AMBIENT ASSISTED LIVING, AAL

JOINT PROGRAMME

ICT-BASED SOLUTIONS FOR ADVANCEMENT OF OLDER PERSONS' INDEPENDENCE AND PARTICIPATION IN THE "SELF-SERVE SOCIETY"

D2.2

Enabling Environments Design Guidelines

Project acronym:	**Entrance**
Project full title:	**ENabling elderly people TRAvel and iNternet acCEss**
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TABLE OF CONTENTS

1 THE CAPABILITIES APPROACH

1.1 Introduction

Information technologies such as those developed in the ENTRANCE project create new spaces of action and experience for elderly users. However, they also raise many **ethical questions** such as the impact of indoor sensing and user loggining analysis on privacy, and the use of computer games and the potential risk of isolation. As suggested by Coeckelbergh (2011), one way of analysing and evaluating what information technologies do and might do to humans and society is using the **capability approach** as a normative-ethical framework. The core ideas of this approach will be very briefly presented below.

1.2 The capability approach to economics of welfare

The **capability approach** (also referred to as the **capabilities approach or the enabling environments framework**) was initially developed in the 1980s as an approach to welfare economics (Sen, 1985). Over the last few decades, it has become influential in a number of other fields such as international development and human rights. In this approach, Amartya Sen, Nobel Prize in Economics, brought together a number of ideas that were hitherto inadequately formulated in traditional approaches to the economics of welfare. Thus, the **capabilities approach** stems from a basic dissatisfaction with traditional theories that identify value with either subjective satisfactions ("utility") or with access to goods or resources (Johnstone, 2007). Utilitarian theories are criticized because of their failure to capture the full range of factors which determine the use of resources (e.g. deprivation, individual states and situations provoking limited capabilities). Capabilities theorists emphasize that **resources** are **not** valued **for their own sake**, but always for some other reason, some type of activity or state that they enable to be achieved. Form a capability perspective, then, utility and access to **resources** matter but in **an instrumental way**, rather than **constitutively** (Johnstone, op.cit.). Thus, trying to specify what a well-lived life is, capability theorists bring forward an activity-based conception of wellbeing based on "functionings" (beings and doings") that an individual or a group has reason to value. Beings and doings include working, resting, being literate, being healthy, being part of a community, being respected, etc. (Robeyns, 2003). The distinction between **achieved functionings** and **capabilities** is between the realised and the effectively possible, i.e. between achievements and freedoms. According to Sen (1993), it is crucial that people have the freedoms (**capabilities**) to lead the kind of lives they want to lead and be the person they want to be.

Since reasons, contexts and people are very diverse, wellbeing may be instantiated in a large variety of forms. In the same vein, wellbeing may fail to be attained for many reasons such as poor health, lack of resources or social exclusion, arbitrary circumstances, motivation, preferences, etc. In this sense, according to the capabilities theories **utility** and **resources** may be used as **"proxy measures"**[1] (Johnstone, 2007) **of wellbeing** but should not be considered as wellbeing itself. As synthesized by Hopper (2007), "actual welfare depends less on what I own or have access to than the real **opportunities** open to me as a result." There is a focus on people's effective opportunities to undertake the actions and

[1] Proxy measurement is the method of determining certain outcomes using calculable quantities or values when you do not have the ability to measure the exact value.

activities that they want to engage in (Robeyns, op.cit.). Thus, the core focus of the capability approach is on what individuals are **effectively** able to do (i.e., or **capable of** doing). From this core focus, a number of core concepts can be derived. They will be briefly presented in the part below.

1.3 Core concepts

The capability approach involves "concentration on freedoms to achieve in general and the capabilities to function in particular" (Sen, 1995). Thus, the core concepts of the capability approach are **functionings** and **capabilities**. According to Sen (1987), "a **functioning** is an **achievement**, whereas a **capability** is the **ability to achieve**."

Another core concept in the capability approach is the notion of **commodities**, i.e. goods and services. Commodities should not necessarily be thought of as exchangeable for income or money (Robeyns, 2003). They should rather be regarded as goods and services with certain characteristics making them interesting for people. These characteristics of a good enable a **functioning**. For example, older adults might not be interested in a new smartphone because it is trendy but rather because it makes the communication with their grandchildren easier and available everywhere and at any moment.

However, the relation between the good and the functionings to achieve certain beings and doings is influenced by **conversion factors**. There are the following three types of conversion factors:

- **Personal characteristics**: these are, for example, physical characteristics, sex, intelligence, literacy level, etc. Thus, taking the example from above, if an older adult suffers from severe hearing loss, the smart phone might be of limited support to enable the functioning of communication.
- **Social characteristics:** these are, for example, social norms, gender stereotypes, power relations. Again, taking the example from above, a social norm saying that using a smartphone in a restaurant is socially unacceptable might impede the achievement of the functioning "communication everywhere".
- **Environmental characteristics**: these are, for example, infrastructure, availability of public services, etc.. In the example above, if the cellular network is not working in certain locations, it will impede the older person from achiving the functioning of communicating everywhere at any time.

The relations between these core concepts can be summarized in the following diagram (Fig. 1, adapted from Robeyns, 2003):

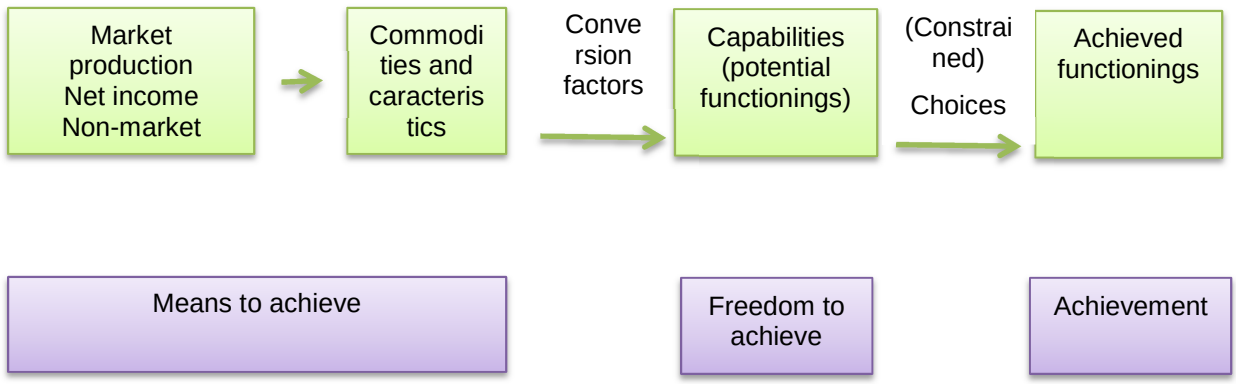

Fig. 1. Core concepts in the capability approach and their relations (adapted from Robeyns, 2003)

Thus, as emphasized by Robeyns (2003), one of the major strengths of the capability approach is that it can account for interpersonal diversity, namely by stressing the importance of the conversion factors and by of the characteristics of the commodities into functionings. We think that **this focus on diversity can be a good start for designing guidelines to be used for technologies for older adults (an extremely diverse population with varied needs and wishes**).

Later, in collaboration with Martha Nussbaum, a political philosopher, Sen tried to establish the capabilities approach as a paradigm for human development. This work, which will be briefly presented below, has attracted considerable interest from researchers in many academic fields, ranging from development studies to education and philosophy. The major reason for this is most probably the universal nature and importance of development and competences/capabilities improvement.

1.4 Nussbaum's interpretation of Sen's capability approach

We think the capability approach, and namely its version presented in Nussbaum's works (e.g. Nussbaum & Sen, 1993; Nussbaum, 2000, 2006) can be a valuable framework for the design and development of technologies for users with specific needs because of its strong **focus on development and dignity**. According to Nussbaum (2006) the concept of **dignity** can even be considered as a basis for capabilities. Dignity requires 'an appropriate threshold level' (Nussbaum, op. cit., p. 75) of the following 'central' human capabilities (as summarized in Coeckelbergh, 2011):

- **Life**: 'Being able to live to the end of a human life of normal length; not dying prematurely, or before one's life is so reduced as to be not worth living'.
- **Bodily Health:** includes nourishment and shelter.
- **Bodily Integrity**: free movement, freedom from sexual assault.
- Being able to use your **senses**, **imagination**, and **thought**; experiencing and producing culture, freedom of expression and freedom of religion.
- **Emotions**: being able to have attachments to things and people.
- Practical Reason: being able to engage in a conception of the good and critical reflection about the planning of one's life.
- **Affiliation**: being able to live with and toward others, imagine the other, and respect the other.
- **Other species**: being able to live with concern to animals, plants and nature.
- **Play**: being able to laugh, to play, to enjoy recreational activities.
- **Control over one's environment**: political choice and participation, being able to hold property, being able to work as a human being in mutual recognition.

This list of capabilities shows that they can be understood **not only as minimal dignity and development requirements**, but rather as formulations of the ethical 'maximum', i.e. they can be interpreted as what **good life** or human flourishment requires. Nussbaum gives an example in this direction showing that after having identified a threshold, 'we seek a higher threshold, the level above which not just mere human life, but good life, becomes possible' (Nussbaum, 2006, p. 181).

1.5 Nussbaum's approach and ICT

If we transpose this to technology, we will move **from accessibility and usability requirements** (threshold 1) to **requirements oriented towards the enhancement of**

users' competences/capabilities (threshold 2). This first and quite schematic transposition is explained by the fact that there is limited research on the use of the capability approach for technology design and evaluation. An interest to this topic in the field of ICT has only recently emerged (e.g. Coeckelbergh, 2011; Johnstone, 2007; Oosterlaken & van den Hoven, 2011; Wresch, 2007; Zeng, 2007).

As mentioned by Coeckelbergh (op. cit.), the usual way of defining the relation between capabilities and technology is to think of technologies as means, instruments or resources to reach the aims (capabilities). However, there should also be "conversion factors", i.e. factors and elements which help users transform a resource into a "functioning", a useful characteristic. More concretely, the idea is that just having access to a PC or a mobile phone is not enough to provide, for instance, one's capability for affiliation. Instead, what matters is that **the person can actually and effectively use the technology** for that kind of activities.

Another idea inspired by Sen's and Nussbaum's works and important for the design of technologies for people with special needs is **human diversity**, a core theme within the capabilitiy approach (Toboso, 2011). Thus, Toboso (op. cit.) asserts that ''a tradition of 'standard' design for users — anchored in some hypothetical parameters of "normality"— still prevails in product and services development. However, in order to expand the capabilities of all people in their full diversity, more attention should be paid to ''universal design'' and **user participation** in the design of ICT. To facilitate this change, Toboso proposes to replace the idea of disability, ''with its negative connotations'', with the more general concept of ''functional diversity''— ''describing the reality of persons who have the potential to access the same functionings as other people but in a different way". Such a vision is very close to the vision of **user empowerment** (e.g. Johnstone, 2007; Mendes-Filho, Tan & Mills, 2010). This approach, together with some other relevant approaches, proposing similar ideas to the ones proposed by the capability approach, will be presented below.

1.6 Other relevant approaches

The idea of **user empowerment** has emerged with the wide-spreading of user-generated content on the Web. User-generated content constitutes the data, information, or media produced by the general public (rather than professionals) on the internet (Arriga & Levina, 2008). In all user-generated content activities, the user is the central point being **not only consumer**, but **also content contributor** playing simultaneously the roles of producers as well as consumers of the Internet content. This fact **gives users unprecedented power** through the web, allowing them to exchange opinions or experiences with others from all over the world (Litvin, Goldsmith & Pan, 2008), enabling electronic word-of-mouth communication through bulleting boards and news groups (Niininen, Buhalis & March, 2007). In general, **empowerment has two meaning**s. First, it can be considered in terms of authority delegation and decentralisation of decision-making power (Burke, 1986) and, second, as a motivational construct (Thomas & Velthouse, 1990). In the light of the capability approach and regarding technologies for users with special needs, including older adults, a view of **empowerment** as a **motivational construct** is particularly valuable, since it can be considered an **enabling process** or a **conversion factor**. This enabling process is based on and **can be measured by** the following four cognitive dimensions (Spreitzer, 1995):

- **Meaning:** defined as the value of a work goal or purpose, judged in relation to an individual's own ideals (Thomas & Velthouse, 1990).
- **Competence:** defined as the individual's belief in his/her capability to perform activities with skill (Gist, 1987).
- **Self-determination**: defined as the individual's autonomy in having choice in initiating and regulating work behaviours and processes, such as making decisions about work methods, pace and effort (Spector, 1986).

- **Impact**: defined as the degree to which an individual can influence strategic, administrative, or operating outcomes at work (Ashforth, 1989).

These dimensions have been validated across multiple sectors and organizations and have been found to be stable over time and reliably measured (Liden, Wayne, & Sparrowe, 2000). In the ENTRANCE project, we transpose them in guidelines for the design and evaluation of HCI. For this, we use the validated instruments (i.e. questionnaires) developed in industrial psychology and management science (e.g. Spreitzer, 1995).

On the basis of these assumptions, concepts and theoretical constructs, we have done an aggregation of design principles and evaluation guidelines which can be associated to the capability approach and Nussbaum's principles presented before. The logic behind gathering the guidelines followed the hierarchy in the diagram presented below (Fig. 2):

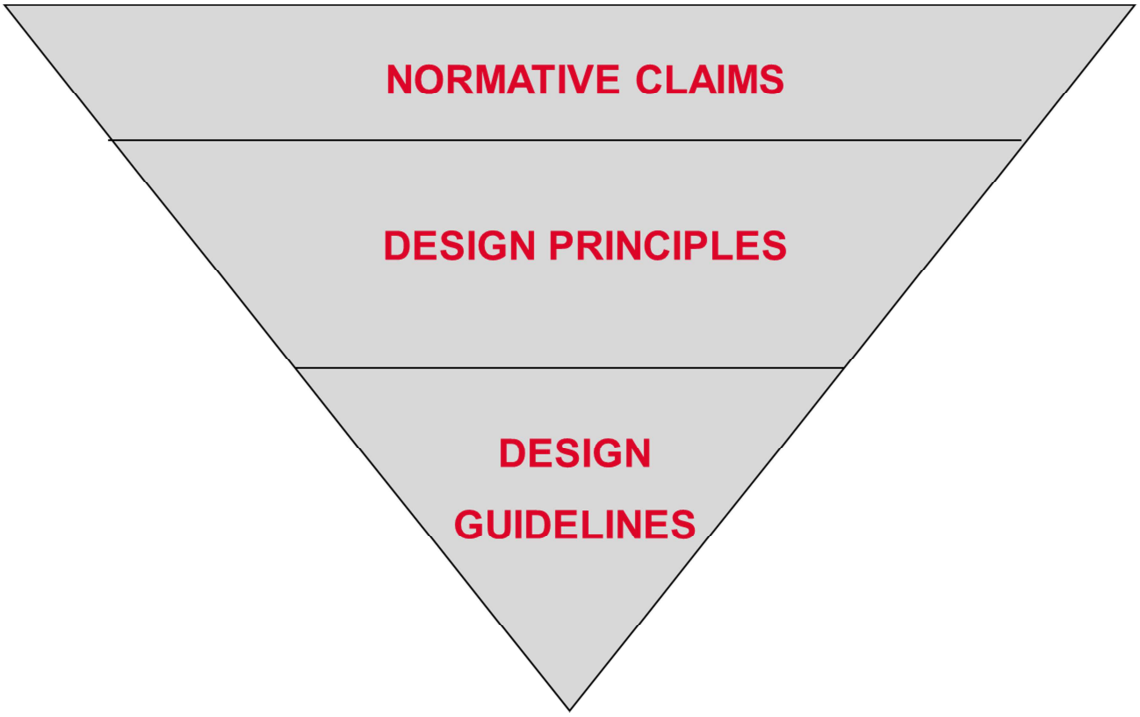

Fig. 2. From normative claims to design guidelines: basic logic

We analysed the normative claims in Nussbaum's approach, then associated them to existing principles from different frameworks such as User Empowerment, Inclusive Design and Value-Based Design.

The resulting transposition is presented in the section below.

2 FROM NORMATIVE CLAIMS TO DESIGN GUIDELINES

These resulting design principles, taken from literature in the field of universal design and user empowerment are summarized in the table below.

Nussbaum's principle	Associated design principles	Associated design guidelines
Bodily integrity: "being able to move freely from place to place; having one's bodily boundaries treated as sovereign	**Cause no harm**: The system should maintain or improve the **safety** of the service user above other quality of life needs. **Low physical effort:** The design can be used efficiently and comfortably and with a minimum of fatigue. **Size and space for approach and use**: Appropriate size and space is provided for approach, reach, manipulation, and use regardless of user's body size, posture, or mobility (Connell et al., 1997; Gray et al., 2012)	The interface shall be operable by users with limited manual dexterity. Design considerations must include: 1) size of interaction components; 2) time-delays of input sequences (i.e. before system prompts for completion of input); 3) Timely and adequate tactile feedback. The interface shall allow the user to maintain a neutral body position. The interface shall require the use of reasonable operating forces. The interface shall minimize repetitive actions. The interface shall minimize sustained physical effort. The interfaces shall accommodate to variations in hand and grip size. The interface shall provide adequate space for the use of assistive devices or personal assistance. The user has to actually use the device. It must require mobility and agility that is with the users ability.
Senses: Being able to use the senses…Being able to have pleasurable experiences, and to avoid non-necessary pain	**Perceptible Information**: The design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities (Connell et al., 1997; Rimmer, 2007). **Sensory Engagement**: The interface should be based on the principle of sensory affordance, i.e. on design feature that help, aid, support, facilitate, or enable the user in sensing (e.g., seeing, hearing, feeling, Hartson, 2003).	Use different modes (pictorial, verbal, tactile) for redundant presentation of essential information. Every action should be acknowledged in some way (visible, audible or tactile) by the system in a way the user expects. Each action should be reversible. Actions which are not reversible should be confirmed by the user. This encourages the user to explore, knowing that no 'damage' can

	Pleasure: The interface should provide the user with emotional and hedonic benefits (Jordan, 1998).	be done accidentally. Provide adequate contrast between essential information and its surroundings. Maximize "legibility" of essential information. Age-related decline in visual acuity means that small text can be difficult to make out. Poor colour contrast also presents a problem, but in particular age-related decline in vision can affect a persons ability to distinguish between different shades of the same colour,. The interface should be accessible by hearing impaired users. It is highly likely that a significant proportion of the target users of this system will have experienced some age-related decline in hearing. Provide compatibility with a variety of techniques or devices used by people with sensory limitations. Provide adequate auditory quality of audio information. Provide adequate quality of haptic, tactile and force interaction. Aim for subtractive design, i.e. - reduce clutter by eliminating any visual/audio/tactile element that does not contribute directly to communication. Sensory hierarchy - by understanding the importance of users' tasks, establish a sensory hierarchy. An important object can be given extra sensory prominence. Affordance - when users can easily determine the action that should be taken with an object, that object displays good affordance. Objects with good affordance usually mimic real world objects. Design a system that can be considered successful even if user engagement is low or nil. While it is likely that many users will wish to interact with

		the system proactively, this should not be critical to the 'success' of the system (Rimmer, 2007). Offer usability plus reliability to prevent frustration from undermining the fun. Engage users with fun features (Scollan, 2007).
Imagination : "Being able to use imagination and thought in connection with experiencing and producing self-expressive works and events of one's own choice…" "Being able to laugh, to play, to enjoy recreational activities" "Being able to have attachments to things and persons outside themselves…To love, to grieve, to experience longing, gratitude, and justified anger".	**Compelling content:** The design should be based on a tension between the user's base knowledge and the gap between the knowledge or skill to be developed. Such tension fosters a sense of curiosity, challenge and imagination (McGinnis et al., 2008). **Designing for pleasure**: The design should be target "physio-pleasure,", "socio-pleasure", "psycho-pleasure" and 'ideo-pleasure" (Jordan, 1997).	It should offer a learning environment in a story format, 'using fantasy to provoke curiosity, allowing the learner choice and control, and providing opportunities for creativity' (Becta, 2001). It should be grounded on a context relevant to older adults' lifelong learning (Brownfield & Vik, 1983; Griffiths, 1996; Prensky, 2001). Keep the start up simple: target audience thresholds of interest and concentration may be low (Oyen & Bebko, 1996; Becta, 2001). Provide short modules (to maximise the likelihood of satisfactory outcomes) but also make available longer sessions (to encourage involvement). Engage players in intrinsic learning via multimedia features that complement each other. Vary the nature of challenge, means of scoring, etc, and provide different levels of challenge. The interface should feel good in the hand. The interface should be easy to carry around. The interface should fit well and comfortably inside one's pocket. The interface should be operable without causing damage to fingernails. The interface should have aesthetic looks. The interface should convey user's socio-economic &

		cultural status. The interface should convey user's interests and should be competitive amongst one's friend's circles. The interface should provide possibilities for personalization.
Thought : Being able to use one's mind in ways protected by guarantees of freedom of expression…	**Authentic learning experience:** The content of the learning game should be linked to users' prior knowledge and be relevant to their everyday lives and careers (McGinnis et al., 2008). **Active user's participation:** In educational games, active participation is the key, as the player seeks to understand and control his/her play cycle while challenged by some form of opposition (Fabricatore, 2000). Learning is usually incidental,or intentional only in respect of becoming a better gamer.	Ensure that the game structure suits the learning objectives (e.g. when designing for memory recall, avoid incorporation of multiple goals and other distracting components that can inhibit performance). Embed learning opportunities in the game structure and make links to external material part of the game (Prensky, 2001). The interface, especially the learning game, should encourage both individual accountability and productive interdependence (Becta, 2001). Keep the games and instructions fairly simple to minimize levels of frustration and time spent learning the rules of the game. Ensure a clear route through the software, and constant access to information that aids navigation. Consider target audience needs when determining the pace and duration of the game. Keep the start up simple: target audience thresholds of interest and concentration may be low (Oyen & Bebko, 1996; Becta, 2001). Ensure that frequent play enables progression through different skills levels and skills sets and that there is a means of recording progress if required. Integrate feedback and debriefing into the game, encouraging a focus on process as well as on performance measures achieved. Different kinds of feedback should be provided (i.e. system-initiated feedback

		as well as opportunities to access debrief or real-world feedback). Afford the chance to correct and learn from errors so that learners can improve performance and achieve goals. Encourage reflection, evaluation and participative learning via opportunities for discussion, annotation and input of resources. Support and prompts should be provided to facilitate effective discussion (Mitchell & Savill-Smith, 2004).
Affiliation : Being able to live for and toward others, to recognize and show concern for other human beings, to engage in various forms of social interaction…	**Social identity:** The content interface should encourage learning achieved through social interaction and collaboration, as the sense of belonging to a social group improves motivation and effective learning overall. **User-generated content:** The interface should provide users with the opportunity to generate data, information, or media, which can be shared with others (McGinnis et al., 2008).	Cater for users' affective and social needs, with opportunities for interaction with human as well as virtual agents (peers, teachers, mentors, Mitchell & Savill-Smith, 2004). Provide the possibility of interaction with "warm experts" (Bakardjieva, 2005). These are friends or family members who know how to handle the applications and devices. They are vital to understanding how to work with them. Put special emphasis on the usability of the tools for content creation (Karahasanovic et al., 2009). Encourage the use and sharing of collective memories (Karahasanovic et al., 2009).
Control over one's environment : Being able to participate effectively in political choices that govern one's life…	**Empowerment:** The user should be in control of their user experience while in a supportive, collaborative environment (McGinnis et al., 2008)	Do not store or transmit personal information without user awareness and autorisation Use procedures to ensure anonymity Use secure means to store and transmit authorized personal information Avoid unnecessary automatic or external decisions by the system Inform the user about decisions taken automatically or externally Allow intervention only by authorized personnel

		Use location systems only with stakeholders' awareness and consent Delete location information after convenient usage and do not record it unnecessarily Use discrete location devices Use tagging devices only with strict ethical considerations (Abascal & Nicolle, 2005)

Table 1: Nussbaum's principles and associated design guidelines

These design principles and guidelines were then refined and organized in form usable for testing. The usable form of the guidelines is presented in the next section.

3 THE GUILDELINES BASED ON THE CAPABILITIES APPROACH

The result is a questionnaire containing 161 questions. There are 45 Questions based on a Likert scale ranged from 1 to 10. These are defined as Likert-Scale Questions (LSQ). There are also 116 Open-Ended Questions (OEQ) used to clarify the concepts examined in the LSQ. The distribution in the questions in Nussbaum's capability categories is the following:

- **Bodily integrity**: 7 LSQ, 18 OEQ;
- **Senses**: 17 LSQ, 52 OEQ;
- **Imagination**: 6 LSQ, 15 OEQ;
- **Thought**: 13 LSQ; 17 OEQ;
- **Affiliation**: 4 LSQ; 12 OEQ.

The resulting guidelines transformed into a questionnaire to be used for HCI evaluation is presented below.

Enabling Environments Guidelines: questionnaire

Bodily Integrity	How operable is the interface with limited manual dexterity?	**Not operable** 0 1 2 3 4 5 6 7 8 9 10 **Very operable**
	Why? Is the size of interaction components appropriate? Are the time-delays of input sequences appropriate? Is the tactile feedback timely? Adequate?	
	How easily can you maintain a neutral body position with the interface?	**Not easy** 0 1 2 3 4 5 6 7 8 9 10 **Very easy**
	Why?	
	How much support does the interface provide to minimize sustained physical effort?	**None** 0 1 2 3 4 5 6 7 8 9 10 **Good support**
	Why? What should be changed for that purpose?	

	How much support does the interface provide to accommodate to variations in hand and grip size?	**None** 0 1 2 3 4 5 6 7 8 9 10 **Good support**
	Why? What mechanisms provide that support? What other mechanisms are needed to enable that?	
	How adequate is the space provided by the interface for the use of assistive devices or personal assistance?	**Not adequate** 0 1 2 3 4 5 6 7 8 9 10 **Very adequate**
	Why?	
	How closely is the required mobility and agility for using the interface matching your ability?	**Not close** 0 1 2 3 4 5 6 7 8 9 10 **Very close**
	Why? Is there a specific level of ability needed? If applicable, how can the gap be reduced?	
	How easy is it to carry the interface?	**Not easy** 0 1 2 3 4 5 6 7 8 9 10 **Very easy**

	Why? Are there some components particularly heavy? Which ones? Are some components unnecessary?	
SENSES	How redundantly is the essential information presented?	**Not redundant** 0 1 2 3 4 5 6 7 8 9 10 **Very redundant**
	Why? What modalities are used for redundant information (pictorial, verbal, tactile)?	
	To which extent are the action acknowledged by the system in a way you expect?	**Not at all** 0 1 2 3 4 5 6 7 8 9 10 **Very well**
	Are there some actions that were not acknowledged the way you expected? If so, which ones? What would you have expected?	
	How easily can you undo the actions you did?	**Not easily** 0 1 2 3 4 5 6 7 8 9 10 **Very easily**

	Which functionalities enable you to do that? Are there some actions that were not reversible? If so, did the interface warn you or prompted you for confirmation before continuing the action?	
	How legible is the essential information?	**Not legible** 0 1 2 3 4 5 6 7 8 9 10 **Very legible**
	Why? Which layout features enable that? How can it be improved? Is adequate contrast provided between essential information and its surroundings? Can the non-essential information be hidden or filtered out? Is the size of the text adequate? Is the colour contrast appropriate?	
	How accessible is the interface?	**Not accessible** 0 1 2 3 4 5 6 7 8 9 10 **Very accessible**

	Why? Is the interface compatible with a variety of techniques or devices used by people with sensory limitations? Is it accessible to the hearing impaired? Is it accessible to the visually impaired?	
	How adequate is the quality of the audio information?	**Not adequate** 0 1 2 3 4 5 6 7 8 9 10 **Very adequate**
	Why? Can it be improved?	
	How adequate is the quality of the tactile and force interaction?	**Not adequate** 0 1 2 3 4 5 6 7 8 9 10 **Very adequate**
	Why? Can it be improved?	
	How cluttered is the communication?	**Not cluttered** 0 1 2 3 4 5 6 7 8 9 10 **Very cluttered**
	Why? Are there any visual/audio/tactile elements that do not contribute directly to communication? If yes, which ones?	

How much sensory hierarchy is available? (i.e. an important object can be given extra sensory prominence)	**None** 0 1 2 3 4 5 6 7 8 9 10 **A lot**
Why? If applicable, which objects are given extra sensory prominence? Which modality with? Are there some objects that should be given such prominence but aren't? Which modality should be used?	
How good is the affordance (i.e. the action to take can be easily determined with the object)?	**Not very good** 0 1 2 3 4 5 6 7 8 9 10 **Very good**
Why? Are real-world analogies used? Which objects is the affordance not good for? How could this be improved?	
How successful do you consider the system?	**Not successful** 0 1 2 3 4 5 6 7 8 9 10 **Very successful**
Why? Does the interface require proactive interaction? Can the engagement be low or nil?	

Imagination	How much is the learning environment based on a story format?	**Not at all** 0 1 2 3 4 5 6 7 8 9 10 **Very much**
	Why? Does it provoke curiosity? Does it provide you choice and control? And opportunities for creativity?	
	How usable is the interface?	**Not usable** 0 1 2 3 4 5 6 7 8 9 10 **Very usable**
	Why? Does it cause frustration?	
	How reliable is the interface?	**Not reliable** 0 1 2 3 4 5 6 7 8 9 10 **Very reliable**
	Why? Does it cause frustration?	
	How much fun features are provided?	**None** 0 1 2 3 4 5 6 7 8 9 10 **Plenty**

	Which ones? What do you enjoy about them?	
	How much is the interface grounded on a context relevant to older adults' lifelong learning?	**Not at all** 0 1 2 3 4 5 6 7 8 9 10 **Very much**
	Why? Is there some context missing?	
	How simple is the start up?	**Not simple** 0 1 2 3 4 5 6 7 8 9 10 **Very simple**
	Why?	
	How adequate is the length of sessions?	**Not adequate** 0 1 2 3 4 5 6 7 8 9 10 **Very adequate**
	Why? Are both short (for satisfactory outcomes) and longer (to encourage involvement) available?	

	How engaging are the multimedia features that complement each other?	**Not engaging** 0 1 2 3 4 5 6 7 8 9 10 **Very engaging**
	Why? Does it enable intrinsic learning?	
	How varied is the nature and levels of challenges, means of scoring, etc.?	**Not varied** 0 1 2 3 4 5 6 7 8 9 10 **Very varied**
	Why?	
	How aesthetic is the interface?	**Not aesthetic** 0 1 2 3 4 5 6 7 8 9 10 **Very aesthetic**
	Why? Is that an issue? Would it limit its use?	
	How well does the interface convey user's socio-economic and cultural status?	**Not well** 0 1 2 3 4 5 6 7 8 9 10 **Very well**

	Why? How is this achieved? Is some information conveyed not necessary? Some missing? Can the information to convey be customizable?	
	How much support is provided for social purposes? (i.e. convey user's interests, be competitive amongst friends' circles)	**None** 0 1 2 3 4 5 6 7 8 9 10 **A lot**
	Why? Can the information to convey be customizable? Is some information missing or not necessary?	
	How much support is provided for personalization?	**None** 0 1 2 3 4 5 6 7 8 9 10 **A lot**
	Why? What should be customizable according to users' preference?	
Thought	How well does the game structure match the learning objectives?	**Not well** 0 1 2 3 4 5 6 7 8 9 10 **Very well**

	Why? Are there too many multiple goals? Are there distracting components that can inhibit performance?	
	How encouraged are your accountability and productive interdependence?	**Not encouraged** 0 1 2 3 4 5 6 7 8 9 10 **Very encouraged**
	Why?	
	How simple are the games and instructions?	**Not simple** 0 1 2 3 4 5 6 7 8 9 10 **Very simple**
	Why? Does the complexity cause frustration? In which cases? Was the time spent learning the rules of the game too long?	
	How clear is the navigation through the software?	**Not clear** 0 1 2 3 4 5 6 7 8 9 10 **Very clear**

	Why? Is some information missing to help navigation?	
	How adequate are the pace and duration of the game?	**Not adequate** 0 1 2 3 4 5 6 7 8 9 10 **Very adequate**
	Why? Which parts were not adequate?	
	How much support is provided for progression through different skills levels and skills sets and recording such progression?	**None** 0 1 2 3 4 5 6 7 8 9 10 **A lot**
	Why?	
	How much support is provided for feedback and debriefing?	**None** 0 1 2 3 4 5 6 7 8 9 10 **A lot**

	Why? Are different kinds of feedback provided? (i.e. system-initiated feedback as well as opportunities to access debrief or real-world feedback)	
	How much support is provided for correcting errors and learning from them?	**None** 0 1 2 3 4 5 6 7 8 9 10 **A lot**
	Why?	
	How well are reflection, evaluation and participative learning encouraged?	**Not well** 0 1 2 3 4 5 6 7 8 9 10 **Very well**
	Why? Are opportunities for discussion, annotation and input of resources provided? Are support and prompts provided for effective discussion?	
Affiliation	How well are affective and social needs catered for?	**Not well** 0 1 2 3 4 5 6 7 8 9 10 **Very well**

	Why? Are opportunities for interaction with human as well as virtual agents provided? Are some interactions missing?	
	To which extent is the interaction with “warm experts” possible? (i.e. friends or family members who know how to handle the applications and devices)	**Not possible** 0 1 2 3 4 5 6 7 8 9 10 **Very much possible**
	Why?	
	How much support is provided for content creation?	**None** 0 1 2 3 4 5 6 7 8 9 10 **A lot**
	Why? How is content creation achieved?	
	How encouraged is the use and sharing of collective memories?	**Not encouraged** 0 1 2 3 4 5 6 7 8 9 10 **Very encouraged**

	Why? What enables it?	
Control	How well is your anonymity and privacy respected?	**Not well** 0 1 2 3 4 5 6 7 8 9 10 **Very well**
	Why? Is authorization asked for storage or transmission of personal information? And for using location-based information? Is the storage or transmission secure? Does the system inform about automatic or external decisions?	

4 EXPERT EVALUATION OF THE GUIDELINES

The guidelines were evaluated in a user study with 4 experts (2 experts in the field of HCI and 2 experts working with older adults). The user study and its results are presented below.

4.1 Objectives of the expert evaluation

The objectives of this evaluation were to test the understandability of the guidelines as well as their applicability for ICT for older adults with different levels of maturity.

4.2 Methodology

The study was done by CEA LIST. Four experts (3F, 1M) participated in the study. Two experts were working in the field of HCI and the 2 others were ergonomists working with older adults. The experts' average age was 35 years (min=28, max=46) and the average time they had worked in the respective field was 12 years (min = 4, max = 23).

The materials on which the guidelines were applied were mockups and demos of the mobile interface and the serious game developed in ENTRANCE (Fig. 3).

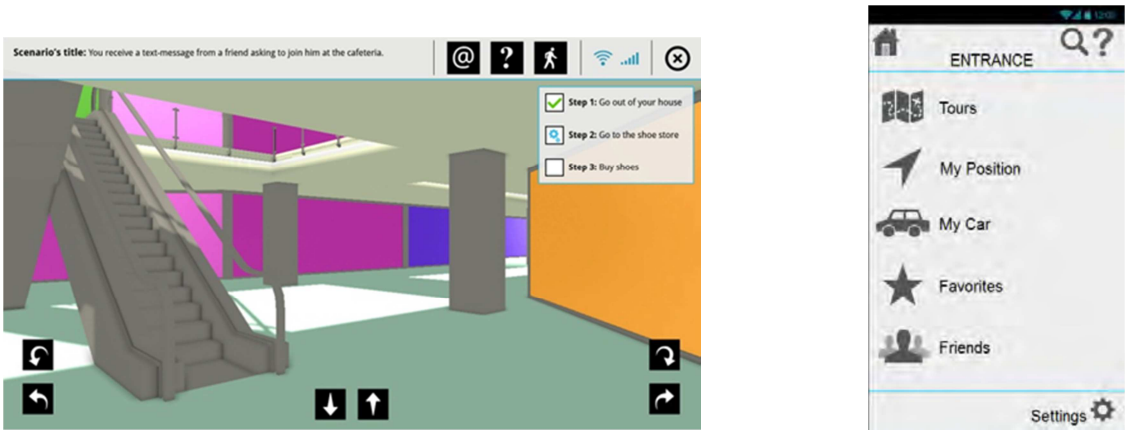

Fig. 3. Mock-ups used for the expert evaluation of the guidelines

The questionnaire, together with the mockups and the demos, were sent by email to the experts. They were free to do the evaluation whenever they liked. They were also invited to ask questions if they had any. After the evaluation, there was an individual debriefing with each expert. The objective of this debriefing was to collect the experts impressions and suggestions for the questionnaire.

4.3 Major results

All the experts managed to use the guidelines and to evaluate the mockups with them. The guidelines were judged useful, understandable and quite complete. Thus, on the average,

only 2% of the questions were judged difficult to understand and, on the average, 81% of the questions were judged adapted to the goal.

However, a number of negative points were brought forward:

- The evaluation using the questionnaire was too long (2 hours on the average, min = 1h, max = 3h).
- The OEQ were judged particularly time-consuming. However, they were judged very useful.
- LSQ were judged not time consuming. However, the 4 experts agreed that as closed questions were not very explicit, they should be complemented by open questions.
- The poor understandability of the 2% of the guidelines which were judged difficult to understand was mainly due to specific vocabulary, i.e. the use of terms such as “sensory prominence” and “accountability and productive independence”.

As for the adaptability to the goal, the 19% of the questions which were judged not sufficiently adapted to the goals of the evaluation were judged so because they were not adapted to:

- the evaluation of mockups and prototypes, namely to the limited content available;
- the lack of access to real users;
- the type of device (e.g. no haptic devices evaluated).

Furthermore, from a more formal point of view, a limited number of questions in the categories “**Thought**” and “**Imagination**” judged redundant by the experts.

Finally, the open questions asking for suggestions for improvements were judged problematic, especially when they appeared at the end of the questionnaire.

5 MODIFICATIONS ACCORDING TO THE EXPERTS' RECOMMENDATIONS

The guidelines were improved according to the experts' suggestions and the results of the evaluation. The following steps were undertaken. First, the questionnaire was divided into different parts according to:

- The type of device
- The maturity of the prototype
- The type of content
- The type of questions

Second, the vocabulary and the wording if the questions judged difficult to understand was improved. Finally, the redundancies were eliminated.

The improved guidelines, presented in the section below, will be used to evaluate new more functional prototypes with new experts in Austria and France.

6 FINAL VERSION OF THE GUIDELINES

Questionnaire

For each hardware device:

Bodily Integrity	How operable is the interface with limited manual dexterity?	Not operable 0 1 2 3 4 5 6 7 8 9 10 Very operable
	Why? Is the size of interaction components appropriate? Are the time-delays of input sequences appropriate?	
	How much support does the interface provide to minimize sustained physical effort?	None 0 1 2 3 4 5 6 7 8 9 10 Good support
	Why? What should be changed for that purpose?	
	How closely is the required mobility and agility for using the interface matching your ability?	Not close 0 1 2 3 4 5 6 7 8 9 10 Very close

	Why? Is there a specific level of ability needed? If applicable, how can the gap be reduced?	

For mobile/portable devices:

Bodily Integrity	How much support does the interface provide to accommodate to variations in hand and grip size?	None 0 1 2 3 4 5 6 7 8 9 10 Good support
	Why? What mechanisms provide that support? What other mechanisms are needed to enable that?	
	How adequate is the space provided by the interface for the use of assistive devices or personal assistance?	Not adequate 0 1 2 3 4 5 6 7 8 9 10 Very adequate
	Why?	
	How easy is it to carry the interface?	Not easy 0 1 2 3 4 5 6 7 8 9 10 Very easy

	Why? Are there some components particularly heavy? Which ones? Are some components unnecessary?	
	How easily can you maintain a neutral body position with the interface?	Not easy 0 1 2 3 4 5 6 7 8 9 10 Very easy
	Why?	

For the overall system:

Static mockups (mostly on content and legibility):

SENSES	How redundantly is the essential information presented?	Not redundant 0 1 2 3 4 5 6 7 8 9 10 Very redundant
	Why? What modalities are used for redundant information (pictorial, verbal, tactile)?	
	How clear and understandable is the essential information?	Not legible 0 1 2 3 4 5 6 7 8 9 10 Very legible

Why? Which layout features enable that? How can it be improved? Is adequate contrast provided between essential information and its surroundings? Can the non-essential information be hidden or filtered out?	
If applicable, how adequate is the quality of the visual information?	Not adequate 0 1 2 3 4 5 6 7 8 9 10 Very adequate
Is the size of the text adequate? Is it legible? Is the color contrast appropriate? Quality of images? Why? Can it be improved?	
If applicable, how adequate is the quality of the audio information?	Not adequate 0 1 2 3 4 5 6 7 8 9 10 Very adequate
Why? Can it be improved?	
If applicable, how adequate is the quality of the tactile and force interaction?	Not adequate 0 1 2 3 4 5 6 7 8 9 10 Very adequate
Why? Can it be improved?	

	How cluttered is the communication?	Not cluttered 0 1 2 3 4 5 6 7 8 9 10 Very cluttered
	Why? Are there any visual/audio/tactile elements that do not contribute directly to communication? If yes, which ones?	
	At this stage, how successful do you consider the system?	Not successful 0 1 2 3 4 5 6 7 8 9 10 Very successful
	Why?	

Dynamic mockups or prototypes with at least some basic functionalities/actions:

SENSES	To which extent are the action acknowledged by the system in a way you expect?	Not at all 0 1 2 3 4 5 6 7 8 9 10 Very well
	Are there some actions that were not acknowledged the way you expected? If so, which ones? What would you have expected?	
	How easily can you undo the actions you did?	Not easily 0 1 2 3 4 5 6 7 8 9 10 Very easily

Which functionalities enable you to do that? How? Are there some actions that were not reversible? If so, did the interface warn you or prompted you for confirmation before continuing the action?	
How much sensory hierarchy is available? (i.e. an important object can be given extra sensory importance)	None 0 1 2 3 4 5 6 7 8 9 10 A lot
Why? If applicable, which objects are given extra sensory importance/dominance? Which modality with? Are there some objects that should be given such importance but aren't? Which modality should be used?	
How good is the affordance (i.e. the action to take can be easily determined with the object)?	Not very good 0 1 2 3 4 5 6 7 8 9 10 Very good
Why? Are real-world analogies used? Which objects is the affordance not good for? How could this be improved?	
At this stage, how successful do you consider the system?	Not successful 0 1 2 3 4 5 6 7 8 9 10 Very successful

	Why? Does the interface require proactive interaction? Can the engagement be low or nil?	
Imagination	How usable is the interface?	Not usable 0 1 2 3 4 5 6 7 8 9 10 Very usable
	Why? Do you consider it efficient? Effective? Are you satisfied?	
	How reliable is the interface?	Not reliable 0 1 2 3 4 5 6 7 8 9 10 Very reliable
	Why? Does it cause frustration?	
	How much fun features are provided?	None 0 1 2 3 4 5 6 7 8 9 10 Plenty
	Which ones? What do you enjoy about them?	

	How aesthetic is the interface?	Not aesthetic 0 1 2 3 4 5 6 7 8 9 10 Very aesthetic
	Why? Is that an issue? Would it limit its use?	
Thought	How clear is the navigation through the software?	Not clear 0 1 2 3 4 5 6 7 8 9 10 Very clear
	Why? Is some information missing to help navigation?	

Prototype close to a final stage:

Imagination	How well does the interface convey user's socio-economic and cultural status?	Not well 0 1 2 3 4 5 6 7 8 9 10 Very well
	Why? How is this achieved? Is some information conveyed not necessary? Some missing? Can the information to convey be customizable?	

	How much support is provided for social purposes? (i.e. convey user's interests, be competitive amongst friends' circles)	None 0 1 2 3 4 5 6 7 8 9 10 A lot
	Why? Can the information to convey be customizable? Is some information missing or not necessary?	
	How much support is provided for personalization?	None 0 1 2 3 4 5 6 7 8 9 10 A lot
	Why? What should be customizable according to users' preference?	
Affiliation	How well are affective needs catered for?	Not well 0 1 2 3 4 5 6 7 8 9 10 Very well
	Why? Are opportunities for interaction with human as well as virtual agents provided? Are some interactions missing?	

	To which extent is the interaction with “warm experts” possible? (i.e. friends or family members who know how to handle the applications and devices)	Not possible 0 1 2 3 4 5 6 7 8 9 10 Very much possible
	Why?	
	How much support is provided for content creation?	None 0 1 2 3 4 5 6 7 8 9 10 A lot
	Why? How is content creation achieved?	
	How encouraged is the use and sharing of collective memories?	Not encouraged 0 1 2 3 4 5 6 7 8 9 10 Very encouraged
	Why? What enables it?	
ol	How well is your anonymity and privacy respected?	Not well 0 1 2 3 4 5 6 7 8 9 10 Very well

	Why? Is authorization asked for storage or transmission of personal information? And for using location-based information? Is the storage or transmission secure? Does the system inform about automatic or external decisions?	

Specific to learning:

Imagination	If applicable, how much is the learning environment based on a story format?	Not at all 0 1 2 3 4 5 6 7 8 9 10 Very much
	Why? Does it provoke curiosity? Does it provide you choice and control? And opportunities for creativity?	
	How much is the interface grounded on a context relevant to the target users' lifelong learning?	Not at all 0 1 2 3 4 5 6 7 8 9 10 Very much

Why? Is there some context missing?	
How engaging are the multimedia features that complement each other?	Not engaging 0 1 2 3 4 5 6 7 8 9 10 Very engaging
Why? Does it enable intrinsic learning?	
How varied is the nature and levels of challenges, means of scoring, etc.?	Not varied 0 1 2 3 4 5 6 7 8 9 10 Very varied
Why?	
How simple is the start up?	Not simple 0 1 2 3 4 5 6 7 8 9 10 Very simple
Why?	

	How adequate is the length of sessions? Or How adequate are the pace and duration of the game?	Not adequate 0 1 2 3 4 5 6 7 8 9 10 Very adequate
	Why? Are both short (for satisfactory outcomes) and longer (to encourage involvement) available?	
Thought	How well does the game structure match the learning objectives?	Not well 0 1 2 3 4 5 6 7 8 9 10 Very well
	Why? Are there too many multiple goals? Are there distracting components that can inhibit performance?	
	How simple are the games and instructions?	Not simple 0 1 2 3 4 5 6 7 8 9 10 Very simple
	Why? Does the complexity cause frustration? In which cases? Was the time spent learning the rules of the game too long?	

How much support is provided for progression through different skills levels and skills sets and recording such progression?	None 0 1 2 3 4 5 6 7 8 9 10 A lot
Why?	
How much support is provided for feedback and debriefing?	None 0 1 2 3 4 5 6 7 8 9 10 A lot
Why? Are different kinds of feedback provided? (i.e. system-initiated feedback as well as opportunities to access debrief or real-world feedback)	
How much support is provided for correcting errors and learning from them?	None 0 1 2 3 4 5 6 7 8 9 10 A lot
Why?	
How well are reflection, evaluation and participative learning encouraged?	Not well 0 1 2 3 4 5 6 7 8 9 10 Very well

	Why? Are opportunities for discussion, annotation and input of resources provided? Are support and prompts provided for effective discussion?	

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