On Some Aspects of Improving Mobile Applications for the Elderly

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Abstract. Improving the quality of life of elderly people is an emerging issue within our information society for both research and development. This paper addresses some issues on the development of applications for mobile devices, which have been designed to enhance the quality of life of the growing number of elderly people, and how they can be made more acceptable to the target population. We summarize some relevant issues in order to devise a research methodology to cover more than just the technological and physical aspects of user interfacing but also psychological and sociological aspects. One aspect of achieving this aim is to confront designers and developers with those problems that the elderly face daily and which are not easily understood – especially by younger designers and developers. Finally, we present some issues on how to simulate certain physical constraints of elderly by using the AgeSim, which is a simulation suit. However, not only physical but also cognitive impairment cause problems amongst elderly and result in fear, anxiety and consequently in rejection. The main goal of this paper is to raise awareness amongst developers on which problems are to be taken into considerations during design and development of mobile applications for the elderly.

Keywords: Usability, Mobile Interfaces, User-Centered Design, Age Simulator.

1 Introduction and Motivation

There is no doubt that the application of mobile devices can improve and support the lives of the elderly, given the willingness on the part of those concerned to use these devices. Increasing *acceptability* must be based not only on a thorough knowledge of the requirements of the elderly but also on their misgivings.

Facilitation of usage is only one aspect of the problem which must be dealt with. In order to bridge the widening digital divide [1] that has grown up between the technical experts and the increasingly older generation, who were adults before the

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electronic revolution, it is also necessary to understand their *uncertainties* and *difficulties*. Research is therefore also aimed at investigating ways to *increase motivation* and *improve acceptance*. It will be geared towards analyzing the fears, problems and requirements of the target group, particularly taking such factors as previous profession and gender [2] into account and using the results to make the design more elder-user-friendly. For example, the same technology which has made miniature digital hearing aids possible has also made other technical devices, such as mobile phones, so much smaller and more compact that the use of these devices has become difficult for the elderly. However, designers and developers need to understand their needs, which need not necessarily be just bigger brighter virtual keyboards and larger script. Their motivation is different, their frustration level is lower and they may have to overcome previous, negative experience. We are of the opinion that the design and development of mobile applications for elderly must support the users to overcome their fears and enable them to accept technological aids and mobile devices without reservations. The design must then reflect this acceptance and not be the cause of new biases.

2 Background: Problems of the Elderly

Problems of the Elderly can be categorized coarsely into *Cognition* (Attention, Memory, see section 2.1.), *Motivation* (Attitudes, Beliefs, Fears, Anxiety etc., see section 2.2), *Physical* (Movement, Balance, Locomotion, Joints (Fingers) etc., see section 2.3), Force Control, etc.) and *Perception* (Vision and Audition, see section 2.4). Cognitive and Motivational Issues are difficult to simulate (see section 4), however, we are able to simulate some physical and perceptual impairments by use of an Age Simulator (see section 5).

2.1 Cognitive Complexity as Barrier

The use of technological applications requires a certain level of *procedural knowledge*. Certain knowledge procedures, stored in the long-term memory permit the required human-computer interaction in a certain situation. The usability of the application essentially supports the acquisition of new knowledge procedures in order to operate and interact with the application properly. The Cognitive Complexity Theory (CCT) by Kieras & Polson (1985) [3] is a formal approach in order to analyze the complexity of an interactive application. The end users' knowledge of how to use a system to accomplish various tasks is represented in a procedural notation that permits quantification of the amount and complexity of the knowledge required. This results in a definite quantification of the *cognitive load* involved in using a system [4]. This implies that making a system more usable could be accomplished by altering its design until the knowledge is adequately simplified. By representation of the device behaviour, it is possible to *simulate* the user-application interaction to obtain rigorous measures of user complexity [5]. Since *cognitive performance* slows down with age, lowering the complexity of applications or the user-application interaction for (novice) elderly users could be a vital factor for design and development of mobile applications. Ziefle & Bay (2005), [6] found that the benefit from lower complexity was much larger than theoretically predicted. This means that simply defining cognitive complexity by the number of production rules does not account for the *real difficulties* which the users experience in real contexts. In the experiment of Ziefle & Bay it was interesting that elderly users had a lower navigation performance than younger users, however, their performance matched the younger users when using *mobile applications with low complexity.*

This was reinforced by the research on Learning done by Midford and Kirsner [7], which confirmed that the implicit learning ability is not reduced by aging, however that older people were at a disadvantage compared to young adults in their ability to perform accurately when complex material was repeated.

2.2 Motivational Issues of the Elderly

We can put such issues as beliefs, attitudes, anxiety, fear, computer literacy, acceptability, etc. under the terminus *motivational issues,* whereby motivation is described as a psychological construct. Therefore, it is interesting that motivation can be stimulated by the use of technology and that motivation is essential for learning.

It is noteworthy that most people attribute the elderly with a reluctance to use modern technology. While it is generally acknowledged that older people are less apt to accept new and unknown technology than their younger counterparts [8] and that it tends to make them feel uncomfortable, some researchers found that older adults are actually motivated to use mobile applications – when they are sufficiently informed as to the resulting benefits [9], [10]. That could mean that the reduced usage rates by the elderly is also the result of poor understanding of the benefits that mobile applications could have for them, as well as their reluctance to learn a skill, which they feel requires a highly specialized form of expertise or special knowledge that they lack.

Basically, computer literacy is highly related to computer anxiety [11]. It is therefore essential to ensure not only a high *learnability* [12] but also a high recognisability content in order to advance a feeling of security. Although the ability to understand and benefit from technology is far less dependant on age than those affected are disposed to believe, it does require flexibility and effort, which many elderly people are unwilling to invest unless the benefits offered clearly outweigh the disadvantages. Some research showed that older adults tend to loose concentration easily and become bored with the subject, one possible cause of this apparent rejection may be due to the form of anxiety that is based on the mistaken distrust in one's own capabilities [13].

Other research indicated that most participants felt less anxious and more confident about using technology after being taught computer-based skills [14]. For the developers it is a must that they understand the attitudes of the elderly towards technology, a good chance to achieve this is the application of User-Centred Development (see section 3).

2.3 Physical Impairments of the Elderly

Clearly, the physical effects of aging cannot be universally quantified; however studies show a number of common illnesses which can be classified as age-related. rheumatoid arthritis, while not being exclusively age-related, has been shown to cause isolation and depression in the elderly [15] and sometimes hinders the use of technological innovations, such as mobile telephones and the internet, which could help reduce the isolation caused by lessened motor activity.

However, in most cases the effects of aging are less drastic. They include slower response times, coordination reduction and loss of flexibility [16] Age-related macular degeneration can be the cause of restricted eyesight without complete blindness, while deafness may be preceded by years of gradual loss of hearing. But this combination of partial loss of vision, hearing, memory and mobility contribute to a loss of confidence, which leads to difficulty in the absorption of information.

The impairment of fine motor skills is also often a factor in older peoples' unwillingness to use a PDA or a laptop with an integrated mouse. For example, the standard setting for desktop icons is small and few older users are aware of the possibilities of user customization, neither do they possess the necessary knowledge for their implementation. Various studies have found that older people have greater difficulty in using a mouse to track on a screen and that, even after some practice, their performance on a computer is generally slower [17]. Basically, there are five distinct human factors which show measurable disparities between older and younger people:

(1) learning time (=time to perform task)
(2) speed of performance
(3) error rate
(4) retention over time
(5) subjective satisfaction

In order for modern technology to be of assistance, it is essential that it takes these differences and the associated difficulties into consideration.

2.4 Perception (Vision and Audition) as Barrier

Changes in vision and audition are the most obvious causes of restrictions to which the elderly are subject. One cause of visual impairment is age-related macular degeneration (ARMD), a disorder that the Rotterdam Study in 1995 [18] cited as being the most frequent cause of blindness in the elderly and has been seen to increase in frequency with people over 65 [19]. However, in the main, this disorder *restricts* the eyesight resulting in partial impairment. With the correct interface design this should not be an obstacle to using modern technology. Other age dependent changes in vision, which must be taken into consideration in design and development, include:

(a) those where ability decreases with age:

(1) visual acuity (ability to resolve detail);
(2) visual accommodation (ability to focus on close objects);
(3) colour vision (ability to discriminate/perceive shorter wavelengths);
(4) contrast detection (ability to detect contrast);
(5) dark adaptation (ability to adapt quickly to darker conditions);
(6) glare (susceptibility to glare);

(b) those where the necessity increases with age:

(7) illumination (required light – increases with age); and

(c) those where an age dependant reduction can be observed:

(8) motion perception (motion estimation);
(9) peripheral vision (width of field narrows).

Presbycusis, which is defined as *an inevitable deterioration in hearing ability that occurs with age* [20], is a multifactorial process that can vary in severity from mild to substantial [21], [22]. Auditory facilities which noticeably decrease with age include:

(1) auditory acuity (ability to detect sound),
(2) auditory localization (ability to localize sound),
(3) audition in noise (ability to perceive speech and complex sounds).

Although, language is closely related to cognition and is often treated as a separate subject, there are many issues which can influence the language comprehension of elderly people [23]. Understanding this is necessary, in order to design both textual and auditory content for mobile applications properly – when designing text-based materials the limitations of the working memory of the elderly must be taken into consideration [24].

3 Some Design and Development Issues for the Elderly

Although touch screens have proved to be very good for older adults [25], [26] touch screens on mobile devices are extremely difficult for older adults to use due to the small size of the targets and the difficult handling of the stylus (see fig. 2).

Jog dials/thumb dial, for example, could be an solution; or if touch screens are used with small devices the application must be optimized by increasing the target areas in order to use rather their fingers than the awkward pointing device (stylus), because (as described in section 2.3) elderly have difficulty in making accurate, movements requiring fine motor skills or even fast movements with their fingers – for example, a double-click with the mouse – is problematic. The elderly are less sensitive than children to tactile feedback [27].

Cognitive Performance can be supported by placing information in the task environment, which reduces cognitive demands on the end user. Perceptual declines can be coped with, to some extent, by improving the physical stimulus in order to perceive and recognize that stimulus. Display information consistency – consistency is required for learning and cognitive performance support. Recognition and incorporation of previous knowledge can increase interest and motivation, which in turn can improve performance levels.

Experiments have been made with the use of speech systems to counteract some of these difficulties, primarily those caused by restricted sight. Menus and usability interfaces have been simplified to minimize the amount which needs to be memorized in order to use the applications and special mobile phones have been designed with only 3 buttons to simplify the connection to emergency services in case of emergency.

Emergency bracelets are available in many countries, which automatically contact an emergency address when the wearer either looses consciousness or presses a button.

However, all these systems are basically designed as emergency backup for invalids or severely disabled people. The question of selective disability – that is elderly people who are otherwise fit – needs to be addressed with insight, not only into what is required to enable older people to remain independent of full time nursing but also their preferred lifestyle and minor incapacities. When the use of a modern cell phone is hampered by partial arthritis, speech control might well be the answer but it is also worth investigating the optimum size of of 12-button cell phone keypad.

In order to develop both useful and usable mobile applications – especially for the elderly – a particular method brings benefits: User-Centered Development (UCD) proved to be very effective [28]. Some key principles of UCD methods include *understanding the end users* and *analyzing their tasks;* setting *measurable goals* and involving the end users from the very beginning. Based on the experiences within previous work [25], [29], [30] we found UCD of particular importance to realize usable and useful applications, especially for mobile devices. However, sometimes the work with end users is not always possible and most of all the issues of the elderly are not totally understood and accepted by the developers, in this case simulation of some of the restrictions, to which they are subject, can make difficulties clear to developers and raise awareness in design issues.

4 Simulation of Cognitive and Motivational Impairments

The main slant of interest in cognitive impairments has been to try and understand those affected from a psychological viewpoint. The HCI approach aims to use simulation to explore ways and means of decreasing difficulties of use caused by assumptions in design. Due to the danger of cognitive overload, applications should be developed in order to achieve cognitive congeniality; further we (designers, developers, engineers, researchers) should target towards *adapting information to people's individual needs and levels of expertise* in order *to enhance cognitive performance.* Ideally the system should learn with the user, offering less and less assistance as the user progresses. It should present an optimal level of relevant information, thereby holding the user in a state of optimal arousal, minimize and optimizing cognitive load and reduce the number of distracting elements.

5 Simulation of Physical and Perceptual Impairments

The main difficulty facing researchers, designers and developers lies in envisioning the difficulties which could arise from a minor physical disability, which they themselves do not possess. During software design, the end users must be included in the specification and testing of any new product. However the variety and extent of physical disability, for example, a partial sight and speech impediment, makes this extremely difficult. We are of the opinion that, in order to actually understand the difficulties of the end users it is necessary for the developers to feel and experience these difficulties during the first design iteration. An American idiom says *"don't* *judge a man until you have walked a mile in his boots"* This metaphorical advice has been taken seriously in the development of AgeSim, which is a device designed to permit a developer to experience the restrictions caused by various types of impairments, whether from age or other causes (see figure 1).

The AgeSim is a current project at the University of Applied Sciences JOANNEUM in Graz and was originally developed by Alexander Nischelwitzer and his students Nina Tomasch and Jasmin Wundara. The AgeSim suit was created to simulate physical restrictions of different groups of people. So it is possible to feel how an elderly, a disabled, an overweight or a pregnant person feels. If you wear the suit you are able to identify barriers more easily. Possible simulations include: old age; overweight; pregnancy and disability. The logger and the AgeSim have to communicate with a headset. We are also able to simulate hardness of hearing with this headset and the test leader can communicate with the AgeSim test user.

The AgeSim suit resembles a boiler suit with some rather shrewd additions. The under arms and leg joints are webbed, thereby restricting the height to which the arms can be raised and the length of the stride. A number of weights fit into the pockets of the suits trouser legs, gloves, designed to simulate arthritic joints and the decreasing sense of touch, and a helmet, which reduces sensory perception. The helmet restricts the mobility of the head and has a number of accessories, one being exchangeable visors to simulate various eye disorders the other is a mountable camera for recording what the user sees during usability tests. The logger and the AgeSim user communicated via a headset. It is also possible to simulate hardness of hearing with this headset and the test leader can communicate with the AgeSim test user.

Fig. 1. AgeSim let designers feel how certain physical impairments feel to the end users

The test person in figure 1 was an engineer, in the best of health. After putting on the suit and gloves, he was weighted and fitted with a helmet, the sides of which hindered sound waves while the visor reduced his vision by more than half.

He was given two exercises: to walk up 3 flights of stairs and to use his mobile telephone. The stairs were less of a problem than we expected, possibly our subject was a little too healthy. But the second exercise caused a total rethink. Not only was it almost impossible to use the stylus to make a connection, the reduced sight made it difficult to see the number being “dialled” and the sound control on the mobile device was insufficient to compensate for the reduced hearing. It is an experience for designers and developers and especially for computer science students, to feel the limitations in fine motor skills and movement during the use of a mobile application – add the visual impairments and auditory limitations (see figure 2) and the necessity for a complete rethink is made clear.

Fig. 2. It is astonishing for developers to feel how complicated the use of a mobile application actually can be for people with physical impairments (movement, eye, etc.)

6 Conclusion

The increasing ratio of older people to younger people in the western world makes it essential that elder people remain fit, independent and secure well into advanced or high age. Medical Informatics undertakes to improve the standard of living for this growing population of elderly people, for people with disabilities, general health problems or ongoing conditions, such as diabetes and epilepsy, but this multimedia information must be presented so that their actions can be supported – particularly in emergencies – with the help of mobile, ubiquitous technology.

Given a sufficiently high acceptance level, mobile technology can help to achieve this goal. However, for any end user to accept innovation, a clear benefit must be offered, whether in a physical, medical or emotional respect. This must be achieved on a number of levels: The design needs to be adapted to the end user’s physical impairments; the interface must offer a relative degree of familiarity to overcome any reservations felt by the end user; the benefit of using the device must be appreciable, in order to provide a motivation for its use and the balance between intuitive use and practicable teaching methods, designed for learning needs of this age group, must be established. This can be as complicated as an ergonomic, *fits-the-hand,* mobile phone or as simple as supplying the mobile with a wrist strap to *decrease the user's fear* of dropping it. The application of AgeSim and similar simulation opportunities can give the designer a closer knowledge of the difficulties facing end users and help answer some of the questions arising around usability optimization for older people:

A further aim is to discover some of the parameters of complexity reduction for information technology by applying Human–Computer Interaction and Usability Engineering (HCI&UE) methodology to the problem of how to optimize information presentation, in order to enhance the design and development of interfaces that will also satisfy the requirements of non-technical generations and simplify interaction with sophisticated devices.

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