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Barriers Faced by Older Users On Static Web Pages

Criteria Used In The Barrier Walkthrough Method

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Demographics indicate that populations are ageing and this trend is reflected in the number of older people now using the Web. However, while the number of older Web users increases, the opportunity to use the Web to its full potential is hindered through the combinatorial effects of ageing. To assist designers with the creation of accessible Websites, accessibility guidelines have been developed. While these guidelines have provided a basis for accessible design, Website evaluation methods assume that all accessibility guidelines must be met. This can be challenging as different user groups will have different requirements that can sometimes be in conflict with each other. This is especially the case of older users who often have a number of mild impairments.

The Barrier Walkthrough (BW) method addresses this issue by applying guidelines to different user categories. The BW method has so far investigated barriers for user groups such as blind persons; motor impaired users; and mobile phone users. Through an analysis of existing guidelines and literature surrounding the effects of ageing, we present a list of barriers faced by older users of the Web. These barriers can be used in conjunction with the BW method to assess the impact a Web page has on older users and their ability to interact with the content effectively.

HCW

Human Centred Web

SCWeb2

The Web is changing. The much vaunted Web 2.0 sees once static pages evolving into hybrid applications. Content which was once simple to surf is now becoming increasingly complicated due to the many components "dotted" throughout the page. The information overload and visual complexity is significant and without a full understanding of the interaction of older people with Web 2.0 technologies the Web will rapidly become unable to support their interaction needs. The objective of Senior Citizens On The Web 2.0 (SCWeb2) is to create a cognitive model of ageing users' Web 2.0 interactivity and suggest interventions to overcome their interactivity problems. The SCWeb2 Web pages may be found at `http://hcw.cs.manchester.ac.uk/research/scweb2/`.

RIAM

The aim of the RIAM project is to investigate ways in which to integrate, to mutual advantage, research into the Accessible and Mobile World Wide Webs (Web), to develop a common infrastructure, and to validate this infrastructure using existing Web documents and Mobile client simulators. The RIAM Web pages may be found at `http://hcw.cs.manchester.ac.uk/research/riam/`.

Reports

This report is in the series of HCW SCWeb2 and HCW RIAM technical reports. Other reports in these series may be found in our data repository at `http://hcw-eprints.cs.manchester.ac.uk/view/subjects/scweb2.html` and `http://hcw-eprints.cs.manchester.ac.uk/view/subjects/riam.html` respectively. Reports from other Human Centred Web projects are also available at `http://hcw-eprints.cs.manchester.ac.uk/`.

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1 Introduction

The number of the worlds older population is expected to exceed one billion by 2020 with one in five people over the age of 65 being disabled. Population demographics indicate that our populations are ageing across the board and this trend is reflected in the number of older people now using the Web. A recent survey by Lenhart [2009] found that 35% of adult Internet users visited social network sites. While this was less than the 65% of teens that used social networking Websites, it represented a larger number as adults make up a higher proportion of the population. In 2005 only 8% of adult Internet users visited social network sites, indicating that adults are increasingly using online resources and participating in the online community.

While the number of older Web users increases, the opportunity to use the Web to its full potential is hindered through the combinatorial effects of ageing. The associated age-related changes in attention, cognition, and behaviour all effect how users interact with the Web. As people age, they experience a degenerative effect which can include varying degrees of reduced vision, hearing loss, psychomotor impairments, reduced attention and memory ability and reduced learning abilities [Kurniawan 2008]. These tend not to be extreme forms of disability but slight and unnoticeable forms of functional impairment. However, older people usually have multiple impairments that have an accumulative effect on their ability [Kurniawan & Zaphiris 2005]. Mortensen & Møller [2007], for example, reported that between 3.8% and 6.8% of people over the age of 80 suffer from high levels of both vision and hearing loss. It is these combinations of impairment that makes designing technology and Web applications for elderly users challenging for designers and developers.

To aid designers with the creation of their Websites, accessibility guidelines have been developed. Guidelines, such as the Core Techniques for Web Content Accessibility Guidelines (WCAG) [Caldwell *et al.* 2008] provide advice on how to design and test Websites to ensure that content is accessible to all users. While these guidelines have provided a solid basis for the implementation of accessible Web design, they are not free from problems [Kelly *et al.* 2005]. One issue is that there seems to be a misconception that from a Web perspective, disability and accessibility refer to visual impairments. This is not the case and an approach is required that does not split people into a binary disability / ability group [Milne *et al.* 2005]. Indeed, older users tend to have multiple impairments that have an accumulative effect and therefore do not easily fit into a distinct disability group.

Secondly, Website evaluation methodologies assume that all accessibility guidelines must be met in order to achieve "Universal Accessibility". This can be challenging as different user groups will have different requirements that can sometimes be in conflict with each other. Furthermore, evaluators tend to check conformance to a guideline on the basis that an accessibility criteria as been met or not met. Evaluators typically do not take into account the severity that the problem will cause for the user [Yesilada *et al.* 2008].

The Barrier Walkthrough (BW) method goes some way towards addressing these issues by enabling guidelines to be applied to different user categories such as motor impairment; hearing impairment; low vision; blind; and cognitive impairment [Brajnik 2006]. The method allows evaluators to rate the severity of the barrier

that is being inspected. The evaluator, for example, can state that a missing `alt` attribute in an image is a severe barrier for visually impaired people using screen reader technology but a less severe barrier for people using screen magnifiers. Such an approach allows an appropriate context of the problems found to be made and can provide a more accurate level of accessibility of a Website for a given user group.

The BW method has so far investigated barriers for user groups such as blind persons; low-vision users of screen magnifiers; motor impaired users [Brajnik 2009] and mobile phone users [Yesilada *et al.* 2008]. Through an analysis of existing accessibility guidelines and literature surrounding the effects of ageing, we present a list of barriers faced by older users of the Web. These barriers can be used in conjunction with the BW method to assess the impact a Web page has on older users and their ability to interact with the content effectively.

2 Barrier Walkthrough Method

The barrier walkthrough (BW) method was first introduced in [Brajnik 2006] as an analytical technique based on heuristic walkthrough [Sears 1997]. An evaluator has to consider a number of predefined possible barriers which are interpretations and extensions of well known accessibility principles; they are assessed in a context so that appropriate conclusions about user effectiveness, productivity, satisfaction, and safety can be drawn, and severity scores can be derived. For the BW, context comprises user categories (like blind users), website usage scenarios (like using a given screen reader), and user goals (corresponding to use cases). An accessibility barrier is any condition that makes it difficult for people to achieve a goal when using the Website in the specified context. A barrier can be described in terms of: i) the user category involved; ii) the type of assistive technology being used; iii) the goal that is being hindered; iv) the features of the pages that raise the barrier; and v) further effects of the barrier on payoff functions. The BW prescribes that severity is graded on a 1–2–3 scale (minor, major, critical), and is a function of impact (the degree to which the user goal cannot be achieved within the considered context) and persistence (the number of times the barrier shows up while a user is trying to achieve that goal). Potential barriers to be considered are derived by interpretation of relevant guidelines and principles[1]; more details are available in [Brajnik 2009]. There are two major benefits of the BW compared to conformance review: by listing possible barriers grouped by user categories, evaluators are more constrained in determining whether the barrier actually occurs. Secondly, by forcing evaluators to consider usage scenarios, an appropriate context is available to them for rating severity of the problems found.

Experimental evaluations of the BW [Brajnik 2006] showed that it is more effective than conformance reviews in finding more severe problems and in reducing false positives; however, it is less effective in finding all the possible accessibility problems. Other studies showed how the BW can be used as a basis for measuring the accessibility level of a Website rather than measuring the conformance level [Brajnik & Lomuscio 2007].

[1] URL: `http://www.w3.org/TR/WAI-WEBCONTENT/`. Last accessed: 26th June 2009

3 Barriers Faced By Older Web Users

This section lists and explains a number of barriers that can be incorporated into the Barrier Walkthrough method to evaluate Web pages for their support of older Web users. These barriers are based on peer-reviewed publications that have focused on the effects of ageing and how the Web can be made more accessible to older users. In addition to the elderly specific guidelines, the barriers are also, where possible, related to the Web Content Accessibility Guidelines (WCAG) [Chisholm *et al.* 1999; Caldwell *et al.* 2008]. While these guidelines are not targeted specifically at older users, they are the de facto standard and used as a basis for a majority of the elderly specific guidelines found in the literature.

Each barrier is grouped based upon the four accessibility principles found in WCAG 2.0 [Caldwell *et al.* 2008]. These groups are Perceivable; Operable; Understandable; and Robust.

3.1 Perceivable Barriers

WCAG 2.0 defines the Perceivable Principle as: *"information and user interface components must be presentable to users in ways they can perceive."* [Caldwell *et al.* 2008]. For Web pages, this means that all content must be available to the user, regardless of any sensory impairment or the assistive technology that may be used to access the Website. The following barriers may hinder older users from perceiving information contained within the page.

3.1.1 High Colour Contrast

User:	Senior
Group:	Perceivable
Guideline:	Medicare Education [Holt 2000] National Institute of Ageing [Hodes & Lindberg 2002] Senior Surfers: 2 [Chadwick-Dias *et al.* 2007] SilverWeb: H8.3 [Zaphiris *et al.* 2007] Universal Usability Web Design For The Elderly [Zhao 2001] WCAG 1.0: 2.2 [Chisholm *et al.* 1999] WCAG 2.0: 1.4.1, 1.4.3, 1.4.6 [Caldwell *et al.* 2008]
Cause:	As people age, they experience varying degrees of reduced contrast sensitivity which reduces their ability to distinguish between similar colours. As a result text should be of a higher contrast to the background colour of the page to allow for users to read the text.
Failure Mode:	When users access pages that contains low contrast between page elements they will not be able to read the content easily.
Effect:	Reduced or complete loss of effectiveness when using the page.
Fix:	Ensure that there is a high contrast between elements of the page. Provide alternative style sheets that provide high contrast versions on the page.

Test: *Human*: Browse the page in monochrome to establish if the content is still legible. *Machine*: Use an automatic tool that can check the contrast levels between elements.

References: From the age of 40, contrast sensitivity declines. By the age of 80 contrast sensitivity can be reduced by up to 83% [Arch 2008]. In addition to this natural decline in contrast sensitivity, other conditions can cause a reduction in contrast. Glaucoma, for example, becomes more common as age increases with 1% of people over the age of 40 and 5% of people over the age of 65 being affected [RNIB 2008b]. Glaucoma results in subtle loss of contrast between objects and their backgrounds.

Cataracts are a clouding of the lens in the eye that can result in blurred vision [RNIB 2007]. Approximately 50% of Americans between the age of 65 and 74, and 70% over the age of 75 suffer from cataracts. This is because in a young person, the lens is clear but as people become older, the nucleus of the lens becomes a yellow / brown colour [Faye *et al.* 2009]. This results in a degradation of the person's visual acuity and contrast sensitivity [Chua *et al.* 2004] which can adversely affect the ability to distinguish between similar colours. It can also make blue, green and violet colours difficult to see [Spiezle & Shambaugh 2001]. Due to the results of age-related conditions, there is a need for strong contrast between elements on a page to cater for the mild visual impairments that are typical of the elderly [Newell *et al.* 2006].

3.1.2 Colour is Necessary

User: Senior

Group: Perceivable

Guideline: Medicare Education [Holt 2000]
National Institute of Ageing [Hodes & Lindberg 2002]
SilverWeb: H8.4 [Zaphiris *et al.* 2007]
Universal Usability Web Design For The Elderly [Zhao 2001]
WCAG 1.0: 2.1 [Chisholm *et al.* 1999]
WCAG 2.0: 1.4,1.4.1 [Caldwell *et al.* 2008]

Cause: The page contains material, such as text, images, background, and videos, where colour is used as the sole means to distinguish between two or more different information items. For example, indicating positive amounts using black and negative amounts using red in a table providing balance-sheet figures.

Failure Mode: The user would have no way to perceive any difference between the information items.

Effect: Reduction, also total lack, of effectiveness.

Fix: Use redundant means to distinguish between two information items and use typographic conventions that are based not only on colours, but have in addition an audio effect when read aloud. For example, use additional words or symbols and do not rely solely on a typographical effect such as boldface or italics.

Test: *Human*: Browse the page in monochrome to establish if the content is still legible. *Machine*: Use an automatic tool that can check the contrast levels between elements.

References: Due to the decline in vision, older users usually have problems with visual acuity, contrast discrimination and a reduction in the efficacy of parafoveal vision [Zhao 2001; Newell *et al.* 2006]. They can therefore have problems when accessing information that is solely encoded in colour. Kurniawan [2008] also notes that *"one of the most common changes in vision is caused by the yellowing of the lens due to discolouration of the eye's fluid... any colour blindness in the eye caused by glaucoma or general genetic colour blindness normally worsens due to decreased blood supply to the retina"*. Therefore, these make it difficult for older users to tell the difference between colours of similar hue or low contrast, making it difficult to differentiate information encoded solely in colour, especially those colours of similar hue or contrast.

3.1.3 Larger Font Size

User: Senior

Group: Perceivable

Guideline: Designing Web Sites for Older Users [Chisnell *et al.* 2004]
Medicare Education [Holt 2000]
National Institute of Ageing [Hodes & Lindberg 2002]
Senior Surfers: 1, 7 [Chadwick-Dias *et al.* 2007]
SilverWeb: H1.1, H9.6 [Zaphiris *et al.* 2007]
Universal Usability Web Design For The Elderly [Zhao 2001]
WCAG 1.0: 3.4 [Chisholm *et al.* 1999]
WCAG 2.0: 1.4.4, 1.4.8 [Caldwell *et al.* 2008]

Cause: As people age, they experience varying degrees of reduced vision which can affect their ability to read small sized text. Therefore text should be set at a size that is easy for people to read. Furthermore, as people age they can develop unsteady or arthritic hands that make precise mouse movements difficult. When hyperlinks are small, they require accurate mouse movements and clicks to activate the link.

Failure Mode: When users access pages that contain small text they will not be able to read the content easily and will have difficulty activating hyperlinks.

Effect: Reduced or complete loss of effectiveness when using the page.
Fix: Use larger font sizes, such as 12pt. In addition, provide the ability for users to easily increase the size of the text by providing an *"Increase Size"* link and using non-fixed size layouts so that increases in font size still maintains page legibility.
Test: *Human*: Test for clear font size of at least 12pt. Check to ensure that there is the ability to increase the font size easily and content is still legible when the font is increased.
References: As people age, they experience varying degrees of reduced vision [Kurniawan 2008; Fozard & Gorden-Salant 2001] with age-related macular degeneration being the most common form of severe sight loss in people aged over 50 [Bressler & Gills 2000]. There are two types of macular degeneration. The first, Dry Age-Related Macular Degeneration, is the most common form of the condition. It develops slowly causing gradual loss of a person's central vision. The second, Wet Age-Related Macular Degeneration, results in new blood vessels growing behind the retina. This causes bleeding and scarring, which can lead to sight loss [RNIB 2008a]. As a result of these age-related conditions, increasing text size can facilitate improving elderly users performance [Hartley 1994].

In addition to reduced vision, movement control becomes slower and more variable with age [Ketcham & Stelmach 2001] with older users sometimes having unsteady hands that make precise mouse movements difficult. Older users tend to pause as they move the cursor around and over the target link as they have difficulty reaching the target itself [Keates & Trewin 2005]. When hyperlinks are small, they require more accurate mouse movements and clicks to activate the target. This can be difficult for older users as they experience increased slip errors when clicking targets with a mouse [Smith *et al.* 1999; Moffatt & McGrenere 2007]. Increasing font size decreases erroneous clicks and increases the speed at which users can select the hyperlink [Nielsen 2002]. Indeed some studies have shown that increasing the size of text so that link targets are increased results in older users having similar performance rates to younger users [Fozard & Gorden-Salant 2001].

3.1.4 Complex Text

User: Senior
Group: Perceivable
Guideline: Medicare Education [Holt 2000]
SilverWeb: H5.1 [Zaphiris *et al.* 2007]
WCAG 1.0: 14.1, 4.2 [Chisholm *et al.* 1999]
WCAG 2.0: 3.1, 3.1.3, 3.1.5 [Caldwell *et al.* 2008]

Cause: The page contains text that is complex to read because of the complexity of the sentences, the structure of phrases or words; the text is ridden with acronyms and abbreviations; or because of spelling errors.

Failure Mode: The user will struggle to understand the content and be able to navigate through it.

Effect: Reduction, even total lack, of effectiveness. Significant reduction of productivity.

Fix: Simplify as much as possible the structure of sentences and the lexicon used. Avoid using jargon. Make sure there are no spelling errors. If possible provide an audio rendering of the text, with a narrating voice. If abbreviations or acronyms are included, always code them with the `<abbr>` or `<acronym>` tags. Provide a glossary in the Website with appropriate definitions of technical terms.

Test: *Human*: Examine content to determine if, given the subject matter, it is appropriate for older users.

References: Studies have shown that there is no significant difference in verbal speed and verbal fluency skills between young and old users [Czaja *et al.* 2001]. However, when a page contains jargon, older users can have problems in understanding and comprehending the language. A study conducted by Sloan & Dickinson [2006] found that older users could not access accessibility statements because of the language used. Similarly, Chadwick-Dias *et al.* [2003] demonstrated that older users had problems in understanding technical terms such as *"minimising a window"* or *"home link"*. As Newell *et al.* [2006] highlights, this is because older users are not familiar with the Internet world, and hence the established terminology has no meaning to them and is considered as a barrier. This assertion was supported by Chisnell *et al.* [2004] who shown that older users were not sure about IT specific terminology or words related to Web. It is therefore important to keep the terminology on a page as simple as possible. Furthermore, providing an online glossary of technical terms can be of assistance to older users as they process information more slowly than younger users [Hodes & Lindberg 2002].

3.1.5 Rich Images Lacking Equivalent Text

User: Senior

Group: Perceivable

Guideline: Medicare Education [Holt 2000]
National Institute of Ageing [Hodes & Lindberg 2002]
SilverWeb: H2.2 [Zaphiris *et al.* 2007]
Universal Usability Web Design For The Elderly [Zhao 2001]

WCAG 1.0: 1.1 [Chisholm *et al.* 1999]
WCAG 2.0: 1.1, 1.1.1 [Caldwell *et al.* 2008]

Cause: The page contains images that provide information, such as a diagram, histogram, picture, drawing, or a graph, but only in a graphical format with no equivalent textual description appears in the page. Older users might have problems in understanding the overall message given by the images, therefore they can use the provided alternative text to read and understand the role of that image. Furthermore, older users may use assistive technologies, such as screen readers, to access pages in audio. If the images do not have alternative text, then the assistive technologies will be unable to render the images in audio.

Failure Mode: Even if an older user perceives that there is an important image, they might not be able to perceive the information it contains. In addition they will spend time and effort trying to find out where in the page that information is contained.

Effect: Significant reduction of effectiveness; also user productivity can be reduced.

Fix: Add an equivalent textual description to the image by using the `alt` attribute of the `<img>` tag. If that is not sufficient, then use the `<object>` tag and specify the text in the content of the tag.

Test: *Machine*: Test to see if all images include alternative text attributes. *Human*: Check all alternative texts and ensure that they clearly describe all content and contexts of those images.

References: Vision decline is a commonly accepted physiological change that often arises during the normal ageing process [Kurniawan 2008]. This means that some older users might use assistive technologies such as screen readers. Rich images lacking equivalent text can therefore be problematic to those users [Nielsen 2002]. Furthermore, older users might have problems in understanding the overall message given by an image. Reading the alternative text will allow them to develop an understanding of what information the image is trying to convey.

3.1.6 Moving Content

User: Senior
Group: Perceivable
Guideline: Medicare Education [Holt 2000]
SilverWeb: H4.2 [Zaphiris *et al.* 2007]
WCAG 1.0: 7.3 [Chisholm *et al.* 1999]
WCAG 2.0: 2.2, 2.2.2 [Caldwell *et al.* 2008]

Cause: Images or text that move, for example running text, or animated GIFs.

Failure Mode: The user may not be able to perceive that the content has changed, they might be distracted from focusing on the main information or they might not be fast enough to interact with the content.

Effect: Reduction of effectiveness.

Fix: Avoid using moving content, and always give the user the flexibility to decide when to move on.

Test: *Human*: Ensure that the user is able to stop the moving content.

References: Ellis & Kurniawan [2000] indicate that fast-moving objects can cause problems to older users. Zhao [2001] and Groff *et al.* [1999] also note that blinking images and animation distract older users' attention from focusing on the main information. Furthermore, Zhao [2001] asserts that older users might not be fast enough to interact with moving objects.

3.2 Operable Barriers

WCAG 2.0 defines the Operable Principle as: *"user interface components and navigation must be operable"* [Caldwell *et al.* 2008]. For Web pages, this means that users must be able to operate all components of the Web page, including widgets and hyperlinks, regardless of any sensory impairment or the assistive technology that may be used to access the Website. The following barriers may hinder older users from operating content contained within the page.

3.2.1 Hyperlinks and Buttons Too Close to Each Other

User: Senior

Group: Operable

Guideline: Medicare Education [Holt 2000]
SilverWeb: H1.1 [Zaphiris *et al.* 2007]
WCAG 1.0: 10.5 [Chisholm *et al.* 1999]
Universal Usability Web Design For The Elderly [Zhao 2001]

Cause: The page contains a sequence of links or buttons that are too close to each other, both vertically or horizontally.

Failure Mode: The user may *slip* when using the mouse to hit hyperlinks or buttons that are located close to each other and will hit the wrong hyperlink or button.

Effect: Reduction of productivity.

Fix: Make sure that hyperlinks and buttons either cover a relatively large clickable area, or that they are well separated by white space.

Test: *Human*: Check the visual rendering of the page and ensure that hyperlinks / buttons are not too close to each other.

References: Movement control becomes slower and more variable with age [Ketcham & Stelmach 2001] with older users sometimes having unsteady hands that make precise mouse movements difficult. Older users tend to pause as they move the cursor around and over the hyperlink target as they have difficulty reaching the target itself [Keates & Trewin 2005]. When hyperlinks are close together, they require more accurate mouse movements and clicks to activate the target, which can be difficult as this requires fine motor movements. This can be difficult for older users as they experience increased slip errors when clicking targets with a mouse [Smith *et al.* 1999; Moffatt & McGrenere 2007]. Studies conducted by Redish & Chisnell [2004]; Zhao [2001] and Hawthorn [2000] highlight that older users often have problems hitting small and close targets because of the problems related to age. Increasing the space between links decreases erroneous clicks and increases the speed at which users can select the hyperlink [Nielsen 2002].

3.2.2 Hyperlinks and Buttons Too Small

User: Senior
Group: Operable
Guideline: Medicare Education [Holt 2000]
SilverWeb: H1.1 [Zaphiris *et al.* 2007]
Universal Usability Web Design For The Elderly [Zhao 2001]
Cause: The page contains hyperlinks and buttons that are too small.
Failure Mode: The user may face difficulties in using the mouse to hit hyperlinks or buttons that are very small.
Effect: Reduction of productivity and perhaps also of effectiveness.
Fix: Make sure that hyperlinks and buttons cover a sufficiently large clickable area so that they can be hit even when the mouse is used with a low precision. Studies show that older users perform better using large buttons, such as 180×22 pixels, with expanded *hot spots* that make the clickable area around the button larger with more space between targets.
Test: *Human*: Ensure that hyperlinks and buttons are not too small.
References: Movement control becomes slower and more variable with age [Ketcham & Stelmach 2001] with older users sometimes having unsteady hands that make precise mouse movements difficult. Older users tend to pause as they move the cursor around and over the hyperlink target as they have difficulty reaching the target itself [Keates & Trewin 2005]. When hyperlinks are close together, they require more accurate mouse movements and clicks to activate the target, which can be

difficult as this requires fine motor movements. This can be difficult for older users as they experience increased slip errors when clicking targets with a mouse [Smith *et al.* 1999; Moffatt & McGrenere 2007]. Studies conducted by Redish & Chisnell [2004]; Zhao [2001] and Hawthorn [2000] highlight that older users often have problems hitting small and close targets because of the problems related to fine motor movements. Both Milne *et al.* [2005] and Fukuda & Bubb [2003] demonstrated that older users find pointing and clicking tasks excessively demanding as manual dexterity becomes more difficult with advanced age. Furthermore, studies conducted by Newell *et al.* [2006] highlighted that older users can have problems with small buttons as they can have poorer motor skills and mild visual impairments that are typical of older people. This was supported by Chisnell *et al.* [2004] who shown that when there were larger text hyperlinks, participants were more likely to see them and click them. Increasing font size decreases erroneous clicks and increases the speed at which users can select the hyperlink [Nielsen 2002]. Indeed some studies have shown that increasing the size of text so that hyperlink targets are increased results in older users having similar performance rates to younger users [Fozard & Gorden-Salant 2001].

3.2.3 Descriptive Hyperlink Text

User: Senior
Group: Operable
Guideline: Designing Web Sites for Older Users [Chisnell *et al.* 2004]
Senior Surfers: 4 [Chadwick-Dias *et al.* 2007]
Usability for Older Web Users [Fidgeon 2006]
WCAG 1.0: 13.1 [Chisholm *et al.* 1999]
WCAG 2.0: 2.4.4 [Caldwell *et al.* 2008]
Cause: As people age, the ability to keep information active whilst processing that information reduces. As a result, hyperlinks that have meaningless descriptions can be confusing to the user as they simultaneously try to understand why they should click the hyperlink and what will happen when they do.
Failure Mode: When users are required to click on a hyperlink to complete a task, they will show signs of hesitancy as they try to determine which hyperlink to select and what will happen when they have made that choice.
Effect: Reduced effectiveness. Tasks will take longer to complete as users will be uncertain of which hyperlink to follow.

Fix: Ensure that hyperlinks are clearly labelled in a verb-action format. This will inform users what to do and what will happen when they do it.

Test: *Human*: Check for the quality of text used as a hyperlink and follow the hyperlink to ensure the destination matches the hyperlink description.

References: The ability to keep information active whilst processing it reduces with age, as does the ability to remember to do something in the future and the ability to learn new skills [Czaja & Lee 2007b]. Reductions in these memory functions, known as fluid memory, makes it difficult for older users to navigate the Web due to the constantly changing nature of the content [Hanson 2009]. This difficulty was demonstrated by Tullis [2007] through the use of eye tracking. The studies shown that older users spent a significant amount of time looking at navigation menus on a page, comparing all the hyperlinks in a menu to each other before deciding which one to select. The use of non-descriptive hyperlinks such as *"click here"* or other non-descriptive text can be a hindrance to users as it is not clear why users should click that link and what the outcome will be if they do [Dalal *et al.* 2000; Caldwell *et al.* 2008].

Recent Studies by Sayago *et al.* [2009] have shown that for older users, expanding the *"click here"* text to incorporate the results of clicking the hyperlink can be of benefit. In the study, the sentence *"Click here to see all photos"* was placed on a Web page and different parts of the sentence formed the hyperlink. For example in one task only *"see all photos"* constituted the hyperlink and in a second task only *"here"* formed the hyperlink. The study found that having the entire sentence *"Click here to see all photos"* consist of the hyperlink helped older users as they understood what they had to do (click on this hyperlink) and they were informed what the result would be (see all the photographs).

3.2.4 Cascading Menus

User: Senior
Group: Operable
Guideline: Medicare Education [Holt 2000]
SilverWeb: H3.4 [Zaphiris *et al.* 2007]
WCAG 1.0: 3.4 [Chisholm *et al.* 1999]
WCAG 2.0: 1.4, 1.4.4 [Caldwell *et al.* 2008]
Cause: The page contains hierarchical cascading menus, where entries of one menu correspond to a second-level menu. This can be implemented through nested CSS `select` statements or through JavaScript code.

Failure Mode: The user cannot correctly or easily move the mouse pointer onto the desired entries and it may be especially difficult to open secondary menus and to keep them open while moving to the desired entry.

Effect: Reduction of effectiveness and satisfaction.

Fix: Avoid using cascading menus. If possible implement separate menus as flat option lists that are selectable by clicking on hyperlinks or by setting radio buttons.

Test: *Machine*: Test for the presence of `<object>` or `<script>` elements in the content. *Human*: If present, test that the user experience is acceptable

References: A number of studies have observed that older adults often have problems in using pull-down menus; menus that suddenly appear; or content that changes when the user hovers the cursor over a target [Coyne & Nielsen 2002; Chadwick-Dias *et al.* 2003; Morell 2002]. A main cause of this difficulty is that movement control becomes slower and more variable with age [Ketcham & Stelmach 2001] with older users sometimes having unsteady hands that make precise mouse movements difficult. Older users tend to pause as they move the cursor around and over the hyperlink target as they have difficulty reaching the target itself [Keates & Trewin 2005]. In addition, older users can suffer from arthritis or slight tremors that mean fine movement and selection of small screen elements can be difficult. Nielsen [2002] demonstrated that pull-down menus, hierarchical walking menus, and other moving interface elements can cause problems for older users who are not always steady with the mouse.

3.2.5 Dynamic Menus in Javascript

User: Senior

Group: Operable

Guideline: Medicare Education [Holt 2000]
SilverWeb: H4.2 [Zaphiris *et al.* 2007]
WCAG 1.0: 6.3, 6.4, 6.5, 8.1 [Chisholm *et al.* 1999]
WCAG 2.0: 2.1, 2.1.1, 2.1.3, 4.1, 4.1.2 [Caldwell *et al.* 2008]

Cause: Older users can have problems in managing mouse movements, especially when the movement requires precision.

Failure Mode: Older users can have problems in managing mouse movements, in particular precise movements, making interaction with dynamic menus difficult. The result is that the menu may not be usable by the user.

Effect: Significant reduction of effectiveness.

Fix: All navigation options and commands, such as menu entries, should be selectable even when JavaScript is not enabled.

Test: *Machine*: Test for the presence of `<object>` or `<script>` elements within the content and ensure that they are validated. *Human*: Turn off scripting in the page and test that the user can still operate the menus.

References: A number of studies have observed that older adults often have problems in using pull-down menus; menus that suddenly appear; or content that changes when the user hovers the cursor over a target [Coyne & Nielsen 2002; Chadwick-Dias *et al.* 2003; Morell 2002]. A main cause of this difficulty is that movement control becomes slower and more variable with age [Ketcham & Stelmach 2001] with older users sometimes having unsteady hands that make precise mouse movements difficult. Older users tend to pause as they move the cursor around and over the hyperlink target as they have difficulty reaching the target itself [Keates & Trewin 2005]. In addition, older users can suffer from arthritis or slight tremors that mean fine movement and selection of small screen elements can be difficult. Nielsen [2002] demonstrated that pull-down menus, hierarchical walking menus, and other moving interface elements cause problems for older users who are not always steady with the mouse.

3.2.6 Mouse Events

User: Senior

Group: Operable

Guideline: Medicare Education [Holt 2000]
SilverWeb: H1.2, H1.3 [Zaphiris *et al.* 2007]
WCAG 1.0: 6.3, 6.4, 9.3 [Chisholm *et al.* 1999]
WCAG 2.0: 2.1, 2.1.1, 2.1.3 [Caldwell *et al.* 2008]

Cause: The page is based on JavaScript in order to obtain specific effects. JavaScript functions are invoked through event handlers, such as `onclick`, `onmouseover`, and `onmouseout`, that are mouse-oriented.

Failure Mode: Older uses, who may have difficulty in mouse control, are likely to prefer using the keyboard rather than the mouse for certain activities. However, mouse-orientated event handlers can create a situation where functionality appears to be available to the user but does not work due to the user not using mouse-orientated input.

Effect: Reduction of effectiveness.

Fix: In addition to mouse-oriented event handlers, use logical event handlers, such as `onfocus` and `onkeypress`. If possible, create the functionality achieved through event handlers without the need for JavaScript.

Test: *Machine*: Check that JavaScript event handlers, such as `onclick`, `onmouseover`, and `onmouseout`, are not the only event handlers associated with a particular HTML element. *Human*: Test to see if the user can still operate the elements that focus on mouse interaction without using a mouse.

References: Studies have shown that older users have difficulty in mouse control, especially with moving the mouse over targets and clicking [Newell *et al.* 2006; Bailey *et al.* 2005; Fukuda & Bubb 2003; Milne *et al.* 2005]. A main cause of this difficulty is that movement control becomes slower and more variable with age [Ketcham & Stelmach 2001] with older users sometimes having unsteady hands that make precise mouse movements difficult. Older users tend to pause as they move the cursor around and over the hyperlink target as they have difficulty reaching the target itself [Keates & Trewin 2005]. In addition, older users can suffer from arthritis or slight tremors that mean fine movement and selection of small screen elements can be difficult. Chadwick-Dias *et al.* [2003] conducted two usability studies to establish how older users interacted with the Web. One result from the study indicated that older users have difficulty in accessing tabbed menus when they are displayed using `onmouseover`.

3.2.7 Provide Orientation Cues

User: Senior

Group: Operable

Guideline: Medicare Education [Holt 2000]
Senior Surfers: 9 [Chadwick-Dias *et al.* 2007]
SilverWeb: H3.3 [Zaphiris *et al.* 2007]
WCAG 2.0: 2.4.8 [Caldwell *et al.* 2008]

Cause: Many older adults suffer from mild cognitive impairments. Such impairments can effect a users' performance as they become lost and have trouble maintaining their location and position within a Website.

Failure Mode: When users are browsing for information, they may become lost and confused within the page and find it hard to complete their task.

Effect: Reduction in effectiveness and satisfaction as the user becomes more confused.

Fix: Provide orientation cues, such as breadcrumb trails and page titles, to enable users to re-orientate themselves with their current location.

Test: *Human*: Check for the availability of breadcrumb trails. Also ensure that page titles are clear and reflect the content contained within the page.

References: Many older adults suffer from mild cognitive impairments, such as an increased tendency to misplace items and trouble recalling names [Arch 2008]. This, combined with a reduced ability to keep information active whilst processing it [Czaja & Lee 2007b] can effect a users' performance when browsing and reduce their ability to complete tasks. Users can become lost and have trouble maintaining their location and position [Fairweather 2008]. Meyer *et al.* [1997] found that during search tasks, older users took on average 9.7 steps to complete a task compared to 6.4 by younger users. This was due to older users returning to the home page to re-orientate themselves before starting a new search. Older users also returned to pages they had already visited when searching for information because they had forgotten that the page had already been visited.

Providing orientation cues, such as breadcrumb trails and clear page titles, can help users re-orientate themselves with their current location within the Website and also allow them to retrace their steps and go back to previous pages more easily [Chadwick-Dias *et al.* 2007]. An investigation by Czaja *et al.* [2001] compared the performance of complex information search and retrieval tasks between old and younger age groups. They concluded that *History Markers* that integrated information from different locations could reduce the load on working memory and increase the speed of performance. This finding was supported by Chadwick-Dias *et al.* [2003], who conducted studies on modifying a Web page to establish how it could be improved for older users. By providing navigational cues users were reminded where they were on the site and performance improved significantly.

3.2.8 Minimise Steps To Reach Content

User: Senior
Group: Operable
Guideline: Medicare Education [Holt 2000]
Senior Surfers: 6 [Chadwick-Dias *et al.* 2007]
SilverWeb: H3.5 [Zaphiris *et al.* 2007]
Universal Usability Web Design For The Elderly [Zhao 2001]
WCAG 2.0: 2.4.5 [Caldwell *et al.* 2008]
Cause: Many older adults suffer from short term memory impairments. As exploration of Web pages relies on short term memory, finding content that is buried within deep hierarchies can be challenging for users.

Failure Mode: When users are browsing for information, they may become lost and confused within the Website and find it hard to complete their task.

Effect: Reduction in effectiveness and satisfaction as the user becomes more confused.

Fix: Keep the hierarchy depth of pages within the Website to a minimum. Ensure that steps taken to find information are logical and clear.

Test: *Human*: Check that the steps users have to take to reach information are logical and not too long.

References: Many older adults suffer from mild cognitive impairments, such as an increased tendency to misplace items and trouble recalling names [Arch 2008]. This, combined with a reduced ability to keep information active whilst processing it [Czaja & Lee 2007b] can effect a users' performance when browsing and reduce their ability to complete tasks. When using the Web, older users know that they will forget how to achieve tasks or reach previously found information if they do not perform the same tasks regularly. As exploration of Web pages relies on short term memory, finding content that is buried within deep hierarchies can be challenging for users [Zajicek 2007].

3.2.9 New Windows

User: Senior

Group: Operable

Guideline: SilverWeb: H4.2 [Zaphiris *et al.* 2007]
WCAG 1.0: 10.1 [Chisholm *et al.* 1999]
WCAG 2.0: 3.2, 3.2.1, 3.2.5 [Caldwell *et al.* 2008]

Cause: The page contains HTML or JavaScript code that opens new browser windows, either when the user activates a hyperlink or button, or after the page has been loaded.

Failure Mode: The user does not realise that a new window has opened and that the interaction context has changed, therefore altering both the content and the set of commands and controls. This is especially frustrating for the user when a new window opens unexpectedly as the user is performing a task. This typically happens with pop-up windows that are not relevant with the current user task. In addition, the `back` button of the browser may not work anymore.

Effect: Reduction of effectiveness and productivity.

Fix: Avoid opening new windows in general, and provide an explanation of such behaviour to the user before the window is opened. If a new window is necessary, or a new window is a de-facto standard, such as selecting a date from a JavaScript

pop-up calendar window, then ensure that at the very beginning of the new window there is a hyperlink or button entitled *"Close window"* so that users understand that this is a new window and the button gives them the immediate opportunity to close it. Do not forget to define an informative title for the page displayed in the new window, such as *"Calendar: select the date"*.

Test: *Machine*: Look for the target attribute on hyperlinks and if present check to see if it has a value different from `-self`, `-parent` or `-top`.

References: Pop-up windows usually hide the information that the user is currently reading behind the new window. This can cause a number of difficulties to older users. For instance, if the pop-up window is a new window, then the user will not be able to use the `back` button with that new window which causes confusion and frustration [Bailey *et al.* 2005; Chadwick-Dias *et al.* 2003].

3.2.10 Overlapping Windows

User: Senior

Group: Operable

Guideline: SilverWeb: H4.2 [Zaphiris *et al.* 2007]
WCAG 1.0: 10.1 [Chisholm *et al.* 1999]
WCAG 2.0: 3.2, 3.2.1, 3.2.5 [Caldwell *et al.* 2008]

Cause: The page contains JavaScript or HTML code that opens new windows that are overlapping with the window that is being used and cover it completely or substantially.

Failure Mode: The user does not distinguish the new window from the previously used one and therefore the new interaction context — including a change of content, layout, hyperlinks, buttons and form controls — can be confusing. For example the user may not understand that the visible scroll bar is the one that belongs to the background window. When the user clicks on the scroll bar with the intention of moving the content of the foreground window, the result is that the two windows switch position. The content that the user was looking at and trying to move disappears as it is covered by the window that has been brought to the foreground. The user might not understand what has happened and why.

Effect: Reduction of effectiveness.

Fix: Avoid opening new windows in general, and provide an explanation of such behaviour to the user before the window is opened. If a new window is necessary, or a new window is a

de-facto standard, such as selecting a date from a JavaScript pop-up calendar window, then ensure that at the very beginning of the new window there is a hyperlink or button entitled *"Close window"* so that users understand that this is a new window and the button gives them the immediate opportunity to close it. Do not forget to define an informative title for the page displayed in the new window, such as *"Calendar: select the date"*.

Test: *Machine*: Look for the target attribute on links and if present check to see if it has a value different from `-self`, `-parent` or `-top`.

References: Pop-up windows usually hide the information that the user is currently reading behind the new window. This can cause a number of difficulties to older users. For instance, if the pop-up window is a new window, then the user will not be able to use the `back` button with that new window which causes confusion and frustration [Bailey *et al.* 2005; Chadwick-Dias *et al.* 2003]. Studies conducted by Newell *et al.* [2006] show that older users have difficulty in understanding multiple windows and how to interact with them.

3.2.11 Scrolling

User: Senior

Group: Operable

Guideline: Medicare Education [Holt 2000]
SilverWeb: H4.1 [Zaphiris *et al.* 2007]
Universal Usability Web Design For The Elderly [Zhao 2001]
WCAG 1.0: 12.3 [Chisholm *et al.* 1999]
WCAG 2.0: 1.4.8 [Caldwell *et al.* 2008]

Cause: When the main content of the page or images or are bigger than the screen size, the user has to scroll up and down, or left to right.

Failure Mode: It can be difficult for a user to read a page that the user has to scroll all the time. It can also become difficult to understand the content.

Effect: Reduction of effectiveness, of productivity and of satisfaction.

Fix: For older users, Hawthorn [2002] suggests adding larger scrolling buttons. Coyne & Nielsen [2002] and Chadwick-Dias *et al.* [2003] suggest that any pop-ups or secondary windows should be opened wide enough, ideally in both horizontal and vertical directions, to eliminate the need for scrolling. Finally Kantner & Rosenbaum [2003] and Coyne & Nielsen [2002] suggest using drop-down menus that stay open once clicked; fields in which users can type; or lists with check-boxes instead of using pull-down menus or scrolling lists.

Test: *Machine*: Check for width attributes and width style properties that are wider than the screen size. *Human*: Ensure that any scroll buttons used are large enough and that secondary windows opened are wide enough, ideally both vertically and horizontally.

References: For older users scrolling can be a problem because novice users might be inexperienced in scrolling [Redish & Chisnell 2004] and, since ability to control movement (kinaesthetic sensitivity) degrades with age, controlling a mouse in combination movements can become difficult [Czaja & Lee 2007a; Fisk *et al.* 2004]. In studies conducted by Newell *et al.* [2006] and Bailey *et al.* [2005] older users had problems when using scrollbars. This was supported by Chadwick-Dias *et al.* [2003] whose study highlighted that older users did not notice the horizontal scrollbar and often never saw and accessed the information on the right of the screen. One reason that older users have problems in scrolling is because of visual and motor factors. The small size of the scroll bar can be problematic and also scrolling requires the complex sequence of moving and holding down the mouse [Hanson 2001; Fukuda & Bubb 2003; Milne *et al.* 2005]. Furthermore, some older users do not know what a scroll bar is and what its purpose is [Newell *et al.* 2006].

3.2.12 Rich Images Included in the Page Background

User: Senior

Group: Operable

Guideline: Medicare Education [Holt 2000]
SilverWeb: H4.2, H8.3 [Zaphiris *et al.* 2007]
WCAG 1.0: 1.1, 6.1 [Chisholm *et al.* 1999]

Cause: Images that convey information are included as part of the background using CSS. This can introduce unnecessary clutter in the interface and can potentially confuse and distract older users.

Failure Mode: These background images mean that the user will not be able to complete the task because the background image confuses and distracts the user.

Effect: Reduction of effectiveness.

Fix: Avoid complex, unnecessary background images.

Test: *Machine*: Test for the presence of a background image. *Human*: Test readability both on devices that support them and devices that do not.

References: As people age, they experience varying degrees of reduced vision [Kurniawan 2008; Fozard & Gorden-Salant 2001] due

to effects such as age-related macular degeneration [Bressler & Gills 2000], glaucoma [RNIB 2008b], and cataracts [RNIB 2007]. Due to the results of age-related conditions, there is a need for strong contrast between elements on the page to cater for the mild visual impairments that are typical of the elderly [Newell *et al.* 2006]. Older users with low vision have problems in reading pages with busy backgrounds [Zhao 2001; Milne *et al.* 2005] as they introduce unnecessary clutter in the interface [Newell *et al.* 2006]. This can cause confusion, can make elements difficult to see and can be distracting for older users [Hodes & Lindberg 2002].

3.3 Understandable Barriers

WCAG 2.0 defines the Understandable Principle as: *"information and the operation of the user interface must be understandable"* [Caldwell *et al.* 2008]. For Web pages, this means that users must be able to understand all the information and content present in the page, regardless of any sensory impairments or the assistive technology that may be used to access the Website. The following barriers may hinder older users from understanding information contained within the page.

3.3.1 Consistent Navigation and Layout

User: Senior
Group: Understandable
Guideline: Designing Web Sites for Older Users [Chisnell *et al.* 2004]
Medicare Education [Holt 2000]
National Institute of Ageing [Hodes & Lindberg 2002]
SilverWeb: H5.5 [Zaphiris *et al.* 2007]
Usability for Older Web Users [Fidgeon 2006]
WCAG 1.0: 13.4; 14.3 [Chisholm *et al.* 1999]
WCAG 2.0: 3.2.3; 3.2.4 [Caldwell *et al.* 2008]
Cause: As people age, the associated decline in cognitive ability is usually associated with the parts of memory that provide the ability to perform tasks that have not been experienced before. Websites that have inconsistent layout and navigation place greater strain on this part of the memory as users can not make use of previous experiences of the page layout to achieve their task.
Failure Mode: Inconsistent layout and navigation prevents users from being able to reuse prior experience of the page to complete their task, therefore making interaction with the page more stressful. This will also increase the time it takes users to complete a task as they have to re-establish what actions they should take on the page.
Effect: Reduction in effectiveness and satisfaction as the user places increased demand on their cognitive abilities.

Fix: Keep the layout of the page consistent. Elements that span multiple pages should be placed in the same location on every page. The look and feel and colour scheme of the Website should be the same across the entire site.

Test: *Human*: Check that the layout does not change from page to page. Also ensure that how users navigate is consistent across the entire Website.

References: Intelligence can be categorised as crystallised intelligence or fluid intelligence. Crystallised intelligence can be characterised as breadth of knowledge, experience, communication and wisdom. Fluid intelligence, on the other hand, can be characterised by the ability to draw inferences from relationships and patterns and the ability to perform tasks where experience does not prove to be of benefit [Horn 1982].

As people age, the associated decline in cognitive ability is usually associated with fluid intelligence rather than crystallised intelligence [Czaja & Sharit 1998]. As older adults rely on crystallised intelligence, older Web users benefit from Web pages that do not frequently change and have a stable, well-known interface [Hawthorn 2000]. For example, older users with cognitive impairments sometimes use behavioural strategies to overcome the difficulties that they face on the page. One such strategy is to become so familiar with a Website that tasks become automated, which places far less strain on working memory [Fairweather 2008]. This was assertion was demonstrated by Pan *et al.* [2004] using eye tracking studies. In the study, a series of Websites, classified as *Shopping*, *News*, *Business* and *Search*, were used with participants being asked to look at two pages on each site. They found that, with the exception of the search task, the second page users viewed of the Website had a higher saccade rate than the first page. As saccade rate is negatively related to task difficulty, this implied that the second page required less cognitive effort from the users as they knew what to expect from the page and where to find key elements. As search results typically have a different style for their second page, this could explain the increased cognitive load. By using consistent navigation and layout, users do not need to think about what will happen when a hyperlink is selected or a page is visited as they will know what to expect [Nielsen 2005]. This in turn will reduce the need for exploration of the page, which is itself reliant on short term memory [Zajicek 2007], and allow users to complete their tasks more productively.

3.3.2 Group Related Content

User: Senior
Group: Understandable
Guideline: SilverWeb: H3.5 [Zaphiris *et al.* 2007]
WCAG 1.0: 12.3 [Chisholm *et al.* 1999]
Cause: As people age, memory functionality is reduced. One consequence of this loss of memory is that the ability to recall lists of words from memory deteriorates.
Failure Mode: Having information distributed across a Website places more demand on a users cognitive ability. This can slow down the task completion rate as users have to spend more time identifying information on the page and determine if that information is relevant to their task.
Effect: Reduction in effectiveness and satisfaction as the user places increased demand on their cognitive abilities.
Fix: Organise information within a Web page into related groups as this acts as a memory cue and can aid older users with their tasks. Use headings to make it explicit what information the upcoming content will contain.
Test: *Human*: Check that information that is closely related is placed near each other on the same page. Ensure that any headings that are used are meaningful and clearly describe what information the user is about to access.
References: As people age, memory functionality is reduced. One consequence of this loss of memory is that the ability to recall lists of words from memory deteriorates [Perlmutter & Mitchell 1982]. To help users make word and language decisions, experiments with priming have been conducted. Priming involves using cues to inform users what content will appear next. For example the category *"animal"* can be followed by words related to animals such as *"dog"* and *"cat"*. By using priming such as this, reaction times can be improved when participants are asked to categorise a series of stimuli [Hartley 1992; Rayner 1998]. Indeed, studies have demonstrated that if priming can be used such that participants know where to focus their attention, there is little difference between older and younger users [Rogers & Fisk 2001].

Grouping words together that are semantically related can also be of benefit to users, even when the primer is not explicit, as the semantic relatedness can act as a priming mechanism [Hartley 1992]. Using semantic categories to organise items within a Web page acts as a memory cue and can aid older users with their tasks [Hawthorn 2000]. For example Newell *et al.* [2006], during the development of a Web portal for older Web users, observed that globally-available buttons

interfered with screen-specific action buttons. As a solution to this, the two sets of buttons were separated so that screen-specific action buttons were located in a column on the left-hand-side of the page and globally-available buttons were located at the bottom. By grouping the related items together and ensuring they were distinct from each other, users found the interface to the Website easier to interact with.

3.3.3 Avoid Unnecessary Clutter

User: Senior
Group: Understandable
Guideline: Designing Web Sites for Older Users [Chisnell *et al.* 2004]
Senior Surfers: 6 [Chadwick-Dias *et al.* 2007]
Universal Usability Web Design For The Elderly [Zhao 2001]
Usability for Older Web Users [Fidgeon 2006]
WCAG 2.0: 2.4 [Caldwell *et al.* 2008]
Cause: Older users are not particularly good at visual searches of complex displays and can be confused when lots of information is presented on screen. They are also more likely to attend to distracting information.
Failure Mode: Having lots of unnecessary content on the same page can be distracting for users which can lead to slower task performance
Effect: Reduction in effectiveness as users are distracted and attend to all the information present on the screen rather than that which is relevant to the current task.
Fix: Keep pages clean and simple. Do not try to put a lot of unrelated information on the same page.
Test: *Human*: Check that content contained on the page is related to each other. Ensure advertisements and flash images are kept to a minimum and are not as predominant as the main content.
References: Eye tracking studies conducted by Tullis [2007] observed that older adults spent more time on Web pages compared to younger users. Reasons for this included a greater degree of caution in interacting with the Website; a greater interest in certain aspects of the page; or a greater confusion in interpreting the information on the pages. During the development of an email interface for older users, Hawthorn [2002] noted that older users were not particularly good at visual searches of complex displays, providing support for the view of Tullis [2007] that older users can be confused when a lot of information is presented on the screen at the same time. Furthermore, older adults have a reduced ability to suppress information that is not relevant to their

current task [May *et al.* 1999]. They are therefore more likely to attend to distracting information which can lead to slower task performance [Lustig *et al.* 2001; Tullis 2007].

Studies with simplified interfaces for Web pages have had positive results for task completion. Aula & Kaki [2005] compared two search engine interfaces. The first was the standard Google search engine. The second was a search engine whose interface was designed specifically for older users. The results shown that simplified user interfaces were not only preferred by older users but that task performance also improved. Similarly Newell *et al.* [2006] developed a Web portal for older users. Studies comparing the simplified portal and the standard Yahoo! internet portal revealed that users preferred using the simple designs of the portal specifically designed for older user's needs than the standard Yahoo! interface.

3.3.4 Complex Data Table

User: Senior
Group: Understandable
Guideline: No guidelines directly refer to this barrier.
Cause: The page contains a data table with a large number of columns or rows.
Failure Mode: The user might face difficulties in identifying the required row, and in understanding the content of a row. In addition, there might be difficulties in understanding information that requires comparison of different rows and / or columns, such as understanding a trend.
Effect: Low effectiveness. Some tasks cannot be completed because of partial understanding of data.
Fix: Not obvious: consider offering alternative views of the data by reducing the amount of detail being shown. For example, by pre-filtering out some of the rows, or by supplying some statistical aggregation, such as an average, median or range of the data. In addition, use alternating or different colours to differentiate among columns and among rows to improve ease of orientation.
Test: *Machine*: Check that there are no nested tables.
References: Many older adults suffer from mild cognitive impairments, such as an increased tendency to misplace items and trouble recalling names [Arch 2008]. This, combined with a reduced ability to keep information active whilst processing it [Czaja & Lee 2007b] can effect a users performance when understanding data spread across a complex data table. Czaja & Sharit [1993] conducted a study comparing task completion time of

computer-based work between older and younger users. One task that older users were particularly slow at completing involved an inventory management task that required users to look at data spread across multiple tables. This was because such tasks place an increased load on working memory, which decreases with age [Czaja & Sharit 1998]. This assertion was supported in studies conducted by Chadwick-Dias *et al.* [2003] who found that if pages include large data tables, older users had significant difficulty in accessing information contained within the page.

3.3.5 Page with Flickering or Flashing Content

User: Senior
Group: Understandable
Guideline: Universal Usability Web Design For The Elderly [Zhao 2001]
SilverWeb: H9.1 [Zaphiris *et al.* 2007]
Medicare Education [Holt 2000]
WCAG 1.0: 7.1 7.2 [Chisholm *et al.* 1999]
WCAG 2.0: 2.3, 2.3.1, 2.3.2, 2.2, 2.2.2 [Caldwell *et al.* 2008]
Cause: The page contains elements, such as images, text or backgrounds, that flash or flicker at a rate between 3Hz–60Hz. In order to cause such an effect the intensity of the flash should be high.
Failure Mode: The page may trigger epileptic seizures for users that have photosensitive epilepsy. A seizure is the result of a sudden burst of excess electrical activity in the brain. This causes the brain's messages to become temporarily halted or mixed up. The type of seizure a person has depends on the area of the brain where this activity occurs [Epilepsy Action 2009].
Effect: Safety threat. A seizure has effects like momentary lack of consciousness, convulsions, falling to the floor.
Fix: Avoid using flashing or flickering content.
Test: *Human*: Check the page content and see if it includes flashing or flickering content.
References: According to Zhao [2001], flashing and flickering content are highly distractive to peripheral vision. Some older users might also have photosensitive epilepsy and can therefore be affected by flickering or flashing content.

4 Discussion and Conclusion

The Barrier Walkthrough method is an analytical technique based on heuristic walkthrough [Sears 1997]. In the method, an evaluator has to consider a number of predefined possible barriers which are interpretations and extensions of well known accessibility principles. They are assessed in a context so that appropriate conclusions about user effectiveness, productivity, satisfaction, and safety can be drawn, and severity scores can be derived. The BW method has so far investigated barriers for user groups such as blind persons; motor impaired users and mobile phone users. Through an analysis of existing guidelines and literature surrounding the effects of ageing, this report has presented a list of barriers faced by older users of the Web. These barriers can be used in conjunction with the BW method to assess the impact a Web page has on older users and their ability to interact with the content effectively.

The barriers presented in this report, however, are for static Web pages. Currently the Web is undergoing a profound change. Pages have evolved from static documents into composite documents created from multiple third party sources delivering dynamically changing information streams. Content which was once simple is becoming increasingly complicated due to the many updating components "dotted" throughout the page [Sàenz *et al.* 2003; Carmi & Itti 2006]. Websites such as Flickr, YouTube, MySpace, Facebook and Google Maps all rely on these new components and are all popular with older users. While barriers to Web access have been identified in this report, additional problems may arise in Web 2.0 pages due to the increased interface complexity which consists of changes in content, context, and multiple dynamic updates, built from "mashed-up" information streams [Wood *et al.* 2006].

While the potential challenges faced by older Web users by the Web 2.0 have been highlighted [Chadwick-Dias *et al.* 2007; Zajicek 2007], there has been little research into the effects that this technology has on older users. Without a full understanding of the interaction of older people with Web 2.0 technologies the Web will rapidly become unable to support their interaction needs. Only by a deep understanding of this interaction can we propose assistive solutions.

References

Arch, Andrew. 2008 (May). *Web Accessibility for Older Users: A Literature Review.* W3C Working Draft. World Wide Web Consortium (W3C), Web Accessibility Initiative, MIT/CSAIL, Building 32-G530, 32 Vassar St, Cambridge, MA 02139, USA.

Aula, Anna, & Kaki, Mika. 2005. Less Is More in Web Search Interfaces for Older Adults. *First Monday (online)*, **7**(10).

Bailey, Susan, Barrett, Sarah, & Guilford, Sheila. 2005. Older Users' Interaction With Websites. *In: Workshop on HCI and the Older Population, British HCI.*

Brajnik, Giorgio. 2006. Web Accessibility Testing: When the Method Is the Culprit. *Pages 156–163 of: CCHP 2006: Proceedings of the 10th International Conference on Computers Helping People with Special Needs.* Lecture Notes in Computer Science. Springer Berlin / Heidelberg.

Brajnik, Giorgio. 2009 (March). *Barrier Walkthrough: Heuristic Evaluation Guided by Accessibility Barriers.* Tech. rept. Università Degli Studi di Udine, Dipartimento di Matematica e Informatica, Via delle Scienze, 206, Rizzi 33100 Udine, Italy. `http://users.dimi.uniud.it/~giorgio.brajnik/projects/bw/bw.html`. Last Accessed 26th June 2009.

Brajnik, Giorgio, & Lomuscio, Raffaella. 2007. SAMBA: A Semi-Automatic Method for Measuring Barriers of Accessibility. *Pages 43–50 of: ASSETS '07: Proceedings of the 9th International ACM SIGACCESS Conference on Computers and Accessibility.* New York, NY, USA: ACM.

Bressler, Neil M, & Gills, James P. 2000. Age Related Macular Degeneration: New Hope for a Common Problem Comes from Photodynamic Therapy. *British Medical Journal*, **321**(7274), 1425–1247.

Caldwell, Ben, Cooper, Michael, Reid, Loretta Guarino, & Vanderheiden, Gregg. 2008 (December). *Web Content Accessibility Guidelines (WCAG) 2.0.* W3C Recommendation. World Wide Web Consortium (W3C), Web Accessibility Initiative, MIT/CSAIL, Building 32-G530, 32 Vassar St, Cambridge, MA 02139, USA. `http://www.w3.org/TR/WCAG20/`. Last Accessed 26th June 2009.

Carmi, Ran, & Itti, Laurent. 2006. Causal Saliency Effects During Natural Vision. *Pages 11–18 of: ETRA '06: Proceedings of the 2006 Symposium on Eye Tracking Research & Applications.* New York, NY, USA: ACM.

Chadwick-Dias, Ann, McNulty, Michelle, & Tullis, Tom. 2003. Web Usability and Age: How Design Changes Can Improve Performance. *Pages 30–37 of: CUU '03: Proceedings of the 2003 conference on Universal usability.* New York, NY, USA: ACM.

Chadwick-Dias, Ann, Bergel, Marguerite, & Tullis, Thomas S. 2007. Senior Surfers 2.0: A Re-examination of the Older Web User and the Dynamic Web. *Pages 868–876 of: Universal Access in Human Computer Interaction: Coping with Diversity - UAHCI 2007: 4th International Conference on Universal Access in Human-Computer Interaction.* Lecture Notes in Computer Science, vol. 4554/2007. Springer Berlin / Heidelberg.

Chisholm, Wendy, Vanderheiden, Gregg, & Jacobs, Ian. 1999 (May). *Web Content Accessibility Guidelines 1.0.* W3C Recommendation. World Wide Web Consortium (W3C), Web Accessibility Initiative, MIT/CSAIL, Building 32-G530, 32 Vassar St, Cambridge, MA 02139, USA. `http://www.w3.org/TR/WCAG10/`. Last Accessed 26th June 2009.

Chisnell, Dana, Lee, Amy, & Redish, Janice (Ginny). 2004 (March). *Designing Web Sites for Older Users: Comparing AARP's Studies to Earlier Findings.* Online Publication.

Chua, B. E., Mitchell, P., & Cumming, R. G. 2004. Effects of Cataract Type and Location on Visual Function: The Blue Mountains Eye Study. *Eye*, March, 765–772.

Coyne, Kara Pernice, & Nielsen, Jakob. 2002. *Web Usability for Senior Citizens: 46 Design Guidelines Based on Usability Studies with People Age 65 and Older.* Nielsen Norman Group Report.

Czaja, S., & Lee, C.C. 2007a. *The Human-Computer Interaction Handbook: Fundamentals, Evolving Technologies, and Emerging Applications.* 2 edn. CRC. Chap. Information Technology and Older Adults, pages 333–341.

Czaja, Sara J., & Lee, Chin Chin. 2007b. The Impact of Aging on Access to Technology. *Universal Access in the Information Society*, **5**(4), 341–349.

Czaja, Sara J., & Sharit, Joseph. 1993. Age Differences in the Performance of Computer-Based Work. *Psychology and Aging*, **8**(1), 59–67.

Czaja, Sara J., & Sharit, Joseph. 1998. Ability-Performance Relationships as a Function of Age and Task Experience for a Data Entry Task. *Journal of Experimental Psychology*, **4**(4), 332–351.

Czaja, Sara J., Sharit, Joseph, Ownby, Raymond, Roth, David L., & Nair, Sankaran. 2001. Examining Age Differences in Performance of a Complex Information Search and Retrieval Task. *Psychology and Aging*, **16**(4), 564–579.

Dalal, Nikunj P., Quible, Zane, & Wyatt, Katherine. 2000. Cognitive Design Of Home Pages: An Experimental Study Of Comprehension On The World Wide Web. *Information Processing and Management*, **36**(4), 607–621.

Ellis, R.D., & Kurniawan, S.H. 2000. Increasing the Usability of Online Information for Older Users: A Case Study in Participatory Design. *International Journal of Human-Computer Interaction*, **12**, 263–276.

Epilepsy Action. 2009 (July). *Epileptic Seizures Explained.* Online Publication, New Anstey House, Gate Way Drive, Yeadon, Leeds, UK. `http://www.epilepsy.org.uk/info/types.html`. Last Accessed 2nd September 2009.

Fairweather, Peter G. 2008. How Older and Younger Adults Differ in Their Approach to Problem Solving on a Complex Website. *Pages 67–72 of: Assets '08: Proceedings of the 10th international ACM SIGACCESS conference on Computers and accessibility.* New York, NY, USA: ACM.

Faye, Eleanor E., Rosentha, Bruce P., & Sussman-Skalka, Carol J. 2009. *Cataract and the Aging Eye.* Online Publication. `http://www.lighthouse.org/medical/eye-disorders/cataract/aging-eye/`. Last Accessed 17th March 2009.

Fidgeon, Tim. 2006 (February). *Usability for Older Web Users.* Tech. rept. Webcredible, 99 Mansell Street, London, E1 8AX, UK.

Fisk, Arthur D., Rogers, Wendy A., Charness, Neil, Czaja, Sara J., & Sharit, Joseph. 2004. *Designing for Older Adults.* CRC.

Fozard, James L., & Gorden-Salant, Sandra. 2001. *The Handbook of Psychology and Aging.* 5th edn. Academic Press Inc. Chap. 10: Changes In Vision and Hearing, pages 267–287.

Fukuda, Ryoko, & Bubb, Heiner. 2003. Eye Tracking Study on Web-Use: Comparison Between Younger and Elderly Users in Case of Search Task With Electronic Timetable Service. *PsychNology Journal*, **1**(3), 202–228.

Groff, Loren, Liao, Corrina, Chaparro, Barbara, & Chaparro, Alex. 1999. Exploring How the Elderly Use the Web. *Usability News*, **1**(2).

Hanson, Vicki L. 2001. Web Access for Elderly Citizens. *Pages 14–18 of: WUAUC'01: Proceedings of the 2001 EC/NSF workshop on Universal accessibility of ubiquitous computing.* New York, NY, USA: ACM.

Hanson, Vicki L. 2009. Age and Web Access: The Next Generation. *Pages 7–15 of: W4A '09: Proceedings of the 2009 International Cross-Disciplinary Conference on Web Accessibililty (W4A).* New York, NY, USA: ACM.

Hartley, Alan A. 1992. *The Handbook of Aging and Cognition.* Laurence Erlbaum Associates. ISBN: 0–8058-0713-6. Chap. 1: Attention, pages 3–53.

Hartley, James. 1994. Designing Instructional Text for Older Readers: A Literature Review. *British Journal of Educational Technology*, **25**(3), 172–188.

Hawthorn, Dan. 2000. Possible Implications of Aging for Interface Designers. *Interacting with Computers*, **12**(5), 507–528.

Hawthorn, Dan. 2002. How Universal Is Good Design for Older Users? *ACM SIGCAPH Computers and the Physically Handicapped*, **73–74**(June–September), 38–45.

Hodes, Richard J., & Lindberg, Donald A. B. 2002 (October). *Making Your Website Senior Friendly.* Tech. rept. National Institute on Aging, Building 31, Room 5C27 31 Center Drive, MSC 2292 Bethesda, MD 20892, USA.

Holt, Barbara. 2000. Creating Senior Friendly Web Sites. *Center for Medicare Education*, **1**(4).

Horn, John L. 1982. *Aging and Cognitive Processes.* Advances in the Study of Communication and Affect. Plenum. ISBN: 0-3064-09461. Chap. 14: Aging of Fluid and Crystallized Intelligence, pages 237–278.

Kantner, Laurie, & Rosenbaum, Stephanie. 2003. Usable Computers for the Elderly: Applying Coaching Experiences. *In: IEEE Professional Communication Conference.*

Keates, Simeon, & Trewin, Shari. 2005. Effect of Age and Parkinson's Disease on Cursor Positioning Using a Mouse. *Pages 68–75 of: ASSETS '05: Proceedings of the 7th International ACM SIGACCESS Conference on Computers and Accessibility.* New York, NY, USA: ACM.

Kelly, Brian, Sloan, David, Phipps, Lawrie, Petrie, Helen, & Hamilton, Fraser. 2005. Forcing Standardization Or Accommodating Diversity?: A Framework For Applying The WCAG In The Real World. *Pages 46–54 of: W4A '05: Proceedings of the 2005 International Cross-Disciplinary Workshop on Web Accessibility (W4A).* New York, NY, USA: ACM Press.

Ketcham, Caroline J., & Stelmach, George E. 2001. *The Handbook of Psychology and Aging.* 5th edn. Academic Press Inc. Chap. 13: Age Related Declines in Motor Control, pages 267–287.

Kurniawan, Sri, & Zaphiris, Panayiotis. 2005. Research-Derived Web Design Guidelines for Older People. *Pages 129–135 of: ASSETS '05: Proceedings of the 7th International ACM SIGACCESS Conference on Computers and Accessibility.* New York, NY, USA: ACM.

Kurniawan, Sri H. 2008. *Web Accessibility: A Foundation for Research.* 1st edn. Human-Computer Interaction Series. Springer. Chap. 5: Ageing, pages 47–58.

Lenhart, Amanda. 2009 (January). *Adults and Social Network Websites.* Tech. rept. Pew Research Center, 1615 L Street, NW Suite 700 Washington, DC 20036.

Lustig, Cindy, Hasher, Lynn, & Tonev, Simon T. 2001. Inhibitory Control Over the Present and the Past. *European Journal of Cognitive Psychology*, **13**(1&2), 107–122.

May, Cynthia P., Hasher, Lynn, & Kane, Michael J. 1999. The Role of Interference in Memory Span. *Memory & Cognition*, **27**(5), 759–767.

Meyer, Beth, Sit, Richard A., Spaulding, Victoria A., Mead, Sherry E., & Walker, Neff. 1997. Age Group Differences in World Wide Web Navigation. *Pages 295–296*

of: CHI '97: CHI '97 extended abstracts on Human factors in computing systems. New York, NY, USA: ACM.

Milne, S., Dickinson, A., Carmichael, A., Sloan, D., Eisma, R., & Gregor, P. 2005. Are Guidelines Enough? an Introduction to Designing Web Sites Accessible to Older People. *IBM Systems Journal*, **44**(3), 557–571.

Moffatt, Karyn A., & McGrenere, Joanna. 2007. Slipping and Drifting: Using Older Users to Uncover Pen-Based Target Acquisition Difficulties. *Pages 11–18 of: ASSETS '07: Proceedings of the 9th International ACM SIGACCESS Conference on Computers and Accessibility*. New York, NY, USA: ACM.

Morell, Roger W. 2002. *Older Adults, Health Information and the World Wide Web*. Lawrence Erlbaum Associates, Inc.

Mortensen, Ole E., & Møller, Bettina U. 2007. The Consequences of Age-Related Sight and Hearing Loss. *DbI Review*, July – December.

Newell, Alan F., Dickinson, Anna, Smith, Mick J., & Gregor, Peter. 2006. Designing a Portal for Older Users: A Case Study of an Industrial/Academic Collaboration. *ACM Transactions on Computer-Human Interaction (TOCHI)*, **13**(3), 347–375.

Nielsen, Jakob. 2002. Usability for Senior Citizens. *Alertbox*, April. `http://www.useit.com/alertbox/20020428.html`. Last Accessed 15th July 2009.

Nielsen, Jakob. 2005. Ten Usability Heuristics. *Alertbox*. `http://www.useit.com/papers/heuristic/heuristic_list.html`. Last Accessed 23rd July 2009.

Pan, Bing, Hembrooke, Helene A., Gay, Geri K., Granka, Laura A., Feusner, Matthew K., & Newman, Jill K. 2004. The Determinants of Web Page Viewing Behavior: An Eye-Tracking Study. *Pages 147–154 of: ETRA '04: Proceedings of the 2004 Symposium on Eye Tracking Research & Applications*. New York, NY, USA: ACM.

Perlmutter, Marion, & Mitchell, David B. 1982. *Aging and Cognitive Processes*. Advances in the Study of Communication and Affect. Plenum. ISBN: 0-3064-09461. Chap. 7: The Appearance and Disappearnce of Age Differences in Adult Memory, pages 127–144.

Rayner, Keith. 1998. Eye Movements in Reading and Information Processing: 20 Years of Research. *Psychological Bulletin*, **124**(3), 327–422.

Redish, Ginny, & Chisnell, Dana. 2004. *Designing Web Sites for Older Adults: A Review of Recent Research*. Tech. rept. AARP.

RNIB. 2007. *Understanding Cataract*. Royal National Institute for the Blind Online Publication. `http://www.rnib.org.uk/xpedio/groups/public/documents/PublicWebsite/public_rnib003640.hcsp`. Last Accessed 17th March 2009.

RNIB. 2008a. *Understanding Age-Related Macular Degeneration.* Royal National Institute for the Blind Online Publication. http://www.rnib.org.uk/xpedio/groups/public/documents/PublicWebsite/public_rnib003635.hcsp. Last Accessed 18th March 2009.

RNIB. 2008b. *Understanding Glaucoma.* Royal National Institute for the Blind Online Publication. http://www.rnib.org.uk/xpedio/groups/public/documents/PublicWebsite/public_rnib003655.hcsp. Last Accessed 18th March 2009.

Rogers, Wendy A., & Fisk, Arthur D. 2001. *The Handbook of Psychology and Aging.* 5th edn. Academic Press Inc. Chap. 11: Understanding the Role of Attention in Cognitive Aging Research, pages 267–287.

Sàenz, Melissa, Buracas, Giedrius T., & Boynton, Geoffrey M. 2003. Global Feature-Based Attention for Motion and Color. *Vision Research*, **43**(6), 629 – 637.

Sayago, Sergio, Camacho, Laura, & Blat, Josep. 2009. Evaluation of Techniques Defined In WCAG 2.0 With Older People. *Pages 79–82 of: W4A '09: Proceedings of the 2009 International Cross-Disciplinary Conference on Web Accessibililty (W4A).* New York, NY, USA: ACM.

Sears, Andrew. 1997. Heuristic Walkthroughs: Finding the Problems Without the Noise. *International Journal of Human-Computer Interaction*, **9**(3), 213–234.

Sloan, David, & Dickinson, Anna. 2006. Accessibility Statements Are Inaccessible to Older Web Users. *In: HCI, the Web and the Older Population – British HCI 2006.*

Smith, Michael W., Sharit, Joseph, & Czaja, Sara J. 1999. Aging, Motor Control, and the Performance of Computer Mouse Task. *Human Factors*, **41**(3), 389–397.

Spiezle, Craig, & Shambaugh, Elizabeth. 2001. *Interface Design Guidelines for Users of All Ages.* Tech. rept. AgeLight Consultancy Group, 9057 Points Drive NE, Clyde Hill, WA 98004-1611, USA. http://www.agelight.com/Resources/webdesign.htm. Last Accessed 17th March 2009.

Tullis, Thomas S. 2007. Older Adults and the Web: Lessons Learned from Eye-Tracking. *Pages 1030–1039 of: Universal Access in Human Computer Interaction. Coping with Diversity*, vol. 4554. Springer.

Wood, Sharon, Cox, Richard, & Cheng, Peter. 2006. Attention Design: Eight Issues to Consider. *Computers in Human Behavior*, **22**(4), 588–602.

Yesilada, Yeliz, Chen, Tianyi, & Harper, Simon. 2008 (July). *Mobile Web Barriers for the Barrier Walkthrough.* Deliverable D3. The University of Manchester, School of Computer Science, Kilburn Building, Oxford Road, Manchester, M13 9PL, UK. http://hcw-eprints.cs.manchester.ac.uk/93/. Last Accessed 10th August 2009.

Zajicek, Mary. 2007. Web 2.0: Hype or Happiness? *Pages 35–39 of: W4A '07: Proceedings of the 2007 international cross-disciplinary conference on Web accessibility (W4A)*. New York, NY, USA: ACM.

Zaphiris, Panayiotis, Kurniawan, Sri, & Ghiawadwala, Mariya. 2007. A Systematic Approach to the Development of Research-Based Web Design Guidelines for Older People. *Universal Access in the Information Society*, **6**(1), 59–75.

Zhao, Haixia. 2001 (April). *Universal Usability Web Design Guidelines for the Elderly (Age 65 and Older)*. Tech. rept. The University of Maryland, Department of Computer Science, College Park, Maryland, 20742, USA.