Cognition, technology and games for the elderly: An introduction to ELDERGAMES Project

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ABSTRACT

Eldergames is a EU-funded project to develop games using advanced visualisation and interaction interfaces to improve the cognitive, functional and social skills of older users. The project merges two major areas to which technology for elderly people is applied: health and social engagement. Its platform will allow users to improve their cognitive skills and individual well-being by playing on a mixed-reality platform; in addition, it will offer the unusual experience of communicating with people located in other countries without the need to share the same language. After introducing the field of gerontology and the project, this paper describes the main cognitive abilities that change with aging (perception, attention, memory, and other more specific processes such as decision-making), and that have to be taken into account while designing a technology for elderly people. Some guidelines that are specifically meant to ensure usability of these products are listed in the conclusions.

Keywords: *successful aging; cognitive aging; gerontechnology; playing*

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1. Introduction

Life is characterized by transformations; every aspect of the human being changes along the whole lifespan during both development and aging, and it is impossible to define exactly the end of the former and the start of the latter. While people aged over 60 can be conventionally considered older adults, yet a more

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complex definition must take into account three levels (Fisk, Rogers, Charness, Czaja and Sharit, 2004): biological, psychological and social. It is easy to think that getting older involves decrease of performance and weakening of memory; however, people believe that the large number gain knowledge and wisdom and accumulate heterogeneity of experiences (Hummert, Garstka, Shaner, Strahm, 1994, in Park, 2000). On the basis of the distinction between a fluid (e.g. problem-solving, distribution of attention on multiple tasks) and crystallized (e.g. cultural knowledge, linguistic competence) intelligence (Horn and Cattell, 1967, in Mata, 2006), Baltes et al. (1999, in Mata, 2006) classify the first set of abilities as the *mechanics* of cognition (basic information processing) and the second kind as the *pragmatics* of cognition (acquired cultural knowledge). Dixon has grouped the advances related to cognitive aging, as "gains qua gains" (some abilities continue to grow, like wisdom; Heckhausen, Dizon and Baltes, 1989, in Dixon, 2000), "gains as losses of a lesser magnitude" (e.g. redefining the goals of life can help to cope with the impossibility of maintaining some usual high standards; Brandstädter and Wentura, 1995, in Dixon, 2000) and "gains as a function of losses" (for example, the brain is able to develop compensatory ways to perform a cognitive task; Buckner, Corbetta, Schat, Raichele and Pettersen, 1996, in Dixon, 2000). This last point links to the notion of plasticity of the neural system, which decreases with age, but is nonetheless able to compensate for the losses due to aging processes (Singer, Linderberger and Baltes, 2001), for instance, by reorganizing the aspects of a problem; Park, Polk, Mikels, Taylor and Marshuetz, 2001).

The possibility of "successful aging" is strictly related to this ability to reshape thoughts and goals in order to cope with the difficulties derived from the elderly condition, such as the consequences of retirement. The present line of thought is to improve the quality of life for these people, not only to extend the duration of their life. In particular, gerontechnology (Burdick and Kwon, 2004) is the expanding field of technology applications to improve the elderly life conditions, considered as a special category of users, whose particular abilities and needs, at cognitive, social and health levels, have to be taken into account during the design process. The goal of this paper is to present a European-funded project in this application area, attempting to use playing as an opportunity to solicit the cognitive activity and to facilitate successful aging in several spheres, including sociability. First we will introduce the ways in which technology can be used to improve elderly people's social life and health; then, from a user-centered design perspective, we will provide a synthesis of the main cognitive changes accompanying aging, for they have to be taken into account when designing technologies for this category of users; finally, we will illustrate the specific purpose of the “Eldergames” project and its starting assumption, according to which, playing represents an advantageous way, from several points of view, to engage users cognitively and socially.

2. Elderly and Technology

From a demographic point of view, the percentage of the older population has increased in the past decades and at present, it constitutes between 6 and 15% of the worldwide population (Kinsella and Velkoff, 2001, in Burdick and Kwon, 2004) and is expected to exceed one billion in 20 years (United Nations, 2001). According to Kinsella and Velkoff (2001, in Burdick and Kwon, 2004), the percentage of older people using computers is also continuously increasing. Stereotypes and myths should be revised according to the latest statistics: 40% of the U.S. population over 65 uses computers (U.S. Department of Commerce, 2002), 35% has access to the Internet (U.S. Department of Commerce, 2002) and 60 to 90% owns new electronic devices like microwave ovens, videocassette recorders, cordless phones and answering machines (Adler, 1996, in Burdick and Kwon, 2004).

Technology helps elderly keep in touch with families and friends, ensures more safety at home, assisting and facilitating them in health care (Czaja, 1996, in Mikkonen Vayrynen, Ikonen, Heikkala, 2002), bringing new stimuli into their lives and providing more access to information (Lehto, Tekniikkaa, 1998, in Mikkonen et al., 2002). Other studies confirm the role of technology in increasing social interaction and pride (Kautzamann, 1990), self-esteem (Lustbader, 1997), life satisfaction (Sherer, 1996), and perceived autonomy (McConatha, McConatha and Dermigny, 1994). Regarding health support, communication technologies and wireless systems enable health consultations, physiological data collection, safety and environmental control in order to avoid disease, maintain physical and cognitive function, and maintain engagement during life (Burdick and Kwon, 2004).

With respect to the first objective, avoiding disease, the HomeCare and Telerehabilitation Technology (HCTR) Center at The Catholic University of America started a project using plain older telephone service (POTS) for health care communication and interaction between remote health care experts and elderly patients at home. Results reported are generally positive (Buckley, Tran and Prandoni, 2001, in Burdick and Kwon, 2004): high levels of tolerance and acceptance by patients, positive impact on the quality of care given, consistence of the support also from a psychosocial point of view. Tele-health technologies can also be employed to diagnose and monitor chronic illnesses, such as heart failure (Fulmer et al., 1999, in Burdick and Kwon, 2004), respiratory diseases (Kinsella, 2000, in Burdick and Kwon, 2004) and diabetes (Gomez et al., 2002, in Burdick and Kwon, 2004). Data collected through common (blood pressure, temperature, heart rate sensors) and specialized (electrocardiograms, heart and lung sounds, blood oxygen levels…) systems is transmitted to monitoring stations or directly to caregivers.

An example of the second objective, maintaining cognitive and physical functions, is provided by a "consumer toolkit" of home automation and monitoring developed by HCTR center with the objective to collect environmental information during daily life activities. In this system there are sensors that continuously collect data about an individual's location and activities; this information is then used to monitor changes in everyday behaviors, which are probably related to changes in health status.

Finally, the third objective, lifelong engagement, is illustrated by technologies that facilitate communication, for they are especially appreciated in case of people who suffer from physical and cognitive disabilities, isolation, frustration and depression (McColl and Skinner, 1995, in Burdick and Kwon, 2004). They give older people the possibility to share their experiences in social networks, perhaps with others who have the same diseases or disabilities who can provide suggestions and emotional support, but could not possibly move from their home or live alone (Charness, Schaie, 2003). For instance, the University of Oulu and Nokia Mobile Phones (Mikkonen, Vayrynen, Ikonen, Heikkala, 2002) are engaged in the implementation of products, services and complete systems for disabled and elderly communication. The major goal is the development of the "Home Assistant," a multimedia communication terminal to keep in touch with families, friends and care assistants. Assistive technology has been defined as "any item, piece of equipment or product system, whether acquired commercially off the shelf, modified, or customized, that is used to increase, maintain, or improve functional capabilities of individuals with disabilities" (Public Law 105-394, 1998). The principal application of assistive technologies concerns daily activities, social relationships, communication, participation needs and self efficacy. Their positive effect has been demonstrated both for the users and for their social world, i.e. the relationships with family and other caregivers (Gitlin et al., 2002, in Burdick and Kwon, 2004), those persons directly involved in daily caring for elderly with chronic illnesses or disabilities. In general, they are members of the family who help with housework, transportation, dressing, bathing, medications…, and are sometimes organized into support groups, in order to get advice, face stress and other possible negative consequences in their private, social and health life (Schulz, O'Brien, Bookwala, Fleissner, 1995, in Burdick and Kwon, 2004). Computer-mediated communication can facilitate this group-interaction, especially when time for regular face-to-face meeting is lacking.

Fisk et al. (2004), who conducted several focus groups with elderly people, found that more than 50% of problems reported by participants in using technological tools related to usability, and could be solved by improving the design (25%) or by providing training (28%). Input and output devices are particularly delicate, because they involve an interaction with the sensory or perceptual system of the user, which undergoes several changes with age that can hamper usability. Fisk et al.(2004) consider "usability" as the possibility to have access to a product, and define "utility" as the capability to provide the functionality the product possesses. They also identify five characteristics related to usability, which are particularly important when speaking about older adults:

- Learnability: how difficult it is to learn to use a device, to understand and to integrate functioning instruction. Time needed to complete a task correctly and results obtained in a certain amount of time are possible measures of learnability.
- Efficiency: the extent to which technological applications satisfy users' needs, avoiding loss of time, frustration and dissatisfaction. It can be measured by an experienced user's performance on a specific task;
- Memorability: elderly users' memorability of a device's functioning is very important in order to avoid frustration and loss of time. A simple measure of this characteristic can be obtained by considering the time needed to perform a previously experienced task;
- Errors: how easily a product can induce errors for elderly users and how easily it recovers from them.
- Satisfaction: users' attitude and adoption of technological applications could be influenced by the pleasure derived from their usage.

3. Eldergames Project

ElderGames is a EU-funded project within the information society technology area (IST), to develop games using advanced visualization and interaction interfaces with a high preventive, therapeutic value that will allow elderly people to enjoy new opportunities for leisure and entertainment situations, while improving their cognitive, functional and social skills. The Consortium is composed of universities, industries, elderly leisure/care centers and technology centers/associations from Spain, Norway, United Kingdom, Finland, Austria and Italy. The project relies on the assumption that playing a game may have several benefits for elderly people, and that technologies may increase these benefits by providing specific integrated solutions to other aspects of elderly people's everyday lives. ElderGames will try to address the problem of older users' exclusion from opportunities and exclusion from advances deriving from technology (SEU, 2005), by designing the tool around their needs and by testing the platform in care/leisure centers.

The assumption according to which gaming may benefit users' cognitive and general well-being is supported by several research findings, both of general users and of elderly users. For instance, according to Rauterberg (2004), entertainment technology has positive effects on human behaviour in areas including:

- general development (thanks to use of logic, memory, problem-solving and critical thinking skills, visualization and discovery);
- collaborative and pro-social behaviour;
- healthcare and therapies (phobia, hyperactivity…).

Participation in entertainment activities could be very helpful for the maintenance of cognitive skills. For example, Goldstein, Cajko, Oosterbroek, Michielsen, Van Houten and Salverda (1997) compared results obtained from two groups of older adults aged 69 to 90; the experimental group played Super Tetris five hours a week for five weeks, the other group did not. Authors measured reaction time (Sternberg Test), cognitive/perceptual adaptability (Stroop Color Word Test), and emotional well-being (self-report questionnaire), before and after this play period. Data analysis showed that the videogame-playing group had faster reaction times and felt a more positive sense of well-being compared to the non-playing one. Whitcomb (1990) reviewed a number of videogames that were enjoyable for the elderly, and considered unsuitable those games that had small objects on the screen, required rapid reactions, or had inappropriate sound effects, generating a certain level of frustration and absence of interest. Whitcomb showed benefits of gaming practice for elderly people revealed by the studies he reviewed, in several domains: stimulation of social interaction and participation; enhancement of perceptual-motor skills (eye-hand coordination, dexterity, and fine motor abilities); improvement of performance speed (basic movements and reaction time); transfer of the skills acquired in the games to other aspects of everyday routine (like automobile driving). Although these studies do not directly focus on improvements in cognitive skills, they report on several effects on information processing, reading, comprehension, memory, self-image.

As mentioned above, the Eldergames platform will not only allow users to play a game individually; it will integrate this facility with other solutions made available by information and communication technology. First, a low cost mixed-reality technology will be used, namely a technology where the real environment is enriched with artificial information generated by the computer. Khoo et al. (2006) developed ‘Age Invaders’, an interactive game, to allow the elderly people to play together in a physical space with grandchildren, while parents could participate through the Web.

Second, Eldergames will implement an unusual communication environment for users, connecting people of different European nationalities; in order to do this, Eldergames will have to use a communication interface that helps overcome comprehension and communication problems, in order to foster cross-cultural interaction. Third, ElderGameshas been conceived as a tool for early diagnosis.

In order to do this, the first steps are to identify the following:

- areas of intervention and cognitive variables that ElderGames should address.
- instruments and indexes, already tested and validated, to measure cognitive skills and quality of life;
- appropriate communication systems that will easily integrate into the ElderGames platform and that would satisfy the communication and interaction needs of culturally and linguistically different kind of users;
- visualisation and interaction technologies appropriate for use by older people or for implementation in recreation and specialized centres.

The level of acceptance and usability of the system will be tested with direct users (older adults) and experts. Taking into account the specific abilities of the elderly user is a necessary pre-condition for usability when designing the system and especially when designing the interface. For these reasons, we will summarize some of the main cognitive changes accompanying aging, and conclude with design guidelines that take them into account.

4. Aging and Cognition

Theories of psychological aging emphasize three aspects of this process: the speed of information processing shows an aging-related decline that negatively affects cognitive abilities (Salthouse, 1996, in Park, 2000); lack of resources and the reduced capacity of working memory (Craik and Byrd, 1982 in Park, 2000); poor capacity of inhibiting irrelevant information (Zacks and Hasher, 1997, in Park, 2000).

4.1 Perception

4.1.1 Vision

The anatomical changes in the ocular apparatus affect adaptation to darkness, visual acuity, glare, contrast sensitivity, peripheral vision, motion perception and color perception. Omori, Watanabe, Takai, Takada, Miyao (2002), for instance, found that bigger font sizes in mobile phones can increase elderly users' speed and accuracy in reading the display. Schieber (2003) analyzed these changes and proposed 9 design criteria within a human-factor perspective in order to compensate for age-related deficits in the visual system:

- increasing the illumination of environment or task context;
- increasing the levels of luminance contrast;
- minimizing the need to use a device excessively close to the eyes;
- adapting the font size;
- minimizing glare;
- minimizing the use of peripheral vision;
- adopting marking strategies to enhance motion perception;
- using great color contrast;
- optimizing the legibility of spatial forms using computer capabilities.

Pinto, De Medici, Zlotnicki, Bianchi, Van Sant and Napoli (1997, p. 343) analyzed the role of environmental design in case of reduced visual acuity in elderly people and proposed recommendations to improve users' comfort and safety (Table 1). These recommendations define the values of a list of perceptual properties of areas (e.g. glare index of the walls, opacity of windows and doors, direct and indirect lightning) to reduce the risks caused by poor design of floor, wall, doors and windows, furniture and equipment, direct lighting, indirect lighting.

4.1.2 Hearing

The anatomical changes in the ear affect absolute sensitivity, frequency and intensity discrimination, sound localization and speech recognition. For instance, Kiss and Ennis (2001) observed that computer-generated speech, which does not match the rhythm properties of natural verbal production, can be problematic for elderly drivers.

Schieber (2003) proposed 9 design criteria, as he did for vision:

- increasing stimulus intensity,
- controlling background noise,
- avoiding the need to detect/identify high-frequency stimuli,
- avoiding long-term exposure to high levels of noise,
- avoiding signal locations with low frequency sound sources,
- using redundant and semantically well-structured speech materials,
- adapting the rate of words per minute,
- asking for feedback from users to calibrate the devices,
- using the Web to provide verbal communication channels for assistance.

4.1.3 Touch and Movement

Aging determines problems (arthritis, tremors, particularly for Parkinson's disease) affecting the manipulation of objects and the perception of sensorial feedback in terms of pressure, vibration, spatial acuity, perception of roughness, length and orientation (for a brief review, see Scialfa et al., 2004). In particular, older adults have a higher threshold of detecting vibrations (Goble, Collins and Cholewiak, 1996, in Scialfa 2004), which has to be taken into account when devising vibrating alerts. In this vein, Liu et al. (2002) realized a system producing a mechanical noise to reduce the vibrotactile detection thresholds in older adults, patients with stroke, and patients with diabetic neuropathy.

4.2 Attention

4.2.1 Attention and Resources

Attention is a multidimensional construct (Parasuraman and Davies, 1984) that categorizes a variety of processes distributing elaboration resources on several dimensions. Attentive processes are necessary to perform complex tasks like planning or problem-solving; aging reduces flexibility in selecting the correct solution, so that the intrusion of incorrect solutions becomes more frequent (Bisiacchi, Sgaramella and Farinello, 1998).

4.2.2 Selective and Focused Attention

Selective attention is the process of selecting certain information to elaborate on it, filtering out the irrelevant information. Rogers (2000); suggests that this ability loss (e.g. lack in inhibitory processes, Zacks and Hasher, 1997, in Park, 2000; augmented probability to be distracted, McDowd and Shaw, 2000, in Burdick and Kwon, 2004) is task-specific and related to previous experience with the objects used as target and distractors in the task (Clancy and Hoyer, 1994, in Rogers, 2000). Therefore, age-related differences in selective attention can be reduced by increasing familiarity with the items manipulated and with cues that change the attentional need from selective to focused, which does not seem to show age-related deficits (Rogers, 2000). For instance, Staplin and Fisk (1991) observed that cues about incoming hazards at intersections improved the safety behavior practiced by older users of driving simulators.

4.2.3 Divided Attention and Attentional Switch

Divided attention is the distribution of processing resources among multiple simultaneous tasks or rapidly switching from one task to another (Rogers, 2000).

Age-related deficits increase with the increase of the stimulus complexity (McDowd and Craik, 1988) and decrease with the increase of the amount of practice in the task (for a brief review: Rogers, 2000). Strayer and Drews (2004) for instance, found that a longer experience in driving and taking fewer risks reduced the predicted augment in reaction time of older compared to young users talking to the telephone while driving in a simulator.

4.2.4 Automatic and Voluntary Processing

Automatic processes are not affected by aging, while voluntary processes, which require a certain amount of attentional resources and awareness, decrease with aging (like fluid intelligence, see above); practice can reduce this decrease through a process of automatization (Rogers, 2000), even though its effectiveness depends on the kind of task: for instance, visual search needs attentional resources even after a long practice (Fisk and Rogers, 1991, in Rogers, 2000). As to the kind of training, Jamieson and Rogers (2000) showed the absence of age-related differences in the acquisition of the ability to perform transactions on a simulated automatic teller machine if the practice schedule was random instead of being organized by blocked sets of trials.

4.2.5 Sustained Attention and Vigilance

Sustained attention means maintaining focus on the same task under continuous stimulation. Vigilance means keeping the focus on waiting for a rare event. Giambra (1993, in Rogers, 2000) observed contradictory results in his review of past studies; when age-related deficits are reported, they are attributed to functions related to task (discrimination and duration of single stimulation, requirement of working memory effort), which are not strictly ‘attentive’. Anstey, Wood, Lord and Walker et al. (2005) insert sustained attention among the age-related factors affecting driving performance, linking them to mental workload like other resource-dependent functions.

4.3 Learning and Memory

Like other cognitive constructs, the memory is a heterogeneous category of processes, each one specifically affected by aging (Craik, 2000). Learning is also affected by interacting factors like affective processes, motivation, strategic approach and metacognition (the knowledge of an individual about her own cognitive abilities): for instance, older people’s lack of confidence in their abilities can create obstacles to the efforts to approach new technologies (Marquié, Jourdan-Boddaert, Huet, 2002) .

4.3.1 Implicit versus Explicit Processes

One of the first characterizations could be implicit (procedural and performance-related) processes versus explicit (declarative and conscious) processes: the first ones seem unaffected by aging (Light and La Voie, 1993), in opposition to second ones. This situation induces an imbalance in cognitive control in older people, which ends up being mainly governed by the unimpaired processes, producing, for example, false memories (Schacter, Koutstaal, and Norman, 1997). Specific training programs for technological tools have been studied by Mead and Fisk (1998, in Burdick and Kwon, 2004) who contrast two kinds of training for older adults, namely ‘Concept’ versus ‘Action’ and found that Action trainees repeat errors less frequently than Concept trainees on menu navigation tasks.

4.3.2 Working Memory

Working memory is conceptualized as a temporary and limited workspace for the manipulation of present and active fragments of information available to the awareness to accomplish a task (Baddeley and Hitch, 1974, in Craik, 2000); it includes the following processes: central executive, phonological loop, visuo-spatial sketchpad, and episodic buffer (Baddeley, 2000). Craik et al. (1990, in Craik, 2000) observed a great deterioration of working memory capabilities in older adults according to task complexity. Reducing the number of options and the speed of item presentation in an interface menu may positively affect the demand for cognitive resources and information manipulation (Reynolds, Czaja and Sharit, 2002).

4.3.3 Semantic Memory

Semantic long-term memory stores general knowledge (meaning of words, concepts, recognizing a location), regardless of when and where it has been acquired (Baddeley, 1986). In this sense, it contrasts with the episodic one, which consists of the recollection of events localized in space and time, even originally experienced ones. Semantic memory is substantially preserved during the normal aging process (Light, 1992) and it is a strong help to build elderly-centered technologies, as was observed above in case of perceptual problems. Neale and Carroll (1997) proposed the use of metaphors to create a semantic-relevant context to guide the use of an interface by elderly people.

4.3.4 Prospective Memory

Prospective memory is the “remembering to remember” (the memory of a task to be accomplished in the future); studies revealed significant age-related increases in error rate (Cockburn and Smith, 1991, in Burdick and Kwon, 2004), more for time-based tasks (acting after a certain time span) than for event-based tasks (acting after a certain event).

The use of cues facilitates this recollection, but depends on the nature of the task (Einstein and McDaniel, 1990, in Mayhorn, Rogers and Fisk, 2004).

4.4 Everyday Cognitive Tasks

4.4.1 Navigating in Environments

Sheperd and Metzler (1971) defined “spatial ability” as the function of manipulating images or patterns. Processes related to space (even visuo-spatial attention and working memory) or to its mental representations decline during the normal aging process (Salthouse, 1992). Environmental cognitive psychology is a field central to aging applied research aimed at improving elderly people’s quality of life by redesigning their everyday life space or integrating it with tools and general cues supporting losses in memory or attention (Sundstrom, Bell, Bubsy, Asmus 1996).

Mayhorn et al. (2004) highlighted the spatial connotation of web-navigation tasks and suggested the implementation of Web site maps as an external support to the deteriorated spatial abilities of the user (Mead et al. 2002, in Burdick and Kwon, 2004).

4.4.2 Reading and Understanding Instructions

Some learning activities start from reading texs; reading ability is relatively preserved in non-visually impaired older people; problems may emerge with texts that do not semantically refer to the readers’ knowledge, as happens with instructions of home medical devices. Hancock, Fisk and Rogers (2001) found that understanding improved by reducing the number of inferences needed.

The perspective of cognitive load theory (Van Gerven, Paas, Merriënboer, Schmidt, 2000) suggests “to optimize schema acquisition by stimulating an efficient use of working memory” (p. 16); some proposals in this direction include: presenting goal-free problems (without a specific solution) to stimulate the exploration of the domain, distributing information over different modalities, avoiding split attention, presenting problems along with solutions and leaving out redundant information.

4.4.3 Risky Decision-making

Decision-making is fundamental to position in a world full of options. In several cases, the prediction of the consequences of a certain choice includes a high degree of uncertainty (Dawes, 1998). Older people seem to have a tendency to search and consider less relevant information when in the process of making a decision, and to perform more slowly in making the choices (Sanfey and Hastie, 2000). The research in this field needs ecological data to situate the decisional act in its context and to monitor the biases occurring in elderly people.
A decisive help to analyze the decisional behavior of older people in potentially dangerous settings comes from the use of instrumented vehicles and simulators. Instrumented vehicles permit collecting quantitative data (strategy, vehicle usage, upkeep, drive lengths, route choices, and decision-making) in the field. Along with driving simulators, they can provide complementary information about driving behavior, accidents and their dynamics (Rizzo, Jermeland, Severson, 2002).

5. Design Implications

Currently, user interface design is oriented to graphic conceptualizations like WIMP (Window, Icon, Menu, Pointing device). Dickinson, Eisma, Gregor (2003, in Van de Watering, 2005):) highlighted several solutions to elderly-related problems with WIMP interfaces,:

- reduction of operations offered at once to avoid excessive interface complexity caused by excessive number of functions;
- minimizing the trees of options to avoid the presence of layered menus, causing a lack in working memory about the existence of “invisible” options;
- realizing specific keyboard commands instead of mouse “drag and drop”, complicated for elderly people at motor level;
- giving immediate feedback about any selection on screen to simplify the understanding of the correctness of the operations;

- maintaining the consistency of the appearance of the interface to minimize the confusion of the user seeing changes when looking at several screens using the same interface.

Chadwick-Dias et al. (2003) observed the frequent tendency of elderly users to click on items that are not links (headings, bullets, icons and plain text, too); they also present difficulties with horizontal scrolling and tabbed navigation. Davies, Haines, Norris and Wilson (1998) cited Easterby and Hakiel (1981) to show how even easily recognizable symbols can lead to poor understanding of their meaning in older adults when compared to younger people, probably for specific lacks in working memory, elaboration speed and basic elaboration to extract of the meaning of new information (computer skill learning could be a new experience for some older adults, with some needing practice periods longer than for young people, even if equally successful at the end; Siek et al., 2006). Apted et al. (2006), to maximize learnability and memorability of new elements of the interface of a tabletop-sharing system for digital photographs, arrived at the following modified version of the Nielsen guidelines:

- relying on familiar aspects of the activity (i.e. manipulating photographs), reducing the amount of learning efforts;
- minimising the number of interface elements;
- maximising the interface consistency;
- using all-new items for new tasks (to avoid confusion with already learnt actions).

According to these criteria, Apted et al. (ibidem) proposed the SharePic multi-user, multi-touch, gestural collaborative tool to help social interactions and digital object interaction “around a table” (the touch-screen tabletop interface). These objects are manipulated through commands operated by a hand-shaped cursor, whose actions are very learnable and natural (like the “rosize” operation: rotation and resizing of the photo using its corners), thanks also to the touch-screen interface. Two new interactive objects were proposed, and both of them were easily mastered by the elderly users: the Frame (to cut photos and create photocards) and the Black Hole (to delete and hide other objects).

More generally, and given changes in the cognitive abilities of elderly people, mentioned at paragraph 4, designers are recommended to respect the following guidelines:

- the signal strength of messages should be increased, especially for warning signals, and, the sources of noise for the system should be reduced. In order to make the product more usable, redundant channels should be provided, using several sensory modalities. It important to allow older people to read printed text easily, by exploiting the contrast between text and background.
- designers should decrease the number of steps and controls needed to complete a task, being aware that mistakes in any part of the serially organized sequence could affect the overall goals' achievement. In particular, the likelihood of committing errors during a long sequence of operations is higher for older people than young users.
- older adults are less experienced with ICTs and could lack some basic knowledge required to effectively interact with them. Thus, the information required to correctly perform a task should be immediately visible in the interface, avoiding older people to rely on intuition or to memorize long sequences of operations.
- designers should also consider users' goals and expectations of how a system actually works and how it matches with their objectives. In particular, older adults' expectations could be strictly anchored to mental models developed in their past experiences with other tools. Yet, interfaces have to provide consistency as much as possible,, in order to have a correct balance between expectations and functioning. Information should also be organized according to past knowledge. Of particular importance is the use of icons and other symbolic representations. They can convey information in a simple and direct way; designers select those icons that can be actually recognized and understood by users, without any ambiguity or misunderstanding.
- Consistency: aging involves a decrease in working memory capabilities. Older users tend to rely on external cues and on environmental support to find out information and correct responses from memory; so it is important to give more evidence to the link between stimuli and learned responses, especially for those users that have some difficulties in quickly learning. Designers have to organize the information framework in order to avoid complex visual displays and, instead, use visual cues that reduce the

search space, because of the likelihood to forget command names and to waste a long time searching for basic information.

- Compatibility refers to the extent to which options offered in the interface and display are compatible with the user's options. For example, it is important that a task labeled in a menu corresponds to labels users would select themselves, capitalizing on users' past experiences and knowledge.
- Finally, design processes have to focus on documentation, available helps, error messages and manuals in order to help users, especially the older ones, to recognize and correct possible breakdowns. Older people are particularly likely to make errors in some steps of the task, thus application should provide information about kind of errors, consequences and recovering strategies. Older people could also prefer formal training and manuals to learn system functioning and they often rely much more on help systems and error messages. Thus it is important not only to make them accessible in an application but also to use the most compatible and consistent ones.

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