process, a method that can be applied within Living Labs for seniors [9]. A Living Lab is an open innovation laboratory where the users are placed in a context of technologies to imagine, develop and create innovative products and services that satisfy their capacities, expectations and needs. Living Labs are involved in the design of innovative systems where people, in our case seniors, are no longer simple users but become actors of the design process.

Given the importance of the first step in the proactive design process, taken into account users' needs, the purpose of this study is to present the "Design for Adapted Devices" method and its corresponding tool, for the diagnosis of deficits and needs of a particular category of users, allowing the choice of aid to provide and specify how devices and services must be adapted (fig. 1).

DAD is a software tool, the object of the tool is to facilitate and standardize procedures for deficit diagnosis of people with some kinds of disabilities. To do this, it proposes available psychometrics tools and an interview guide to refine the evaluation.

DAD was first developed to provide ergonomics solutions for users with different disabilities in work places, to permit them having a professional activity, and it is presently used to support the decision-making on the type of technologies that should equip Smart Homes for seniors. Inputs and outputs of DAD are provided in figure 1.

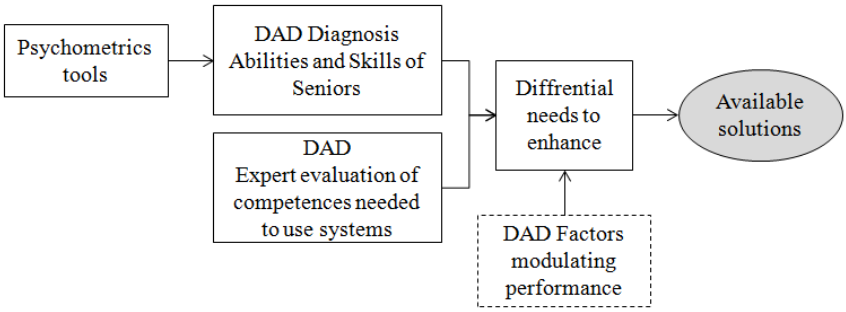

Fig. 1. Design for Adapted Devices method for evaluating deficits and needs of seniors and for providing adapted solutions

2 The Diagnosis of Deficits and Needs

The research on person-system interaction generally focuses on a single aspect of interaction (either sensory deficits, motor, or cognitive), without considering the cumulative and interactive effects of different deficits. In a prospective ergonomic approach, as that proposed by Robert and Brangier [10], DAD is to develop adaptable systems based on the comprehensive diagnosis of human deficits and needs of future users, taking into account the aspects of the individual's activity.

To proceed with DAD, several dimensions of user diversity were taken in account and more precisely those found in the literature [11], [12], keeping in mind that these dimensions could be specified in different ways (e.g., more precisely or more widely). Effects of some of these factors in using and adapting technology are well documented in literature [13], [14], although interpretation differs among researchers.

Seniors' deficits may be classified as disabilities when they are not modulated by skills and abilities (motor, cognitive skills, etc.). The DAD diagnosis grid is made of 10 dimensions. Six dimensions measure deficits, while four dimensions evaluate those factors that modulate performances (social support, experience, strategies, etc.). Each of these dimensions comprehends sub-dimensions for further specifications (Table 1 and Table 2).

While making a diagnosis of a person's abilities, "modulating factors" must be evaluated because they could influence in a positive or negative way a person's performance:

- Effects of medication on the ICT supported activity: drugs may play a role in the task realization. For instance, chronic treatments must be taken into account because they may have an important role in the activity (memory, attention, etc.),
- Interpersonal skills and social support: ability to be in relationship with others as a function of intrinsic qualities such as self-control, communication, social network, being in an environment facilitating social support and exchanges, etc.,
- Expertise and experience with ICT may facilitate adoption of proposed solutions,
- Interest for solutions proposed that might induce positive or negative attitude.

Table 1. Impairments dimensions evaluated with DAD (Design for Adapted Devices)

Abilities / skills			*Tasks / Needs*	*Diag-nos. Grade*	*Need / Task Grade*	*Diff. Needs Grade*
Physical and sensory capacities	D1. Motor skills and physical resistance	Physical strength	To take, to lift and to move objects	2	4	- 2
		Mobility and balance	To move kipping balance	4	1	+3
		Gestures precision, Manual and digital dexterity	Adapting movements to goals	1	4	-3
		Fatigability / stamina	Having a steady performance with time and effort	2	1	+1
	D2. Perceptual abilities	Vision (close / distant)	Perceiving visual close and distant stimuli	2	3	- 1
		Hearing	Thresholds for perceiving auditory stimuli	5	3	+2
		Skin sensitivity	Perceiving tactile and thermic stimuli	3	3	0
Cognitive Capacities	D3. Memory and attention	Attention (selective / divided / steady)	Being able to focus on a task / to select relevant stimuli / to carry out several tasks	5	5	0
		Working memory	Retaining, recovering and processing information for a short period	5	5	0
		Long-term memory	Retaining, recovering and processing information for a long period (episodic / semantic / procedural)	5	5	0
	D4. Language	Oral comprehension	Ability to understand oral language	5	3	+2
		Written comprehension	Ability to understand written language	5	5	0
		Oral Expression	Ability to use words and grammar in oral conversations	5	3	+2
		Written Expression	Ability to use words and grammar to produce written discourse	5	3	+2
	D5. Tempo - spatial orientation	Temporal orientation	Ability to locate him (her) self in the course of time	5	1	+4
		Visuo-spatial orientation	Ability to analyze, represent and to locate him (her) self in the space	5	5	0

Table 1. (*continued*)

	D6. Planning and problem solving	Reasoning	Ability to combine different sources of information in order to formulate rules and conclusions	4	5	-1
		Problem identification	Ability to identify that something is going wrong and find solution	5	3	-2
		Planning	Being able to anticipate and foresee actions and results	5	3	-2

Table 2. Performance modulating factors evaluated with DAD (Design for Adapted Devices)

Factors modulating activity	D7. Social / interpersonal skills	Environment and social support	Being in a environment facilitating social support and exchanges	5
		Extent of social network	Extent of social network and exchanges	4
	D8. Expertise and experience with ICT	Novice	Having reduced skills in using technical systems	5
		Intermediate	Having intermediate skills using technical systems	1
		Expert	Having excellent skills in using technical systems	1
	D9. Interest for ICT and acceptability	Support	Taking an interest in technical support	1
		Functionalities	Taking an interest in technical functionalities	3
		Goals	Taking an interest in goal system	5
	D10. Effects of medication on the ICT supported activity	Psycholeptics	Reduction of psychological activity (sedatives)	5
		Psychoanaleptics	Stimulating action on activity	5
		Psychodyslectics	Disrupting effects on activity	5

In addition, and to establish which deficit should be compensated or rehabilitated for seniors, experts with the system or with the technical domain are submitted to the same grid, in order to evaluate the skills required to use the ICT device or service. Each ability or skill is evaluated on a Likert scale from 1 to 5. Expert grade for each sub-dimension is the mean of all evaluations. The differential between a given person evaluation and the expert evaluation provides what is to make up.

To illustrate how to use DAD, let us to examine the case of Mrs. Jeanne Jones, a fictitious character described by the persona (Brangier and Bornet [20]) represented in figure 2.

This persona profile was derived from structured interviews carried out among different populations of seniors (retirement homes, pensioners' clubs, elderly people associations, etc.). The object of this complementary work was to obtain different profiles of seniors with specific needs in different contexts, and to confront our

analysis grid to different cases in order to dress senior profiles in terms of disabilities to be compensated.

In this Persona profile, diagnosis (see table 1 and figure 2) shows two main deficits (manual and digital dexterity and close visual acuity) carried out by two main pathologies that many elderly people suffer from: polyarthritis and macula degeneration. However, as she was a literature professor and she adores reading and writing, she would like to continue these activities. She does not take medication; she is socially supported, but doesn't like technology. Even though, technology can most likely give her a better life… Facilitating access to writing, helping with orientation, and increasing perceptual abilities are activities that could be supported by adapted technology. In fact, differential analysis between deficits of Mrs. Jones and expert evaluation shows that e-books and programs for writing are not adapted for Mrs. Jones and that ICT technologies should provide ways to compensate her weaknesses (see tab. 1).

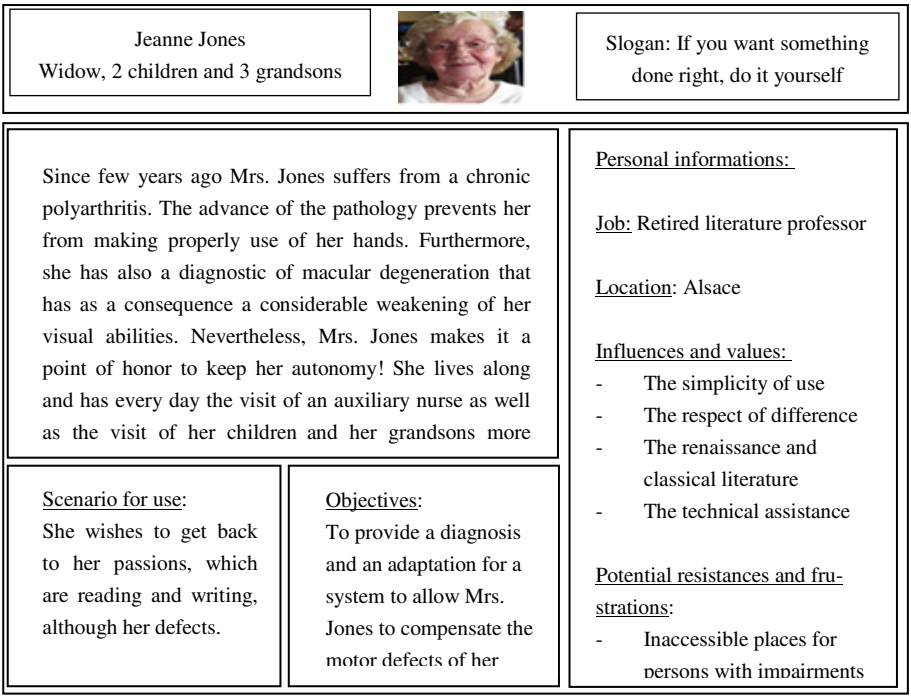

Fig. 2. Persona profile of a senior used to take into account her needs

Data obtained from DAD can be presented also in a radar chart format, which permits to visualize directly the deficits to be compensated (see figure 3). In this graphic we can see the gap between the individual abilities and skills and the abilities and skills, as evaluated by experts, required to meet the need and to maintain the person's independence and activity. As we can see in this person's profile, cognitive skills as memory and attention are well preserved, although the person may have some

difficulty in planning and problem solving. Similarly, we notice a decrease of some motor and perceptual abilities, which should be made up for the intended purpose.

Although the issues addressed here concern research in ICT devices and services, this tool may also be useful for other practitioners working with senior impairments (occupational therapists, physical therapists, public health nurses, psychologists, etc.) for envisioning solutions with respect to age or disability. On the other hand, many practitioners and researches in the ICT field (computer science, engineers, etc.) have not been made aware of issues related to disabilities, or have not been trained in the theory and practice of evaluating users with specific needs. This tool may help them improve their practical skills.

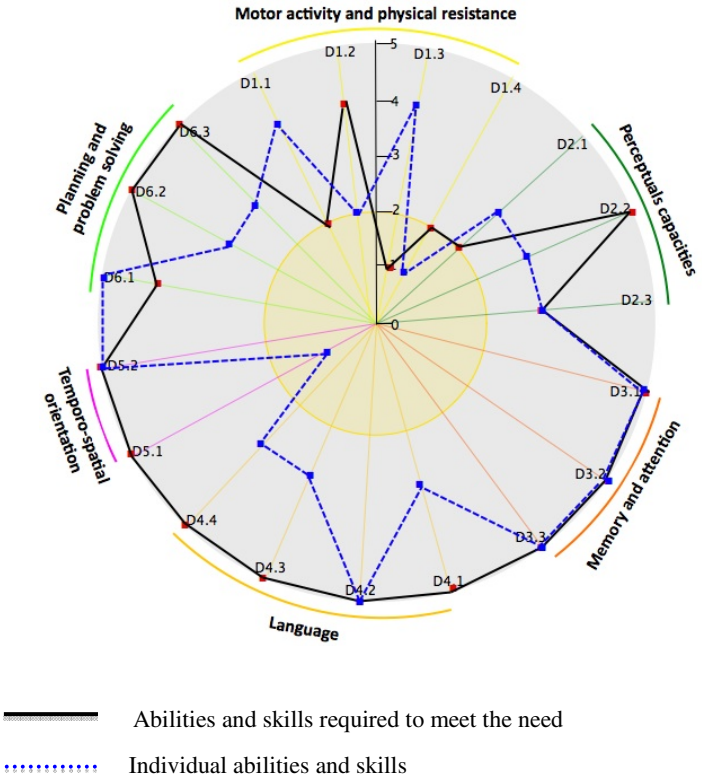

Fig. 3. Diagram showing the profile of impairments to be compensate resulting of the differential evaluation of needs and abilities required, as evaluated by experts

3 Providing Solutions

Providing solutions is figuring out how to adapt ICT technologies to the seniors' profiles. In terms of innovative solutions, since DAD was defining the users' requirement

profile, a module configuration that you can enable / disable can optimize the adaptation of the interface of the ICT technology to each senior.

For example, Fitts's Law [15], which is associated with affordance principles [16], can be used to configure interactive tablet interface in a way that is adapted to the "visual perception - finger" loop for each senior. Fitts's Law predicts the time required to reach a target, according to the distance of the target and the size of the target. Based on data obtained from a senior (time taken to reach a target icon interface), Fitts's Law should help find the right size to give activated areas of the touch interface to optimize the senior's interaction with the tablet. To visually distinguish the target from its distractors in order to visually guide the senior's touch, the work of Treisman about how to make icons pops out [17], [18], [19] can help organize icons within the interface to maximize their discriminability based on contextual categorization that create affordance.

In Smart Homes, an ICT-based solution for self-management of daily life activities of seniors at home, there are a number of techniques and devices that are useful, easily interactive, decision-making, with a high level of acceptance, learnability, usability and satisfaction by end-users. In this perspective, DAD can be used

- to assess the physical, perceptive, attention and cognitive dimensions of their use by seniors;
- to develop data-mining algorithms for extracting patterns of human-devices interaction from supervised learning,
- to implement the dedicated apartment for seniors with software;
- to supervise, collect and analyze traces of actions implemented on the seniors in-home assistance devices.

All of these might provide ways for optimizing the ICT devices and services according to DAD diagnosis profiles.

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