A Function Based Approach towards Adaptive Interfaces for Elderly Users

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Abstract. Recent information technologies may support elderly people in living independently even when they become immobile. Most computer systems, however, are hard to use when age-related impairments increase. While sensory and motor deficits can be alleviated by built in accessibility tools, cognitive alterations with increasing age are often not addressed. Here, we present an approach that intends to evaluate the adaptation of interfaces based on individual capabilities.

Keywords: Accessibility, information technologies, higher age, cognitive functions.

1 Introduction

Because of current social and demographic trends, an increasing amount of seniors may be at risk of being socially isolated or lonely [31]. The trend towards smaller families and higher mobility in young generations cause that it is rare to have many members of a family living in close proximity [15]. When elderly people additionally become limited in personal mobility due to driving cessation, out-of-home activities decrease [20], which may have negative consequences also for cognitive functioning [19].

Using current information technologies such as computers or mobile phones may help elderly people to maintain a social network and to live on their own even when mobility is alleviated. These systems, however, are hardly adjusted to the needs of elderly people, inevitably resulting in a poor usability of the system for this user group. Besides impairments in sensory and motor systems, elderly people often experience a decline in cognitive abilities and, possibly as a consequence of all factors mentioned so far, a fearful relationship to modern technologies. Therefore they might dismiss even obviously helpful tools due to overall poor design.

Technical systems, in particular commercial ones, which are adjusted to elderly users have not been established so far. This is not surprising since the needs of elderly users are not easy to define. The decline in cognitive functions is quite selective. Two people of the same age might both be impaired in some sense but the kind of impairment might be quite different. Also the time course of decline varies individually. Thus, the "group" of elderly people is quite heterogeneous.

The present study intends to evaluate issues in usability for elderly users based on an exhaustive analysis of physiological and psychological alterations with increasing age.

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2 Functional Ageing

Aging goes along with a potential decline in numerous functions. Most important for the area of computer usability are changes in sensory functions, motor behavior and cognitive abilities.

2.1 Elementary Deficits

Visual abilities decline during normal (non-pathological) aging. Most prominent are deficits in visual acuity and spatial contrast sensitivity (especially for low luminance levels), suprathreshold contrast vision and contrast gain, temporal-frequency contrast sensitivity and resolution, spatial-temporal interactions, hyperacuity, binocular processing, and sensitivity to motion [26]. The decline might be of peripheral as well as of cortical origin [10]. Besides visual deficits, 30 to 35 % of adults aged 65 to 75 years have age-related hearing loss, as do 40% of those older than 75 [8]. It seems to be noteworthy that decline in these sensory functions appears to be correlated to impairments in intelligence [17].

Also basic motor abilities suffer from an age-related decline [27]. Loss of muscular strength, endurance and tone [12] impair the execution of physically demanding tasks at older age. Furthermore, coordination, that is the ability to control multiple movement components at any one particular time, becomes increasingly difficult with advanced age. The loss of coordination affects a variety of movements including aiming, reaching and grasping, drawing, handwriting, and bimanual coordination tasks [4], [6], [29].

One of the most conspicuous age-related changes, however, is generalized slowing that affects also physical performance. Slowing has been found already for the time needed to initiate and execute very simple movements [23]. Motor slowing already begins to develop in early adulthood [28], [33] and thus slowing is not merely a problem at higher age, but also prominent in adults below retirement age.

2.2 Cognitive Deficits

Results of a large number of studies on cognitive ageing suggest that cognitive performance does deteriorate with age, but that there are also domains that remain intact for a long time. As mentioned above, the speed at which the mind operates in general decreases [24]. Such global slowing that affects behavior at all levels is accompanied by more specific deficits in working memory capacity [21], [22], [25] and long-term memory functions [22]. But also the selective processing of relevant against irrelevant information is disturbed with increasing age [2]. On the other hand, knowledge about the world, vocabulary and semantic knowledge, remains largely intact, or may even grow with age [22].

Since the selection is essential in environments that are rich of information, such as a computer interface, this issue will be discussed here in more detail. Many studies have shown that elderly subjects have problems to ignore irrelevant information [13]. Thus, elderly people are always prone to get overwhelmed by incoming signals. Such a deficit might not only impair the identification of target items, as evident from research on visual search [18]. Additionally, impaired suppression of

irrelevant information may influence higher cognitive processing such as working memory [9]. Age-related decline in selective attention has been even proposed to be the basis for generalized slowing.

These and many more cognitive functions, such as the ability to flexibly switch between tasks, to detect errors, or to perform two or more tasks at the same time, are related to frontal structures of the human brain. These regions are especially vulnerable to physiological and metabolic age-related changes [32]. Therefore, functional processes being linked to the frontal lobe and especially to dorsolateral prefrontal areas are particularly subject to age-related deterioration. These structures play an important regulatory role for cognition by distributing information across other cortical regions [5], [30].

3 System Adaptation

3.1 Accessibility Tools

Common operating systems (Windows, Linux, Mac OS-X) include a number of accessibility tools that intend to help the elderly user to overcome deficits, in particular with respect to elementary cognitive functions.

The size of display items as well as the contrast of elements presented can be adjusted to individual needs. For more severe deficits in visual acuity, display utilities are available that make the computer screen more readable by creating a separate window that displays a magnified portion of the screen. Text to speech utilities may enable even blind users to extract reliable information.

On the motor side, deficits can be covered by adjusting the behavior of the mouse or even substitute mouse actions by keyboard commands. Adjusting keyboard repeat rates may compensate for severe motor slowing and speech recognition may completely substitute manual interaction with the computer.

However, adapting the system cannot be done by the impaired user autonomously for several reasons:

1. People are often not aware or do not want to be aware of their deficits [11]. They may attribute problems that arise when interacting with a computer to the machine and not to an individual deficit of themselves. Therefore, accessibility tools are often not used.
2. Accessibility tools are often not approachable for those who need compensation for a particular deficit. For a demonstration see two examples regarding the configuration tool for the visual display below (figure 1). Within the dialog fonts are huge and buttons large. However, up to this point the user has to navigate through dialogs that are of regular fonts and not accessible if vision is impaired.
3. Those features need to be found. For example, the double click interval that has to be adjusted for many elderly users who suffer from motoric slowing cannot be found in the accessibility tools in OS-X. There is a separate mouse configuration tool that might easily be neglected when the intention is to increase accessibility.

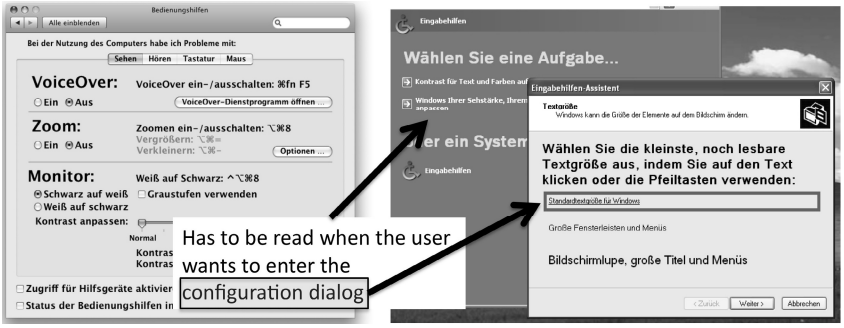

Fig. 1. Configuration tools for increasing accessibility for visually impaired persons (left: Mac OS-X; right: WindowsXP). In both cases, regular (small) font sizes have to be processed until the user enters the final configuration menu. Only at that level, font sizes are increased in order to support the handicapped user.

3.2 Advanced System Adaptation

Already basic installations of common operating systems include an incredible number of programs installed. They all have strange names (Outlook, Thunderbird, Entourage) which are not self explaining and in the worst case the user has to list all in order to find the correct tool to accomplish a particular goal.

As outlined above, one of the core cognitive deficits with increasing age is the inability to separate relevant from irrelevant information (see also [1], [3]). Thus, visual search for a particular feature (e.g. a launch button) may become really hard and time consuming and therefore potentially frustrating. In addition, if the user is not familiar with the English language, he/she experiences the program names as nonsense syllables.

As for elementary functions, there are numerous tools to alleviate the access also at this higher level. Menu lists may be edited easily in most operating systems, however, again an expert is needed to do this. Also, program names may be replaced by functional descriptions for example in KDE. But also this feature requires profound knowledge of the operating system, which lacks before most in novices and elderly users. Thus, adaptation requires the help of an expert, shaping the system based on knowledge of the actual user.

3.3 Substantiating the User Model

The user model that underlies the configuration of a computer system may be based on usability surveys or solely on assumptions about the potential users (or user groups).

The latter may fail when a system should be adjusted to elderly people. Alterations of both physiological as well as cognitive functions vary enormously across this group. Global setting might therefore be experienced as if the system would be created for heavily impaired subjects. Surveys might be helpful when the complexity of the system is to be reduced to individual needs but will, for already mentioned reasons, never be able to capture physiological decline.

Thus, deficits in elementary functions should be evaluated empirically. Simple psychological in situ tests may measure individual capabilities in all relevant areas and adjust the system accordingly. Such a procedure may be embedded in a way that most users are able to access it autonomously even when e.g. vision is impaired. Such a tool would circumvent subjective misjudgments of abilities, shape the system as optimal as possible and does not require a difficult search for functionality.

A short survey would be in particular helpful to cover the cognitive deficits of elderly users. As outlined above, one of the main problems is the inability to suppress irrelevant information. Thus, menus need to be as simple as possible. Only functionality should be visible that is actually needed. If the number of entries exceeds a comfortable size, they should be organized in suitable groups to reduce the effort needed to accomplish a goal as much as possible.

3.4 Considering Emotions

Computers came into the private use in the mid 80s. Today's 35 to 45 years old are the first generation that was confronted with information technologies already at school. Additionally, people retiring now have less experience with computers from their working life if compared to the younger generation. Therefore, it is not surprising that computer anxiety, which is strongly related to experience, is more common in the elderly [7], [16].

Function based adjustment may help to overcome this problem, may help elderly users to be more confident with computers. However, systems that had already addressed this point did not succeed on the market. In 2006, Fujitsu-Siemens introduced a Linux desktop computer, which was called "Simplico". Visible functionality was reduced to surfing the net, use e-mail, write letters, play along and look pictures and videos. These features were additionally organized into contend defined groups which were color-coded.

Although initial critics were enthusiastic, the system did not become a top seller. Besides possible technical problems with a linux based system (some complaints have been raised regarding the possibility to connect any desired hardware), the system appeared to be too obviously fitted to senior use which is generally known to be a major obstacle for purchasing a system. As with other technologies, shaped for the elderly should not mean that it has to look like it. There should be no obvious connotation to disabilities.

3.5 Evolving Systems

Since elderly users are often inexperienced when starting to use a computer, their capabilities to improve performance are sometimes larger than those of younger users. Thus, when they had started off with an individually adjusted system that covers all possible impairments, they may soon wish to use more of the potential of the machine.

Adaptive (or evolving) systems [16] might detect changes in the user's level of expertise and optimize the system accordingly. More features might be activated or parameters of accessibility setting might be changed. Such mechanisms might nicely add on the initial configuration. However, some problems may raise with such modification that are not well understood yet:

1. Elderly people may be irritated by sudden changes of the system that are not due to their own interaction with the machine. Especially in early stages of experience, when confidence in the technology has not established yet, unexpected modifications may decrease the efficiency of interaction.
2. Usage of the system by any other person (e.g. a visiting, a younger family member that enters the system on the same user profile) may recalibrate the system in an unpredictable way.

Thus, it has to be evaluated whether automatic adaptation or rather proposal-based variation should adapt the system to increasing experience [14]. In any case, as can be learned from the Simplico disaster, potential availability of full functionality is necessary to avoid the image of disabilities and give the opportunity to adjust for any increase in experience.

4 Summary

Elderly people represent the fastest growing group in our society. Using recent information technologies might essentially increase live quality and, before most, help them to remain independent even when mobility is limited. These technologies, however, are hardly adopted to special needs and to age-related functional decline. Accessibility tools as implemented in all operation systems address this problem only superficially, by widely ignoring individual levels of sensory and motor functioning, cognitive changes with age and computer experience. Thinking on adjusted systems is confronted with the enormous heterogeneity of this group with respect to all determinants.

The fact that more and more elderly people use computers for many purposes does not mean that their interaction with this technology is efficient. Elderly people tend to adapt to the system in order to accomplish a particular goal. Often, they need to learn processes by rote since they have no mental model of the machine. Adjusting the system to individual capabilities and reducing the amount of information that needs to be processed might not only increase accessibility for those who already use computers, but also help not-users to overcome the fear of the unknown.

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