AGE RELATED COGNITIVE IMPAIRMENTS AND ASSISTIVE WEB-BASE TECHNOLOGY

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Abstract

Several researchers argue that age related cognitive impairments have detrimental affect on use of web services by older adults. However little and systematic applied research has been conducted on how age related cognitive impairments might affect the usage of web services by older adults. Undoubtedly, understanding the relationship between the cognitive changes that accompany aging and their impact on older adults' usage of web services will be beneficial for designing web services for this group. The paper demonstrates how such understanding has been employed to develop an assistive technology in order to improve older adults' interaction with online forms.

Key words: Age related cognitive impairments, Older adults, Assistive technology, Online forms and web services.

1. INTRODUCTION

The increasing numbers of older adults are living in their homes with limitations in mobility, dexterity, and cognitive ability(Grundy 2003). Currently there is considerable discussion about the scope of improving the older adults' autonomy and independence that is restricted by age related impairments, using recent developments in information technology (McMellon and Schiffman 2002). One of such development is web services and recent surveys show that older adults constitute the fastest growing demographic group of web service users (Morrel, Mayhorn et al. 2000). However they use web services less often and have less experience with them than younger adults (ibid). Lack of web service use puts older adults at disadvantage in terms of their abilities to live and function independently. Furthermore the full benefits of web services may not be realised by the older adults (see Czaja and Lee 2008). There are several reasons for the discrepancy between younger and older adults using web services. One major reason is the age related impairments which hinder the visual,

auditory, motor and cognitive abilities of older adults (Czaja and Lee 2008). The research indicates that such impairments have detrimental affect on use of web services by older adults (Mead, Lamson et al. 2002).

Several researchers have taken considerable efforts to investigate the potential implications of age related visual, auditory and motor impairments for web services design. For example Fisk et al show that age related visual decrements may make it more difficult for older adults to perceive small icons on toolbars or locate information on complex websites. Further more Smith et al(1999) investigate older adults' motor skills related to computer usage and demonstrate that older adults have considerable difficulty in performing complex computer tasks such as pointing, clicking, double-clicking and dragging when using web services.

However little and systematic applied research has been conducted on how age related cognitive impairment might affect the usage of web services or other information systems by older adults (see Czaja, Charness et al. 2006). For example there are well established interface standards which cover the visual, auditory and motor impairments but it is a no doubt that there is a less well developed understanding of age related cognitive impairments among standard bodies such as W3C (Gulliksen and Harker 2004). Undoubtedly, understanding the relationship between the cognitive changes that accompany aging and their impact on older adults' usage of web services will be especially beneficial for designing web services for this group. Consequently this paper (1) attempts to understand how age related cognitive impairments affect general use of web services by older adults (2) present results from a study which use this understanding to develop an assistive technology to enable older adults with age related cognitive impairments, to confidently and successfully use web services.

2 AGE RELATED COGNITIVE IMPAIRMENT

Many studies demonstrate that cognitive abilities of individuals decline with age (Ardila, Ostroosky-Solis et al. 2000; Saczynski and Rebok 2004; Craik and Bialystok 2006; Boutet, Milgram et al. 2007; Czaja and Lee 2008). Main cognitive abilities that decline include the following (see Park 1992; Morrel, Mayhorn et al. 2000; Boutet, Milgram et al. 2007; Newell, Carmichael et al. 2008).

Working memory

Research shows that that working memory capacity declines with age and is especially strained when task complexity is increased. Working memory is usually conceptualized as "the temporary storage of information that is necessary for such activities as learning, reasoning, and comprehension"(Bradeley 1986). The usual tasks carried out by working memory are those in which the individual must hold a small amount of material in mind for a short period of time while at the same time performing further cognitive operations (e.g. comprehension), either on the material held or on other incoming materials (Morris, Craik et al. 1990). The decline of working memory holds a number of implications for the use of web services by older adults. Kurniawan, King et al(2006) list some of those implications:

- Inability to use language properly (e.g. text comprehension, putting together keywords for search engines)
- Limited abilities in reasoning (e.g. understating the information on a web page organised)
- Weak procedural memory (e.g. performing a large number of steps in the online transaction)

The above implications could cause older adults to experience feeling of lost or confused within a website and consequently they might become frustrated with the website and lead to discontinued use.

Perceptual speed

The age related cognitive impairment make older adults to have a general slowing of perceptual and motor processes involved in perceiving and responding to items. In other words the perceptual speed (the speed at which mental operations are performed) is decreased with increased age. Such slowness is raised, when task complexity increases. As a result older adults have difficulties performing complex tasks on websites which must be done externally imposed time constraints (see Newell, Carmichael et al. 2008).

Spatial Abilities

Spatial ability refers to skill in perceiving the visual world, transforming and modifying initial perceptions, and mentally recreating spatial aspects of one's visual experience. Several categories of spatial abilities can be notable. Spatial orientation is the ability to keep track of objects or locations in space even after a rotation or movement to a new location; spatial perception involves determining spatial relationships with respect to one's own body in spite of distracting information; and spatial manipulation involves the ability to mentally rotate two- or three-dimensional figures rapidly and accurately (Howard 1985). Spatial abilities boost during adolescence, reach their height during the second or third decade of life, and shrink steadily thereafter. Thus older adults have lower levels of abilities in performing tasks which require spatial visualisations, integration of spatial information, and ongoing information processing (Morrell and Echt 1996). For example Uttl and Graf (1993) investigated museum visitors age 15 to 74 on their memory for the spatial displays they had seen in the museum and found that museum visitors over age 55 exhibits clear declines in spatial memory. Other investigators examined how these spatial abilities affect older adults' usage of computers. For instance Westerman et al (1995) examined the relationship between spatial ability, age and the ability to retrieve information from a computer database and found that older adults were slower in retrieving the information than the younger adults due to decreased spatial abilities. As many websites have complex computer screens which contains complex menu structures, banners, animations, three dimensional presentations etc which demands high degree of spatial abilities, older adults will have difficulties in using existing websites (see Kurniawan, King et al. 2006).

Attention

Gross(2001) shows that there are two major ways of defining and investigating attention:

1. the mechanism by which certain information is registered and other information is rejected, whether or not the latter enters conscious awareness. This mechanism is generally referred as a *selective or focus attention*.

2. the process which enable individual to allocate cognitive resources when two or more distinct cognitive tasks. This process is referred as a *divided attention*.

Although there is some debate as to whether older adults exhibit a general decline in selective attention, Roger(2000) reviewing the evidence up to that time, notes that there is no concrete evidence to suggest that selective attention declines with age. On the other hand several studies demonstrate that there is a significant difference between younger adults and older adults in their ability to divide their attention between tasks when such tasks are complex and demand cognitive resources. However evidence suggests that for relatively simple tasks younger adults and older adults can divide their attention equally well. These studies demonstrate that age related difference in divided attention depends on the complexity of the tasks (ibid). As existing web pages present scenarios where users require doing more than one thing at time older adults will have difficulties in using them. Further

more walking, blinking, flashing objects and multiple frames in web pages demand high cognitive resources and consequently divided attention become mandatory rather than optional. As a result older adults using such web pages will have problems in allocating their attention appropriately.

From the above discussion it is clear that age related cognitive impairments have detrimental impact on how older adults use web services. As a result older adults continuously face more difficulties than younger adults when using web services. Although there is very little research examining how such difficulties can be minimised, some research suggests that age related cognitive declines can be mediated by the manner in which web services are designed. Such research demonstrates that designing web services that take into consider age related cognitive impairments would consequently enhance the usage of web services and other computer applications by older adults (Holt and Morrell 2002; Sharit, Czaja et al. 2003). For example Holt and Morrell(2002) demonstrate that efficiency of text comprehension by older adults is improved when the text is well organised and clearly presented in short segments on web pages. Further more, Sharit, Czaja et al (2003) show in their study on interactive telephone menu systems that older adults experience difficulties in using menu systems as they have declined spatial abilities and have to use repeat function more frequently than younger adults. Consequently they demonstrate how simple graphical aid that depicted the structure of the menu system help the older adults to use interactive telephone menu systems. Consistent with cognitive aging literature, these results suggest that in order to design web services so that they are usable and useful for older adults, it is important to consider their age related cognitive impairments

3 WAY FORWARD

Although the above discussion present that older adults with age related cognitive impairments face challenges when using existing web services, the literature generally suggest that older adults are receptive to services based on new technologies (Czaja and Lee 2008). However the nature of their experience with existing technological applications such as web services is not pleasant. One major reason seem to be that developers do not appear to pay important attention to older adults' declined cognitive abilities and impact of such abilities on use of web services by older adults(ibid). Thus what is lacking is systematic effort to understand older adults' needs related to web services that are shaped by their declined cognitive impairments and incorporate them into design solutions.

Consequently this paper presents the results from a research project currently being undertaken in the UK, Norway and Italy. This research project is called DIADEM and funded by the EU. It aims to develop an assistive technology; to help the older adults with age related cognitive impairments, to use the web services more effectively. The goal of DIADEM is to provide an adaptable client-side technology that enables people, who suffer a reduction of cognitive abilities due to aging and consequently remain active and independent members of society. The research has very applied characteristics and developed through collaboration with the older adult users of web services, the developers of assistive technology and the web service providers. The project focuses on the problem of accessing services online where older adult users need to fill in forms on the screen. In this context even quite simple services can be complex to use; for example, to purchase a train ticket online, one needs to negotiate 11 screens, 18 selections and 8 typed in responses. This can easily become a barrier to the older adults with age related cognitive impairments making it harder for them to remain active and independent members of society. The rising number of online transactions will only magnify the problem making them more marginalised and disadvantaged. In order to overcome such problems the DIADEM will use Expert System technology to adapt and personalise the computer interface (the web browser) to help older adults fill in online forms and thereby interact successfully with most of the web services to remain active and independent members of the society.

3.1 Methodology

Most significant information systems send ripples around organisations and developing and implementing, them is a challenging task which grows as information systems extend from back ground internal tasks to those that affects other organisations and members of the public (Boddy, Boonstra et al. 2005). This challenge could be much more complex and demanding in the DIADEM project as the older adults with age related cognitive impairments have very complex needs and understanding such needs by the key stakeholders (the developers and the service providers) is non a trivial activity.

For example Orlikowski and Gash (1994) argue that as there are many stakeholders involved in information systems development activities, deep understanding of their needs in the organizational context, can lead to more successful information systems outcomes. Building on a cognitive approach they suggest that different stakeholders have different mental models. Such mental models create differences in their actions and behaviours related to information systems development processes and usage. They argue that such differences in key stakeholders imply different ways of knowing and making sense of information systems. As these different interpretations are not explicitly discussed or articulated they may result in misaligned expectations and contradictory actions. So they claim that such misaligned expectations and contradictory actions in information systems development and use, may eventually lead to unanticipated consequences such as project failures.

In order to reduce such consequences the DIADEM project allowed the older adult users, the developers and the service providers involve at the every step of the development process. Thus, at the onset of the DIADEM project it was considered important to investigate the needs of older adults, not only with older adults but through discussion with key-stakeholders. It was hoped that by doing so, a more rounded view of the problems that older adults and the agencies that support them would be obtained. Key-stakeholders comprised not only the developers and the service providers but also representatives from government agencies, private care/medical agencies and charities that support the elderly in each partner country (the UK, Norway and Italy). Consequently the key-stakeholder focus groups and the end user (older adults) investigations were designed to elicit the core functional requirements of the DIADEM system. The aim of both the key-stakeholder focus group and the end user trials and interviews was to:

1. Identify social and technological barriers (if any) to online form access, completion and submission

2. Identify the basic functionality of the DIADEM software through identification of user interaction needs

3. Identify the design features (e.g. calendars. Self-populating fields etc) that might support end-user interaction with online forms.

To enable work to proceed on as many fronts as possible, ethical approval was sought independently for each study by first going to the Brunel University's ethics committee and then locally by each partners. Furthermore Mini Metal Assessment (MMSE) was employed to choose and recruit older adults who have appropriate age related cognitive impairments. The MMSE is the most commonly used instrument for screening cognitive functions. In general, the MMSE provides a brief screening test that quantitatively assesses the severity of cognitive impairment and documents cognitive changes occurring over time (see Tombaugh and McIntyre 1992).

3.1.1 Key Stakeholder Focus Group Interviews

In each partner country 5 – 12 participants were invited to attend a focus group that, through moderated discussion, to consider the above listed aims. The focus group interviews lasted approximately 1.5 hours. Although group interviews are often used simply as a quick and convenient way to collect data from several people simultaneously, focus groups explicitly use group interaction as part of the method. This means that instead of the researcher asking each person to respond to a question in turn, people are encouraged to talk to one another: asking questions, exchanging anecdotes and commenting on each others' experiences and points of view (Kitzinger 1995). Consequently the researchers at Brunel encouraged participants from key stakeholder group to explore the issues of importance to them, in their own vocabulary, generating their own questions and pursuing their main concerns. The data captured during the key-stakeholder focus group was collated and subjected to a thematic analysis as described by Braun and Clarke (2006).

3.1.2 End-user Interviews

End user interviews were conducted to identify social and technological barriers (if any) to (1) online form access, completion and submission, (2) the basic functionality of the DIADEM. These interviews were also employed to identify the design features (e.g. calendars, Self-populating fields etc) that might support end-user interaction with online forms. Each partner country recruited 30 end-user participants. Prior to the investigation each partner had identified four online forms that were considered to be 'complex' (as describe by Miller and Jarrett 2001) .

During the interview, interviewee's interacted with one of the online forms identified as 'complex' by the partner countries. The user-interaction task was conducted using the think aloud technique whereby the interviewee was encouraged to voice both the positive and negative experiences incurred throughout their interaction with the online form. Data recorded during the end user interviews was subject to a thematic analysis.

3.2 Functional and Usability Requirements

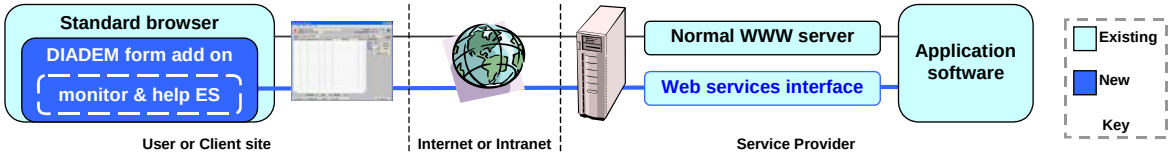
From the analysis of the key stakeholder focus group and the end-user interviews, core functional and usability requirements was identified for all applications as they are presented and accessed through DIADEM.

3.3 Software Specification

The software specification is the main output from the gathering and analysis of the functional and usability requirements. The main focus of this software specification was a description of what all the functions of the software of the DIADEM are. These were defined in grate length to ensure that the developers understand what the end-users require from the DIADEM and prioritise the requirements to pay considerable attention to the items that were perceived by the end-users as very important.

3.4The End Product- DIADEM

The DIADEM was the main outcome from the above discussed activities (see DIADEM Architecture).



DIADEM Architecture

To respond to the challenges faced by older adults with age related cognitive impairments the DIADEM constructs components that employ Expert System techniques to analyse user behaviour and adapt the presentation of the transaction dialogue to mitigate the cognitive problems exhibited by the user. This client component is data driven, by using XML control files from the server, so that it can interface to different services and will use a rich set of multimedia devices (e.g. sound, video, document scanning and smart cards) to reduce the cognitive load on the user. In order to reduce the impact of age related cognitive impairments on the users' interaction with web services, the DIADEM has following characteristics:

- The DIADEM uses Expert Systems (ES) to monitor usage and control personalisation or intervention strategies. The ES records the user's behaviour with respect to the user's interaction with the user interface. In particular, the following types of events are recorded along with their occurrences on the time axis: 1) time delays in filling in boxes 2) number or frequency of incorrect key strokes 3) backward moves through the dialogue 4) consistency of responses. Then the DIADEM analyzes the user's user interaction profile and infers the user's cognitive characteristics and store these in the user characteristics profile. Using this knowledge the DIADEM adapts web applications to each user so that he/she is able to use these applications with fewer difficulties.

- All user interaction with web applications takes place through a web browser. If the system fails to provide adequate assistance to enable the user to use web application the system shall provide some external means of support to the user. In every help functionality is presented in a consistent way across the entire service. When symbols or icons are used as help buttons, these follow established standards or conventions.

- The DIADEM allows the end-user's computer to have a facility for user authentication that is not password-based (e.g., fingerprint, retina, smartcard, signature recognition). Each user is given an authentication token necessary for the chosen means of authentication. The system has a facility that issues authentication tokens (e.g., smartcards) to users of the system. The DIADEM keeps all user profiles confidential from other parties than their respective users. It also protects the integrity of all user profiles so that the profile can only be modified by the system or by an authorised individual.

All the above characteristics of the DIADEM will reduce the impact of age related cognitive impairments on older adults' usage of web services. For example consider a case where an older adult filling an online form to buy a train ticket. The older adult may find it difficult to comprehend the text on the web page or to perform a large number of steps in the online transaction due to his declined working memory. He may also have difficulties in finding important information in the online forms that has visual clutter, background images and distracting animation as he has declined spatial abilities

and perceptual speed. The above mentioned characteristics in the DIADEM will simply the online form and guide him to fill out the form though simple steps.

4 CONCLUSION

The paper present that how age related cognitive impairments would affect the use of web services by older adults. It emphasis that developers and providers of web services need to have significant understanding of the impact of age related cognitive impairment on usage of web services. The paper demonstrates how such understanding has been employed to develop an assistive technology in order to provide an adaptable web browser for the older adults with age related cognitive impairments to improve their interaction with web base forms. This improvement is achieved by developing an Expert System, which monitors the user's behaviour to adapt and personalise the computer interface as the user interacts with web based forms whilst providing privacy and security. However it should be emphasized that it is also important to think about the future – to be thinking about how older adults accept this innovation. The usability is a constant factor which influences such acceptability. But there is little usability research has been carried out to find out how older adults with age related cognitive impairments cope with assistive web-base technologies developed for them. Therefore future research needs to focus on the evaluation of usability of the DIADEM. Further more future research also needs to look at how and why service providers make purchase decision for the DIADEM as the answers to these questions would help innovators of the DIADEM to understand (1) how quickly the DIADEM might take off in the unconventional marketplace (2) critical barriers to commercialisation and diffusion of the DIADEM. Such research would help the innovators of the DIADEM and similar technologies to develop effective marketing strategies to improve the commercialisation and diffusion of such technologies.

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