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Personalising web page presentation for older people

S.H. Kurniawan *, A. King, D.G. Evans, P.L. Blenkhorn

School of Informatics, the University of Manchester, PO Box 88, Manchester M60 1QD, UK

Abstract

This paper looks at different ways of personalising web page presentation to alleviate functional impairments in older people. The paper considers how impairments may be addressed by web design and through various personalisation instruments: accessibility features of standard browsers, proxy servers, assistive technology, application adaptors, and special purpose browsers. A pilot study of five older web users indicated that the most favoured personalisation technique was overriding the CSS (cascading style sheet) with a readily available one using a standard browser. The least favoured one was using assistive technology. In a follow-up study with 16 older web users, performing goal-directed browsing tasks, overriding CSS remains the most favoured. Assistive technology remains the least favoured and the slowest. Based on user comments, one-take-home message for web personalisation instrument developer is that the best instrument for older persons is one that most faithfully preserves the original layout while requiring the least effort.

Keywords: Ageing; Elderly; Gerontology; Web; Assistive technology; Accessibility

1. Introduction

The web can potentially help older adults maintain their independence and improve their quality of life (Ellis and Kurniawan, 2000). More and more web-related businesses aim to attract older adults as customers for obvious reasons. Older adults constitute the fastest growing group of computer users and information seekers on the web. A survey in 2003 found that 50% of people aged 60–64 years old owned a computer with 37% online at home, and that they represented 12% of Internet users in the UK (Jeffrey, 2003).

* Corresponding author. Tel.: +44 161 306 8929; fax: +44 161 306 1281.
E-mail addresses: s.kurniawan@manchester.ac.uk (S.H. Kurniawan), a.king@manchester.ac.uk (A. King), david.g.evans@manchester.ac.uk (D.G. Evans), p.blenkhorn@manchester.ac.uk (P.L. Blenkhorn).

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Going online has become the number one hobby for British pensioners (BBC News, 2002). Around 83% of older people in the UK go online on a regular basis.

However, for many older adults, using a computer and looking for information on the web are brand-new experiences. People who are new to this technology are more likely to be frustrated rather than impressed by site designs that use a plethora of bells and whistles, and they may not have a sense of how to navigate through such sites (Christopher, 1999).

2. The web in theory and in practice

Hypertext documents written in the hypertext markup language (HTML) are the basis for the web (W3C, 2004a). They are intended to divorce presentation—font, colour and layout—from content, by using mark-up to indicate emphasis, structure and other semantic content. For example, the text of the heading of this section, 'The web in theory and in practice' might be marked up with the 'h1' tag, indicating that it is a first-level heading. HTML documents are rendered by browsers in a way that preserves this meaning and are interpreted in a way that best suits the user. For example, text marked up with the 'h1' tag might be presented in a larger, bold font, with surrounding white space in a standard browser. A browser for people with visual impairment might use a larger font and a special typeface and colour scheme. Alternatively, an audio browser (e.g., when a web page is delivered through the phone) might use a different voice, or pause, or state the fact that this is a headline. The HTML document is interpreted by the client, in theory, so the designer need not pay any concern to the presentation.

In practice, HTML documents are generally not so client-neutral. First, most web pages are visually oriented and assume that users do not have (severe) functional impairments. This can be attributed to the fact that most users and developers are sighted, accustomed to the visual presentation of content (for example in newspapers or magazines) and the visual modality is powerful and well-suited to the presentation of information. Second, most people access the internet through a single browser, Microsoft's Internet Explorer, which is a de facto standard (CNET, 2003).

The importance of this situation is that mark-up is divorced from semantics in HTML documents. Web designers use mark-up to create visual effects that create meaningful semantic structures when rendered by a standard browser, but the code they use to do it has no semantic meaning. If the user is unable to use the browser as intended by the designer, confusion may result. The most obvious example is the use of tables to align text and images on the screen. Without analysing what ends up where on the screen—what text is directly below what image, for example—nothing can be inferred about the semantics and relationship between items on the page. The client certainly cannot infer that tabular data is being presented. The predominance of Internet Explorer gives confidence to designers that their effect will be consistent for the great majority of their users. However, the same predominance goes further in exacerbating the situation by allowing developers to add functionality to web pages using client-side scripting, frames, pop-up windows and embedded content. This makes for a rich, flexible and powerful visual interface driven by mouse use, and it works because of the existence of a de facto standard. This is effective for the majority of users, but it poses problems for some users.

3. Ageing-related functional impairments and their implications for web interaction

Most papers that discuss functional impairments and the web concentrate on visual impairment. Whilst visual impairment is the biggest problem in web interaction (because, in general, the web adopts a visual interaction paradigm) cognitive and motor impairments also prevent older people from interacting with the web effectively and efficiently.

Even though any of these individual functional impairments might not result in a noticeable difference in the user experience, taken together they may have a cumulative effect that makes web interaction more difficult for older adults. Further, they may result in 'knockoff effects,' e.g., the cognitive effort required to do sensory processing diminishes the remaining mental resources available for engaging in deeper, interpretive processing of the information.

3.1. Visual impairments

Decline in visual acuity is small and gradual, although the cumulative effect of these changes is noticeable by the mid-forties. Several types of physical changes take place in the eye during this time, which include the following (Capitani et al., 1988; Christopher, 1999; Ellis and Kurniawan, 2000; Straub and Weinschenk, 2003).

- Generally failing vision, this necessitates the information to be presented in a larger size. Empirically derived guidelines suggest presenting important information in 12- to 14-point font size and at least 180×22 pixels for a graphic button for older persons with normal decline in their vision.
- Corneal flattening which reduces the amount of light that passes into the eyes, calling for maximisation of information/background contrast in critical content areas.
- Reduced lens elasticity, which reduces focusing power and gives rise to a feeling of 'tired eyes'. Using all capital letters, all emboldened letters, and several types of fonts mixed together or very narrow or decorative fonts tends to lead to higher levels of eyestrain and eye fatigue because it does not give the eye sufficient rest. Bright and extremely vibrant colours can have edges that appear blurred, create after-images and tire the eyes; therefore, their use should be limited. An effective use of white spaces and presenting text in small blocks provides mitigation.
- Yellowing of the lens means less violet light is registered by the eye, which makes it easier to see reds, oranges and yellows than it does to see blues, greens and violets. Presenting information in the colours that are easier to see and use the colours that are more difficult to see as background provides solution to this problem.
- Visual field reduction resulting in reduced peripheral vision, requiring important information to be presented as close to the centre of the screen as possible (which might be difficult to implement given that the screen objects need to be larger to ease general failing vision).
- Reduced retinal efficiency resulting in a diminished ability to adapt to glare or changing light conditions—meaning that negative polarity (light coloured text on dark coloured background) is likely to be more readable than a positive polarity setup in certain lighting condition.

- Reduced ability to recognise figures that are embedded within other figures. A direct implication of this condition is that older people are easily distracted by background patterns, drop shadows on text or floating text over images. The use of a faint grid pattern as background was found to provide the best compromise.
- Loss of near vision, indicated by the need for bifocal lenses. The main problem for bifocal users is that the average distance from the eyes to the monitor falls in neither the near vision nor far vision range of most bifocals. Although usually a significant amount of time is spent looking at a screen, only a small subset of older users have lenses that optimise visual acuity for screen viewing. Unfortunately, there is no direct solution for this condition.

3.2. Motor impairments

The beginning of 1980s marked a paradigm shift from command line interface to graphical user interfaces (GUIs). Increased popularity of GUIs makes the use of a mouse necessary in computer interaction. In web interaction, the use of a mouse is essential. On the positive side, a mouse reduces the typing activities needed for the interface. However, ageing-related motor impairments mean that simply using a traditional mouse can provide a formidable challenge. These motor impairments include the following (Christopher, 1999; Jagacinski et al., 1995; Krampe and Ericsson, 1996; Walker et al., 1997).

- Stiffening of the joints and arthritis, which causes difficulty with finer movements and motor coordination. 'Click-and-drag' activities are extremely difficult for some older people. Microsoft™ provides a ClickLock setting that does not require click-and-drag, a possible solution for this problem. Scrolling may also prove difficult for some, but can easily be solved through considerate design. Breaking pages into chunks of no more that one or two screens' worth of information will eliminate much of the need for scrolling. Homing into a small target is also problematic. Large buttons and hyperlinks (or a hot area around a hyperlink) will help in this aspect, while at the same time assist people with declining vision.
- Slower response times on more complex motor tasks. Older people are slower in tracking and capturing a moving target with a mouse. They also tend to break movements into many sub-movements. Minimising the use of walking menus (which tend to disappear before a user can 'walk' to their sub-menus) definitely helps.
- Reduced ability to cope with repetitive fast movement. This means, double-clicking mouse may be difficult. Microsoft's single-clicking option or changeable double-clicking speed can potentially solve this problem.

3.3. Cognitive impairments

Web interaction involves a tremendous range of cognitive skills, including recalling, reasoning, recognition, skill acquisition and comprehension. Ageing research indicates that older adults have poorer performances in almost all of these skills compared to their younger counterparts. Cognitive impairments that occur with ageing include the following (Byrne, 1996; Saczynski and Rebok, 2004).

- Reduced working memory capacity causes poorer performance in a wide variety of tasks, including natural language use (e.g., comprehending text, putting together keywords for search engines), reasoning tasks (e.g., understanding how a web hierarchy is organised), procedural memory (e.g., performing a large number of steps in an e-commerce transactions), etc. Limiting the use of deep hierarchies; providing site maps, orientation information and navigation bars; and cutting down the number of steps required in a transaction (e.g., amazon.co.uk's 1-Click™ ordering) can alleviate this problem.
- Diminished ability to consciously learn and retain new information (i.e., declining explicit memory). It helps to provide, online, a simplified tutorial or manual, which they can refer to from anywhere in a web hierarchy. The learning tasks explained in the tutorial need to be broken into subtasks. It is useful to provide context-sensitive help, reminders and FAQs to assist recall. Providing clues on how information is organised, such as providing information overview and outline is also a big help to older adults.
- Reduction of perception, spatial and visual information processing meaning that older adults are slower in finding a target in a complex web page. They also have more problems reading a map than written directions to get to a place (unfortunately, many web pages only provide maps when giving directions). Finally, presenting information in three-dimensional forms proves to be unfavourable for older adults' understanding. One- or two-dimensional presentation of information is more easily comprehended.
- Overall slowing of cognitive processing speed means that older users should be given control over time-sensitive content changes in web interaction. At the design stage, there is a need to carefully consider the speed of walking banners and flashing text. However, there are instruments that can stop walking and flashing text, which will be discussed later in the paper.
- Decline in divided attention (the ability to pay attention to particular details in the presence of distracting information) and in maintaining attention. Unless they convey important information, walking, blinking and flashing objects should be avoided. Tiled windows or multiple frames compete for older adults' attention. Indeed, informal observation shows that older users tend to maximise their current viewing windows. Focusing aids (e.g., highlighters, emboldened fonts, bright coloured objects) should be used with caution.
- Increased chance of experiencing interference in long-term memory. Applying consistency when designing web pages can minimise the problem caused by interference (e.g., only using underlining for links).

3.4. Hearing impairments

With the increased use of multimedia information in web pages, hearing impairments can potentially cause older adults to miss some information. Ageing-related hearing impairments include the following (Hawthorn, 2000; Zhao, 2001; Brandeis University, 1998).

- Presbyacusis (reduced ability to hear higher pitched sounds). Interfaces that use sound to get the users attention will need to use lower frequency sounds for older users. It is found that a beep that sweeps across 0.5–1.0 KHz was reasonably effective. Recorded voice should also use speakers with low-pitched voices.
- Reduced ability to decipher fast speech (more than 140–180 words per minute) and reduced ability to understand speech over noisy background. Providing audio captions for online news and weather forecasts, especially when the journalists reported the news over noisy backgrounds (e.g., an onsite war report), will help older users.

3.5. Attitudes towards computers and the web

There is a widely held belief that older people shy away from computers and the web and do not perform as well as their younger counterparts in a variety of computer and web tasks. Part of this misconception is due to some behavioural characteristics of older people, including the following.

- Increased cautiousness (hesitancy about making responses that may be incorrect) (Salthouse, 1991). This causes older adults to take more time to perform tasks. Speed–accuracy trade-off analysis reveals that older people do not always make more errors than younger people; they just took longer to finish a task. It might be helpful for older users to provide assurance throughout the website that a user is in the right (or wrong) path to their information target, by providing breadcrumbs and forward overview (what is to come). The most commonly used navigation method after the hypertext link is the back button (Hawthorn, 2000) so the instruments that can suppress pop-up windows that break the user's navigation path will be helpful.
- Less confidence about their ability to use computer technology, including the web, which causes computer-phobia, anxiety, resistance and negative attitude towards computers (Christopher, 1999). This is partly due to fact that some older people have never used or been shown how to use computer technology and have never had the opportunity to learn (Microsoft, 1999). The same research pointed out that older people are more receptive to using computers when they perceived the technology as being useful and the tasks that they were able to perform with the technology as being valuable and beneficial. One study found that introducing the technology in a highly interactive and understandable manner was one factor that was likely to influence the receptivity of older adults toward computers (Edwards and Englehardt, 1989).

4. Personalising web page presentation

Even though many of the presentation problems can theoretically be solved at the design stage, as described in Section 3, the need for personalising web page presentation for older people remains. There are several reasons for this. Firstly, it is unavoidable that some designers do not comply with any accessibility guidelines. Examples include unlabelled images for buttons and links, absolute font sizes, default colours that are difficult to read or scripts that make pages operate only with mouse actions.

Secondly, some designers follow accessibility guidelines but they assume that users are able-bodied and familiar with the technology. Some consequences of this assumption include, users are thought to always understand implicit information communicated by the visual layout of web pages. An example is the use of a navigation bar on the top of every page of a site with internal site links. Visual users can simply scan the page for the page content, and jump to the navigation bar as necessary. However, when a user does not use a visual browser (e.g. when using a screen reader or accessing a web page delivered through the phone), the page is presented linearly following its HTML code sequence. This means that these users must work their way through the navigation bar content before reaching the content of interest for every page they access. This can be a slow and frustrating process.

And finally, the need of one user might conflict that of others. For example, while high-contrast presentation benefits most older users, it hampers older users with dyslexia. These three reasons lay the case for personalising web page presentation to fit an individual's need.

There are a number of instruments that allow a web page to be personalised so that it meets the needs of an individual older user, ranging from utilising the accessibility features of standard browsers to using dedicated special purpose browsers. These instruments are described in great detail in Sections 4.1–4.5.

4.1. Accessibility features of standard browsers

If HTML designers follow the principle of separation of content and presentation (e.g., no absolute font's or table's sizes are used), a standard browser provides a first step of accommodating declined functional abilities in older people. Standard browsers, including Internet Explorer, allow users to select colour schemes or font sizes and types that suit the user, and override the design dictated by the HTML codes. This does require some configuration of the browser—which may not be obvious to less experienced and/or confident users, especially the more complex changes (e.g., customising a CSS file to match one's preference).

In the context of Microsoft IE, broadly speaking, there are three ways of personalising how a page is presented. The first (and easiest) way, under 'View' menu, allows users to alter the font size (useful for visual and motor impairments), text alignment (might help in some cases of dyslexia—justified text creates river effect, which is very detrimental for some people with dyslexia) and the language encoding. The second way is under 'Internet Option → Accessibility' menu. Users can choose to ignore the designer's settings and use the default browser's setting. Or more advanced users can use their own CSS. And finally, there are some options hidden in the 'Internet Option → Advanced' menu that can improve the accessibility of a web page (e.g., hiding pictures).

The main problem related to personalising web pages just using the functionalities of a standard browser is when visual tricks (e.g., layout tables, frames) or embedded non-HTML scripts or files (e.g., Flash) are used. In the former case, changing font size might alter the layout of the information. In the latter case, changing font size or colour scheme might not have any effect on the presentation.

4.2. Transcoding proxy servers

A proxy server is a server that sits between the users' machine and the web page server and acts as an intermediary. The user's requests are routed through the proxy server to the actual server and the information provided by the web page server is routed to the user via the proxy server. If the proxy server changes the HTML codes provided by the web server en route back to the user, it is referred to as a *transcoding proxy server*. Hypertext links from the transcoded content can be altered to reference the transcoding proxy again, which fetches the next page and so on. Most proxy services allow users to set up their own preferences.

Proxy servers are traditionally employed by users of limited browsing devices, such as mobile telephones and other consumer hand-held devices with limited screen sizes, processing and memory restrictions and limits on support on embedded content. These cannot handle fully featured web pages and relay on proxies called gateways to transcode the standard web pages into the format is supported by the device (Kennel et al., 1996).

In addition to pure appearance settings, the transcoding proxy can effect changes to how an HTML document is presented, in a way that cannot be accomplished by standard browsers. For example, a proxy server might convert every link that utilises an image to a plain text one using the ALT text for the image. Similarly, frames and tables can be stripped from the code to make the structure of the page simpler. Changes can be made that alter the underlying structure or code of the HTML document, rather than simply redefine how the content is displayed, e.g., by moving navigation bar to the end of the page so that when a page has to be presented linearly, the user can get straight to the content of interest.

Proxies have several strengths. Firstly, although in theory users' settings can override those of the web designers', this is not always honoured: using a proxy server ensures that the presentation preferences of the user prevail. Secondly, a transcoding proxy server is platform-independent as far as the user is concerned because it runs remotely and returns standard HTML, the browser can be operating on any platform or device that supports the HTML used. This approach also eliminates the requirement for users to install an application in the local machine (which helps users without administrator privilege, such as users accessing computer from a common room).

Proxy server facilitates more fundamentally different ways of supporting accessibility, such as cooperation and collaboration between users, the referencing of external databases for additional accessibility information and page-by-page customisation or scripting. For example, an early proxy server called the Shodouka service allows Japanese characters to be displayed in browser clients without Japanese language support (Shodouka, 2004). Japanese characters are converted into images displaying the Japanese glyphs, and links are transformed into references to the proxy, so no changes at the client's side were required.

Kennel et al. developed a proxy server called 'WAB: W3-access for blind and visually impaired computer users' (Kennel et al., 1996). WAB makes significant changes to the HTML of a web page in an attempt to make it more accessible. A list of all the hypertext links in the page is appended to the bottom of the page, and a link to the list is added to the top. A list of any items marked up as headers (‘h1’, ‘h2’, etc.) is added to the top of the document and the list links directly to the headers in the text. Finally, page components such as links, images and form elements are labelled with text so that a screen reader can identify them even if it does not support the items. Even though WAB was originally designed for visually impaired people, this proxy server can potentially help older users. The changes WAB made address the lack of semantic and navigation information in web pages, and are therefore helpful for users’ location awareness and orientation.

The British Broadcasting Corporation (BBC) provides a proxy server for its website called ‘Betsie’ (BBC Education, 2005). The user does not have to amend their proxy settings; simply use a variation on the BBC web address. The BBC homepage is reformatted and altered by Betsie, which presents text in large font (helpful for general failing vision in older people) in yellow on a black background (good for sensitivity to glare experienced by older people) by default. It also allows users to set preferences for colour and font and provides a version for mobile devices (or small screen browsers, in general). Inaccessible features, like frames and tables, are altered into linear presentation mark-up and JavaScript is removed. Embedded audio content, which is accessible to users with the appropriate common media plug-in, is retained. Most significantly because the system is intended to be used for accessing the BBC website only, and the structure of these pages is largely a fixed and known quantity to the Betsie developers, changes can be made to the order of the contents of each web page, such as placing the standard navigation bars at the end rather than beginning of the content.

The ALT Server from the world wide web Consortium (W3C) (Dardailler, 2004) was intended to provide a solution to the problem of inaccessible content. Client browsers who encounter content (images) without accessibility information can refer to the ALT server for the information and receive either an automatically extracted response or accessibility information provided by a human annotator. The ALTifier project (Vorburger, 1999) intended to provide a similar automated mechanism. The transcoding proxy developed by Takagi and Asakawa (2000) relied upon human annotation of web pages to provide information on inaccessible content and web page structure. Fairweather et al. (2002) describe a system that represents HTML documents according to a set of user preferences held on the proxy server. All of these systems expose a fundamental problem with proxy servers. They rely upon the provision of an accessibility service by the proxy provider. This is especially a problem for systems which assume some annotation or page-specific configuration must be provided (i.e., created and maintained by human effort), or which perform transformations based on an assumed constant structure of web pages (which break when the pages change and need to be monitored and updated).

Using a proxy server requires that the user can cause their HTML transfers to go through it. Some provide a web interface, where the user enters the page they want to fetch into a web page for the proxy server. The HTML of the fetched web page can be changed to refer back to the proxy server, so following links will also be routed through the server. This requires nothing to be installed or amended on the user’s machine: all the user needs is the web address of the proxy server website. This has a great advantage the user can access the proxy server from any place with Internet connection. The disadvantage is that the operation of the proxy server is not transparent.

An alternative approach requires configuring the browser to route requests through the proxy (or having the user's network route requests through a proxy automatically, depending on the user's environment). This has the advantage of making access transparent—the user uses his/her web browser in the normal way, but introduces a disadvantage namely that some re-configuration of the user's web access is required. This can be trivial, changing a setting in the browser, or impossible, if the user is on a network and their traffic is routed according to the needs of the network, as is typical in educational or workplace arrangements.

Transcoding proxy servers appear to offer a reasonable way to presenting information according to a user's needs, but they do have some significant drawbacks. The most significant drawback relates to the second-hand nature of the HTML document transmission. The proxy may not support page features, such as client redirects, and many websites assume the direct use of a client and provide functionality based on this assumption (for example, the use of cookies to track users and provide password-authenticated services to them). Java is unusable through transcoding proxies, since the changes in the HTML code required break the Java class security model. Finally, the processing performed by the proxy server requires the server to have full access to the content of the HTML document, which can render unusable secure transmission protocols such as HTTPS that are used in e-commerce and for restricted access to online resources. The secure protocols encrypt the pages in transit, and the proxy server therefore cannot access and amend them.

4.3. Application adaptors/mediators

A proxy server is positioned between the server and the user's client, transforming HTML documents before they reach the browser. An application adaptor or mediator is positioned in front of the browser between the browser and the user. It performs the transformation of the HTML document after parsing (and rendering) by the browser.

A mediator usually linearises text and provides user control over how the text is visually presented. This means that a visually impaired user who has functional vision can control the size, colour and font in which the text is displayed. Because it linearises the web page, the user only has to scroll vertically (studies with older web browsers indicated that they disliked horizontal scrolling). Moreover, linearisation and the stripping of extraneous images can greatly simplify the web page, benefiting users with cognitive impairment.

A mediator usually runs simultaneously with Internet Explorer so the user can switch between the mediator and the browser. Aside from the accessible text presentation, the applications provide functions to help the user, such as bringing up lists of links or frames or providing a cell-by-cell mode for exploring HTML tables. Examples of mediators are WebWizard (Baum, 2004), WebFormator (Audiodata, 2004), Webbie (King et al., 2004) and Web Adaptation Technology (Hanson, 2004). The last one is a mediator specifically designed to accommodate the needs of older users.

Mediators benefit from using the standard web browser, which remains as a fallback option for the user if they need it (and can use it) and guarantees the maximum compliance with the de facto web standard. Internet Explorer makes available a parsed, hierarchically structured representation of the loaded HTML document, the W3C Document Object Model (DOM) (W3C, 2004b). This considerably reduces the development and support load on the mediator developer, who is insulated from parsing and supporting new HTML developments. Instead, the developer can take advantage of being an application, and provide functions and features beyond those possible with simple representation of the web page content. The drawback is that this requires installation of the mediator on the local machine, which may not be possible for the user, as not all users have administrator privilege or feel confident installing software.

4.4. Assistive technology

According to the Section 508 Standards, assistive technology (AT) can be defined as “any item, piece of equipment, or system, whether acquired commercially, modified, or customised, that is commonly used to increase, maintain, or improve functional capabilities of individuals with disabilities” (Center for IT Accommodation, 1998).

Using AT on the top of a standard browser has distinct advantages. It is the default browsing experience, so supports all websites, has a full range of functionality, and generally requires little or no configuration or installation by the user. Users can use the same software as colleagues and friends, which reassure them that they have access to the same content. Support for the browser and any related problems is easy to find.

AT allows a great flexibility for personalising how a web page is viewed. Users can simply install the necessary system that will match their requirements, e.g., a screen magnifier/reader to enlarge and read out screen information, text summarisation software to simplify the text, a large keyboard or voice recognition software to address motor impairment, etc. Most are available for free or at low cost.

The problem with traditional AT is that they were designed to handle a single disability. For example, basic screen magnification software magnifies the whole screen, which might be problematic for older users for several reasons. Firstly and most importantly, the distribution of information over a large screen area may require scanning and tracking, and older users (especially ones with reduced spatial abilities) may get lost or miss information. These problems must be set against the ability to use a mouse pointer and to take advantage of website functionality such as scripting and non-HTML content such as Flash or Java applets. Secondly, some AT products are difficult to learn and use; hence, older people with declined cognition might find it discouraging to adopt this approach.

4.5. Special purpose browsers

A dedicated special purpose web browser is a stand-alone application that is responsible for presenting HTML documents to the user. It requires installation on the user’s machine and the developer must take responsibility for its support and function, for instance keeping it up-to-date with HTML developments. This can be ameliorated by using off-the-shelf software engineering components, which are common for Internet applications. For example, Microsoft Windows programs can use an internal instance of Internet Explorer to get and parse web pages, handling the network and transfer protocols. A similar component is available for the Mozilla browser.

The great advantage of creating a special purpose browser is that it affords the greatest number of presentations and technological solutions. The developer has the maximum flexibility in creating the interface to HTML documents and reshaping the HTML documents themselves. For example, a developer might be able to handle embedded non-HTML content by calling another application or convey table layout by manipulating the origin of spoken text around the user using two-dimensional sound. Special purpose browsers allow different strategies and functions to be tried.

Special purpose browsers can self-voice or provide an accessible interface. Self-voicing applications have more options, for example reading body text and link text in different voices to differentiate them. However, they do require users to stop using their familiar interface (e.g., IE) and learn to use the new browser. This does not take best advantage of user's familiarity and existing mental model.

The special purpose browser approach is exemplified by the Home Page Reader (IBM, 2004). This is a self-voicing application that provides a complete audio interface to web pages and is based on work by Asakawa and Itoh (1998). It breaks down a web page into a linear array of items, which can be moved through by the user and are voiced as they are encountered. The user can select the granularity of the array, from letters upwards. Links are presented in a different voice (e.g., voice with lower pitch, good for addressing presbyacusis) to distinguish them: this kind of approach is an advantage of developing a self-voicing application. The default setting presents the page as an array of structural mark-up elements: list items, headers, and paragraphs. This is a good level of resolution for well-constructed web pages, since it allows the user to immediately access the document via a reasonable number of segments that reflect the semantic meaning known to the document author. Less well-designed web pages where mark-up is used for visual presentation are presented less successfully, since there is less scope for inferring the semantic meaning of particular items of content from the mark-up.

Other dedicated web browsers include BrookesTalk (Zajicek, 2000). This is another self-voicing web browser that employs a very similar approach to Home Page Reader. In addition, it attempts to address the problem of communicating to the end user the structure of a page by providing summaries and keywords obtained by analysing the structure of the HTML code. The paper reported that although the speaking front end improved usability of the system, it also introduced more human–computer interface design issues concerning the length and structure of speech output and functionality of systems for older visually impaired users with poor memory.

The talking web browser developed by Asakawa et al. (2002) focuses on the problem of communicating visual web page structure to the user. It utilised a number of different auditory and tactile interfaces to communicate structural information derived from analysis of the rendering of the HTML of a web page in a visual browser. Assuming that visual users used grouping of similar elements as a vital part of understanding web page structure (e.g. 'those link buttons make up a navigation bar') Asakawa et al.'s system attempted to group HTML elements by colour, area and border, identify items of emphasis, and communicate the resulting groups using background music and tactile output. Individual components of the page, such as text or buttons, were communicated with auditory icons and earcons. Emphasis was communicated through bell sounds. Results indicated that the indication of emphasis was well received: it may be that this is because it successfully communicated important semantic information about the page.

5. A pilot study: testing various instruments

Even though the various instruments presented in Section 4 are theoretically useful for older web browsers, there is a need to investigate whether in practice older users can utilise these instruments. For this purpose, five older web browsers (aged 56–62 years old, mean = 59.8 years, S.D. = 2.68 years, 3 females/2 males) were asked to evaluate them. These five persons are regular web browsers. In the month prior to the case study, they browsed the web for at least 3 h per week. All had browsed the web for more than 1 year. One had built his own personal web page using Microsoft FrontPage. None had ever personalised the web page viewing, and none had ever used AT. All wear bifocal glasses but none are aware of any cognitive or motor impairment.

The experimenter was allocated a classroom in a computer centre of an organisation attended by the participants. The participants were given lectures, complemented with demonstration and hands-on training on personalisation using various instruments. A paper manual was distributed after class, and participants were asked to practise for 30 min everyday, using different instruments, during the following week. The instruments used are:

- Access Gateway, a proxy server that was originally designed for users with low vision and is currently hosted by http://www.accu.org. This proxy server allows users to customise practically any aspects of web page presentation, from basic colour changing function to more advanced functions such as how frames, scripts, applets and tables should be presented (Brown and Robinson, 2001).
- Webbie mediator, originally designed to work with screen readers, but has evolved to accommodate various impairments (King et al., 2004).
- Dual screen reader and magnifier, assistive software system that can magnify the whole screen or just a part of the screen, invert colour, smooth out jagged edges of magnified text, etc. It also speaks out the text (Evans and Blenkhorn, 2003).
- Overriding the original CSS with a given CSS, which is the CSS used to set the layout of the W3C's pages which provides as a guideline for authors test their browser's conformance to the CSS1 specification (W3C, 2004a).
- Overriding the original CSS with a CSS that the participants have to create using a given application: 'Focus on CSS', a GUI-based CSS modifier (Ahmed, 2005).

Each participant was given a different instrument sequence (e.g., Participant A needs to practise using proxy on Monday, AT on Tuesday, etc). The participants were warned not to use any instrument outside the allocated time.

A week later, the experimenter returned to the classroom and tested each participant separately. The participants were asked to personalise the homepage of a Website that was considered to violate accessibility and usability principles of accessibility, navigation and use of graphics (termed 'web blooper'): http://www.spool.com.au (Alexander, 2001). Fig. 1a–d depicts the different representations of the homepage. The page with its CSS

Fig. 1. (a) The original homepage. (b) The CSS-overridden page with a given CSS. (c) The page as displayed by the proxy server. (d) The page as displayed by Webbie.

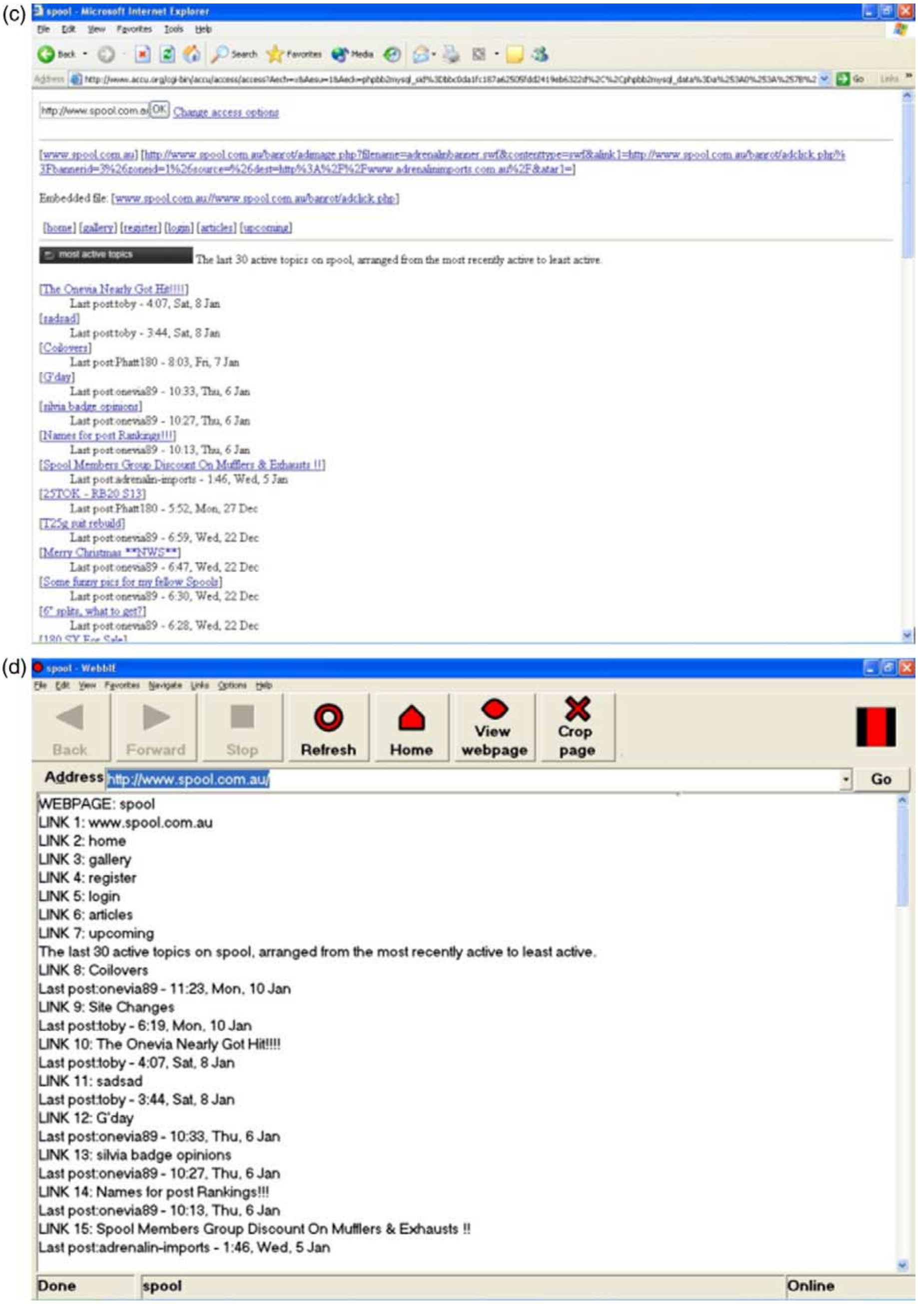

Fig. 1 (*continued*)

overridden by user-created CSS is not presented because it differs from user to user. The magnified homepage cannot be screen-captured due to the nature of the operation of a screen magnifier.

All participants were able to personalise the given homepage using each instrument within the time limit (set at 5 s). A thinking aloud protocol was used to extract users' opinions and problems. Thinking aloud is a well-established usability technique that is very flexible as it can be applied in laboratory setting as well as in the field (Nielsen et al., 2002). Some of the comments the participants made are:

> I don't see much difference between pages presented by proxy and by Webbie.

> I don't like proxy and Webbie, they remove the pictures.

> I don't like screen magnifier, it is difficult to find my way. I like the voice, though. It would be good to have the voice without the magnifier.

> I don't think creating my own CSS was necessary. The CSS you gave is excellent.

Participants were also asked to navigate the personalised pages and to comment on how easy it was to orientate and find their way around. Again, none commented during the navigation process, but once they stopped navigating, most of them made comments. Some of these comments are:

> I don't like navigating pages presented by proxy and Webbie, they are too different from the original one.

> I can't navigate magnified pages. I don't know where I am even in the page, let alone across pages.

> I don't think navigating the original page was any more difficult than navigating in any other modes.

After the session finishes, the participants were asked which instrument they preferred and why. All of them preferred personalising pages using a given CSS as it was the instrument that *preserves the original layout most faithfully—just making it easier to read*, *requires the least effort*, *easiest to navigate* and *easiest to understand how it works*. They dislike the screen magnifier/reader the most (four participants), but three mentioned that they liked the *voice*. However, it should be noted that all participants have corrected vision; therefore, they do not naturally require screen magnification. One participant found that setting the magnification to 1 provides the best compromise as it still provides the voice but does not magnify the page.

6. A user study of goal-directed web browsing using various personalisation instruments

The pilot study provides a glimpse of the usefulness of the various personalisation approaches. In this section, a larger user study with objective measures of performance is described. Sixteen older web users who did not participate in the pilot study were given a series of browsing tasks (mean age = 60.4, S.D. = 3.52 years; mean Internet experience = 18.8, S.D. = 6.48 months, mean frequency of Internet use = 6.6, S.D. = 2.36 h per week; 9 females, 7 males). They are graduates from computer classes of the computer centre attended by the pilot study participants. None had ever personalised the web page viewing, and none had ever used AT. All but three wear bifocal glasses. Six experienced occasional joint pain (two have mild arthritis). Two use walking sticks but none use wheelchair. Eight complained that they forgot more than when they were younger but none was diagnosed with memory-related illness. All of them rated their health condition as either average (6 participants) or good (10 participants).

Eight websites with the lowest compliant scores when evaluated using 'senior-friendly' guidelines published by the National Institute of Aging (Hart, 2004) were used as stimulus. Those websites are: http://pacesaver.com, http://go60.com, http://grandtimes.com, http://seniors-place.com, http://seniorsurfers.org, http://geriquest.com, http://KCElderlaw.com and http://seniorresource.com. The study was performed in the classroom where the pilot study was conducted. A Pentium M 1.5 MHz laptop running Windows XP Home edition with 15″ screen set at 1024×768 pixels and equipped with an external mouse was used. Internet Explorer v. 6.0 was used as the browser.

Each participant performed the study independently. The session started with a demonstration, followed by 5-min practice for each personalisation instrument (mediator, AT with 2× magnification, proxy, and standard browser with accessible CSS). The participants were then given a set of eight 3″×5″ index cards, each containing the URL they needed to type manually, the personalisation instrument, and the information to look for. The timer started when the page loaded. Two websites were accessed using each instrument to improve reliability. When the participants were satisfied that they found the right page, they clicked a button marked 'Found' (to stop the timer). The website-instrument pairing and the order the sites presented were randomised. The target information was carefully chosen to always be located at a third-level page (to allow the browsing times of the three pages to be averaged, again to improve reliability). The participants were free to take any break between tasks. After the participants finished the browsing tasks, a debriefing interview was conducted.

6.1. Results

The time stamps were captured from the server logs. For this study, the performance time calculation can be illustrated as follows.

Webbie was used to access Grandtimes.com and KCElderlaw.com by Participant A. She needed 36 s to find the answer in Grandtimes.com and 45 s to find the answer in KCElderlaw.com. Participant A's Webbie performance is the average of the two times divided by three (as she looked at three pages to find the answer):

$$\frac{(36+45)}{2}\times\frac{1}{3}=13.5\ \text{s}$$

Only successful direct paths were included, i.e., the tasks where the participants could not find the answer (3 cases) or ones where the participants had to click the back button (2 cases)

Table 1
Participants' performance times by instrument

Participant	Mediator	Proxy	AT	CSS
1	11.5	13.3	16.7	14.3
2	20.1	18.2	22.7	12.6
3	20.6	19.1	23.4	16
4	18.4	17.1	15.5	9.8
5	11.1	18.8	18.6	11
6	16.9	17.4	24	12.4
7	11.8	17.2	23.1	15.9
8	13.5	13.1	23	19
9	14.3	18.7	19.7	15.3
10	15.7	17.8	18.4	14.5
11	16.2	14.9	20.1	10.9
12	12.2	10.8	22.8	15.8
13	12.9	16	15.7	13.9
14	14.9	14.7	23.1	16.6
15	13.1	16	17.2	14.4
16	17.7	13.4	21.2	17.2
Mean	15.1	16.0	20.3	14.4
S.D.	3.03	2.45	2.97	2.50

were disregarded. Table 1 lists the performance times for all 16 participants for each instrument.

Pairwise comparisons (t-tests) revealed that the average time of browsing using the assistive technology were significantly longer ($p \leq 0.05$) than browsing using other instruments. The average times of browsing using Webbie, proxy and standard browser were not significantly different.

After the browsing session, the participants were interviewed to gain insight on their preferences and causes of problems. Similar comments to those expressed in the pilot study were noted. Fourteen participants stated that using a standard browser with a given CSS as their most favourite personalisation instrument. Two preferred using the given proxy server. The least favoured instrument for all participants was the assistive technology. When asked to describe problems they experienced during the browsing tasks, most participants described their problems orientating when using the magnifier.

7. Concluding remarks

It is clear that there are a number of instruments to personalising web pages for older people in a way that addresses the problem of functional impairments brought on by the ageing process. Many issues can be addressed through good website design and guidelines. Nevertheless, one size does not fit all and whilst good practice in web design can assist users view and navigate, it does not remove the need to address more severe and multiple impairments through further accommodation.

One important trade-off of personalisation instrument is the demands they place on the end user (or those supporting the end user) and the demands they place on the developer (or those implementing or providing the system to end users). These demands include:

- Support and intervention requirements. If an instrument requires skilled and constant development or input, it will succeed only with great and consistent commitment. This is a significant problem for scripted proxies and dedicated alternative browsers, where an agency is responsible for updating scripts or code on a regular basis to handle changes in websites or web technology.
- The extent to which the user must be in control of the setting and installation and understand how the personalised page works. Does the user have to change settings? Does the user have to install something, which requires some administrator privileges? The more demands an instrument makes of a user, or the more is expected of it, the more powerful can be the instrument but the more obstacles will exist to having it adopted. Users may be unable to install software, or be unwilling or unable to change configuration or stray from their tried and tested solutions. Relying on working with default, omnipresent browsers such as Internet Explorer may be better approach.

A second trade-off occurs between faithful representation of the original content and layout and users' impairments. For most older users, instruments that can make a page more readable and easily navigable, while at the same time preserving the original layout and content, are preferable. However, when impairments become severe and users have no choice but to rely on magnified and read-out information, they might be more receptive towards simplified and alternative presentation.

The paper sets out to investigate the usefulness of various personalisation techniques to help older people use the web more effectively. The study revealed that older web users were able to use these various instruments with high rate of success (only 5 out of 40 cases were unsuccessful). They were also able to do this within 5 s. In terms of preference, our participants prefer the instrument that best preserves the original layout while requiring the least effort (i.e., using a standard browser and overriding the site's CSS with a readily available one) and dislike the most the instrument that hampers their orientation. This can be a useful piece of information for developers of web personalisation instruments for older people.

There are some limitations of the reported user study. For example, this study is a snapshot study, which unavoidably cannot capture the shift in pattern and preference over time. The study also involves only the younger-old group with mild visual impairment. At the moment, a follow-up longitudinal study is being designed.

References

Ahmed, Y., 2005. Focus on CSS. Available from: http://www.yehiaeg.com/focusoncss/desc.php.

Alexander, D., 2001. Web Blooper Report—Site: Spool. Available from: http://deyalexander.com/blooper/report.php?id=65.

Asakawa, C., Itoh, T., 1998. User interface of a home page reader. Proceedings of the Third International ACM Conference on Assistive Technologies, January 1998, Marina del Rey, USA. ACM Press, Toronto, pp. 149–156.

Asakawa, C., Takagi, H., Ino, S., Ifukube, T., 2002. Auditory and tactile interfaces for representing the visual effects on the web. Proceedings of the Fifth International ACM Conference on Assistive Technologies, Edinburgh, Scotland, UK, July 2002. ACM Press, Toronto, pp. 65–72.

Audiodata, 2004. WebFormator. Available from http://www.Webformator.com/index.html.

Baum, 2004. WebWizard. Available from: http://www.baum.de/English/Webwizard.htm.

BBC Education, 2005. Betsie Home Page. Available from: http://www.bbc.co.uk/education/betsie/.

BBC News, 2002. Elderly Take Up Net Surfing, May 10. Available from: http://news.bbc.co.uk/1/hi/sci/tech/1977823.stm.

Brandeis University, 1998. Older adults' speech-processing difficulties may stem from 'fast, noisy talk,' not deafness. Science Daily, October. Available from: http://www.sciencedaily.com/releases/1998/10/981023073930.htm.

Brown, S.B., Robinson, P., 2001. A world wide web mediator for users with low visions. Presented at the Workshop of CHI'01, Seattle, Washington, US, 31 March–5 April 2001.

Byrne, M.D., 1996. A computational theory of working memory. Proceedings of ACM Conference on Human Factors in Computing Systems (CHI'96), Vancouver, Canada, pp. 31–32.

Center for IT Accommodation, Section 508 Standards, 1998. Available from: http://www.section508.gov/index.cfm?FuseAction=Content&ID=12.

Capitani, E., Della, S.S., Lucchelli, F., Soave, P., Spinnler, H., 1988. Perceptual attention in aging and dementia measured by Gottschaldt's hidden figures text. J. Gerontol. Psychol. Sci. 43, 157–163.

Christopher, P., 1999. Older Adults—Special Considerations for Special People. Available from: http://www.gsu.edu/~mstswh/courses/it7000/papers/newpage31.htm.

CNET, 2003. Internet Explorer 95.3, Mozilla 0.4. Available from: http://news.com.com/2100-1023-938784.html.

Dardailler, D., 2004. The ALT Server. Available from: http://www.w3.org/WAI/altserv.htm.

Edwards, R., Englehardt, K.G., 1989. Microprocessor-based innovations and older individuals: AARP survey results and their implications for service robotics. Int. J. Technol. Aging 2, 56–76.

Ellis, R.D., Kurniawan, S.H., 2000. Increasing the usability of online information for older users: a case study in participatory design. Int. J. Hum. Comput. Interact. 2, 263–276.

Evans, D.G., Blenkhorn, P.L., 2003. Architectures of assistive software applications for windows-based computers. J. Comput. Netw. Appl. 26, 213–228.

Fairweather, P.G., Hanson, V.L., Detweiler, S.R., Schwerdtfeger, R.S., 2002. From assistive technology to a web accessibility service. Proceedings of the Fifth International ACM Conference on Assistive Technologies, Edinburgh, UK, July 2002. ACM Press, Toronto, pp. 4–8.

Hanson, V.L., 2004. The user experience: designs and adaptations. Proceedings of the International Cross-Disciplinary Workshop on Web Accessibility, New York, USA, May 2004. ACM Press, Toronto, pp. 1–11.

Hart, T.A., 2004. Evaluation of websites for older adults: how "senior-friendly" are they? Usability News 6, 1. Available from: http://psychology.wichita.edu/surl/usabilitynews/61/older_adults.htm.

Hawthorn, D., 2000. Possible implications of aging for interface designers. Interact. Comput. 12, 507–528.

IBM, 2004. IBM Home Page Reader 3.04. Available from: http://www-306.ibm.com/able/solution_offerings/hpr.html.

Jagacinski, R.J., Liao, M.J., Fayyad, E.A., 1995. Generalized slowing in sinusoidal tracking in older adults. Psychol. Aging 9, 103–112.

Jeffrey, S., 2003. Over 60s reach for the mouse. Guardian Unlimited, July 8. Available from: http://www.guardian.co.uk/uk_news/story/0,994112,00.html.

Kennel, A., Perrochon, L., Darvishi, A., 1996. Wab: world-wide-web access for blind and visually-impaired computer users. ACM SIGCAPH Bull. 55, 10–15.

King, A., Evans, D.G., Blenkhorn, P.L., 2004. WebbIE, a web browser for visually impaired people. Proceedings of the Second CWUAAT, Cambridge, UK, pp. 35–44.

Krampe, R.T., Ericsson, K.A., 1996. Maintaining excellence: deliberate practice and elite performance in young and older pianists. J. Exp. Psychol. General 125, 331–359.

Microsoft, 1999. Effective Web Design Considerations for Older Adults. Available from: http://www.microsoft.com/seniors/default.asp.

Nielsen, J., Clemmensen, T., Yssing, C., 2002. Getting access to what goes on in people's heads?: reflections on the think-aloud technique. Proceedings of the Second Nordic Conference on Human–Computer Interaction, Aarhus, Denmark, October 2002. ACM Press, Toronto, pp. 101–110.

Saczynski, J.S., Rebok, J.W., 2004. Strategies for memory improvement in older adults. Top. Adv. Practice Nursing 4 (1). Available from: http://www.medscape.com/viewarticle/465740.

Salthouse, T.A., 1991. Theoretical Perspectives on Cognitive Aging. Lawrence Erlbaum Associates, Hillsdale, USA.

Shodouka, 2004. Available from: http://sklab-www.pi.titech.ac.jp/~supoj/supoj/shodouka.html.

Straub, K., Weinschenk, S., 2003. The gradual graying of the internet. UI Design Update Newsletter, June. Available from: http://www.humanfactors.com/downloads/jun03.asp.

Takagi, H., Asakawa, C., 2000. Transcoding proxy for nonvisual web access. Proceedings of the Fourth International ACM Conference on Assistive Technologies, November 2000, Arlington, Virginia, USA. ACM Press, Toronto, pp. 164–171.

Vorburger, M., 1999. ALTifier Web Accessibility Enhancement Tool. Available from: http://www.vorburger.ch/projects/alt/.

Walker, N., Philbin, D.A., Fisk, A.D., 1997. Age-related differences in movement control: adjusting submovement structure to optimize performance. J. Gerontol. Psychol. Sci. 52B (1), 40–52.

W3C, 2004a. CSS1 Test Suite. Available from: http://www.w3.org/style/CSS/Test/CSS1/current.

W3C, 2004b. W3C Document Object Model. Available from: http://www.w3.org/DOM/.

Zajicek, M., 2000. Interface support for elderly people with impaired sight and memory. Proceedings of the Sixth ERCIM Workshop "User Interfaces for All", Florence, Italy, 2000, pp. 177–182.

Zhao, H., 2001. Universal Usability Web Design Guidelines for the Elderly, Age 65 and Older, April. Available from: http://www.otal.umd.edu/uupractice/elderly/.