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# Elderly in the Digital Era. Theoretical Perspectives on Assistive Technologies

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**Abstract:** The present paper presents a theoretical perspective on assistive technology for elderly people. In a context characterized by an aging population and an increased life expectancy, it is highly likely that we will become the spectators of a powerful pressure on the medical assistance process. An increasing life expectancy means an increasing need of assistance for longer periods of time, which might become an unfeasible and unrealistic policy due to limited medical resources. In this context, assistive technology might become the only solution. Starting from an international context, this paper aims to theoretically present the way technology can be used as a tool for the elderly's needs.

**Keywords:** elderly; assistive technology; life expectancy; aging population; healthcare system

## 1. Introduction

The present paper begins from two distinct but interconnected realities. First, there is an accelerated pace of aging and of increased life expectancy at both the European and national level [1]. The main implication of these phenomena is linked with both a substantial pressure on the healthcare system [2] and with a progressively greater need for self-care of the elderly. Moreover, the world today is increasing technologically. Considering these two realities, the main question is how can technology be used as an efficient tool for helping the elderly to live an independent life. Starting from the international context, this paper offers a theoretical overview on the way the literature is considering the assistive technology issue.

Starting from the digital divide issue and from presenting the way human abilities weaken over a lifespan, the paper focuses on the concept of assistive technology, as a possible solution to improve the elderly's lives. As this is a very complex notion, after defining assistive technology, a state-of-the-art perspective is given. Assistive technology acceptance models and technology design recommendations are described in order to provide an in-depth overview of the most important variables that can influence the decision of elders to accept the use of technology.

In a context in which the elderly, people over 65 years old [3], are considered to have accumulated a large amount of knowledge and experiences [4], eliminating them from social life, especially through retirement, and considering the aging issue of the population, can bring an important social capital deficit. Thus, the new technologies (devices that can help with communication and in monitoring certain behavioral or medical issues) can help (re)integrate the older persons within the natural process of life. Technology has the capacity of improving the quality of life especially for the elderly, mainly by monitoring their health conditions through remotely controlled technologies, by increasing self-esteem through not being dependent any longer on other people, by integrating them into specific online

communities, thus reducing loneliness levels, or by keeping the elderly active through the possibility of online communication [4].

Although technology is omnipresent (from banks where the bills should almost exclusively be paid at an automatic machine, to bus stations where bus tickets can be bought from an automatic machine as well), for the elderly, the motivation to work with the new devices is usually reduced. In a context in which, by aging, there is a decline in sensory and cognitive abilities, it is likely that older people consider the need for learning new abilities as a barrier in the process of using the new technologies, such as ATMs, computers and online navigation [5].

The aging process is considered to be the result of social evolution (medicine, life quality, social protection, etc.) and it is due to the decline in mortality among old people, the increase of life expectancy, and to the significant decrease in the birth rate [1]. Aging is a global phenomenon which, currently, affects all countries. Thus, the decrease of the number of children at the same time as the increase in the number of old people is generating a change in the equilibrium between the generations. Being a long-term and irreversible phenomenon, there is a high probability that it will have the same effect during the entire 21st century. It is believed that in 2050, the elderly will be around 22% of the total population of the world [1], and, based on the United Nations Department of Economic and Social Affairs [6], growth rate for people over 65 is 2,4 per cent annually worldwide. In 2047 estimations show there will be higher number of old people compared to the number of children [3].

At the European level, the average age has increased on average by 0.3 years every year from 2004 to 2014 [7]. The European Union's average for people between 65 and 84 years of old is 6.8% of the total population [8]. Men of the age of 65 are expected to live, on average, 17.9 years more, while for women this is 21.3 years [8]. In this latter case, the intervention of public policies is required. Since there is a growing number of people incapable of self-sustaining, the pressure on the medical assistance system is higher than ever [9].

Based on the data provided by Eurostat [3], the internet activities of seniors aged 65–74 in selected European countries in 2012 were diverse. Thus, more than 55% were not interested in the internet, 27% declared that they do not need the internet, 19% did not own a computer, 16% considered computers as being too expensive, 15% did not know how to use a computer, and 12% claimed that no training was available.

Hence, considering the alarming predisposition for aging, the low level of use of the internet and new technologies by the older population, and the capacity of new technology to improve the quality of life for the elderly, there is the need to accustom older people with technology use, for their advantage.

## 2. The Digital Divide

In 1977, the sociologist Daniel Bell, the first sociologist to describe the social impact of digital media communication, considered that technology has major social consequences [10]. Besides the political and economic benefits of the internet, the literature emphasizes the social benefits of computer networks. Thus, the internet can be perceived as a new form of socialization, of community creation, or as a form of meetings in the "electronic town" [11].

The degree to which a community adopts something innovative depends, in the first place, on the compatibility level (the existing values, the past experiences, the existing needs of the individuals) and, in the second place, on the relative advantages of that particular technology [12]. Besides the issue of intimacy, inequality is a problem that is being debated within the technological development process. Inequality, in the digital language, is named the digital divide [10].

Olphert et al. [13] underline that there are different types of digital divide. The first one is the global divide that refers to the internet access differences between industrialized and developing countries. Second, there is the social divide that emphasizes the gap between the people rich in information and the people poor in information in every nation. Finally, he talks about a democratic divide that implies differences between those who do and those who do not use technology in order to engage and participate in public life [13].

More specifically, in the online context, the digital divide means unequal internet access from the point of view of the knowledge involved, of the quality of connection, or of the ability to evaluate information. Studies and reports developed in the United States by the National Telecommunications and Information Administration claim that internet access is encouraged for individuals with high education, with average and above average incomes, under 55 years old, mainly men from urban areas. Interestingly, the studies underline that two discrepancies (the advantage of men over women and of young over old) are not valid any longer, especially in the context in which technology is becoming more and more user friendly and widely used [10].

Another study indicates that the effects of using the internet vary based on the competencies of the user. Hence, a novice is likely to have difficulties in finding the needed information and, therefore, to develop contradictory feelings on technology, such as frustration and incapacity [10].

## 3. Impact of Aging

Knowing how elders perceive technology and understanding their profile are vital aspects that need to be taken into account by businesses, government and social service stakeholders that provide services, products or programs aimed at the elderly. Thus, the elderly are considered a sensitive community characterized by medium and sometimes low income, fewer financial demands and plenty of leisure time. However, they need social integration [14].

The changes are present at the physical, emotional and social level as well. Hence, in respect to sensory changes, both visual and hearing acuity is diminished and can affect the way the information is perceived [14]. The elderly are likely to show a reduction in the width of the visual field, in light sensitivity, in color perception, in resistance to glare, in acuity, in contrast sensitivity, in visual search and processing, and in pattern recognition [15]. Aging people need more light for both reading and writing, the speed of processing information declines, and the field of vision become smaller [3] (p. 18). Vision problems are also related to reading small text, seeing in dim light, locating objects visually, and seeing objects or people located closely. Although, these problems are usually present for around 15–20% of the adult population, almost all adults over 55 years of age need glasses [16] pp. 4–5). In the same respect, it is believed that hearing loss is the third most common chronic condition reported by the elderly, approximately 30–35% of the people over 65 having this problem, especially men [16] (pp. 4–5). At the acoustic level, the impairments are related to decreased hearing, a worsening of correct perception and the localization of sound [3] (p. 18). Caused especially by the lifetime exposure to noise, hearing problems result in a decrease in the ability to hear certain speech sounds or high-pitched sounds (e.g., the chirping of a bird, the ringing of a phone, etc.) [16] (pp. 4–5). Due to a decrease in hearing, in the design of an interface or website, sound should be in lower frequency ranges than usual [15].

Table 1 provides an overview of the way some of the human abilities evolve over time. For instance, starting with 35 or 40 years age, vision abilities (related to light intensity and spatial features) and some hearing abilities (related to the physical aspects of the ears and to external variables) start to deteriorate [3].

**Table 1.** Progression of sensory abilities across lifespan, adapted after [3].

| | | **Age at Which the Sensory Ability Starts to Change** |
|---|---|---|
| **Vision** | Enhanced need for light | 35 |
| | Decreasing accommodation width | 40 |
| | Increased glare sensitivity | 40 |
| | Reduced depth perception | 40 |
| | Reduced eyesight | 50 |
| | Reduced adaptation to darkness | 55 |
| | Restricted visual field | 55 |
| | Diminished color perception | 70 |

**Table 1.** *Cont.*

| | | Age at Which the Sensory Ability Starts to Change |
|---|---|---|
| **Hearing** | Diminished hearing | 35 |
| | Distraction by background noises | 45 |
| | Diminished localization of sound | 70 |
| | Hearing loss of higher frequencies | 70 |

At the physical level, the elderly tend to have problems with flexibility, strength, speed of execution, hand-eye coordination, mobility and agility [14]. Regarding the motor skills, the main changes refer to a decrease in speed of movement, a decline in strength and endurance, a decline in balance and coordination, and the likelihood of involuntary movements [17].

It is believed that up to 65 years old, a person has already lost one-third of his/her muscular mass. Therefore, not only balance and standing up worsen, but the coordination, precision and fine motor skills diminish over time. Thus, when using technology, issues can appear in a context of a fast input required (e.g., double click) or in the situation of pressing more than one button at the same time [3] (p. 18).

At the cognitive level, the main affected elements, especially for elders, are memory, reasoning and abstract thinking [14]. Some of the most common manifestations are memory loss, confusion, "disorganized thinking, impaired judgment, trouble expressing themselves, difficulty recognizing familiar people, and disorientation to time, space, and location" [16] (pp. 4–5). In addition, due to the fact that focused attention becomes a challenge, the amount of provided information should be reduced and presented in a simple and recognizable way [3] (p. 18).

Considering the context of an aging population, of the heterogeneity of the population over 65 years of age, and of the normal health problems associated with this age, effective communication with the elderly, especially from health care professionals, becomes a challenge [16] (p. 3). Loss of language comprehension is usually attributed to a decline in working memory, "the brain system that provides temporary storage and manipulation of the information necessary for complex cognitive tasks" [16] (pp. 4–5). However, the existing research has not found evidence regarding the elderly's decline in language ability (language sound, meaningful combination of words, or verbal comprehension). On the contrary, considering that long-term memory is not affected (knowledge, vocabulary, family history), it is believed that vocabulary improves with age and intelligence remains stable [16] (p. 4).

Social changes can include the decrease of income, the loss of pre-existing social networks, and isolation. Based on the above changes, emotional shifts can include the appearance of loneliness, tension, anxiety of becoming dependent on others, and fears about safety [14].

## 4. Assistive Technology for Elderly

Technology can help elders to stay in touch with their families and friends, develop a safer environment in the house, facilitate medical care, introduce new motivations in a person's life, generate a larger access to information, and increase the level of social interaction, self-esteem, life satisfaction and autonomy [4] (p. 287). Thus, by having access to technology, the elderly can be more independent and more socially involved.

The literature talks about advanced sensors and networks of technologies that can improve the quality of life. Examples include intelligent houses equipped with lighting intelligent systems, intelligent kitchens (systems for the detection of dangers from kitchen devices), supervision of energy use, security systems, etc. These technologies are useful especially for elderly people that aim to live independently in their own homes and, at the same time, to have the control over their medical status [2]. Moreover, the human-robot or human-device interaction can be beneficial in an emergency situation as, for instance, in the detection of a fallen person in the kitchen. An intelligent house can recognize this abnormal situation and can send the robot-device to that person in order to give first aid [18].

Assistive technology is defined as equipment that can be personalized and that can maintain or improve the capacities of a person with medical problems [4] (p. 288). Wireless communication systems can facilitate medical examinations, data collection about the patient, control the environment in which the individual is living in order to prevent sickness, maintain physical and cognitive functions and active involvement [4].

Gamberini et al. [4] (pp. 287–288) talk about several sets of objectives that link the elderly to technology. First, mainly to avoid sickness, technology can become a bond between medical specialists and the elderly that can receive advice (tele-health technology) or that can be remotely supervised [2]. Second, the technology can help with the cognitive and physical supervision of the individual through sensors that constantly collect data related to the location of the person and the activities he/she has completed. This is the case for individuals with physical disabilities (e.g., who cannot leave the house), cognitive disabilities, individuals that suffer from isolation, frustration or depression and that can communicate with persons who have a similar disease [4] (pp. 287–288).

The literature discusses two concepts related to assisting the activities of daily living (ADLs), namely personal assistance and technological assistance. While personal assistance implies help given to a disabled person from others (e.g., spouse, child, friend, paid caregiver etc.), technological assistance implies using equipment (e.g., wheelchair, walkers, raised toilet seats etc.) in the daily activities of the enabled person. Technological assistance creates more independence than personal assistance [19] (p. 330).

There are two main arguments for the need for assistive technology in the elderly's daily life. The first one refers to the expectation of a shortage on staff and qualified healthcare personnel in the near future. The second refers to the fact that people tend to increasingly prefer to live in their own houses instead of being institutionalized in sheltered homes when it is the case [20].

In this context, there are many attempts to create the most efficient robots that can be used in health-care. There are two directions for health-care technology development. The first direction refers to physical assistive technology (rehabilitation robots) that are not primarily communicative and social, such as wheelchairs, artificial limbs, exoskeletons, etc. The second direction refers to health-care technologies that imply communication and that can be considered social robots or social entities that communicate with the user (assistive social robots) [20] (p. 95).

Within the assistive social robot field, the literature talks about service type robots and companion type robots. Service type robots support the basic activities (e.g., eating, bathing, using the toilet, getting dressed), enhance the mobility level (e.g., navigation), provide household maintenance, and monitor individuals that need permanent attention. Examples of this type of robot are the nursebot Pearl, the Dutch iCat, and the German Care-obot [20] (p. 95). Companion type robots have the main function of enhancing the wellbeing of the user. Several examples provided in the literature are the Japanese seal-shaped robot Paro, the Huggable, and the Aibo developed by Sony. Equally importantly, the literature emphasizes that there are robots that are both assistive and companion technologies (e.g., Aibo) [20]. Table 2 provides insights on some of the above mentioned assistive robots.

**Table 2.** A selection of assistive social robots (adapted after [20] (pp. 96–97) and completed with other references).

| | | |
|---|---|---|
| **Aibo** |  | - produced by Sony<br>- entertainment robot (moveable head, legs and tail)<br>- include a set of sensors (camera, touch sensor, infrared and stereo sound)<br>- capable of expressing emotions and communication<br>- while the first model was the simplest one (sold between 1999 and 2001 [21]), the most sophisticated model is able to connect wirelessly with other electronic devices, to transfer photos, files and messages, to fetch a bone [22]. |

**Table 2.** *Cont.*

| | | |
|---|---|---|
| **Paro** |  | - developed by the National Institute of Advanced Industrial Science and Technology (AIST), Japan<br>- developed to study the effect of animal therapy<br>- include a set of sensors (touch sensor over the body, an infrared sensor stereoscopic vision and hearing)<br>- used since 2003, it was found to reduce stress, to stimulate interaction, to increase motivation [23]. |
| **iCat** |  | - produced by Philips Electronics<br>- it is able to express emotions (facial expressions)<br>- it is more used as a functional assistance, not as a companion<br>- the robot can respond to different stimuli and can do basic tasks (turning on the light, acting as a TV guide, checking and reading emails) [24]. |
| **Pearl** |  | - developed by Carnegie Mellon University<br>- it reminds people about routine activities (eating, drinking, taking medicine, using the bathroom) and it guides users through their environment [25]. |
| **Huggable** |  | - developed by MIT Media Lab<br>- it is designed to function as a team member, to enhance the human social interaction<br>- it has a body sensitive skin with over 1500 sensors, video cameras in the eye, microphones in the ears, a speaker, an embedded PC<br>- the main goal is to make technology invisible to the users [26]. |

Based on these examples, the existing research reports an increasing positive reaction from elders, especially at the level of mood, loneliness, and social connection [20] (p. 100). Judged on their appearance, some robots can be considered as more appropriate for children (e.g., Huggable is a teddy bear mainly used in children's hospitals). However, the technology can be tailored to assist and entertain the elderly.

## 5. Adoption vs. Acceptance of Technology

Renaud and Van Biljon [27] make the distinction between adoption and acceptance of technology. While technology adoption implies a process (from becoming aware of the technology to using the technology as a way of life), acceptance is defined as an attitude towards technology. The example given by the two authors refers to a user that purchases a device but who needs time until adoption per se. Full adoption happens only after full acceptance [27].

Interestingly, while the information system domain talks, at the micro-level, about technology acceptance models without considering the process of full adoption, sociologists underline a macro-level approach by considering a purchasing decision (acceptance or rejection) as part of the adoption process [27].

The technology adoption process is described by Renaud and Van Biljon [27] as a set of five stages: the knowledge stage (the individual gets to know about the product), the persuasion phase (the individual becomes persuaded of a need for the product), the decision stage (that leads to purchase), the implementation stage (the product is being used), and the confirmation stage (the need to confirm the decision taken to buy the product). In the same respect, Renaud and Van Biljon [27] talk about the

domestication of technology, in which users are considered social actors and in which the main focus is on the way technological innovations change and are changed by the social context.

The most important model related to technology acceptance is the technology acceptance model (TAM). This model was introduced by Fred Davis in 1986 and it helps explain and predict user behavior for information technology [28]. In other words, TAM can explain why a user accepts or rejects information technology and it is based on two cognitive beliefs: perceived usefulness and perceived ease of use [28] (p. 151).

The technology acceptance process is translated into TAM by relying on six variables: external variables (demographic variables, perceived usefulness, perceived ease of use), perceived usefulness (the degree to which the technology is enhancing performance), perceived ease of use (the degree to which an individual considers the technology as being free of effort to use), attitude towards use (the desirability of using the system), behavioral intention (predicted by attitude towards use and perceived usefulness), and actual use (predicted by behavioral intention) [27]. However, this model does not take into account the social influence [27].

The main description of TAM refers to the fact that the use of technology is influenced, directly or indirectly, by the user's behavioral intention, attitude, the perceived usefulness of the system, and the perceived ease of using it. At the same time, external factors can affect intention and use through the perceived usefulness and ease of use [28]. Figure 1 represents an adaptation of the original TAM model.


**Figure 1.** The main variables of the Technology acceptance model (TAM), adapted after [28].

Besides the original TAM, Venkatesh and Davis talk about improved models, such as TAM2, that try to explain the perceived usefulness and usage intention by including social influence and pressure (e.g., subjective norms, voluntariness, image, etc.), cognitive instrumental processes (job relevance, output quality, result demonstrability), and experience [29].

In the same respect, there is the senior technology acceptance and adoption model (STAM), in which the link between variables is much more complex. In this case, experimentation depends on the intention to use, on the perceived usefulness, on the facilitating conditions, on the confirmed usefulness, and on the ease of learning and use. In the same respect, acceptance and rejection depend on the ease of learning and use [30]. Figure 2 presents the main variables of the STAM model.

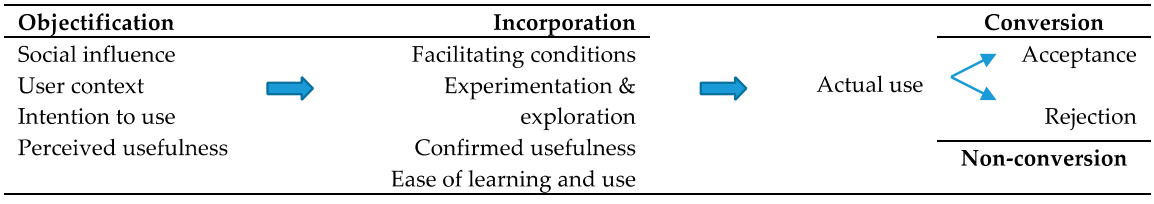


**Figure 2.** The main variables of the Senior technology acceptance and adoption model (STAM), adapted after [27].

STAM is a model that includes both acceptance and adoption factors. However, STAM does not include attitude as an independent variable [27]. While the objectification phase refers to the role the technology will play, the incorporation phase refers to the interaction with the technology [27].

Regarding the elderly group and the TAM model, the correlation between performance and ease of use is usually found to be strong [27]. In the same manner, the perceived usefulness and the ease of use are major variables determining technology acceptance [27]. Specific to STAM, considering that, in most of the cases, the first mobile phone of an elderly person is not bought but received from a relative, the appropriation phase for the technology is usually skipped. Therefore, due to poor ease of use and unconfirmed usefulness, adoption is a stage that an elderly person is not likely to reach [27].

Renaud and Van Biljon talk about another developed model, namely the unified theory of acceptance and use of technology (UTAUT), which distinguishes between the factors determining use behavior (the constructs of performance expectancy, effort expectancy, social influence and facilitating conditions) and the factors mediating the impact of these variables (gender, age, experience, and voluntariness) [27].

While both TAM and UTAUT are applicable for any type of technology, Know and Chidambaram consider that there are models designed specifically for mobile devices—the mobile phone technology acceptance model (MOPTAM) [27]. This model takes into consideration variables such as: demographics, socio-economic variables, ease of use, apprehensiveness, extrinsic motivation (perceived usefulness), intrinsic motivation (enjoyment, fun), social pressure, and extent of use. While the main drawback of the model is that of excluding infrastructure factors, it claims that perceived ease of use affects extrinsic and intrinsic motivation, and that apprehensiveness negatively affects the intrinsic motivation [27]. The most important variables of the MOPTAM can be found at Figure 3.

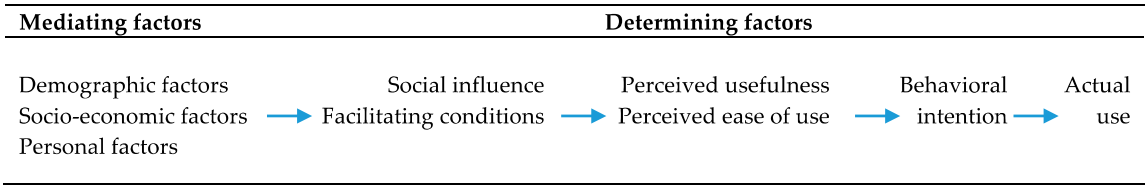


**Figure 3.** The main variables of the Mobile phone technology acceptance model (MOPTAM), adapted after [27].

Considering the framework of the MOPTAM model, the mobile phone is considered the easiest device to use by the elderly. It can be perceived as a critical tool for emergency and health support situations [27]. The literature underlines four contexts that need to be considered when talking about mobile phone use [27]. First, there is the physical context. In this respect, the physical constraints of the device are discussed, such as limited screen size, memory, storage space, input and output facilities, and poor voice recognition. Elders are not used to the standard menu, struggling to find the needed features. Moreover, due to a decrease in dexterity, large buttons are required. Second, there is the social context. Considering the reduction of social interaction while aging, the mobile phone becomes an important tool for communication with family and friends. Moreover, social variables are considered an important factor for mobile phone acceptance. Third, the mental context is brought into discussion and it refers to the degree to which elders understand the mobile handset usage model [27]. Thus, although the ability to learn is not impaired, the rate of learning is believed to be reduced in the elderly. In addition, due to reduced visual processing speed, issues such as the lack of precision and the slow process of using the phone are taken into account. Finally, the technological context refers to the available infrastructure. Consequently, mobility, portability and personalization features are considered [27].

## 6. Designing Technology for Elderly

When it comes to assistive technology for the elderly, there are two major issues raised by the literature. First, technology is perceived as being unfamiliar and is associated with anxiety of use. Second, the investment cost in technology is usually perceived as being too high [31]. Starting from

the hypothesis that age alone does not predict technology acceptance, Nedopil et al. [3] talk about a distinction between the factors that influence technology acceptance and the factors that influence the need for technology. Thus, the factors influencing technology acceptance are cost, compliance with individual needs, personal experience with technology usage, and accessibility barriers (physiological, cognitive). At the same time, the factors influencing the need for technology are user generation, housekeeping style, number and type of inhabitants in household, and personal attitude towards technology [3].

The literature [3] considers that the elderly are motivated to use technology especially in certain situations. Hence they are more open when the technology is compatible with their routine and when they can assess that the technology benefits outweigh the effort of learning to use it. Moreover, it is important to notice that, as expected, the numbers of elders that use information and communications technology (ICT) are constantly increasing [3].

A large amount of applications and products available for the elderly, although accessible, are not specially created for their needs, and thus do not sufficiently generate familiarity [31]. Regardless of its utility, technology is frightening and is perceived as a sensitive issue for the majority of elders, mainly if it is too intrusive, complex, embarrassing, or environmentally disruptive [32] (p. 1703). In this respect, the familiarity of the design and the interface is considered a very meaningful issue that should be addressed for the e-inclusion of the elderly [31]. As Wakefield [33] emphasizes, there is a gap between the way mainstream technology works and the abilities of elders. For instance, while the response time for an icon on an Apple device is 0.7 s, the response time for a person over 65 years old might be about one second. While the existing touch screens are not suitable for a person with less sensitive nerves in the fingers and thus with a heavier touch, a slight tremor of the hand might be interpreted but the device as a swipe rather than as a touch [33]. Therefore, the existing technology should be completely adapted for the needs and abilities of the elderly.

There are a large number of companies trying to create the most suitable device for elders and their needs. However, there are studies emphasizing that assistive technological solutions must be aware that the elderly do not want to be perceived as needy and frail [3].

Considering that the issues related to the use of technology by the elderly can be solved through the improvement of the design and through training, Gamberini et al. [4] (p. 289) talk about five characteristics of using technology: the difficulty level of learning (the needed time to complete an activity), efficiency (the degree to which the applications fulfill the needs of the individual, thus avoiding lost time and frustration), errors (the degree to which certain applications give errors and the degree to which the individual is capable of solving them), and satisfaction (the satisfaction related to the use of a certain device or application).

At the same time, while the elderly tend to perceive monitoring technology in a positive manner, their acceptance depends on its usefulness in supporting independent living, and on the level of intrusion into private life [32] (p. 1704), especially considering their concern for the privacy of space and not of information [32] (p. 1704). Leonardi et al. [31] propose an interaction modality that is based on known and natural gestures that are familiar to the elderly. For instance, they propose scrubbing an object with a finger instead of the "erase" command, the avoidance of the standard menu and tools, representing a discussion forum as a town square, and using a classic style instead of stunning shapes and colors.

In the same respect, there are studies showing that internet access can increase social interaction and cognitive performance among the elderly, mainly because browsing the internet implies cognitive and motor abilities [34]. In a neuroimaging study, involving 24 elderly and mature adults, Small et al. showed that both while reading a book and while searching the internet, similar brain areas are activated [34]. The only difference is that the internet search activates the prefrontal cortex more intensively, an area responsible for quick decisions and complex information assessment. Hence it can be claimed that digital inclusion enhances the cognitive abilities of the elders, contributes to their physical and mental health, and provides an opportunity for them to have an independent

life [34]. In the context of progressive physical, cognitive and psychological difficulties, technology can be a valuable component for improving independent home living for the elderly [32] (p. 1703). The main situations in which technology can be helpful are the following: simplification of domestic duties and safety (e.g., task reminders, gas, fire and intrusion alarms, fall detectors, visual and acoustic monitoring systems), and maintaining communication and social networking (e.g., video-communication systems) [32] (p. 1703).

Nedopil et al. [3] (pp. 21–22) provide several elements one should be aware of when designing a product for the elderly. First, one should provide additional value, value related to a perceived future advantage, such as safety and comfort. Importantly, what it is promised should be delivered. Second, the technology should be an adaptable support. This means that it should generate help for those tasks that help the elderly become independent, not for those tasks he/she can easily manage. Third, the product should be designed in a very simple and understandable manner. Although an appealing design remains an important component for the elderly as well, the functionality should take into account that concentration and memory decrease with age. Finally, the device should enable a joyful experience, be easy to use and to generate positive emotional practices [3] (pp. 21–22).

There are three main stages within the process of designing suitable products that fit the needs of the elderly: understanding, conceptualizing, and testing. The first step, understanding, refers to the phase in which the information related to the behavior and needs of an elderly person is gathered (self-documentation, interviews, market research, literature). The second step, conceptualization, is the stage of generating ideas, of developing concepts that should properly satisfy the users' needs. Finally, testing is the phase in which the new concepts and products are tested in order to receive valuable feedback for improving the final item [35].

Based on the elders' characteristics, the devices should include large buttons, be more suitable for shaky hands, provide alerts in the case of a detected emergency, be easy to clean, have a waterproof display, display good contrast, have a glare-free display, have compatibility with other interfaces/applications, have an easy-to-read manual with pictures and step-by-step instructions, have large data storage, etc. [35]. Table 3 indicates some of the most important recommendations in designing guidelines for interfaces for elderly users.

**Table 3.** Design guidelines for interfaces for elderly users, adapted after [3] (pp. 47–48).

| Supported Dimension | Recommendation |
| --- | --- |
| Vision | - an adaptable display size with a minimum font of 12 or 14 point<br>- a high contrast between the background and text or buttons<br>- size, volume and texture should be taken into account as distinction variables (instead of color)<br>- avoidance of background images, since they create visual clutter |
| Hearing | - low-range to mid-range frequencies and pulses of sound<br>- avoidance of computer-generated voices<br>- natural speech rhythm, stress and intonation |
| Mobility | - sufficient time for inputs<br>- motoric input for users with motor control problems kelp to a minimum<br>- reduced number of targets/buttons, increased size and sufficient space between them<br>- static menus instead of dropdowns |
| Cognition | - task-relevant information only<br>- information presented in small, screen-size chunks<br>- no parallel information at the same time (e.g., video and text)<br>- common metaphors (such as symbol for 'folder') that are intuitive and known from real life. |

The way a mobile interface is organized can strongly influence the way it is perceived by individuals. The perceived quality of an interface depends on the level of entertainment, navigation difficulties, and how informative it is. While navigation difficulties or accessibility regard timeliness, convenience, interpretability, and completeness, being informative implies accuracy, relevance, comprehensiveness, recentness, and credibility [36].

## 7. Conclusions

This paper is a theoretical overview of the ways technology can be used in an assistive manner by the elderly. Taking as a starting point the aging of the population and the increasing life expectancy, the work underlined the need to remove pressure from the medical assistance system through the use of assistive technology. Although there is certain level of anxiety when it comes to technology, the elderly can be significantly helped through technology in different situations, from communicating with family and friends to being monitored with respect to health issues.

By emphasizing state of the art assistive technologies and the proposed theoretical models of technology acceptance, this paper can be perceived as a starting point for developing research and for proposing public policies for the elderly. Moreover, it can assist in developing adapted technology with specific features for the needs of the elderly.

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