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Non-Visual Access to the Digital Library (NoVA): the use of the digital library interfaces by blind and visually impaired people

by

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The information seeking behaviour of visually impaired people has been explored in this study to develop further understanding of user behaviour with web based resources. Using a sample of twenty sighted and twenty visually impaired people, users undertook the same four information seeking tasks using four different electronic resources. Results confirmed that it takes visually impaired users longer to complete searching and browsing tasks, with times varying considerably depending on the design of the site. Overall, visually impaired users spend more time navigating around each page, especially if, for example, the page contains a lot of information or has many links. Observations revealed that those using screen reading technology tended to find searching the web much harder than those who had some sight and could use screen magnification or read a screen at close proximity. People with more experience with the assistive technology they were using were also more successful with the task, which raises training issues both for users and trainers. The type of assistive technology used also had a bearing on the search process - the more advanced features offering the user a more flexible approach to searching.

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"It just takes so long – sighted people just go click, click, click, and there's the answer …… while I'm still looking for the first bloody link.

It's very frustrating!"

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CONTENTS

1 INTRODUCTION

One of the hallmarks of a civilised society is its commitment to ensuring that all of its citizens can play a full part in its life, and that none are excluded by reason of birth, belief, aptitude or circumstance. Exclusion takes many forms and must be countered in many different ways. Undertaken by the Centre for Research in Library and Information Management (CERLIM) at the Manchester Metropolitan University, the Non-Visual Access to the Digital Library (NoVA) project was concerned with exploring the exclusion from access to information which can all too easily occur when individuals do not have so-called "normal" vision. Our domain in this project is digital library services, and our concern is to improve understanding of the differences between the information searching behaviour of sighted and visually-impaired users in such environments and thus to contribute to the development of more accessible services.

The rapid development of networked information and communications technologies provides opportunities for radical changes in the services which can be delivered to all information users, including those who need to use "accessible" formats and systems in order to overcome visual or other disability. During usability testing carried out as part of the REVIEL project (http://www.cerlim.ac.uk/projects/reviel.htm) in which blind people accessed a variety of online resources, it became apparent that navigation is a major problem within digital library systems. A good example is the use of frames in a web environment to enable the user to perform complex selections across categories. A sighted person navigates between frames in a complex, non-linear manner which displays strong parallelism. A non-sighted person using audio or Braille output has to navigate linearly within one frame at a time, and may need to backtrack a long way (again in a linear manner) in order to reach the desired point (and then maybe track forward again). Although REVIEL provided the initial impetus for investigating this area, NoVA was designed to investigate it in depth.

Of course, much work is continuing to make interfaces accessible - witness, for example, the work of the World Wide Web Consortium's Web Accessibility Initiative (W3C WAI) - but there is little current work on how blind and visually impaired people navigate interfaces, and in particular on how the serial paradigm of a blind person's search maps onto the parallelism displayed by so many interfaces. Work on accessibility concentrates on transcribing text (or replacing images etc. with text) when the problem may in fact be much deeper. Work on information seeking behaviour and the use of interfaces assumes visual capabilities, which blind and visually impaired people often do not possess.

The overall objective of the NoVA Project, therefore, was to develop understanding of serial searching in non-serial digital library environments,

with particular reference to retrieval of information by blind and visually impaired people.

The term visually impaired is generally used to describe "all those who have a seeing disability that cannot be corrected by glasses" (Hopkins 2000). This includes people who are entitled, under UK regulations, to register as blind or partially sighted. A blind person can be registered as either blind or partially sighted, although registration as blind rarely means total loss of sight. The measure is based on the "quality of distance and side vision as measured by consultant ophthalmologists" (Hopkins 2000).

The sample of visually impaired sample who took part in the NoVA project will be referred to in this report as "visually impaired" whether or not they had total or partial sight loss. This is in no way an attempt to over-simplify eye conditions, or to try and define the sample as one homogenous group. It is merely an attempt to simplify the terminology used in the report and to concentrate on the key issue of navigation where "standard" visual cues are not available. It is acknowledged that exploration of the variations in behaviour imposed by different types of impairment would require a different, and more extensive, study.

2   ADAPTING TO VISUAL IMPAIRMENT

Before turning to the specific area of web environments, it is useful to review briefly the development of navigational and other aids for use in the everyday life of people with visual impairments. This gives some hints of the kinds of strategy that are adopted in the face of other access challenges, but it is also useful because very often web designers use spatial metaphors which may or may not translate well into non-visual approaches.

How do people who have been blind since birth navigate their way around a room or a building? Is it possible for a blind person standing in the middle of a large open town square to perceive that feeling of space? Or, if they have been taken on a specific route, perhaps to school or to work, are they then able to hold a mental picture in their mind of that route and if so, would it resemble the mental map of a sighted person? These questions were explored by Dodds *et al.* (1982) who undertook a series of tests with congenitally blind (i.e. blind from birth) children and with children who had become blind since birth. The tests attempted to explore previous theories relating to spatial representation and whether someone who has no visual experience can develop an idea of space.

Each child was taken on a specific route and then asked to draw a representative map of that route. The tests revealed that the children who had become blind (and therefore possessed some previous visual experience) could produce a more realistic map of the route taken – in other words one that resembled the actual route, whereas the children who were born blind had to draw on their own perception of the route, producing a personal map which in most cases bore very little resemblance to the actual route map.

The tests showed that although congenitally blind people do posses spatial perception, in the absence of previous visual experience they tend to "adopt egocentric or self–referent special coding strategies" (Dodds *et al.* 1982). These findings could be an important factor for consideration when describing layout and structure to a congenitally blind person. For a sighted person the obvious pointers and description of, for example, a route map or the plan of a building could bear little resemblance to the mental map drawn by the blind person. Could these factors also be taken into consideration when designing interfaces? Certainly the analogy of a desktop, often used to represent items in two dimensions on a PC, could be redundant to someone who has never actually seen the layout of a three-dimensional desk and has a different mental map of it.

Learning how to describe layout and surroundings is not an easy task, as each person will have their own perception of space (Dodds *et al.* 1982). Crossland challenges traditional rehabilitation training methods which in the

past have relied on the practice of blindfolding trainee rehabilitation workers and getting them to undertake tasks or navigate around towns, as this may give them a misguided view in which they "believe that they know what it is to be blind"(Crossland 1996). Another example of this is the Channel 4 programme "Blind Man's Bluff" screened in 2001, which involved four sighted TV celebrities who were given glasses that "simulated sight loss". They were all set a task of navigating a 250 mile journey from Blackpool to London, with minimal support, the idea being to give them an idea of what it would be like to be blind.

As an alternative to this approach, Crossland stresses the importance of addressing the individual needs of visually impaired people and helping them engage in activities which are important to them, which may be "partly personal, partly cultural and partly generational". In this view, daily living skills can generally be met through advice and guidelines but need to be individually interpreted. Rehabilitation should focus on "a more client-centred approach" which helps the person "find new ways to relate to the environment and their mobility" (Crossland 1996).

The ways visually impaired people relate to the environment are discussed by Lindo and Nordholm using a model developed by Persson to compare adaptation strategies used by visually impaired people in performing activities of daily living (Lindo and Nordholm 1999). The Persson model identifies positive and negative adaptation strategies:

Positive strategies are:

- Acceptance
- Trust
- Positive avoidance
- Minimization
- Independence
- Control.

Negative strategies are:

- Denial
- Resentment
- Shame
- Isolation

- Helplessness

(Persson 1990)

Other strategies for adapting to sight loss are also discussed by Lindo and Nordholm. Comparisons are made of positive and negative adaptation strategies used by visually impaired people who attended a rehabilitation program with two other groups – one group of people with neurological problems and a group of non-disabled people. Data was collected using three models:

Persson's adaptation questionnaire (Persson 1990), which describes positive strategies of acceptance.

The Mood Adjective Checklist (Sjoberg, Svensson 1979), which uses 71 adjectives describing various moods, such as, "elated", "nervous", and "indifferent", which the respondents rate on a 4-point scale.

The Activities for Daily Living (ADL) questionnaire (Kroksmark and Thoren-Jonsson 1985) which assesses the level of difficulty in performing everyday tasks experienced by visually impaired people.

James notes that, like many other people, blind and visually impaired people are turning to the Internet for their information needs which "may be the only source that they can use to access information for their daily lives, such as bus schedules and movie listings" (James 1998 p.27). Earlier work on adapting to sight loss needs to be revisited in the context of this new environment

2.1 Everyday tasks for visually impaired people

Todd and Wolf (1994) provide a comprehensive guide to dealing with sight problems, with topics ranging from "coming to terms with sight loss" to "dealing with money matters". Everyday tasks are covered in a chapter on "Coping day by day" which describes how to make daily tasks such as cooking and housework easier by using improved lighting and colour contrasts – e.g. dark chopping board for light foods and vice versa. Not surprisingly given the date of publication, access to IT and computers is only covered briefly and some activities such as shopping may have changed since the book was written – the pros and cons of online shopping for example are not mentioned.

The RNIB produces some useful fact-sheets for visually impaired people, available via their web site (www.rnib.org.uk). These fact-sheets include how to travel independently, shopping made easier and going on holiday, as well as useful guidelines for sighted people on how to meet and interact with blind people. Advice on travelling independently includes general common sense tips such as checking bus times, making sure you are familiar with the route to

a bus stop or train station, but also suggests asking if Braille timetables are available or whether there is a telephone timetable service. Advice on the use of technology for visually impaired people is also available and includes fact-sheets about personal computers, choosing the appropriate equipment, and access to the Internet.

The study by Lindo and Nordholm referred to earlier found that people expressed the most difficulty with reading, writing and watching television, followed by mobility problems such as "using public transportation, doing postal and bank errands, socializing, shopping and engaging in leisure activities" (Lindo and Nordholm 1999) and to a lesser extent daily living skills such as setting a table, eating, and drinking. The study showed that people use a combination of positive and negative adaptation strategies and that each person needs support at two levels: for coping with daily living activities and, as Crossland (1996) has also pointed out, to offer emotional support.

Kleinschmidt's study of older adults' adjustments to sight loss includes a section on the "problem solving perspective" in which a group of older visually impaired or blind adults talk about coping with everyday tasks through simple techniques such as labelling objects more clearly using "glue, toothpicks, emery boards, red blobs, and electrician's tape" (Kleinschmidt 1999) as well as listening to changing sounds such as the dial on a clothes dryer. A comment made by one person was that often it was very simple adjustments such as asking for a larger plate to avoid spilling food on the table, which made all the difference. Undoubtedly there are parallels in the use of ICTs.

2.2   Mobility issues

Travel aids have successfully improved the mobility of blind and visually impaired people by helping them to navigate their way around obstacles, often with the aid of primary aids such as a guide dog or a white stick. Development of primary aids includes obstacle detectors and sensors, laser canes and ultrasonic aids to inform people of obstacles, turnings and objects. Petrie *et al.* refer to this level of mobility as micro-navigation, in which people need to negotiate obstacles and pathways before moving on to the macro level of navigation which involves knowing which street they are on and in which direction they are heading (Petrie, *et al.* 1996). They describe the development of an electronic travel aid called the MoBIC travel aid (MoTA), which aims to address the macro-navigation problem.

The MoTA consists of two components. The first is the MoBIC Pre-Journey System (MoPS) which helps with the use of maps for planning a journey – these could include maps from public and personal sources as well as specific information such as information on specific surfaces underfoot (for example cobbled pavements and grassed areas). The second component is the MoBIC Outdoor System (MoODS), which provides orientation and navigational assistance during the journey by using the information provided in the MoPS.

Types of information provided in the MoTA include landmarks such as buildings, post boxes, phone boxes etc, street names, surfaces underfoot, distance between landmarks or turns, directions and instructions for navigation.

Work undertaken by Harper on standardising electronic travel aid interaction for visually impaired people puts forward a proposal for a universal interface to aid visually impaired users (Harper 1998). The study compares real life travel tasks with virtual ones such as travelling around a website, and suggests that just as sighted people's real life travel tasks will differ from those of people with sight problems, the same is true in a virtual world. Harper thus makes the explicit connection between navigation in "real" and "virtual" environments.

The stages of a journey have been broken down into what Harper calls the "Travel Task Model", which includes elements of orientation (direction, route, desired location etc) and navigation (use of maps, landmarks, knowledge of obstacles etc). The flow of travel in the travel task model takes the following route:

- Decide on start and destination
- Pre-plan the route
- Start the journey (throughout which obstacle detection and avoidance must be performed)
- Orient to waypoint, information point or orientation point.
- In-route guidance
- Moving to next point
- Achieve next point.

(Harper 1998 p.20).

An example of a sighted person's description of their travel task might be: "walk to pedestrian crossing and then continue to bank" whereas a visually impaired person may say "walk 20 metres ahead, then from the tactile surface walk 10 metres to the North West of that position and you are at the bank" (Harper *et al.* 2000). This demonstrates that in the real world it takes a sighted person much less time to orientate themselves and less time to navigate to a landmark than a visually impaired person, who needs to "break their journey into shorter stages and orientate themselves within the journey a great number of times".

2.3   Conclusions

The ways in which people adapt to visual impairment and in which navigational aids are used to overcome problems in everyday situations

provide useful insights into the problems experienced in networked information environments. The literature analysed in this section illustrates how visually impaired people apply a variety of strategies to cope with daily living problems. These include reproducing materials in enhanced media such as large print, or adding features to a product such as a tactile surface or a brightly coloured label to inform the person of its contents. Parallels in a web environment would include assistive technologies to read out or magnify a screen, and accessibility features applied to the HTML encoding to enable interaction with the web page and the assistive technology. However, as in everyday life, different user needs and behaviours also need to be taken into account.

Studies of travelling and mobility reveal that someone with a visual impairment will have a very different experience to that of a sighted person. When asked to describe the travel experience they will generally reproduce a different description of the route taken - including more detailed information such as the feel of a surface or the exact number of steps taken before making a turn. Studies have also shown that someone born blind will have more difficulty with visual representation, such reproducing a map to describe a route taken. This is likely to be the same in the virtual world as the "desktop" or other layout of a computer screen or the parallel layout of a page in frames may have little meaning to someone who has never seen a web page or computer screen.

To aid travelling in the real world, navigational aids have been developed for visually impaired people such as tactile maps or route descriptions that include details of surfaces and obstacles. The way a visually impaired person "travels" around a web site will also be a different type of experience to that of a sighted person, and it is likely that these real-world experiences could be used to advise interface designers of the inclusion of useful features such as landmarks or pointers to aid navigation in the virtual world.

A clear message to emerge from the literature is that whatever the task, be it going on holiday, shopping, travelling or using a computer, people want to be able to undertake it as independently as possible and will adopt a strategy to try and attain independence and to overcome any problems. The next section will look more specifically at web design and accessibility and how these issues will impact on the ability of blind and visually impaired people to interact successfully and independently in web-based environments.

3   ACCESSIBILITY & DESIGN FOR VISUALLY IMPAIRED PEOPLE

3.1   Accessible web interfaces

There has been considerable research into accessible web interfaces. TIDE ACCESS is described in a paper by Stephanidis and Emiliani (1998) which stress its focus on the "design for all" concept. The SPEECH project (Zajicek and Powell 1997) built a conceptual model of the web for visually impaired users through development of the BrookesTalk web browser, which aims to present the contents of web pages for anyone using speech-only technology. Other development work includes that undertaken by the Trace Center (O'Briant 1999) and the W3C Web Accessibility Initiative (Casey 1999). For a review of this work see the REVIEL Project final report (Brophy and Craven 1999).

Early papers on accessibility (e.g. Astbrink (1996), Dixon (1996), Kerr (1997)) offer practical advice on accessible web design stressing that correctly applied HTML will help ensure universal access and should be provided as "a right, not a favour". Both Dixon and Astbrink provide advice on all the main accessibility points such as the handling of images, forms, tables etc. Kerr also offers practical advice for making web pages accessible, and although the paper concentrates mainly on the problems faced by blind users trying to access web pages using a screen reader, the article emphasises the fact that making web pages accessible for this group of people improves access for all. The paper covers technical solutions for accessing web pages such as access technology; then moves on to consider some general design principles such as the use of images, columns and forms; and finally covers more advanced design issues such as the use of JavaScript and PDF files.

Basic design principles are addressed by Poulter *et al.*, concentrating mainly on the structure of files and hypertext links (Poulter *et al.* 1999). Ormes and Peacock focus on the need for public libraries to be aware of accessibility issues and summarise the main points such as the use of images, maps, tables, frames etc (Ormes and Peacock 1999). The paper goes on to describe the work of the W3C and describes how to check web pages for accessibility. The final report of the REVIEL project, published under the title *The Integrated Accessible Library: A model of service development for the 21st century*, includes a chapter devoted to "Making Electronic Formats Accessible" as well as another chapter on the "Accessibility of current electronic information services in the UK" which looked specifically at the JISC online services and also at a selection of UK Higher Education libraries' web sites (Brophy and Craven 1999).

A wide range of articles, books and reports can be found on the subject of web accessibility: see for example Waters (1997), Paciello (2000) and Nielsen

(2000). Many organisations have also produced their own accessibility guidelines, usually based on the recommendations of the World Wide Web Consortium, perhaps tailoring this approach to make it more user friendly or to address specific issues. For example, Jenkins describes how the Web Accessibility Guidelines were implemented at IBM (Jenkins 1997), covering steps taken including information relating to general disability issues. The paper describes how different types of visual impairment can present different problems, for example with colour, depth and fonts and also covers hearing, mobility and cognitive impairments. Solomon recognises that whilst it is important to try to adhere to the W3C guidelines, some organisations "may not have the resources to allow developers to learn these standards end-to-end", therefore producing a basic guide for developers which covers the main accessibility issues can act as a starting point "rather than not thinking about accessibility at all" (Solomon 2002).

The development of an accessibility policy is described by Foley and Regan who view accessibility as an "important and timely issue" which needs to be addressed by any organisation that has a website. The paper provides advice on the identification and adoption of a policy as well as validation methods to check for accessibility based on the W3C guidelines. The authors conclude that "there are no quick fixes for accessibility, but careful and thoughtful planning can minimize many of the challenges of accessible design"(Foley and Regan 2002). Thatcher describes implementation of accessibility standards relating to testing for Section 508 compliance in the USA (see section 3.2), but he warns that when testing web pages for accessibility it is important not to rely solely on automated checking tools (such as Bobby and Lift) because although software tools provide an initial check, "human judgement is essential" (Thatcher 2002). User testing of websites is strongly advocated by Nielsen (2000), who provides advice on accessible design of websites based on usability studies, as well as guidelines for conducting usability tests.

Brazier and Jennings provide an insight into the users' perspective, which can be compared with published guidelines and is based on consultations with users (Brazier and Jennings 1999). Also looking at specific issues rather than general design principles is a study commissioned by the RNIB (Buultjens *et al.* 1999). It examines font size and styles of print for visually impaired students to ascertain which are the most popular. Unsurprisingly the results showed a wide range of preferences but conclude that Helvetica N24 plain text is the most generally acceptable font size and style.

The perceptions and experiences of web use by blind and visually impaired users have been summarised by Berry in a literature review on issues of visual impairment (Berry 1999). The paper describes a study undertaken using a group of blind and partially sighted students and staff to ascertain their experiences in accessing and using the web. Not surprisingly, poorly designed web pages were identified as a severe problem for blind people. Beginners

and inexperienced users were more likely to become frustrated and switch off the computer. A study by the Nielsen Norman group also found that blind and visually impaired people experienced problems navigating the web and estimate that "the Web is about three times easier to use for sighted users than it is for users who are blind or who have low vision" (Coyne and Nielsen 2001 p.5).

3.2   Legislation

In the UK the Disability Discrimination Act (DDA) 1995 requires (under Part III of the Act) providers of "goods, facilities and services", such as libraries, to provide an equal level of services to all their customers. It states also that no extra charges can be imposed for service provision in relation to a person's disability, for example charging a fee to produce materials in alternative formats (Great Britain 1995.).

A summary of relevant legislation in the UK is provided by Oppenheim and Selby in a paper on access to the Web for blind and visually impaired people (Oppenheim and Selby 1999). The possible effects of the DDA are discussed, recognising that although the Act requires equal access to goods services and facilities, it is still unclear with whom responsibility lies, for example whether "an Internet Service Provider is responsible in this respect for the content of the web pages it carries" (Oppenheim and Selby 1999 p.337) or the actual creator of the page. Of greater concern to institutions is whether responsibility lies with the creator, the institution, or the individual of an institution providing links to resources from the institutions website. This still remains something of a grey area, although since technology plays such a big part in everyday life it is an issue that needs addressing. Orme suggests that lessons could be learned from US legislation, where steps have been taken to ensure universal access in Amendments to Section 508 of the Rehabilitation Act (1998) (http://www.section508.gov). The Act now makes it "unlawful for Federal Agencies to purchase inaccessible systems" (Orme 2001), although there are still areas which need further clarification. For example it is generally accepted that contrasting colours should be used for pages, but "Section 508 does not have such a provision requiring adequate contrast" (Thatcher 2002).

Implementation of measures outlined in the DDA under "goods, facilities and services" is required to take place between 1999 and 2004, by which time service providers must have taken "reasonable steps" to meet the needs of disabled people and to be providing an equitable service to all. As providers of services, libraries must ensure their buildings are accessible and must consider alternatives to service provision for those who cannot physically visit the library. Libraries should also provide alternative means of accessing resources, such as reading aids and alternative formats. This will help break down barriers to the information society, in particular to information that is available electronically.

Exemptions under the goods, facilities and services section of the DDA originally excluded the educational provision of institutions, such as universities. The Special Educational Needs and Disability Act (2001) (Great Britain 2001) (Part 4 of the DDA) will be implemented in September 2002 and although covering services already included in Part 3 of the DDA will affect all education and training provision in higher education, including services such as libraries. The new legislation "require(s) UK universities to provide access to assistive technologies such as Braille readers and speech encoders (and) requires that material placed on the Web is accessible" (Doyle and Robson 2002). However, there are some areas of the new Act that require further clarification. For example, it is still unclear whether an individual providing an accessible web site, but with links to inaccessible resources is in breach of the Act. A Draft Code of Practice to the Special Educational Needs and Disability Act 2001 has been produced by the Disability Rights Commission (http://www.drc-gb.org/drc/documents/post16cop.doc), which should help clarify such issues. As well as the Code of Practice, a comprehensive guide to the provision of accessible curricula has been produced by the University of Wales Cardiff, the Learning and Teaching Support Network and TechDis, and includes details about universal design and web accessibility (Doyle and Robson 2002).

3.3   Design considerations for human-computer interaction.

3.3.1   The users

Users can be categorised in many different ways: novice or expert; occasional or frequent; literate or illiterate; well-equipped or resource-starved; and so on - and each of these categories represents a spectrum rather than an absolute. Few of the possible categories will be mutually exclusive. While visual capability can form a useful categorisation - or spectrum of capability - it is important to recognise that this is but one more way of categorising individuals and that the same multiple underlying differences would characterise any population being studied.

When considering users and their needs, good system design will take account of users' characteristics in relation to the tasks they are performing as well as considering "user characteristics independently of tasks" (Hackos and Redish 1998 p.23). Indeed there is considerable evidence to suggest that task is one of the most important of all variables (Griffiths *et al.* 2002). A task-oriented view would suggest that a number of specific questions need to be answered during the design and evaluation of any system. Examples include the users' perceived relationship with their work, how the users envisage using the system (e.g. occasionally, frequently, within particular contexts), previous experience performing similar tasks and motivation to perform the specific task (Hackos and Redish 1998). Clearly in order to answer such questions it is also important to establish who the users are, or are likely to be.

In any research study there is a trade-off between the number of variables which can be investigated and the depth of investigation. While not neglecting the characteristics of the user samples selected, NoVA has been primarily concerned to explore use in depth with small numbers of users rather than superficially with a large sample. As a result, no claims are made for significance of results in respect of user variables other than visual impairment. Other studies which have explored user characteristics in depth need to be consulted for this perspective.

3.3.2   Information gathering as a physical process

Human beings gather data through the five senses: vision, hearing, taste, smell and touch. It is generally accepted that for most people vision is the most important and the most used and is the one they will concentrate on first. For this reason the design of human-computer interfaces tends to concentrate on vision first and foremost, and at present is concerned almost exclusively with only three of the five senses, vision, hearing and touch. Taste and smell do not generally feature in serious interface design.

Vision is a complex function, which not only involves the physical capture of light (including shade, colour and contrast) by the eye itself but also interpretation by the brain. Theories of perception take us well beyond the scope of NoVA (although see section 3.3.3 below for some brief comments on this topic), but it is important to note the range of physical disabilities which can result in visual impairment. So, for example, the degree of visual acuity and visual field will impact on the quality of sight, a loss of visual acuity causing objects to become blurred. Restricted field of vision will have an effect on the user's ability to view several pieces of information on one screen – in frames for example. Colour, hue, brightness, contrast and ambient light will each have a different effect on different users, and for those with visual impairment they may effectively result in exclusion.

For someone who is blind or severely visually impaired, and effectively unable to process information visually, the most important senses will probably be hearing or touch. Sound can be used as a locator and as an alerting device, not just for visually impaired people but also for sighted people as "people respond more quickly to auditory signals than to visual signals" (Faulkner 1998 p.27). Auditory output is increasingly moving "beyond the regular error beep" (Lowgren 1993 p.91) used in many applications and of course speech output is now in the mainstream (though perhaps not for web-based applications). However, a number of research projects have looked specifically at the production of auditory sounds to depict graphical icons to enable access to graphical user interfaces by blind and visually impaired people (see 3.3.5 below).

Touch can be a useful way of presenting information for someone who is blind or deaf-blind, or for users working in a very noisy environment. Touch has been important in the development of keyboards: research has found that

users can be affected by the feel of a system and touch has been used to provide feedback on "simulated physical manipulation" (Lowgren 1993 p.92). Tactile images, graphs and maps are also used to display visual information to someone who is unable interpret the screen visually. Tactile or "feelable" mice have also been developed which make different vibrations according to different areas on-screen such as the tool bar or the edit box.

In essence these approaches all help to make information available by using a range of sense-data and thus compensating for impairment. However, the success of this approach is entirely dependent on whether both the content and the structure of the information object can be successfully translated in this way. Users are participants in this process and are able to adapt themselves to the available technology and systems; NoVA was interested in how this adaptation works in practice, and how successful users are in developing strategies which use available technology to overcome potential and actual access problems.

3.3.3   The interpretation of information through cognitive processes

As noted above information is interpreted not only through the senses, but also through c ognition. Simply seeing, hearing or touching provides primary data but for users to be able to turn data into information they need to have a "cognitive framework upon which to hang their understanding" (Rowley and Slack 1998 p.25). Cognit ion is "what enables the perception of objects and events" (Faulkner 1998 p.12).

The cognitive framework is only one of the models which needs to be elucidated if the process of understanding data, and turning it into information and knowledge, is to be understood. Again this takes us well beyond the scope of NoVA itself, but it is worth noting here that one of the ways in which systems designers seek to aid cognition is by using analogies. So, a dustbin (or trash can if the software is of US origin) is used to depict the action of deleting files. This can be useful because familiar actions from other environments provide powerful aids to cognition in unfamiliar ones. However, the approach must be used with great care. For example, the analogy of a card catalogue may be too limited to map onto the reality of an OPAC and may mislead the user into thinking that all actions will be analogous - the debates which at one time raged over the concept of the "main entry" in computer-based catalogues form a good example of the confusion that can arise.

Among the other cognitive models which need to be considered, learning styles may be particularly important in the context of electronic information systems, though this is an area that has attracted only limited research. Rowley and Slack (1998) use Kolb's learning cycle to demonstrate a perspective on adult learning based on four learning styles: activist, reflector, theorist, pragmatist – all of which can be mapped onto the learning cycle (Rowley and Slack 1998 p.32). Brophy (2001) points out that "learning models

can be related to personality types" and that "influences range from past experiences, habits of thought, basic personality, education, specific environmental demands from the learner's chosen profession, current job, and specific task in hand".

As an example of the relevance of this approach, research into cognitive styles and their influence on information seeking behaviour undertaken by Kim suggests that the Field Dependent (FD) and the Field Independent (FI) styles are likely to impact differently on the success of the user searching in a non-linear web environment. FD users tend to navigate in a linear way whereas FI users move freely around the system, trying a "higher number of access attempts than FDs" (Kim 2001 p.235). User testing found that FIs tended to be more successful in their searching than FDs if they were novice searchers, although experienced FD and FI users tended to have similar information seeking behaviour. If users whose natural inclination is to adopt an FI approach are forced into FD type searching by their visual impairment, there is a clear danger of disadvantage. Again, however, this introduces another type of variable into the analysis and would require further research.

3.3.4   Human-computer interfaces

A further area of research which is of considerable relevance is that of human-computer interaction (HCI) and in particular its influence on the design of interfaces. Marchionini defines an interface as a communication channel which "serves as an intermediary between the user and the database" (In: Church 1999 p.6). HCI itself has been defined by Booth as "the study of the interaction between humans and computers" (Booth 1989 p.4). The following areas of HCI research are of particular importance:

- Users' methods of interaction and how these affect communication at the interface.

- More broadly, how users interact with computer systems as a whole.

- How well systems meet users' task requirements and information needs.

- User centred design and development: improving the design and development of systems by placing the user at the centre of the design process.

- The impact of the computer on individuals within an organisation and on the organisation as a whole.

Dillon & Watson have suggested that further research is needed into user differences and how these could influence interface design. Different interface types for instance may work best for particular groups of users (Dillon and Watson 1996 p.620): an obvious example is the provision of separate interfaces for beginners and experts, though this is now becoming subsumed into research on personalisation. Aspects such as domain knowledge, general

computing experience and more specific application experience are all of relevance. This approach is stressed by Church who suggests that "an evaluation of the receiver's traits should be an initial step in instructional design" (Church 1999 p.6) and also by Green who, referring to the cognitive approach, states that "it starts from considering the mental life of the user to reveal what he or she knows about the interface and how that knowledge is put to use" (Green 1986). Other variables could include the user's background and the types of web pages a user typically visits (James 1998 p.27).

The nature of HCI has evolved over the years. Marchionini and Komlodi (1998 p.92) track the development of HCI from one of an interface designed for specialists who acted as professional intermediaries to satisfy users' information requirements, to the interface designed for generally computer literate end-users performing their own information seeking tasks. The current emphasis is on universal access for all whether computer literate or novice.

3.3.5 HCI Design for visually impaired users

In various fields there are examples of design for disabled users leading to access for all – such as the development of the talking book for blind and visually impaired people led to books on cassette tape, and a well known example is that of curb cuts, designed for wheelchair users but of benefit to people with shopping trolleys and pushchairs.

Chong states that "each step in the evolution of computer technology posed a different set of problems for the blind" (Chong 1994 p.53) although he goes on to acknowledge that some of the problems have been addressed, if not overcome. Graphical User Interfaces (GUIs) have posed particular problems for visually impaired users, not least because "they cannot interact with the computer using a mouse and pointing system" (Boyd *et al.* 1990) although this mode of interaction is often simply assumed by designers.

A considerable number of research projects have explored the development of systems which overcome the problems of the GUI. In some cases this is achieved by providing a dual access system which can be used by both blind and sighted people simultaneously. Systems developed include *Soundtrack* (Edwards 1996), *Outspoken* (Edwards 1996 p.48), *Mercator* (Mynatt and Weber 1994), *GUIB* (Gill 1993), (Mynatt and Weber 1994), (Petrie and Morley 1995), (Edwards 1996), *HOMER* (Savidis and Stephanidis 1995), *Emacspeak* (Raman 1996), *DAHNI* (developed for the TIDE ACCESS project) (Morley et al. 1998), (Petrie and Morley 1997) and the development of the audio HTML access (*AHA*) framework (James 1998).

Features include the use of non-speech auditory icons to help users to navigate around a page. These are everyday sounds used to substitute for a graphical icon - such as the sound of a dustbin lid crashing as an analogy for the waste bin icon or delete key. *Earcons* is another approach which uses

sounds or tones such as a "bing" sound to denote movement from frame to frame. This helps with more abstract concepts such as the scrollbar which are difficult to translate (Mynatt and Weber 1994). The use of non-speech sounds is felt by developers to be more useful than speech because they are less time consuming to listen to and can hold a great deal of information in a relatively short processing time (Petrie and Morley 1998 p.207), although the users may have more difficulty in learning the meaning of auditory cues and not everyone finds them easy to learn and remember. Mynatt and Weber found that "although the auditory icons were readily learned, the intuitive nature of the interface suffered from the subjects' frustration with identifying the auditory cues" (Mynatt and Weber 1994 p.169).

Auditory and vocal cues are used in the Audio HTML Access (AHA) framework. This is based on the idea that "usable audio renderings can be produced in the same way that usable visual renderings are … directly from the HTML mark-up of pages" (James 1998 p.27) and follow a number of set principles:

- Vocal source identity: number of voices, context switches.
- Recognisability: sound identity, identity of prominent features and identity of metaphors.
- Distraction: number of sounds, signalling tendency (e.g. to denote the importance of tags), length of sounds, aesthetics (e.g. loud or soft cues, the use of abrasive or annoying cues).

Different sounds have been chosen to relate to the expectations of a variety of users. For example, children will be provided with different sounds to those designed for adults (another example of personalisation). It is generally recommended that, in the same way that prolific use of colours or fonts on a page can be confusing or too "busy" and therefore should be avoided, "the total number of speakers (i.e. different sounds) should be small" (James 1998 p.28).

The problem of controlling the mouse and locating the cursor has been addressed in many research projects. Substitutes for the mouse have been developed, including tactile displays (Ebina 1999), touch tablets (Mynatt and Weber 1994), (Petrie and Morley 1995) and Braille characters (Petrie and Morley 1995), (Edwards 1996), (Ebina 1999 p.41), although there are differing opinions as to whether the mouse should be replaced or simply eradicated (Mynatt and Weber 1994). Non-visual methods for locating the cursor have been developed to help prevent users from losing their bearings within a webpage or parts of a page. These include an overview of information such as quick navigation through the links on a page, headings for each section of a page together with quick navigation through headings (Petrie and Morley 1997 p.49).

The *Emacspeak* interface is designed to provide spoken feedback into the application i.e. not relying on using a separate screen reader to access what is on screen: "a screen reader speaks *what* is on the screen without conveying *why* it is there" (Raman 1996) and will therefore provide more richly spoken feedback. The idea behind this system is to allow the use of either the visual application or the spoken one (or the two combined).

Work has also been undertaken to develop an interface that can be used by sighted and non-sighted people simultaneously rather than using two separate systems. Part funded by the TIDE project, the *HOMER* tool was developed to enable the use of integrated interfaces which would be accessible to blind, visually impaired and sighted users.

For someone with a disability such as a visual impairment, searching and navigation will have limitations ranging from mild to severe, depending on the level of disability. Basic principles recommended by Carey and Stringer (2000) can be applied to the design of navigation and search screens to enable easier use by people with limitations:

- Synchronicity and integrity: information presented in a variety of formats (audio, visual, interactive) should be self-sufficient.

- Degrees of simplicity and complexity: users should have control over the way information is delivered to them and should be able to define the level of information required (basic, advanced etc).

- Multiplicity: establish a system to enable users to customise hardware, software and information systems to meet their individual needs.

- Over-ride: users should be able to over-ride the presentation of the original document on a temporary basis in order to render it accessible, but this should be done without changing the original document.

Requirements of a navigation system for people with disabilities may include:

- The conceptual model: the ease of which the user can understand the purpose and function of a system.

- Usability: the ease of which the system can be operated – either by the end user of by an intermediary system of device.

- Durability: the ability of the system to handle different materials and platforms.

- Aesthetics: resulting from a mix of the above requirements.

Carey and Stringer see the desktop metaphor becoming less useful due to the increasing complexity of computer functions and requirements. New models are emerging, but many have elements which make them difficult for disabled people to understand. The authors believe that navigation should be the starting point of any model and that a bi-directional network structure is a more useful model to adopt using a requirement that each level (or node) of the network structure has no more than nine links "and the maximum number of steps from any given start point not just the central node, to any other node does not exceed 9" (Carey and Stringer 2000 p.15). This model could be applied to web pages although it is recognised that "most web pages have more than nine links" (Carey and Stringer 2000 p.20) but it is felt that this could be overcome in part by observing user behaviour as to which links are most popular and grouping these into sets. The thinking behind this bi-directional model is in part based on observation of the interface layout of a phone-pad or a 3x4 grid, this addresses the durability requirement as this model can be adapted to different platforms such as mobile phone, web page or Palmtop.

The Towel project at Manchester University (www.man.ac.uk/towel/) aims to devise a framework for "identifying travel objects and registering them as either cues to aid travel or obstacles that hinder travel for visually impaired users" (Goble *et al.* 2000) – the aim being to minimise obstacles and maximise cues by using travel as a metaphor. This framework will then be fed into the design of better user agents and of improved web design to aid visually impaired (and other) web users. The authors suggest that whilst the work of the W3C and the Web Content Accessibility Guidelines cover issues of content presentation and navigation there is still much work to be done on how visually impaired people actually move around websites.

The Towel project identifies a number of issues relating to travel and mobility which visually impaired persons will need to address in order to achieve their travel task. For example, they need to be able to have advanced knowledge of any obstacles on the route (in other words a preview of what is ahead). Goble *et al.* (2000) describe this as "granularity" or "environmental cue availability" and suggest that the lack of a preview may cause people to bump into objects. As well as a preview of what is ahead, visually impaired people also need to have some form of a mental map of the route. This may be aided by the use of appropriate or "egocentric" terminology to describe points along the way (i.e. with less emphasis on the spatial and visual). It is also noted that people with visual impairments are also more able to relate to environments with regular features. Harper and Green (2000) suggest that a man-made environment such as a city is easier to relate to than a natural one, i.e. countryside. Finally, spatial information needs to be described in a more appropriate way to aid navigation and location and tracking of position.

3.4   Information seeking behaviour

3.4.1   General research into information seeking behaviour

Research into models of information seeking behaviour up until the mid-1970s is identified by Wilson as being mainly "document-focused studies" and "attempts to explore information needs" which were generally concerned with system use rather than user behaviour (Wilson 2000 pp. 51-53). The shift towards a "person centred" approach rather than "system centred" has developed since the 1980s and the work of Ellis, Dervin, Kuhlthau and Wilson are often cited with this shift.

Ellis' model, for example, includes features of information seeking behaviour rather than prescribed stages. This takes into account variables such as the task in hand and the individual. The model begins with "starting" and finishes with "ending" but suggests features such as chaining and browsing which may occur at different intervals during the process. Kuhlthau's model, which is related, has been developed to include feelings associated with various stages and activities such as initiation and selection (Wilson 1999 p.255).

Wilson presents a broader model of information behaviour in which:

information seeking behaviour arises as a consequence of a need perceived by an information user, who, in order to satisfy that need, makes demands upon formal or informal information sources or services which result in success or failure to find relevant information (Wilson 1999 p.251).

Dervin (1973) identified four elements, which comprise the information seeking environment of individuals:

- The individual information seeker.
- His or her information needs.
- Available information providers.
- Possible resolutions.

Of these four elements, six linkages comprise the information seeking network of the individual:

- Individual/information providers.
- Individual/information solutions.

- Information needs/information providers.
- Information needs/information solutions.
- Information needs/solutions to information needs.
- Information providers/solution to information needs.

With each link, barriers may arise denying effective information access to the individual. Dervin identifies barriers which might arise to deny effective information access, including societal, institutional, physical, psychological and intellectual.

At much the same time of Dervin's work, a study by Warner *et al.* (1973) related information seeking variables directly to a person's income, age and education. It was suggested that these variables influence whether a person tends to seek information more or less often and whether they tend to call upon a wider range of services. In a study of adults and the role of public libraries Zweizig found that both demographic and non-demographic variables affected information seeking patterns. Non-demographic examples could include the amount of book reading undertaken, the amount of community involvement, past use of professional sources, how open minded people were, knowledge of the library and the perceived credibility of the library as an information provider. Demographic examples are similar to those of Warner and include the level of education, gender and age (Zweizig 1973).

The above examples conducted in the 1970s looked at information needs of populations. Later research concentrated more on the information seeking individual as the basis for understanding and assessing individual information needs. For example Chen and Hernon identified *physical* barriers which are imposed when the individual is unable to "make contact with the appropriate information providers due to some physical consideration" (Chen and Hernon 1982 p.19). The example given was the absence of an alternative to library stairs for the "handicapped individual". This barrier to physical access would then have been a major consideration when providing access to information providers, i.e. the librarian.

Apart from the interface itself, important factors for consideration in the usability of networked information are the individual and the task (Nielsen 1993). In a review of research on Web search behaviour conducted between1995 and 2000, Hsieh-Yee identifies similar patterns emerging from 40 different studies (Hsieh-Yee 2001), although he points out that many of the studies lacked external controls. Comparisons between expert and novice searchers revealed that expert searchers have a more flexible approach to searching and browsing, tend to use more of the features offered and can cope better with problems that might arise. Novice searchers tend to approach a task in a more chaotic way and often rate success of a search with the ease of use and number of results returned. This last point was also identified in a

study undertaken of students' searching behaviour that which indicated that "the amount of time and effort required from the user matters more than traditional recall and precision" (Craven and Griffiths 2001).

Large scale unobtrusive user-based studies conducted by Spink and by Wolfram using the Excite search engine revealed that "users submit largely unique queries and engage in similar, non-persistent browsing habits" generally not viewing results past the first two pages. Fewer than 10% of those conducting searches used Boolean operators (Wolfram 2000) and where they were used it was found that "every second user made a mistake" (Spink and Xu 2000). Because data was gathered anonymously, both of these studies were unable to ascertain user motivation for searching and browsing. However, these and other studies revealed that users tend to submit short, basic queries which are rarely modified, though often to good effect, for as Jansen concludes, "the use of more complex queries appears to have a very small impact on the results retrieved" which as a result "may not be worth the increased effort required to learn the advanced searching rules or the increased risk of making a mistake"(Jansen 2000).

Marchionini states that it should be possible to present information in different forms which "better suit the needs of the information seeker" (Marchionini 1995 p.191) and that "the provision of minimal, standardised and culturally diverse interfaces will lead to rapid changes as more users acquire habits and preferences" (Marchionini 1995 p.178-179). The rapid development of networked information and communications technologies provides opportunities for radical changes in the services which, increasingly, users - including those who need to use "accessible" formats and systems in order to overcome visual or other disability - must be able to access and use.

3.4.2   Information seeking behaviour of blind and visually impaired people

There is little published work specifically on the information seeking behaviours of blind and visually impaired people, although some examples such as the study by Oppenheim and Selby (1999) and the work of Jakob Nielsen have emerged in recent years. Marchionini and Komlodi refer to a number of GUI/HCI research projects which have been undertaken to help enable universal access, but these are focussed more on product development than on the question of how people search (Marchionini and Komlodi 1998 pp. 103-104). Williamson *et al.* conducted a literature search on the information seeking behaviours of blind and visually impaired people (Williamson *et al.* 2000). Although they identified a number of studies conducted on the information needs of blind and VIPs (Astbrink 1996; RNIB 1998; Williamson 1995; Williamson 1998), they concluded that their search revealed "no major study of the information needs and information seeking behaviour of this group of people (sight impaired citizens)…".

As a follow up to their literature review, a study focussing on blind and visually impaired people revealed that sight impaired users need to be provided with a

variety of methods for meeting their information needs. Like all people, sight impaired people have a "different set of strategies for finding the information they need for their daily living" (Williamson *et al.* 2000). Problems experienced when using the Internet were, unsurprisingly, related to the poor design of some web sites. However positive attitudes were expressed about the potential of the Internet for information seeking coupled with users' desire for independence, which "appears to be rooted in the freedom to choose".

The question of how people develop search strategies and perform information seeking tasks is not explored in any depth in the above report but it is addressed in the *Power of Nine* report by Carey and Stringer (Carey and Stringer 2000). Five key characteristics in information handling are identified: access, apprehension, navigation, interaction, and expression. Although it is not clear whether these are derived from empirical studies.

Carey stresses that the navigation element needs further investigation as clarity of structure is particularly useful for the blind and visually impaired user. Users are able to find the information they want more easily if the sequence of the layout is consistent, but increasingly information is displayed out of sequence or in a way that loses sequence altogether (e.g. frames, where the user may be unsure which frame should be examined first).

In the Web environment, studies into usability have identified content organisation and navigation paths as the most important factors to aid web mobility (Goble *et al.* 2000). Other factors include link effectiveness and differentiation and destination prediction.

Goble *et al.* define a web page in terms of the page itself and the "user agent" i.e. the method used to present information to the user (Goble *et al.* 2000). For sighted people the user agent may refer to the web browser, but for the visually impaired person this may also include assistive technology such as a magnifier or a screen reader. The user agent could be a screen reader, which reads out the text on screen word by word and line by line (i.e. in a serial way) and forces users to listen to large blocks of text rather than allowing them to move around the page between headings and frames. Specialist browsers (BrookesTalk for example) allow more flexibility as they use the HTML elements to form headings, lists etc and can also cope with frames. Although assistive technologies enable visually impaired people to access information from a screen, Goble *et al.* (2000) found that moving around the page in a serial way does not support travel or mobility. Likewise specialist browsers tend to concentrate on sensory translation, but pay little attention to mobility within a page.

3.5 Conclusions

The background documentation analysed in this section has been used to inform the directions taken by the NoVA project. The range of issues to be considered is very wide, including accessible web interface design, legal and ethical requirements of the provision of digital resources, and user behaviour in web environments.

Although issues relating to the design of accessible web interfaces are covered extensively in the literature, gaps still exist in other areas. For example, much work is evident in the development of specialist systems such as speech output devices and specialist web browsers to improve accessibility. However, there is less evidence of research and development work on mainstream computer accessibility undertaken by HCI specialists, which should lead to implementation at the design stage rather than as an afterthought. Current and impending legislation (both in the UK and other countries) relating to the provision of services to disabled people may force designers and developers of systems to take accessibility issues more seriously. Many organisations are now developing their own accessibility policies to help ensure they meet legal requirements.

General information seeking models, such as those developed by Wilson and Ellis, have been used by HCI designers to aid the development of user-friendly interfaces. However, whilst there is evidence of work on the information needs of blind and visually impaired people, there is less work specifically on information seeking behaviours of this group (although in recent years the work of Nielsen's team (Coyne and Nielsen 2001), and research such as the Towel project (Harper *et al.* 1999), have started to address user behaviour and usability issues). Learning and cognitive styles may also have a bearing on the way visually impaired users approach an information seeking task and how they navigate their way around websites.

In order to make recommendations for accessible digital library system design taking into account areas of both accessibility and usability, further understanding is needed of serial searching in non-serial digital library environments. This formed the core of the NoVA project's work. Later sections of this report will address these issues.

4   DIGITAL LIBRARIES

The context of NoVA lies in the development of digital library services, understood broadly. While there is no universally accepted definition of a digital library, it is useful to think of it as a series of interrelated services built on digital information content. The key user-related processes have been variously defined, perhaps most commonly as resource discovery, location, request and delivery. In order for resources to be discovered and used they must be described (i.e. metadata created) and organised. Services are then built on this organised content. In order for the effort expended to be worthwhile these s ervices must be used, and for that to take place there must be some kind of user interface. It is the interaction which takes place at the interface which is the locus of NoVA's concern. As Arms (2000, p. 160) has put it, "a digital library is only as good as its interface". We should add that in NoVA we have not been concerned with the case where the interaction is machine-to-machine except insofar as specialised applications (such as screen readers) are used to make the service accessible.

Digital libraries may be conceived of, on this definition, as analogous to physical libraries, and it is quite likely that many users will interact with both - the realisation of the hybrid library concept which has received attention in recent years (Brophy and Fisher, 1999). This posits that legacy (mainly print) collections will remain important for a considerable time to come and that services must be based on a managed mix of resource types. One of the key tools which enables access to both the digital and non-digitised content of such libraries is the Online Public Access Catalogue (OPAC), which may be seen as a gateway to the hybrid library.

The development of digital libraries has been informed by both theoretical and practical perspectives, to which the UK's Electronic Libraries Programme (eLib) made a very considerable contribution. In the UK academic sector eLib led to the development of the Distributed National Electronic Resource (DNER) and more recently to the concept of an Information Environment. Other sec tors have seen parallel (though perhaps not as advanced) developments and there is evidence that these are now converging towards national services. The local library or other institution remains the focus of access however, not least because it can offer localised information and support services to the individual user.

It is now difficult to differentiate meaningfully - as far as users are concerned - between "library" and other information services in the electronic landscape. Indeed there is considerable evidence that at least some groups of users tend to try to resolve their information needs first by use of general search engines and only move on to library services when that source fails (see, for example,

some of the results of CERLIM's current EDNER Project, available at http://www.cerlim.ac.uk/projects/edner/). It is unlikely, however, that. they would distinguish any one set of services as a "library". Increasingly portals are being developed to provide an access point to a range of such services, and it is now perhaps more meaningful to speak of the digital library as encompassing a wide range of services, accessed through a portal, which may be "internally" or "externally" provided and mediated.

The interface of choice for nearly all digital library services is the World Wide Web. Although significant changes are taking place in web technologies, this style of graphical user interface has rapidly become dominant and looks likely to remain so. From an accessibility perspective this has at least allowed standard approaches to be developed to try to ensure that all users are able to access all services. But the very nature of web pages makes them inherently inaccessible. The widespread use of graphics is the most obvious case in point, but concern also extends to the widespread use of tables and frames and to more subtle issues concerned with users' perceptions and cognitive processes.

In the NoVA project it was decided that the best way to explore user behaviour in "digital libraries" would be to devise a set of realistic information seeking tasks and to ask users to undertake these with selected web-based resources. These resources would include what might be thought of as typical library resources (such as an OPAC) but would be extended to include both a search engine and directory, since these have become common access methods. Finally, after some deliberation, an online shopping site was included so as to give some evidence of user behaviour in what it might be argued is an increasingly important electronic information sector.

At the core of NoVA's concerns, then, are the issues of digital library accessibility and usability. To quote Arms (2000, p. 143) again, "digital libraries are of little value unless they are easy to use effectively". This is particularly true for those who approach them with a visual impairment that all too often in the past has been treated as a side issue in designing the user interface.

5   METHODOLOGY: NOVA EXPERIMENTAL FRAMEWORK

5.1   NoVA Project Aims

The formal aims of the NoVA project were, in the context of access to the digital library by blind and visually impaired people:

- To develop an experimental framework for exploration of serial searching and retrieval in non-serial environments
- To undertake a series of experiments with serial searching and retrieval, and subsequent use of digital content
- To map serial/non-serial approaches so as to develop understanding of how serial searching, retrieval etc. can be optimised in non-serial environments
- To report on findings and to make recommendations for digital library system design.

5.2   NoVA Experimental Framework

The NoVA experimental framework included, as indicated in Chapter 4, four different electronic resources selected for the usability testing phase. These were a search engine, a library online catalogue, an online directory of Internet resources and a commercial online shopping site. Resources were chosen to reflect the aims of the NoVA project: "to map serial/non-serial approaches so as to develop understanding of how serial searching, retrieval etc. can be optimised in non-serial environments". Therefore each resource chosen had, to greater and lesser degrees, elements of parallelism in their interfaces. At the same time it was important that a set of different types of site was chosen, reflective of the range of sites likely to be encountered in real-world environments. It will be noted that in selecting these resources a broad view of the digital library was taken.

Four information seeking tasks were devised and piloted using each of the selected resources. The tasks were devised so that, where possible, users could choose whether to use a search facility or to follow links from the home page. For example, users were asked to look for the UK weather forecast using a specific Search Engine. It was possible to find this by either typing in search terms and exploring relevant hits or by following a "weather forecasts" link on the Search Engine's Home page, which led to a summary of the weather forecast. Again, the aim was to reflect as far as possible the real-world choices which users are offered.

5.3   The Sample

In order to obtain specific data on the way people search electronic sources it was necessary to select a sample who were reasonably familiar with using the Internet and were comfortable using assistive technology. The sample was therefore a purposive one, i.e. handpicked for the research and included users of similar IT ability. The minimum requirements for the sample were that:

- Users could understand the basic concepts of the Internet and the Web.
- Users could interact with a screen unaided using a keyboard, mouse or assistive technology.
- Users had used at least one search engine to retrieve information.

The sample size comprised 40 users, split equally between sighted (the control group) and visually impaired users. Although official definitions of "sighted" and "visually impaired" were taken into account, users for the NoVA project were grouped according to their ability to read a standard (14" or 15") sized computer screen. Therefore, the "sighted" sample were users who could comfortably read a standard sized screen and the "visually impaired" sample were users who needed to use assistive technology or to be very close up to a standard sized screen in order to read or interpret it.

5.4   Tasks

Tasks were consistently set so that comparative analysis could take place between the sighted and visually impaired users. It was recognised that success in performing searches could be influenced by previous knowledge or experience, either of the technology or the subject matter of the task, or by individual interpretation and approach to a task. In an attempt to obtain a balanced picture the tasks set covered a fairly broad subject base such as weather forecasts, shopping for clothes, travel information etc., and using a "simulated work task situation" (Borlund and Ingwersen 1997 pp. 225-246) to try and dispel feelings among the users that they were being tested or timed in any way (although inevitably this still occurred to some extent). The tasks were:

- Search Engine: look for a current weather forecast for the United Kingdom and then the most recent weather forecast for Manchester.
- Directory: look for any resources relating to the Solomon Islands.
- OPAC: find details of the *British Journal of Visual Impairment* and then find out who published it and what its former title was.
- Online Shopping site: look for a selection of men's suits and then find any priced between £100 and £200.

The users were allowed to choose how they undertook each task, although to ensure everyone started from the same place they were required to commence using the stated electronic resource. So for example, to look for the national weather forecast for the UK, users were not allowed to simply type the Met Office URL into the location box but had to start from the Search Engine home page. Information about the weather for the Search Engine task could be retrieved either from within the Search Engine site itself or from external sites retrieved via the search function.

Users were allowed to choose whether they used the search facility provided by the resource or to simply browse through the stated resource's site for relevant links. For example, the Search Engine, Directory and the Online Shopping site provided links from the Home Page to information required for the task, as well as offering a search option. The OPAC was the only resource used where it was necessary to initially type something into the search box, after which it was possible to browse through the site clicking on relevant links.

Users were not given a time limit to complete each task. At the beginning of the session they were told that they could stop the task at any time and were given examples such as "if you are satisfied that you have completed the task", "if you are not satisfied, but think you have found all the information there is", "if you are fed up with the task". Users were asked to indicate to the observer when they wished to stop the task. This was done to help ensure completion was determined by the user rather than the observer. Only on a very few occasions did the observer prompt a tactful termination of the task. This was done, as suggested by Tamler, when "the user is either at a loss or has reached the point of diminishing returns" (Tamler 1998). On these few occasions the observer generally said something like "do you want to stop, or are you happy to carry on?" to reassure the user that it was still up to them whether to continue or not. Once the user indicated that they wished to stop, the task was counted as "completed" whether or not they had found all, some or none of the information required. The reason for this was to try and simulate real life or "work task" information searching behaviour, where information required by a user may or may not be found from within a specific resource. "Completion" thus refers to the task and is not a judgement of the amount of information retrieved.

5.5   Pre- and Post-Task Interviews

The pre- and post-task interviews consisted of a set of semi-structured questions based on Ravden and Johnson's method of evaluating usability of human computer interfaces (Ravden and Johnson 1989 pp.27-44). Questions were set in accordance with the "person centred" approach recommended by Duckett and Pratt (2001), where the participant's role is one of a collaborator rather than a subject to be investigated and the researcher adopts a non-

judgemental attitude towards each participant's experiences, opinions and feelings (Duckett and Pratt 2001 p.819).

Interviews began with a set of **user profile questions** to help draw up a profile of user characteristics. Questions included details such as age range, use of the Internet, location of access and a brief description of their visual impairment (if applicable).

The nature of a user's visual impairment has only been gathered to provide a clearer picture of the range of users involved in the study rather than an indication of the problems faced by different impairments. Likewise, age and experience have been used as an indication of demographic spread rather than to analyse behaviour according to a person's age or ability. The aim of this is to adhere to a social model of disability, which focuses on the "social, economic and political barriers that 'disable' people who have impairments" (Duckett and Pratt 2001 p.816) in contrast with the medical model, which focuses on the disability itself and how it can be overcome to fit into society.

The semi-structured interviews were also conducted to provide data on emotion, feelings and experience. These comprised **general questions,** such as how to tell a page is loading, initial comments about the interfaces and the type of information provided; and **usability questions,** such as their experience in finding resources required, correcting errors, knowing where to input information, online help facility. Interviews were conducted before (general) and after (usability) each task to help ensure the electronic resource and the task performed were still fresh in the user's mind before moving on to the next resource.

5.6 Recording tasks

Data from the information searching tasks was logged using a combination of Lotus ScreenCam (http://www.lotus.com/products/screencam.nsf), and sound recording and note taking. ScreenCam records on-screen activity plus verbal dialog, and thus "provides a more qualitative observational approach to transaction logging " as it "captures everything that the user sees and interacts with on the screen" (Griffiths *et al.* 2002). For the visually impaired sample, it was found that ScreenCam can interfere with the assistive technology they were using, and therefore observation, sound recording and note taking replaced the on-screen recording. All other elements of task recording remained.

The observer attempted not to prompt subjects or give any instructions while the subject was performing the task. This proved difficult at times, particularly when it was evident that the user was becoming distressed, as it was felt that undue stress was not a helpful way forward. Therefore in some cases the observer provided a "hint" to enable the user to continue. Nielsen suggests

that this type of intervention is necessary in certain circumstances, as is prompting a user to ensure the transcription is accurate (Nielsen 1993 p.197).

Both methods used for logging data were tested to ensure valid and reliable data could be transcribed. As well as logging the information retrieval process, pre and post-task questions were asked in order to gather data of a more qualitative nature so that as well as logging **what** the users did, it was also possible to ascertain (to some degree) **why** they did it and **how** they felt about it.

5.7   Data Analysis

Analysis of data logged from the searches and the pre- and post-task interviews was entered into the Atlas.ti software analysis tool (http://www.atlasti.de/). This method of analysis was chosen because it enabled large amounts of data to be analysed qualitatively and to some extent quantitatively.

Data analysis for the NoVA project concentrated on the text retrieval and code and retrieve functions available in Atlas-ti. The "text retrieval" function was used to analyse the pre - and post-task interviews. Data from the interviews was coded according to instances of words and phrases, using general headings such as **"GEN :Doc Done"** or **"GEN:Status Bar"** for responses from users to the question **"how do you know the page is loading or has finished loading"**. As well as logging the number of responses given it was also possible to log comments such as:

It says document done - assume that it has finished, although it doesn't always mean that (sighted user).

I look for the egg timer (visually impaired user).

Using the "code and retrieve" function, each step of the NoVA search process was coded to describe a particular action undertaken by the user. Movements from page to page (serial step) such as clicking on a link, or clicking on the back button were coded as CO (Click On) and BACK. Movements within the screen (parallel steps) included actions such as typing in search terms (coded as TI), or scrolling up and down the screen (coded as CU and CD). Each of the assigned codes is explained further under the appropriate heading of this report and a short description of each is given in Appendix One.

6   USER PROFILE CHARACTERISTICS

The sample was made up of 20 sighted and 20 visually impaired people and was gathered partly on a voluntary basis and partly on a selection basis: sighted users included staff and students from the Department of Information and Communications and library staff from Manchester Metropolitan University. Visually impaired users were contacted via organisations such as the National Library for the Blind, the Royal National Institute for the Blind, Action for Blind People and Vision First, as well as some public library Visual Impairment Units. A selection criterion was set to ensure that all the users included in each sample were at least familiar with the Internet and with basic searching or browsing of sites.

Participants ranged in age from under 21 to over 50 years old. The visually impaired sample included three users who were in the range 21-30, eight users were 31-40, four were 41-50 and five users were over 50. The sighted sample included three users who were under 21, ten users were 21-30, three were 31-40, two 41-50 and two users were over 50. A graphical depiction of the age range of users in both samples is given in Appendix Two.

Of the twenty sighted users, thirteen said they used a PC every day and four every other day (one user said he/she used a PC every working day, i.e. week days and one every other working day). One user used a PC once or twice a week and one user used a PC once or twice a month. The most popular location of access was at work (seven users) or college/university (four users). Home was also cited as a location of access (one user). Nine users cited a combination of home, work or college/university.

Of the twenty visually impaired users, 10 said they used a PC every day, three every other day, six once or twice a week and one user said he/she used a PC once or twice a month. The most popular location of access to a computer was at home or at work (six said at home, one and work and six both at home and work). The local library, college and university were also cited, as were local societies such as Action for Blind People.

Ten of the visually impaired users had no vision at all or very little (i.e. a small degree of light perception); nine had some vision ranging from degenerative conditions to involuntary eye movements and one user could see print but needed access technology to be able to interpret it. Eye conditions mentioned included: retinitis pigmentosa; nystagmus; optic atrophy; high degree myopia; macular degeneration and cataracts. The majority of the visually impaired users in the sample needed assistive technology to be able to read a standard size screen. Assistive technologies included screen readers (the majority using speech output systems, with one using a talking web browser), electronic Braille bars, screen magnification and combinations of screen

magnification and screen reading. One of the users could look at a standard (14" or 15") size screen, but needed to use a screen reader because dyslexia prevented him/her from interpreting the text. Others needed to be extremely close up to the standard screen to be able to read it, often with some difficulty as they would not be able to interpret a whole screen displaying different frames with different functions.

7 THE SEARCH PROCESS

7.1 Completing the task

Completion refers to the time logged from the moment the observer asked the user to proceed with the task to when the user indicated that they wished to stop. To complete the task does not necessarily mean that the user found the information they were looking for: NoVA was not designed to investigate this issue. For example, some of the users were unable to find any part of the information required for a specific task but still went through the search process, thus simulating a real life search situation.

Some users were forced to abandon tasks because of software compatibility problems. For example, one visually impaired user was unable to find the required information for any of the tasks and felt this was because a recent computer upgrade was no longer fully compatible with the access technology used. Another user experienced problems with the talking web browser reading out the Online Shopping site, and one user had problems getting the screen reader to read out graphical links. Other users experienced problems related to the sites themselves, for example three sighted users were forced to abandon the Online Shopping task because the site had suspended the online shopping facility that day.

7.2 Time taken to complete the task

The time taken indicates how long people spent on each task. Comparisons made between the times taken for sighted and visually impaired users to "complete" each task are described below and depicted graphically in Appendix Three.

7.2.1 Search Engine

Sighted users took between 1.5 minutes and 15 minutes to complete the task. Ten users took 10 minutes or less. Two took between 11 and 20 minutes and none took over twenty minutes. The mean time taken was 6.4 minutes.

Visually impaired users took between 2 and 45 minutes to complete the task. Eight took 10 minutes or less. Seven took between 11 and 20 minutes, and five took over 20 minutes. The mean time taken was 16.5 minutes.

7.2.2 OPAC

All the sighted users took between 1 and 5 minutes to complete the task. The mean time taken was 2.8 minutes.

The visually impaired users took between 5 and 25 minutes to complete the task. Ten users took 10 minutes or less, nine took between 11 and 20 minutes and one user took over 20 minutes. The mean time taken was 11.3 minutes.

7.2.3 Directory

The sighted users took between 50 seconds and 19 minutes to complete the task. Eighteen took 10 minutes or less and two took between 11 and 20 minutes. The mean time taken was 5.2 minutes.

The visually impaired users took between 2 and 20 minutes. Seventeen took 10 minutes or less, three took between 11 and 20 minutes and none took over 20 minutes. The mean time taken was 7.4 minutes.

7.2.4 Online Shopping

The sighted users took between 3 and 18 minutes to complete the task. Seventeen took 10 minutes or less and three took between 11 and 20 minutes. None took over 20 minutes. The mean time taken was 7.2 minutes.

The visually impaired users took between 2 and 30 minutes to complete the task. Fourteen took 10 minutes or less, three took between 11 and 20 minutes and three took over 20 minutes. The mean time taken was 10.2 minutes.

7.3 Surveying: Look At (LA) and Read Out (RO) codes.

The action of scanning a web page for options before taking any further action is described by Hawk and Wang as "surveying" (Hawk and Wang 1999). Surveying during the tasks included looking at a page or listening to the details of a page read out (by a screen reader). Codes used to describe both of these surveying actions are LA (Look At) and RO (Read Out). Comparisons made between the instances of surveying by sighted and visually impaired users are described below and depicted graphically in Appendices Four and Five.

7.3.1 Search Engine

During the Search Engine task the sighted users LA pages on a total of 180 different occasions in order to decipher either what the page was about or what to do next. The maximum number of times was 16 and the minimum 3. The mean for the number of times sighted users had to LA pages was on 9 different occasions. None of the sighted users listened to pages RO to them.

The visually impaired users had text RO to them in total 223 different occasions (max 28, min 1) and LA pages a total of 45 different times (max 23, min 1). The mean number of times users LA pages was on 2.3 occasions and had text RO to them on 11.2 occasions during the task. Of the twenty, thirteen just listened to text RO and three users only LA pages (using magnification or looking at the screen up close). Four used a combination of RO and LA

(although this tended to be a quick scan once or twice with more emphasis on listening to text read out). Only one made use of RO and LA in fairly equal measures (LA on 8 occasions, RO pages on 11 occasions).

7.3.2   Directory

For the Directory task, sighted users LA pages a total of 155 different times (max 24, min 2). The mean number of occasions the sighted users LA pages was 7.8. Again, none of the sighted users listened to pages RO to them.

The visually impaired users LA pages in total on 26 different occasions (max 10, min 2) and listened to text RO in total on 109 different occasions. The mean number of times users LA pages was on 1.3 occasions and listened to text RO on 5.5 occasions during the task. Of the twenty visually impaired users, fifteen just listened to the text RO to them and two just LA pages. Three used a combination of LA and RO.

7.3.3   Online Shopping

The sighted users LA pages in total on 206 different occasions during the Online Shopping task (max 20, min 4). The mean number of times sighted users LA pages during the Online Shopping task was 10.3. Again, none of the sighted users listened to pages RO to them.

Visually impaired users LA pages on 32 different occasions (max 10, min 1) and listened to text RO on 157 occasions (max 23, min 3). The mean number of times they LA pages was on 1.6 occasions and listened to text RO on 7.9 occasions. Of the twenty, three did not listen to text RO but just LA pages (using magnification or looking at the screen up close) and seventeen just had text RO to them. Three of the users used a combination of LA and RO.

7.3.4   OPAC

Sighted users LA pages during the OPAC task on 153 occasions (max 23, min 5). The mean number of occasions sighted users LA pages was 7.7. Again, none of the sighted users listened to pages RO to them.

Visually impaired users LA pages during the OPAC task on 49 occasions (max 17, min 4) and listened to text RO on 163 occasions (max 27 and min 6). The mean number of times the visually impaired users LA pages was on 2.5 occasions and they listened to text RO or LA pages on 8.2 different occasions. Three users LA pages rather than have them RO (using magnification or looking at the screen up close) and seventeen just had text RO to them. Two of the users used a combination of LA and RO.

8 SERIAL AND PARALLEL STEPS.

8.1 Number of keystrokes per task

Sighted users tended to use the same 6 keystrokes (or mouse clicks) during each task: scroll up (CU), scroll down (CD), click in (CI), type in (TI), click on enter (CO), click back (BACK).

The visually impaired sample tended to use around 16 different keystrokes during a task (these might differ between tasks). These included click in (CI), type in (TI), click on enter (CO), click back (BACK), Tab up or down (TU/TD) cursor or arrow keys to move up, down or around a page (AU, AD, AA), and sometimes using a number of different keystrokes to perform the same or similar functions. Examples would include using the tab key or cursor keys to move through hypertext links, or using cursor keys or control keys to get back to the top of the page (a graphical depiction of keystrokes is in Appendix Six).

Steps taken can then be broken down into serial and parallel steps. For the purpose of this study, serial steps are defined as a movement from page to page, such as the Click On (CO) or Click Back (BACK) keystrokes. Parallel steps are defined as movements within a page, such as Click In (CI), Scroll up (CU) Scroll down (CD), Tab up or down (TU/TD) use of arrow keys (AA, AU, AD), and keystrokes such as Control Home (CH). Note that reading text within a page or frame (LA or RO) is not defined as a "step" in this context.

Comparisons have been made of the number of serial steps and parallel steps taken by the two samples. This provides some insight into the information seeking behaviour of each group when interacting with web-based resources. Descriptions are provided in the following sections and graphical depictions can be found in Appendix Seven.

8.2 Serial and Parallel comparisons

8.2.1 Search Engine

Sighted users in total took 201 serial steps (i.e. clicking on a link or clicking back) and 181 parallel steps (i.e. clicking in edit boxes or preferences, scrolling up and down pages, typing in search terms etc). The mean number of steps was 10.1 serial and 9.1 parallel.

Visually impaired users in total took 288 serial steps and 345 parallel steps (which include around sixteen different keystrokes). The means are 14.4 serial steps and 17.3 parallel. This indicates more on-screen activity within pages than the sighted users as well as more movement from page to page.

8.2.2 Directory

Sighted users took a total of 161 serial steps and 172 parallel steps. The mean was 8.1 serial steps and 8.6 parallel steps during the task.

Visually impaired users took 111 serial steps and 149 parallel steps (mean of 5.6 serial steps and 7.5 parallel steps), indicating slightly less on-screen activity within the Directory pages than the sighted users and less movement from page to page. This was the only task where visually impaired users took fewer s teps, both serial and parallel, than the sighted users. Possible reasons for this are discussed in the Summary of Findings, section 11.1.

8.2.3 Online Shopping

Sighted users took a total of 224 serial steps and 77 parallel steps (with a mean of 11.2 serial steps during the Online Shopping task and 3.9 parallel steps).

Visually impaired users took a total of 223 serial steps and 234 parallel steps. (with a mean of 8.5 serial steps and 11.7 parallel steps). This indicates that in total, sighted users moved from page to page almost the same number of times as visually impaired users, but the visually impaired users spent much more time within a page, i.e., scrolling around, examining links etc.

8.2.4 OPAC

Sighted users took a total of 148 serial steps and 82 parallel ste ps. The means were 7.4 serial steps and 4.1 parallel steps during the OPAC task.

Visually impaired users took a total of 223 serial and 247 parallel with a mean of 11.2 serial steps and 12.4 parallel steps. Again, the visually impaired users spent much more time within pages (moving through links, typing in terms etc) than the sighted users but they also moved from page to page more than the sighted users.

8.3   Serial Steps

The term "Serial" has been used to describe a linear movement between pages. For example, moving forwards from page to page or from one website to another by following hypertext links, or by moving backwards to re -trace steps or re-submit searches. Codes used to describe Serial Steps are Click On (CO) and Back (BACK) and will be described further under the appropriate heading.

8.3.1   Click-On (CO) code

The Click-On (CO) code is used to describe the movement from page to page following hypertext links by either clicking on a link using the mouse, or by pressing the Enter key (for example, when the link is read out). To CO a link

could mean the user has either been taken to another page within the same site or may be taken off-site via an external link, or even to a reference point within the same page. The Search Engine and Directory tasks both presented users with the option of following external links if they wished. Hypertext links on the OPAC and Online Shopping sites generally kept users within the same site (although of course they might click off-site accidentally).

8.3.1.1 Search Engine

During the Search Engine task, the sighted users Clicked On a total of 171 times. The maximum number of times a user CO during this task was 18 times (one user) and the minimum was twice (one user). All users operated the CO button at some time during the Search Engine task. The mean number of times was 8.5 times.

The visually impaired users Clicked On to follow a link a total of 241 times during the Search Engine task. The maximum number of times a user CO during this task was 23 times (one user) and the minimum twice (two users). One user did not CO anywhere (giving up because he/she was unable to read the page properly). The mean number of times was 12.0

8.3.1.2 Directory

During the Directory task, the sighted users Clicked On a total of 139 times, the maximum by one user being 25 and the minimum of once (one user). The mean number of times was 7.0 times.

Visually impaired users Clicked On a total of 103 times. The maximum number of times a user Clicked On during this task was 12 times (one user) and the minimum was zero (one user). The mean number of times visually impaired users used the Click On button was 5.2 times.

8.3.1.3 Online Shopping

Sighted users Clicked On a link a total of 194 times during the Online Shopping task. The maximum number of times was 21 (one user) and the minimum was twice (one user). The mean number of times per user was 9.7 times.

Visually impaired users Clicked On a total of 149 times during the Online Shopping task. The maximum was 16 times (two users) and the minimum was twice (two users). The mean number of times per user was 7.5 times.

8.3.1.4 OPAC

During the OPAC task, sighted users Clicked On 133 times, with a maximum of 23 times (one user) and a minimum of 4 times (eight users). The mean number of times per user was 6.7.

Visually impaired users Clicked On to follow a link a total of 198 times. The maximum number of times was 23 (one user) and the minimum was four times (three users). The mean number of times per user was 9.9 times.

8.3.2   Use of Back (BACK) code

The Back (BACK) Code describes the movement taken by users to go a step or several steps backwards. This may be performed to re-submit a search or to re-trace steps having gone down an unsuccessful path. Users activated this step by either clicking on the BACK button or using an equivalent keystroke.

8.3.2.1 Search Engine

Sighted users operated the Back button a total of 30 times, the maximum by one user was 6 times and the minimum was zero (eight users). The mean number of times was 1.5.

Visually impaired users operated the Back button a total of 47 times during the task, the maximum number of times one user operated this button was 8 times and the minimum was zero (six users). The mean number of times was 2.4.

8.3.2.2 Directory

The Back button was used by the sighted sample a total of 22 times, the maximum number of time by user was 4 and the minimum was zero (eleven users). The mean number of time the Back button was used was 1.1 times.

The visually impaired sample used the Back button 8 times. This was used by only four of the users- one user activated the Back button on 4 occasions during the task, one user activated it twice and two activated it once, giving a mean of 0.4 times.

8.3.2.3 Online Shopping

During the Online Shopping task the sighted users operated the Back button a total of 30 times. The maximum number of times was 5 (two users) and the minimum was zero (seven users). The mean number of times the Back button was used was 1.5 times.

The visually impaired users operated the Back button a total of 21 times. The maximum number of times was 4 (two users) and the minimum was zero (nine users). The mean number of times was 1.1.

8.3.2.4 OPAC

During the OPAC task the sighted users in total operated the Back button 15 times. The maximum number of times by one user was 6 times and the minimum was zero (thirteen users). The mean n umber of times was 0.8 times.

The visually impaired users operated the Back button a total of 25 times during the OPAC task. The maximum number of times by one user was 6 times and the minimum was zero (nine users). The mean number of times the Back button was operated was 1.3.

8.4   Parallel Steps

As described earlier, the term "Parallel" has been used to describe movements within a page. This could be typing in search terms, clicking in edit boxes or selecting options. A parallel step could also describe scrolling up and down a page or tabbing through links on a page. Codes used to describe Parallel Steps are:

- Type In (TI) [Section 8.4.1].

- Click In (CI) [Section 8.4.2].

- Movement codes [Section 8.4.3]

- Click Up/Click Down (CU/CD)

- Page Up/Page Down (PU/PD)

- Tab Up/Tab Down (TU/TD)

- Arrow Up/Arrow Down (AU/AD)

- Control Home (CH)

- Zoom In/Zoom Out (ZI/ZO).

All of the codes listed above will be described in more depth under each appropriate heading.

8.4.1   Type In (TI) code

The Type In (TI) code refers to typing in search terms to an edit box such as a search facility or a "find in page" feature. During each task a reformulation could occur when a user revised search terms or when a user decided to try another method of searching. For example, they may have started by typing terms into a search box but later decided to go back to the Home Page and follow relevant links instead. Logan and Driscoll define these types of reformulations as revisions and iterations. They are described thus:

- Revision: revising a search statement

- Iteration: an ongoing interplay between keywords, indexes or search engines

(Logan and Driscoll-Eagan 1998 p.422).

8.4.1.1 Search Engine

During the Search Engine task, three of the sighted users did not Type In any search terms, preferring to follow links to the weather from within the page. The remaining seventeen Typed In search terms, using between 1 and 2 terms. Search terms used included:

"weather"

UK weather

National weather AND uk

Today's weather

Met office

"manchester and weather"

Five of the sighted users reformulated the query twice. Of the five, two reformulated the original query for the national weather forecast, to search for the Manchester forecast, e.g.

"weather"

"manchester weather".

The other three reformulated either to refine the search, e.g.

weather uk

"weather forecast" uk

or to try other combinations of terms or phrases, e.g.

national weather AND uk

weather forecast.

Four of the visually impaired users did not Type In any search terms. The remaining sixteen Typed In between 1 and 8 terms during this task. Search terms were either submitted to the search box or to the "Find in page" facility offered by the access technology. The "Find in Page" facility could help the

user find relevant links in the Search Engine Home Page or help to find where the terms occurred within the results retrieved. Terms used to search for links were generally **weather** or **manchester** depending where the user was up to in the task. Terms used to "Find in Page" were generally the same or similar to the terms applied to the original search.

Terms used for the Search Engine search facility included:

weather

weather forecast

uk weather forecast

national weather

weather uk

manchester weather uk bbc

national weather manchester

weather in manchester

Twelve of the visually impaired users reformulated the query. This was done between two and six times.

Reformulations were sometimes used to revise the search, for example:

weather

weather uk

weather manchester

or

national uk weather

national weather

Other reformulations were the same terms re-submitted. For example, if the search button was not activated properly, or because the user was unable to find the results the Search Engine had displayed. Some users submitted the search and then re-typed the same terms into the "Find in page" facility to locate them from within the results.

Reformulations were sometimes due to the mis-typing of terms. Whereas sighted users were able to quickly look at the terms used and often realise their mistake, it took visually impaired users longer to ascertain this. It was often not obvious to the user that the error had occurred. For example, the screen reader would sometimes read out a word sounding like the term used when in fact it was mis-spelled, e.g. **manchester** and **manchestwer** sound very similar when read out, but the latter may not retrieve any useful results. One user re-tried the search using the same mis-typed terms twice before realising a spelling error had occurred and correcting it.

8.4.1.2 Directory

Ten of the sighted users Typed In search terms when undertaking the Directory task, two using more than one reformulation. The other ten preferred to follow links, or were unaware that a search facility was provided.

Search terms used were **Solomon Islands** and **Solomon Island.** One user reformulated the query twice, the first time having mis-typed Solomon, and one reformulated five times, trying the same terms but limiting each search by title, subject etc. to see if any different results were retrieved.

Eight of the visually impaired users chose not to enter any search terms – preferring to follow links instead, or because they were unaware of the search facility.

Of the remaining twelve, users either typed in search terms or used the "Find" feature to search for relevant links in the page. Terms used for both included:

Solomon Islands

Geography

"s"

SO

No reformulations as such were performed, although a number of terms were input to the "Find" feature during one task.

8.4.1.3 Online Shopping

Only five of the sighted users Typed In any search terms, most preferring to follow links on the page.

Of the five, terms used were **suits** and **mens suits** (although one user was prompted to type **"Java Script"** into the location box because there was a

problem with the page, not realising that this was a system error message. After two attempts the user abandoned the task).

Five of the visually impaired users chose to Type In terms. These included:

suits

men's suits

mens

formal suit

Reformulations were undertaken once, due to a miss-spelling of **men's wear** in the first instance, the term **mens** was then tried before moving on to use the drop down combination boxes instead of Typing In terms.

Terms were also Typed into the "Find" facility to locate the **search** facility. The search facility was then used to search for **men's suits**.

8.4.1.4 OPAC

All of the sighted users Typed In search terms during the OPAC task, unsurprisingly since this was initially required in order to search for anything. Users were asked to find details about the "British Journal of Visual Impairment" and almost all the users type in the exact terms, **British journal of visual impairment**, with a few exceptions where **british journal of visual** or **visual impairment** were used. Three users performed more than one formulation.

Reformulations were performed by the sighted sample to refine the search or to search under different options such as the title, the class mark, or the former title (although no useful results were retrieved in these cases). Other reasons for reformulating the search were due to the mis-typing of the title, which resulted in no items retrieved e.g. **British journal of the visual impairment**. Reformulation also occurred when the search was not activated properly so that the user decided to start again.

All the visually impaired users apart from one (who had a problem moving between frames and reading the text) Typed In search terms. Terms used were **British Journal of Visual Impairment**, **British Journal of Visual**, and **Journal/s**. The spelling of the title at times presented problems for the users. For example **British Hournal** sounds very similar to **British Journal** when read out by a screen reader but the former did not retrieve any useful results. However it was not clear to the user why no results had been retrieved as they were not aware of the mis-spelling.

Eight of the users reformulated the search more than once. Three of the users reformulated the search twice and five users reformulated the search three times.

There were a number of reasons for reformulating the search. Some of the visually impaired users were unable to locate the results the first time, so went back and started again:

I can't find a title… I am going to go back to the search page and re-enter my terms (visually impaired user)

Or, when a user clicked off-site by accident and then had to type the OPAC URL again before finding the search edit box. Others found the results difficult to interpret because the screen reader kept reading out a lot of redundant information such as **"link to frame, link to frame"** before getting to the results, or they were unsure where to go next and so went back and re-tried the search. One user had trouble reading the text with a magnification package:

I can't read it, I can't understand why when you type in the title, it doesn't give you all the details on one page (visually impaired user)

In this case the same search was applied with different options (i.e. title search, keyword search and author/title search) in the hope of retrieving the information required – commenting that it was very confusing and at times it was just guess work.

One user put the CAPS LOCK on and, although the search facility would have ignored this, the screen reader reads out capitalisation in a different voice and the user was therefore unhappy with the process. It took the user several attempts to switch CAPS LOCK off – each time re-trying the search.

8.4.2   Click In (CI) code

The "Click In" facility refers to both mouse clicks or keystrokes such as the Enter key or control keys (e.g. F4, F1). The reason these have been coded as Click In is that the visually impaired users who could not see the screen at all used them instead of a mouse.

8.4.2.1 Search Engine

The sighted users Clicked In a total of 43 times during the Search Engine task. The maximum number of times was 6 (one user) and the minimum was

zero (two users). The mean number of times users Clicked In during this task was 2.2.

Visually impaired users Clicked In a total of 52 times during the Search Engine task. The maximum number of times was 12 (one user) and the minimum was zero (six users). The mean number of times users Clicked In was 2.6 times.

8.4.2.2 Directory

The sighted users Clicked In a total of 34 times during the Directory task. The maximum number of times one user Clicked In was 8 and the minimum zero (seven users). The mean number of times users Clicked In during the Directory task was 1.7 times.

The visually impaired users Clicked In a total of 15 times during the task. The maximum number of times one user Clicked In was 6 times and the minimum was zero (fourteen users). The mean number of times users Clicked In during the Directory task was 0.8 times.

8.4.2.3 Online Shopping

The sighted users Clicked In a total of 43 times during the Online Shopping task. The maximum was 16 times by one user, the minimum was zero (nine users) with a mean of 2.2 times.

The visually impaired users Clicked In a total of 39 times during the task. The maximum number of times by one user was 17 times and the minimum was zero (eleven users). The mean was 2.0 times.

8.4.2.4 OPAC

The sighted users Clicked In a total of 44 times during the OPAC task. The maximum number of times was 9 (one user) and the minimum was once (five users). The mean was 2.2 times.

The visually impaired users Clicked In a total of 23 times during the OPAC task. The maximum number of times was five (one user) and the minimum was zero (ten users). The mean was 1.2 times.

8.4.3   Movement around the page

When undertaking the tasks, users utilised a number of different methods to move around a page. These were logged as:

- Scroll Up and Scroll Down: refers to using the mouse pointer to move up and down the scroll bar.

- Tab Down: used to move back and forth through links and sometimes headings.

- Tab Up: refers to the Shift/Tab key, which moves back up a page through the links or headings.

- Arrow Up, Arrow Down: refers to the up and down cursor keys used to navigate the cursor through the page when using assistive technology such as a screen reader.

- Arrow Around: refers to navigating the left and right arrow letter by letter (for example, to check a spelling) when using assistive technology.

- Page Up and Down: are keystrokes which move the cursor either to the top or to the bottom of the screen.

- Control Home: this keystroke takes the cursor to the top of the document.

- Zoom In and Zoom Out: are keystrokes used with screen magnification to enlarge the page (or part of a page) or to decrease the enlargement.

8.4.4   Search Engine

During the Search Engine task the sighted users moved around pages using Scroll Up and Scroll Down. The visually impaired users moved around pages using 12 different keystrokes: Scroll Up, Scroll Down, Arrow Up, Arrow Down, Arrow Around, Control Home, Tab Up, Tab Down, Page Up, Page Down, Zoom In, Zoom Out. Findings from each of the codes are summarised as follows:

8.4.4.1 Scroll Up and Down

During the Search Engine task the sighted users moved around pages using the mouse to Scroll Up and Scroll Down at total of 116 times.

The total number of times users Scrolled Down the page was 91 times with a maximum number of times per user of 8 times (two users) and a minimum of twice (three users). The mean was 4.6 times.

Sighted users Scrolled Up the page a total of 25 times, with a maximum of 5 times (one user) and a minimum of zero (eight users). The mean was 1.3 times.

Scroll Down was used by the visually impaired users a total of 20 times. The maximum number of times was 13 (one user) and the minimum was zero (sixteen users). The mean number of times was 1.0.

Scroll Up was used just once by one of the visually impaired users.

8.4.4.2 Arrow Up, Down and Around

Arrow Up, Down and Around was not used by any of the sighted users.

Visually impaired users used the Arrow Up key a total of 24 times during the task. The maximum number of times per user was 5 times (two users) and the minimum was zero (twelve users), the mean was 1.2 times.

Arrow Down was used by visually impaired users a total of 50 times. The maximum was 15 times (one user) and the minimum zero (nine users), with a mean of 2.5 times.

Arrow Around was used a total of 24 times by the visually impaired users. The maximum was 5 times (two users) and the minimum was zero (eleven users) with a mean of 1.2 times.

8.4.4.3 Control Home

Control Home was not used by the sighted sample.

Control Home was used by the visually impaired sample a total of 10 times. The maximum number of times was 6 (one user) and the minimum was zero (fifteen users), with a mean of 0.5 times.

8.4.4.4 Page Up and Down

Page Up and Down keystroke was not used by the sighted sample (they used the mouse to Scroll Up and Down the page instead).

Page Up was used by the visually impaired sample a total of 12 times. The maximum was 3 times (two users) and the minimum was zero (thirteen users) with a mean of 0.6.

Page Down was used by the visually impaired sample a total of 11 times. The maximum was 5 times (one user) and the minimum was zero (fourteen users) with a mean of 0.6.

8.4.4.5 Tab Up and Down

Tab Up and Down was not used by the sighted sample.

Tab Up was used by the visually impaired sample a total of 12 times. The maximum was 6 times (one user) and the minimum was zero (sixteen users) with a mean of 0.6.

Tab Down was used by the visually impaired sample a total of 77 times making it the most popular keystroke used by this sample for moving around the page during the Search Engine task. It was used a maximum of 13 times (two users) and a minimum of zero (seven users) with a mean of 3.9 times.

8.4.4.6 Zoom In and Out

Zoom was not used by any of the sighted sample as it refers to screen magnification assistive technology used by some of the visually impaired sample. It should be noted that the Zoom functions are only of relevance to users with some vision.

Zoom In was used by the visually impaired sample on 8 occasions. The maximum number of times by one user was 7 and the minimum was zero (eighteen users) with a mean of 0.4 times.

Zoom Out was used on only 1 occasion.

8.4.5   Directory

8.4.5.1 Scroll Up and Down

During the Directory task the sighted users moved around pages using the mouse to Scroll Up at total of 31 times, with a maximum of 5 times (one user) and a minimum of zero (eight users) and a mean of 1.6 times.

The total number of times users Scrolled Down the page was 92 times with a maximum of 14 times (one user), a minimum of once (three users) and a mean of 4.6 times.

The Scroll Up function was used just 3 times by the visually impaired users, twice by one user and once by another giving a mean of 0.2. The remaining 18 users did not Scroll Up during the task

Scroll Down was used by the visually impaired users a total of 12 times. The maximum number of times was four (two users), the minimum was zero (sixteen users) and the mean was 0.6.

8.4.5.2 Arrow Up, Down and Around

Arrow Up, Down and Around was not used by any of the sighted users.

Visually impaired users used the Arrow Up key a total of 12 times during the task. The maximum number of times per user was 4 times (one user) and the minimum was zero (twelve users) with a mean of 0.6 times.

Arrow Down was used by visually impaired users a total of 35 times. The maximum was 9 times (one user) and the minimum zero (eleven users), with a mean of 1.8 times.

Arrow Around was used a total of 13 times by the visually impaired users. The maximum was 5 times (one user) and the minimum was zero (thirteen users) with a mean of 0.7 times.

8.4.5.3 Control Home

Control Home was not used at all by the sighted sample and only once by one of the visually impaired users during the Directory task.

8.4.5.4 Page Up and Page Down

Page Up and Down was not used by the sighted sample at all. Instead they used the mouse and scroll bar to Scroll Up and Down the page.

The Page Up keystroke was used by the visually impaired sample a total of 4 times. It was used 3 times by one user and once by another giving a mean of 0.2.

Page Down was used by the visually impaired sample a total of 6 times. It was used 4 times by one user and once by two users giving a mean of 0.3 times.

8.4.5.5 Tab Up and Tab Down

Tab Up and Tab Down were not used by the sighted sample.

Tab Up was used by the visually impaired sample a total of 3 times, twice by one user and once by another, giving a mean of 0.2.

Tab Down was used by the visually impaired sample a total of 28 times. It was used a maximum of 7 times (one user) and a minimum of zero (eleven users) with a mean of 1.4 times.

8.4.5.6 Zoom In and Zoom Out

Zoom was not used by any of the sighted sample.

Zoom In was used by one of the visually impaired users on 3 occasions. Zoom Out was not used by any of the visually impaired sample.

8.4.6   Online Shopping

8.4.6.1 Scroll Up and Down

During the Online Shopping task the Sighted users moved around pages using the mouse to Scroll Up a total of three times, once each by three of the users, giving a mean of 0.2 times.

Sighted users Scrolled Down the page a total of 25 times, with a maximum of 13 times (one user) and a minimum of zero (eleven users) and a mean of 1.3.

The Scroll Up function was used just once by one of the visually impaired users.

Scroll Down was used by the visually impaired users a total of 21 times. The maximum number of times per user was 11 (one user) and the minimum was zero (seventeen users). The mean was 1.1.

8.4.6.2 Arrow Up, Down and Around

Arrow Up, Down and Around was not used by any of the sighted users.

Visually impaired users used the Arrow Up key a total of 17 times during the task. The maximum number of times per user was 4 times (two users) and the minimum was zero (thirteen users), the mean was 0.9 times.

Arrow Down was used by visually impaired users a total of 41 times. The maximum was 9 times (one user) and the minimum was zero (ten users), with a mean of 2.1 times.

Arrow Around was used a total of 32 times by the visually impaired users. The maximum was 11 times (one user) and the minimum was zero (ten users), with a mean of 1.6 times.

8.4.6.3 Control Home

Control Home was not used by any of the sighted users.

Control Home was used by the visually impaired sample a total of 5 times – twice by two users and once by one user, giving a mean of 0.3 times.

8.4.6.4 Page Up and Page Down

Page Up and Page Down were not used by any of the sighted users.

Page Up was used by the visually impaired users a total of 4 times. The maximum was twice (one user) and the minimum was zero (seventeen users) with a mean of 0.2 times.

Page Down was used by the visually impaired sample a total of 6 times. The maximum was twice (one user) and the minimum was zero (fourteen users) with a mean of 0.3 times.

8.4.6.5 Tab Up and Tab Down

Tab Up was used by the visually impaired sample a total of 7 times. Three times by two users and once by one user with a mean of 0.4. Seventeen of the users did not Tab Up the page during the task.

Tab Down was used by the visually impaired sample a total of 49 times. It was used a maximum of 7 times (three users) and a minimum of zero (eight users) with a mean of 2.5 times.

8.4.6.6 Zoom In and Zoom Out

Zoom was not used by any of the sighted sample.

Zoom In was used by one of the visually impaired users on 3 occasions.

Zoom Out was used by one of the visually impaired users once.

8.4.7 OPAC

8.4.7.1 Scroll Up and Down

During the OPAC task, sighted users moved around pages using the mouse to Scroll Up twice in total. Two users Scrolled Up the page on one occasion each giving a mean of 0.1 times.

The total number of times sighted users Scrolled Down the page was 11 times with a maximum number of 4 times (one user) and a minimum of zero (sixteen users). The mean was 0.6 times.

The Scroll Up function was used once by four of the visually impaired users, giving a mean of 0.2.

Scroll Down was used by the visually impaired users a total of 13 times. The maximum number of times per user was 8 (one user) and the minimum was zero (sixteen users) with a mean of 0.7 times.

8.4.7.2 Arrow Up, Down and Around

Arrow Up, Down and Around was not used by any of the sighted users.

Visually impaired users used the Arrow Up key a total of 18 times during the task. The maximum number of times per user was 4 times (one user) and the minimum was zero (thirteen users). The mean was 0.9 times.

Arrow Down was used by visually impaired users a total of 63 times. The maximum was 10 times (one user) and the minimum zero (eight users), with a mean of 3.2 times.

Arrow Around was used a total of 30 times by the visually impaired users. The maximum was 6 times (one user) and the minimum was zero (ten users) with a mean of 1.5 times.

8.4.7.3 Control Home

The Control Home keystroke was not used by any of the sighted sample.

Control Home was used by the visually impaired sample a total of 5 times. The maximum number of times was twice (two users) and the minimum was zero (seventeen users), with a mean of 0.3 times.

8.4.7.4 Page Up and Page Down

None of the sighted sample used the Page Up or Page Down keystrokes.

Page Up was used once by two of the visually impaired users (mean of 0.1).

Page Down was also used once by two of the visually impaired users (mean of 0.1).

8.4.7.5 Tab Up and Tab Down

The Tab Up and Tab Down keystrokes were not used by any of the sighted sample.

Tab Up was used by the visually impaired sample a total of 3 times, twice by one user and once by another, giving a mean of 0.2.

Tab Down was used by the visually impaired sample a to tal of 48 times. It was used a maximum of 15 times (one user) and a minimum of zero (ten users) with a mean of 2.4 times.

8.4.7.6 Zoom In and Zoom Out

Zoom was not used by any of the sighted users during the OPAC task.

Zoom In was used by the visually impaired sample on 4 occasions by one user.

Zoom Out was not used by any of the visually impaired users.

9 GENERAL QUESTIONS

General questions related to overall aspects of using the web and the resources chosen. Users were asked what clues they look for to tell them that a page is loading, their first impressions of the websites' interfaces, and their preferred choice of resource.

9.1 How do you know the page is loading, or has finished loading?

Users were asked how they identified whether the page they were linking to was loading or had finished loading. One or more clues were generally mentioned and these remained consistent with users across each resource. Clues have been grouped into two main headings, visual clues and aural clues:

Visual clues:

- Status Bar: The coloured bar at the bottom of the page moves from side to side or fills up as the page loads.

- Egg Timer: The egg timer appears on screen, telling you that something is happening on screen.

- Percentage: A percentage is given in the status bar, indicating how much of the page has loaded.

- On-screen Activity: The screen begins to load up bit by bit.

- Browser Icon: The Web Browser Icon moves around while the page is loading and is still when the page has finished loading.

- Document Done: where the status bar says "Document Done" when the page had loaded.

Aural Clues:

- Hard Drive: Noises from the Hard Drive indicate that something is happening on screen.

- Keystroke: To activate the screen reader – for example it will read out the URL if it has appeared in the location box.

- Document Done: Screen reader reads out "Document Done" when the page had loaded.

- Read out: Screen reading software starts reading out from the top of the page when it has loaded.

The sighted users all mentioned visual clues to tell them a page was loading or had finished loading, while one user said that they could also "hear the computer working". In total, the sighted users cited the status bar as the most popular indication that the page was loading (sixteen users), followed by on-screen activity (twelve users) and the Browser Icon (eleven users). Document Done was cited as the most popular way of telling a screen had actually finished loading (thirteen users).

Comments from the sighted users included:

> **I have a little box that fills up with purple and the bit at the bottom [status bar] that says finding page, or whatever.**

> **... I might look to see if any graphics appear.**

> **... what is happening on screen.**

> **I was looking at the browser and the percentage that tells you how much of the page is loaded.**

> **... image coming up bit by bit on screen.**

> **.... When the page looks complete. Menu bar dropped down very quickly so we seem to be ready to go.**

Most used a combination of clues such as on-screen activity in conjunction with the status bar or the Browser Icon in order to decide that a screen was loading or had loaded:

> **I look at the Netscape Icon and the status bar at bottom and image coming up bit by bit on screen.**

> **See if the url has come up in the address box. Also the status bar (blue bar) and the percentage. Also I can see the screen has loaded.**

> **I can hear the computer working. There is some colour moving at the bottom (status bar), and I can see the page coming up, the wandering gauge at the bottom, see file information and the**

images are coming up, percentage loaded etc, details at bottom of the page.

The visually impaired users mentioned a number ways of telling the page was loading, both visual and aural.

Aural clues included waiting for the assistive technology to start reading out. This was the most popular way to tell that either the page was loading or that it had loaded (twenty-one users). Four users mentioned using a keystroke to trigger the screen reader to read out the location and six users mentioned listening to noises from the hard drive to tell them that something was happening.

Visual clues mentioned by the visually impaired sample (i.e. those with some sight) were "looking at the status bar" (five users) and "general on-screen activity" (four users).

Comments from visually impaired users included:

... things flashing on screen

I have a bit of vision, so I look at the blue indicator at
the bottom of the screen

Sometimes the thing at the bottom stops and also Done.

A keystroke I can use that tells me what is at the bottom
of the page

.... the graphics have loaded up although I can't really tell the page has finished loading.

... I can tell [it's loaded] when I've got a screen full.

Starts reading from the top. If status bar is on then it will read out Document done. Sometimes reads bits of information out, jumping all over the place. When it settles down a bit you can

usually tell the page has loaded and you can tab through the links if there aren't too many.

Sometimes I just need to hear a few characters read out

then I know the page has loaded.

One user who had difficulty interpreting text mentioned three things to watch out for: "... the turning globe, the things flashing on screen and the bar thing" but went on to say that "some of the visual clues can be misleading".

9.2 Comments about the interface.

Users were asked to briefly describe the layout of the page, indicating the type of information provided and their overall first impression of the interface. Answers given were very varied. Some users just commented briefly on the type of site, e.g. a shopping site, or that it was a page with a lot of links. Others went into more detail, describing the features offered and their opinion of the layout of the page.

9.2.1 Search Engine

The sighted users mentioned a range of features offered by the Search Engine, such as the search facilities, the choice of directories, files and links to other options. Generally, the sighted users appeared more interested in either the search facility or the links provided on screen. Fifteen users mentioned the search facilities and eleven mentioned the links provided. Comments included:

There is a lot of information on it, which I don't really look at because I know where I want to be- in the search box (sighted user).

Lots of information and a search box which is quite small (sighted user).

I spotted straight away where the Help is and where to type something in, but I really wouldn't take any notice of anything else (sighted user).

It offers the opportunity to browse things like the web directory and different topics I could go into if I wanted to browse (sighted user).

They also made general comments about their overall impression of the interface. Comments included:

Everything seems quite straight forward, help is available if I need it. You have to scroll down to see the whole page, but I don't really have a problem with this (sighted user).

Too many links, it is quite confusing and unorganised (sighted user).

Maybe if I read some of the information I would find things quicker, but I don't (sighted user).

I don't really like flashing stuff, but that's just me (sighted user).

The visually impaired users also mentioned a range of features offered by the Search Engine and again, the majority mentioned the search facilities and the links provided. Comments included:

The fact that it is a search engine is not immediately apparent – searching bit is hidden quite a way down (visually impaired user).

There's categories I can use and an edit field here where I can search, a combo box and a search button (visually impaired user).

They have departments, but they have mixed up with this with financial reports and accounting information. It repeats links as well (visually impaired user).

I get a rough idea what's on the page, some links I can read some I can't (visually impaired user).

There is a search facility and links to all their departments as well and there may be a search facility within each department as well (visually impaired user).

The visually impaired users also made some general comments about the interface. These included:

I know I can find things by tabbing through (visually impaired user).

I imagine it is a vertical line, but there's no reason it should be! (visually impaired user)

It tells me that there is a text-only version, I tend to steer clear of them because they are often not as up to date as the graphical version (visually impaired user).

It is a very busy site, there is a load of crap on it – you know, it's full of adverts really (visually impaired user).

A lot of it means nothing to me (visually impaired user).

It would be more useful for just a menu, to dump all this link image information (visually impaired user).

I can see where to type in a search but I can't read any of the text, it's all broken up (visually impaired user).

If I get to a complicated site like this I would go into properties and fonts [to change the settings] (visually impaired user).

Overall, users (both sighted and visually impaired) found the Search Engine interface to be rather a busy one with a wide variety of different options and categories to choose from. Because the interface was a very visual one, the sighted users were better able to quickly pin-point areas such as the search box or relevant links, which would help them undertake the task. In contrast many of the visually impaired users found moving through the page quite laborious. A comment that summed up this frustration was:

… you've got a lot of things to get through before you get to the subject matter. I don't like all this http this and http that. That's what I like about Google, it puts you straight into an edit field (visually impaired user).

(Note: the search engine used for the task was not Google, but might be regarded as one of its competitors).

9.2.2 Directory

Comments about the Directory interface from the sighted sample were generally positive, for example:

> **Apart from telephone numbers and things on the bottom, the page is entirely on one screen (sighted user).**

> **Nice and easy on the eye, quite gentle colours. Looks quite neat (sighted user).**

although one sighted user commented that it did not offer much more than **"just a load of categories and no search boxes".**

Positive comments after using the Directory were also made by the visually impaired sample, such as:

> **Quite good descriptions to each of the services and what each one does but do get the impression that when it comes to looking for anything it might be a bit messy (visually impaired user).**

> **Seems accessible, all the links are speaking to me (visually impaired user).**

> **I can tell there are links as soon as I look at it. It has a lot better contrast and I can read this much better (visually impaired user).**

> **Very clear, says what it is (visually impaired user).**

However, other visually impaired users were less happy with their first impressions of the interface, for example:

> **I hate all this rubbishy logo stuff - it doesn't mean anything to me … (visually impaired user).**

> **Still too cluttered - especially the top menus (visually impaired user).**

> **It didn't give me any kind of an edit field, which is my favourite thing (visually impaired user).**

Hopeless! I'm assuming there are links but I can't read them. I can read some of the links but not the descriptions. I can't read the links at the top (visually impaired user).

Users from both samples commented that the headings and terms used did not always fully explain to them what the site was about, for example:

There are various links but it doesn't really tell you what (the site) is (sighted user)

I would have to click on a lot of the links to see what it was offering (sighted user).

I am getting links and figuring out for myself what information it has, but it is mixed up with a lot of organisational information – at one point I think it is a company, then at the next I think it is a database (visually impaired user).

Doesn't always describe what the links are for (visually impaired user).

9.2.3   Online Shopping

Comments about the Online Shopping site were quite mixed. Positive comments included:

Offers lots of choices (sighted user).

Clean and not tacky - not too busy (sighted user).

Not bad at all, quite neat really for one that is selling something (sighted user).

It's pretty bold, pretty striking really. Usually on an opening page you don't get many pictures, but these are quite big, it's the first thing that strikes you (visually impaired user).

Looks quite good, links are quite clear (visually impaired user).

Some users thought the interface was quite cluttered, or that the information was badly arranged. Comments included:

I now have quite a lot of info on screen, including two windows (sighted user).

Now I can see a lot of graphics and quite small text (sighted user).

Seems to be quite a busy site (visually impaired user).

This could be structured better, information seems all over the place (sighted user).

Pictures with very small writing. I'm not entirely sure what I am suppose to be clicking on (sighted user).

It repeats links as well, are they the same link? Which do I choose? (visually impaired user).

The colours are horrible. Some bits are more contrasting and you've got proper words so that's better. But text is often broken, it's readable but I think my eyes are getting tired (visually impaired user).

Despite offering a search facility on the Home Page, only two users (one sighted and one visually impaired) mentioned this with their initial comments about the interface. Although some users tried the search facility after some initial browsing, all the users (sighted and visually impaired) chose to follow links to look for the information required by the task. The range of options offered on the Online Shopping site were mentioned by users included:

Information is good as there are a lot of options and I can just pick what I want (sighted user).

Various areas you need to go to, like basket and checkout (sighted user).

There is a search facility and links to all their departments as well and there may be a search facility within each department as well (visually impaired user).

I get a rough idea what's on the page, some links I can read, some I can't (visually impaired user).

Occasionally pop-up windows appeared on screen, advertising new collections or new services. Apart from one user (visually impaired) who commented that pop-up windows were usually informative, but **"not always easy to close"**, most of the users seem unanimous about their dislike or disregard of pop-up windows. Comments included:

I will close that as I don't like them (sighted user)

The first thing I can see - and one I usually close immediately - is the pop up window and this blocks out the main site, I'll close it down (sighted user)

There's an advert coming up so I'll get rid of that (visually impaired user).

9.2.4 OPAC

Users' first impressions of the OPAC interface were generally positive. Comments mainly related to the choice of information provided. For example:

Has a number of choices (sighted user).

Very neat and tidy, says quite clearly what it is and gives an index on the left hand side (sighted user).

Headings and text are a good size (sighted user).

Tells me everything I need to know to look up anything in the library really (sighted user).

Seems quite good, lists at the top of the page the various things you can do – the various searches (visually impaired user).

Well labelled, quite easy from the beginning to go straight to wherever. Right frame appears to me first, but don't know what the layout would look like (visually impaired user).

> **A basic description of what it is and a load of links (sighted user).**

> **I get a very rough idea, but to be honest, sometimes if I can't read it I will just click on it to see what happens (visually impaired user).**

> **It's got my preferred format for links, within an image and there is ALT text. It shows me all of the page (visually impaired user).**

> **Specific comments were made about the search facility provided and about the hypertext links to information given, such as:**

> **You have got the types of searching down the left hand side - author, title, keyword, classification number..... and near the bottom left is Help (sighted user).**

> **Just before the link it seems to describe what the search is, like author or book (visually impaired user).**

> **There are separate searches for each kind of thing you might want to search for (visually impaired user).**

However, one user expressed confusion about hypertext links to search screens:

> **I expected to hear an edit field first of all, but there wasn't, I have to tab down to find the search box (visually impaired user).**

Some of the design features presented on the interface, which were commented on as pleasing for sighted users, were less accessible for the visually impaired sample. Examples included the use of frames and the highlighting feature over hypertext links. Comments included:

> **These are quite good because they light up, or highlight when you move onto them (sighted user).**

> **I don't like the tones when you put the cursor over some of the text, it changes (visually impaired user).**

Now, this sort of thing frightens me [frames]. If I use the Virtual PC I can hear what is in each frame, so I might try and find out what's there (visually impaired user).

Some negative comments were made about the interface. The majority of these were made by the visually impaired sample and related to accessibility issues. For example:

Well, it's not accessible, as there appear to be no links at all (visually impaired user).

I had a problem there because it wasn't maximised so it wasn't reading the correct information (visually impaired user).

It is full of unsupported scripts and link images. Can't tell what the page is about, don't think I will be able to read it (visually impaired user).

It gives me different categories to search using categories like author search. It tells me that there are different options on the left, but I can't find them at the moment! (visually impaired user).

There are some links but I can't read them. I could probably guess at some of them – that's what I usually do (visually impaired user).

Some users made general comments about the layout of information in two frames, commenting that although they looked at the links provided on the left, they did not really bother with the information provided about the site in the middle of the screen:

My eyes are drawn to the menus on the left and not really to the centre of the screen (sighted user).

It has some information - which I never read! (sighted user).

I don't read the description of the site, I know the options are down the left hand side (sighted user).

9.3 Which electronic resource would you have used for this task?

Users were asked what electronic resource they would use if given the choice. A variety of resources were named and these have been grouped into the following categories:

- Same resource as used in the task.
- Search engine.
- Bookmarked (or "favourite") site.
- Would not use the web at all (for example, some users said that they would not shop online but just go straight to the shop. For other tasks users said they might use printed versions).

9.3.1 Task 1: to find the national and regional weather forecast

Users were asked to find out the national UK weather forecast and then the regional forecast for Manchester.

Three of the users said they would use the Search Engine that was used for the task (all sighted users).

Fourteen users said that they would go straight to a bookmarked or "favourite" site (nine sighted and five visually impaired). The BBC website was mentioned by 10 of the users. Other sites mentioned included Annaova, Ask Jeeves, and the Met Office and Capernic.

Twelve users (nine sighted and three visually impaired) said that they would use another search engine to the one used for the task. Search engines mentioned included Yahoo (mentioned by four of the sighted users), Google (mentioned by two sighted and two visually impaired users), Metacrawler and AlltheWeb.

Three users said that they would not use the Web at all (one sighted and two visually impaired). Instead they would:

Probably just look it up on the TV teletext.(Sighted user).

Just ring someone up! (Visually impaired user).

9.3.2 Task 2: to find any resources relating to the Solomon Islands

Users were asked to look for any resources relating to the Solomon Islands. Although most users said they would have used other resources than the stated one, this was possibly due to the fact that many were unaware of this

particular resource until undertaking the task. One user (visually impaired) said he/she would use the Directory used in the task. Four of the users (all sighted) said that now they had used the Directory they would probably use it again, perhaps in conjunction with another resource. Comments included:

> **Now that I know what (this site) is I might use it. Prior to this I would have probably used Google. (Sighted user)**

> **I would probably use (this site) or a search engine. (Sighted user).**

> **I would probably have gone to Google and type in Solomon Islands, but I suppose this site might guarantee quality. (Sighted user)**

Seven users (four sighted, three visually impaired) said they would go to a bookmarked or "favourite" site. Sites mentioned included KnowUK, Mytravelguide.com, Lonely Planet and the online CIA World Factbook. Directories that have been edited by humans for quality assured results were also mentioned.

Twenty-seven of the 40 users mentioned search engines as their preferred method of finding resources on the Solomon Islands (15 sighted and 12 visually impaired). Search engines mentioned included Google (mentioned by 6 sighted and 5 visually impaired users), Yahoo (mentioned by 4 sighted and 1 visually impaired user), Mama, MetaCrawler, AltaVista and Web Ferret.

Five users said that they would not use the Web at all (4 sighted, 1 visually impaired). Given the choice most said they would generally use a printed encyclopaedia or a CD-Rom encyclopaedia because, as one user put it:

> **At present it is a chore, a struggle and a bore to use the Internet. (Visually impaired user)**

9.3.3   Task 3: to look for men's suits in a specific price range

Users were asked to find a selection of men's suits within a specific price range. Given the choice, nine of the users would have used the stated resource (six sighted and three visually impaired). Comments included:

> **I haven't shopped online before but this was encouraging. I'd rather go to the shop still, but it would be good to look up what there was first (visually impaired user).**

Yes, I think I would go to a shop's web site (sighted user).

Eight users (three sighted, five visually impaired) said they would have gone to a bookmarked or "favourite" site, which included references to other online shopping sites.

Only two users (both sighted) said they would have searched for this information using another search engine, such as Yahoo's directory or shops listed on AltaVista, although one user said they would go to any site that provided a box to search.

Twenty-two of the users (thirteen sighted, nine visually impaired) said they would not use the Web at all. The most common alternative suggested was to go to the actual shop rather than trying to buy something online (although one user said that they hated clothes shopping anyway!). Typical comments included:

> **I wouldn't shop online, never have done and certainly wouldn't try at the moment, I'd rather go to the shop (visually impaired user).**

> **I would go to the shop, not the website (sighted user).**

9.3.4   Task 4: to find details of the *British Journal of Visual Impairment*.

Users were asked to look for a specific journal, find its publisher and identify its former title. When asked what resource they would have used to find out this information, given the choice, a fairly mixed response was given.

Twenty-one said that they would use the OPAC used in the task (nineteen sighted and two visually impaired).

Eight said that they would use a favourite or bookmarked site (three sighted and five visually impaired). Sites mentioned were KnowUK, Visugate, Capernic, RNIB, NLB, and the British Library.

Fifteen users (five sighted, ten visually impaired) said they would use a search engine for this task. Search engines mentioned were Google, Web Ferret, or just a "bog standard search engine".

Ten users (six sighted, four visually impaired) said that they would not have used the web at all. Alternatives suggested were:

I might just go into the library and ask the librarian (sighted user).

I might try a printed source (sighted user).

I would ring up the library and ask them (visually impaired user).

I think I would just phone someone up for this question (visually impaired user).

I'm old fashioned, I might just walk into the library (visually impaired user).

10 USABILITY QUESTIONS

Usability questions referred to the users' experience of undertaking the search process. Questions related to overall ease of navigation during each task, executing the search, locating hypertext links, finding the required resources and general feelings during the task, such as satisfaction levels.

10.1 How easy did you find navigation of the Interface to be?

Users were asked how easy they found navigating around the resource.

10.1.1 Search Engine

Of the forty users, just over half commented in a positive way to the question **"how easy did you find navigating around the Search Engine?"**. Comparisons between sighted and visually impaired users reveal that of the twenty-one who responded in a positive way, fourteen were sighted and seven were visually impaired. Comments included:

It was quite easy for straightforward searching.

Pretty easy really.

I find (The Search Engine) one of the better search engines.

Easier because I saw the link to Weather (sighted user).

I use the web that much that I don't really find it much of a problem (visually impaired user).

Of the forty respondents, fourteen expressed negative comments about the ease of navigation around the Search Engine. Negative responses were made by two of the sighted users and by twelve of the visually impaired users. Comments included:

Unpleasant, too many adverts and outside services (visually impaired user).

It's quite difficult because it is quite cluttered. There is too much information there (sighted user).

If the print had been better it would have been easier, but the print was awful (visually impaired user).

What choice language would you like me to use?! I don't like web pages with too much information…. (visually impaired user).

Five of the respondents expressed having neither a positive nor a negative experience – in other words they were neutral to the question. Of this, four were sighted and one visually impaired. Typical comments in this category were:

I use search engines a lot so I'm used to it. They get good search results, but the opening page of (the search engine) is a bit bland (visually impaired user).

Well, you tend to get into a habit of using certain search engines - I use Google which is very clear. In the Search Engine I did find that when I got the list of results I couldn't see them immediately - maybe that's just the size of the screen - you have to scroll down (sighted user).

10.1.2 Directory

Of the forty users in the sample, thirty-nine provided a response to the question **how easy did you find navigating around the Directory?** Twenty-one users commented in a positive way.

Of the twenty-one who responded, there was a fairly even split between the two samples (ten sighted and eleven visually impaired). Comments from the sighted sample included:

Yes, that was very slick. You have got three different ways of doing it (sighted user).

A lot easier than I thought it would be (sighted user).

Quite easy, has categories and links. Only the search box at the bottom is quite small (sighted user).

Quite good actually, really good (sighted user).

Comments from the visually impaired sample included:

Fairly easy to navigate… brought up some results fairly quickly once it was clear what to do…(visually impaired user).

Really easy, the easiest journal site I have come across (visually impaired user).

Very easy, it was good. Anything with text only is good for people with no sight (visually impaired user).

It was cool actually (visually impaired user).

Seven users responded in a negative way to questions about ease of navigation (four sighted and three visually impaired). Negative comments from the sighted users included:

Not very easy when you are looking for an area and you are not sure what it comes under (sighted user).

Not very easy at all ….. it wasn't clear what it was all about (sighted user).

Not really that helpful … it wasn't that clear what the A-Z list was, just a mish-mash of titles not in order (visually impaired user).

Negative comments from the visually impaired users included:

Not too good, a lot of it I couldn't read …. I was guessing really (visually impaired user).

… some of the text was hard to read …. a pretty nasty colour (visually impaired user).

Eleven users were fairly neutral about navigation of the Directory interface. This broke down into six of the sighted users and five of the visually impaired users. Neutral comments included:

It wasn't too bad …. Instructions given were not that clear (sighted user).

I found it a bit more difficult because I am not used to it, but eventually found my way around (sighted user).

Brought up some results fairly quickly and once it was clear what to do I managed to get information…. (visually impaired user).

Not too bad (visually impaired user).

Easier than the search engine (visually impaired user).

10.1.3 Online Shopping

Of the forty users in the sample, fifteen responded in a positive way to the question about navigating around the Online Shopping site. Of the fifteen, eight were sighted and seven visually impaired. Positive comments included:

Easy once I had found the links, the links weren't very clear at the beginning (sighted user).

It was easy to navigate. You just followed links (sighted user).

The navigating part wasn't difficult, it is quite nicely laid out, it was logical (sighted user).

Easy, not a problem at all. All the links had labels on them, just goes to show what I use the web for… (visually impaired user).

Absolutely easy (visually impaired user).

Easier than I first thought. You don't g*et all* that information at the top, like with (the search engine) (visually impaired user).

Quite good actually. It's quite well structured. When it first came up it was a bit confusing, there were only about three links on the page, then it said 'new browser' so I knew I was in another window (visually impaired user).

Negative comments were made by thirteen of the users, four sighted and nine visually impaired. Comments included:

Not very clear at all, not sure where to click or where to go (sighted user).

Quite difficult with all the problems with not loading properly, also I couldn't find the page I was originally on (sighted user).

That was awful, I didn't like that at all. I clicked on suits and it gave me the jacket and I wanted the trousers too and I wasn't sure where to go to get the trousers (sighted user).

Not something I would do for fun (visually impaired user)

Not that good. Too many different categories, but if you were shopping you would want all that information but it can be a bit, you've no idea what it is going to be made out of (visually impaired user).

Well, I don't normally bother to search for so long – there is so much to read and so many duplicates. I get tired and it gets on my nerves (visually impaired user).

Awful. The text was unreadable and there are that many graphics (visually impaired user).

Neutral comments were made by eight of the sighted users and four of the visually impaired users. Comments included:

Once you go into the links it was ok, but the order of the suits wasn't helpful at all (sighted user).

I found it easy at first, but I didn't quite understand about the display of the clothes (sighted user).

A bit easier, you can tell that the text is children's wear, women's wear etc but links are not specific, they are mixed up and repeating (visually impaired user).

10.1.4 OPAC

Of the forty users, one of the visually impaired sample did not respond to this question. Eighteen of the remaining thirty-nine expressed positive comments about the OPAC website: twelve sighted and six visually impaired. Positive comments included:

Entirely intuitive and transparent. Tries to do what it says it will (sighted user).

It was a lot easier that I thought - I was looking for problems that weren't there. It is very well laid out and not cluttered and you can see quite quickly where to go (sighted user).

Very simple - yes, it is quite straightforward. The reference list was something I hadn't come across before, had to make a bit of a leap there (sighted user).

I think it is well designed and quite easy to use (sighted user).

I didn't think the info would be there – but found site easy to navigate around (visually impaired user).

This site is much better [than the search engine], it is so easy. The information was there but at first my impatience led me to miss things (visually impaired user).

Pretty easy, pretty self explanatory. Not as many links [as the search engine] and they are pretty clear – title details (visually impaired user).

Eight of the users commented negatively on navigation of the OPAC website (one sighted user and seven visually impaired). Comments included:

I have always found it confusing - what actually links to what (sighted user).

Quite confusing, it had that table that looked quite simple but what was underneath it was a load of jumble (visually impaired user).

It was giving me clues on how to do it, for example where to put the title and that it has an index, but unfortunately I couldn't do it (visually impaired user).

That was not easy - a lot of people would have given up. That first page was a killer! Once you got to other pages it still wasn't e asy, but not impossible, first page was like a blank wall, nothing on it. Had to use a lot of guesswork (visually impaired user).

Not very easy, I was looking to find out where to put in the search (visually impaired user).

Thirteen of the users commente d in a neutral way on navigation around the OPAC website (seven sighted and six visually impaired). Neutral comments included:

Not too bad - it was easy to find the journal but less easy to find the former title (sighted user).

I didn't exactly know where to look for the former title, I just thought this link might work (sighted user).

It was ok with the bits I am familiar with but with the former title I would probably have looked in title details but I am not sure (sighted user).

I was just guessing in parts but it is a shame because the links were fine, they stood out. I suppose if I used it regularly I might get used to it, but it was so hard to read (visually impaired user).

There is probably a shorter way to find out the publisher. I prefer a search box on the page, like a search engine, rather than having to follow links to search, but basically it was ok (visually impaired user).

The first bit was really good, there were so few links and it was fairly self explanatory, some text and easy to select a type of search. But, when I got to the next stage [the search] it was less easy, especially when I got to the 'Alls well that ends well' – that was a bit distracting (visually impaired user).

10.2 Could you easily locate where to enter search terms?

Users were asked if they could easily locate the search box and where to enter search terms.

10.2.1 Search Engine

Twenty-two of the users said that it was obvious to them where to enter search terms. The majority in this case were sighted users (sixteen) with comments such as:

It was easy to see where to enter search terms (sighted user).

The search facility was one of the first things you saw (sighted user).

It is probably the clearest thing on the page, and it's at the top of the page so you don't have to scroll down (sighted user).

One sighted user said they had to guess, commenting that:

Couldn't see a category so assumed I had to enter search terms (sighted user).

Six of the visually impaired users said it was obvious where to enter search terms, commenting that:

Entered terms where the flashing cursor is, it is quite good, a good size (visually impaired user).

It's got contrast so it's not too bad (visually impaired user).

Four of the visually impaired users used keystrokes to find the search box, three mentioned listening to the screen reader for "edit box" or "find this" to be read out. Four of the visually impaired users said that locating the search box was unclear and one user said that they didn't really get anything at all. Comments from visually impaired users included:

Originally I found it, but there was too much other stuff, it was complicated (visually impaired user).

I thought I knew where to enter terms but it didn't seem to work (visually impaired user).

Even when it was clear where to enter search terms it was not always clear how to activate the search, as one visually impaired user commented:

Sometimes you can just press return, not always though, but don't always know what to press so it is good if you can just press enter (visually impaired user)

10.2.2 Directory

Fourteen of the users (nine sighted, five visually impaired) said that it was obvious to them where to enter search terms. Comments included:

… it was easy to see where to enter terms (sighted user).

it was obvious where to enter the terms but I wasn't convinced that I would get anything just typing it in there (sighted user).

Yes, there was an edit box to enter a simple search – it's good when it says that because 'simple' indicate s that there is an advanced alternative (visually impaired user).

I had to scroll down to the bottom but I knew that (the search) would either be at the top or the bottom, search boxes are rarely in the middle (visually impaired user).

Six users (all vis ually impaired) found the search box when it was read out to them by the screen reader, although it was not always obvious to them where to enter their terms:

Typically, once you got into the search it was by no means clear where to enter your search term – this may be the fault of the screen reader though, it didn't put you right into the place you wanted to be (visually impaired user).

One visually impaired user typed in search terms but was not in the edit box so when they activated the search, no results were retrieved. The user then changed strategy to follow links and was more successful.

Four of the users (all sighted) commented that they did not realise there was a search facility at all:

I didn't see anywhere to enter search terms.

It wasn't obvious where to enter search terms, I don't remember seeing that.

Didn't notice the search facility.

Six of the users (three sighted and three visually impaired) said that it was unclear where to enter search terms. Comments included:

No, not really clear where to enter terms (sighted user).

You couldn't input your own terms… (sighted user)

I just came across the search box [at the bottom of the page] by accident (visually impaired user).

Two users (both sighted) commented that the search box at the bottom of the page was very small:

you don't immediately see where the search box is, you could very easily miss it (sighted user).

One visually impaired user commented that the placing of the search box at the bottom of the page:

was in the wrong place, you had to go all the way down reading everything to find it (visually impaired user).

10.2.3 Online Shopping

Nine of the users (four sighted, five visually impaired) said that it was obvious where to enter search terms. Comments included:

Entering terms was obvious, but the rest was a bit different, with the little boxes to select from rather than typing things in (sighted user).

You could type in the terms, but I don't think it would give you anything that you couldn't get on their list (sighted user).

The edit box was as usual with combo boxes after that (visually impaired user).

Search terms were ok, I am used to this type of searching but there was no real explanation of what to do (visually impaired user).

Six users (four sighted, two visually impaired) said they were confused as to where the search box was. Comments included:

Search was useless. I could select items from the drop-down menu ok, but wasn't sure if I had to type suits into the dialog box and then select other options – so I had to take the trouble to read them (sighted user).

I didn't really know what I was doing and it didn't really come up with what I expected (sighted user).

I was looking for an edit box not a link on a page, it wasn't obvious (visually impaired user).

Two users (both sighted) did not notice that there was a search facility at all, and one (sighted) user commented that **"the search box was a bit small".**

10.2.4 OPAC

Twenty-one of the users (thirteen sighted, eight visually impaired) said that it was obvious where to enter search terms, comments included:

Entering search terms was ok, but it was a bit awkward having to click in the search box before typing anything in (sighted user).

Where to type search terms was clear, it gave me choices to do keyword or title searches (sighted user).

There is a search box, and it is the only box you can type something into (sighted user).

It was clear where to enter search terms, but you have got to have a bit of experience to get more out of the site (visually impaired user).

I had to do a bit more digging, but once I found it (the search box), it wasn't too bad (visually impaired user).

The screen reader has a keystroke that will take you straight to the first edit field on a page and tell you what it is (visually impaired user).

The first edit box was fine, but on some of the pages there are other bits which can throw you (visually impaired user).

Of the visually impaired sample, two users said that they were confused as to where to enter search terms, two said they guessed and one user said that he/she **"did not know where to enter search terms"**. Other comments included:

It was not obvious where to enter terms, the language used by the OPAC was not familiar to me and it was not clear whether it was just text or a dialog box to enter text (visually impaired user).

It was not obvious where to put search terms, I just guessed (visually impaired user).

I was looking for where to enter terms, this is the trouble with websites – there's nothing standard about them, in particular the beginning of them… you really do have to search around to find where you are supposed to input something (visually impaired user).

10.3 Could you easily locate where the hypertext links are?

Users were asked if they could easily locate the hypertext links.

10.3.1 Search Engine

For the Search Engine task, six sighted users and two visually impaired users said that text in a different colour indicated a hypertext link to them and underlined text was cited by seven of the sighted users. A visually impaired

user mentioned that when using a Braille bar, a row of dots along the bottom of the bar indicates a link, and a sighted user mentioned that **"links have buttons, like GO or SEARCH or FIND MORE"**. Other comments included:

I can tell they are links because they look different to the other text – I think they are blue and perhaps underlined (sighted user).

They are in a different colour aren't they? (sighted user).

I know that links are often in blue (visually impaired user).

No problem with links, but there were too many (visually impaired user).

The mouse pointer (or cursor) turning into a hand was mentioned by six sighted and two visually impaired users:

When the cursor changed to a hand I know that's where a link was (sighted user).

If it turns into a hand I tend to think that's a link to somewhere (sighted user).

You can tell links because you get the hand – I look for the hand (visually impaired user).

It says "link" and also "visited link" (visually impaired user).

(The screen reader) says Link first and then reads out the link (visually impaired user).

Using information from the status bar was also mentioned:

Usually links give you something at the bottom – an address that tells me it is a link (visually impaired user).

Two users (both visually impaired) had problems with links, one found the amount of information on the page confusing and one said that they found a link but **"it wouldn't let me go to it"**. Some of the users said they just assumed (or guessed) which text was a hypertext link:

Often I just assume it is a link (sighted user).

I often just click on text because I think it will be a link (sighted user).

10.3.2 Directory

Seven users (six sighted, one visually impaired) looked at the colour of the text. Four users (three sighted, one visually impaired) mentioned underlined text. Two visually impaired users mentioned the mouse pointer or cursor turning into a hand. Other comments relating to hypertext links in the Directory task included:

It was obvious where the links were, but it wasn't obvious where they were going to lead. It was a bit vague (sighted user).

Hypertext links were obvious, they are green not blue, but they are underlined and you still get a sense that they are links (sighted user).

Links were much clearer, it just gave the link with the menu option, not a lot of rubbish (visually impaired user).

Links were ok, but it didn't matter so much because it was a flat structure – one title or country at a time (visually impaired user).

Four users (three sighted, one visually impaired) said locating links were not obvious to them and were sometimes confusing. Comments included:

Links were not obvious no, but I had a feeling that each country would have a link to it (visually impaired user).

Others assumed or guessed which were links, or where the links would lead:

Hypertext links were clear, although some terms were not – what does A-Z mean? A-Z of what? You have to assume. You have to rely on the voice synthesiser and have to retain a lot of information (visually impaired user).

... it was more guesswork than usual really (sighted user).

10.3.3 Online Shopping

Four users (three sighted, one visually impaired) mentioned the mouse pointer or cursor turning into a hand. Three (two sighted, one visually impaired) mentioned the colour of the text being different when it was a link. One (visually impaired) user said that underlined text were links. Eight visually impaired users mentioned the screen reader reading out any links to them and one sighted user said that the status bar told them it was a link. Using the alternative text to locate links in the online shopping task was cited by one of the visually impaired users.

Locating links was sometimes done without thinking**:**

> **I didn't think about it really, but I don't think I clicked anywhere expecting to go somewhere and didn't – I assume places are links, I don't know why (sighted user).**

Users experienced various problems with links in the online shopping task:

> **links were ok at first, but finding links to suits was hard, I was struggling there, had to really hunt (visually impaired user).**

> **I could tell it was a link but I was not sure where I was going (visually impaired user).**

> **Links are blue, it's ok, but having them all higgledy-piggledy, all over the place is not good (visually impaired user).**

> **Links aren't that obvious, if you look at the top of the screen they are really small and not separated by anything (sighted user).**

> **Links were not clear on the Home Page, but when you got to the selection of suits they had underlined links – they should stick to one thing, either underline them all or not (sighted user).**

10.3.4 OPAC

Eight users (seven sighted, one visually impaired) said that the colour of the text in the OPAC task indicated a hypertext link. Seven (all sighted) said that underlined text indicated links, and six users (three sighted, one visually impaired) said that "the hand" indicated where the links where. Comments included:

Links are blue and underlined; on the left hand menu the colour changes when you move your cursor over the links (sighted user).

I know it is a link because the mouse pointer turns into a hand (sighted user).

Links were obvious and they were labelled with meaningful words, which is good, but I was not always sure what was in them (visually impaired user).

Links were easy, the finger points to them (visually impaired user).

Four of the users (three sighted, one visually impaired) said that they assumed or guessed where the links were:

Links weren't always obvious, just assumed sometimes (sighted user).

Links were not at all clear, it was mixed with the text – it didn't tell you where links were, I just had to guess (visually impaired user).

10.4 Where the results pages easy to "read"?

Users were asked if the results pages displayed easy to "read".

10.4.1 Search Engine

Fourteen users (eight sighted, six visually impaired) said that they found the results pages in the Search Engine task easy to read and understand.

Positive comments about the results pages included:

Gave you a lot of detail which was good, I have been on some where they only give you a title and that's it (sighted user).

Usually give a better description than other search engines (sighted user).

It gives a bit of an abstract so you can tell what type of site it is and it gives the address (sighted user).

Quite liked the descriptions given, didn't find much though, but I only looked at the first page – seemed to be a lot of junk (visually impaired user).

Thirteen users (one sighted, thirteen visually impaired) said they found the results pages hard to read. Comments included:

It reads out a lot of link images, you don't really know how far you have to go to get something sensible, you have to check every option out (visually impaired user).

I can't read the broken text, I have to have it read out or highlight it (visually impaired user).

No, I didn't know what I was doing then (sighted user).

Negative comments relating to the Search Engine results pages were that they were confusing (two sighted, four visually impaired users), there were too many of them (three sighted, two visually impaired) and that they were of poor quality (three sighted, two visually impaired). Comments included:

I find the screen rather too busy, too much going on (sighted user).

Sometimes when I clicked the link I wasn't sure if it was really about the weather… wasn't always sure how results related to my keywords (sighted user).

Seemed to be a lot of junk (visually impaired user).

I was surprised that I couldn't see how many hits I had, so couldn't tell how far I should go (sighted user).

Each link said more or less the same thing with something different below – that put me off a bit (visually impaired user).

Two users (one sighted, one visually impaired) had problems locating the results, commenting that:

I don't like the hits, they are way off down the bottom somewhere and before you get there there's loads of rubbish on screen (visually impaired user).

It wasn't immediately obvious where the results were, it said how many results were there but you had to scroll down the page to view them (sighted user).

10.4.2 Directory

Twenty-three of the users (twelve sighted, eleven visually impaired) said that they found the Directory results pages easy to read and understand. Comments included:

Very clear and uncluttered page (sighted user).

The results were detailed but it was not clear what kind of an audience they were suited for (sighted user).

Results were quite easy to listen to and I can use navigation mode to read line by line (visually impaired user).

Easy to read, brought up plenty with various subjects relating to the Solomon Islands (visually impaired user).

Quite comprehensive - useful information. It was very effective really (visually impaired user).

Three users (all visually impaired) found the results pages hard to read and understand, and six (three sighted, three visually impaired) said they found them rather confusing. Two users (one sighted, one visually impaired) commented that there were too many results. Comments included:

There is a lot of detail, possible a bit too much at one stage (sighted user).

I was not sure what the information was, I had to listen to it (visually impaired user).

I couldn't really see them properly, it would have been extremely frustrating if it was something I really wanted to know about (visually impaired user).

Six users (four sighted, two visually impaired) said that they just read the titles and followed the links rather than reading results descriptions.

To be honest, I didn't really bother to read it, just clicked on links to see what it is (sighted user).

I recognised the sources so didn't even read the description (sighted user).

I didn't really think about it, I just went into them (visually impaired user).

10.4.3 Online Shopping

Thirteen users (four sighted, nine visually impaired) said that they found the Online Shopping Results pages easy to read. Comments included:

Yes, once you got the hang of it – would normally expect to see the price of a suit though, not suit pieces (sighted user).

Results were easy to read, but you really need to know what you are looking for (visually impaired user).

Yes, easy to understand and gave me important information, like it was one of three pages (visually impaired user).

Not sure I'd buy a suit, but I knew what it was wittering on about (visually impaired user).

Ten users (eight sighted, two visually impaired) found the results confusing and eight (six sighted, two visually impaired) thought the results given were of poor quality. Comments included:

The letters underneath the pictures were a bit small, yes they were very small, I think I missed some things (sighted user).

No, they kept going on about suit pieces and I didn't really understand that (sighted user).

These ones (suit descriptions) are tragic because it took me quite some time to realise what they had done, and then it was irritating and in no order (sighted user).

The results were initially a bit confusing…. and I didn't realise at first that I could click on each picture (sighted user).

The suits descriptions were not clear, I made a guess at what it meant (visually impaired user).

10.4.4 OPAC

Twenty-six users (seventeen sighted, nine visually impaired) said that the OPAC results were easy to read and understand. Comments included:

Yes, I think it is a great OPAC actually (sighted user).

The results were arranged in quite a systematic way that you quite quickly get used to (sighted user).

Yes, absolutely easy, (the screen reader) has a very good speech output and it will read out everything to you uninterrupted if you wish (visually impaired user).

Three (visually impaired) users said they found the results hard to read and understand, and seven (three sighted, four visually impaired) said the results were confusing. Comments included:

Some of the results were easy but some (recent issues received) were a bit confusing (sighted user).

I don't think it is obvious what the publisher is - you wouldn't know, it could have been a bit clearer really (sighted user).

The language was not obvious to me, wasn't sure what Serial Holdings meant, but if I used it a bit more I would get used to it (visually impaired user).

The links were clear, but what was behind them was difficult to understand (visually impaired user).

There was not enough information (visually impaired user).

When I hit "begin search" it said that I had one entry, but it listed other entries – the design of the table was unclear (visually impaired user).

The text was broken and horrible, I couldn't highlight either to improve it – although I wouldn't want them to think that I can just highlight it, I would prefer better text (visually impaired user).

10.5 Was it clear where you were in the task?

Users were asked if it was clear where they where during each task.

10.5.1 Search Engine

Twenty-one users (sixteen sighted, five visually impaired) said that it was clear where they were during the Search Engine task. Comments included:

Quite straightforward to use, no problems. Did not get lost at all (sighted user).

I knew where I was in the sites and could go back if necessary, so I didn't feel lost at all (sighted user).

Did not get lost, quite happy. Could press Back to get me back through the layers of results (visually impaired user).

I tried to do it in a methodical way, so no, I didn't really feel lost (visually impaired user).

Six users said that they got lost (all visually impaired) and six (one sighted, five visually impaired) were sometimes confused as to where they were during the task. Comments included:

Oh I got lost! But that doesn't bother me at all, I just go back and try again – if I get lost because there are so many links then I might say "oh sod it" and give up (visually impaired user).

Yes, I got lost, you saw me! Basically I go back and start again (visually impaired user).

I got lost at several points, not just one…. I don't think that was very clear, it is not an easy search engine (visually impaired user).

I felt pretty clear about the path I wanted to go down, it was just that it took me to different places (visually impaired user).

I only got lost when things didn't happen when I expected them to – then I didn't know what to do next (visually impaired user).

Seven of the users (four sighted, three visually impaired) expressed mixed feelings, saying that at times they felt lost, at other times it was clear where they were. Comments included:

When I hit F3 I got lost, that can happen a lot – you just click on something and don't know where you've gone. Also, with someone watching you, you feel stupid and take longer to recover, but I didn't feel it was worse than any other site (visually impaired user).

It wasn't always as clear as it could have been really (sighted user).

I got lost a little bit with the number of times I had to go into different pages to find what I wanted – too many hyperlinks (visually impaired user).

I didn't feel lost, although I did feel frustrated that I was on sites that I thought should be weather forecasts but gave lots of other information, all sorts of stuff (visually impaired user).

10.5.2 Directory

During the Directory task, twenty-five of the users (eleven sighted, fourteen visually impaired) said that it was clear at all times where they were. Comments included:

> **Yes, it was ok, once you got used to using the site you would be able to navigate around quite quickly (sighted user).**

> **Didn't get lost because I used the Back button and could see where I had been before (sighted user).**

> **I think I knew where I was up to - it was better defined at the top of the page and the links were better defined too (visually impaired user).**

> **Clear at every stage (visually impaired user).**

> **Can't remember having got lost in that one (visually impaired user).**

Three users (two sighted, one visually impaired) said that they got lost and one user (sighted) said they felt confusing about where they were during the task. Comments included:

> **It wasn't clear what category I had to go into, I felt lost right from the very start (sighted user).**

> **I didn't get lost, but I wasn't sure what the categories were (sighted user).**

> **I felt a bit lost and anxious, it wasn't easy (visually impaired user).**

Eight of the users (four sighted, four visually impaired) expressed mixed feelings – saying that at times they felt lost and at other time it was clear where they were.

> **At the beginning I got lost because I didn't know where to find the information but then I found the alphabetical list (sighted user).**

When I clicked on General References it took me to a page where there were too many choices – I felt then that I could get lost and I might have to go back and start again (sighted user).

I got a little bit lost in what I was looking for, because for some items, it was not clear what the link was for (visually impaired user).

I didn't go too far because most of it I couldn't read (because the text was broken) (visually impaired user).

10.5.3 Online Shopping

Twenty-one of the users (thirteen sighted, eight visually impaired) said it was clear to them where they were at each stage of the task. Comments included:

It was ok, and there was always a point where you could go back to the Home Page (sighted user).

Yes, pretty obvious where I was, one or two pages took a long time to load though (sighted user).

I didn't feel lost, I just felt the information wasn't very forthcoming, it wasn't very good (sighted user).

It was clear where I was up to and I could find the actual pages, like the next page and previous page (visually impaired user).

It was very clear, it was quite good (visually impaired user).

I knew where I was on that one – you can quickly get used to that page, I've only been onto it once before (visually impaired user).

Only two said that they felt completely lost (both sighted) and three said they felt confused at times (one sighted, two visually impaired). Ten users (four sighted, six visually impaired) expressed mixed feelings about the task, saying that at times they felt lost and at other time it was clear where they were. Comments included:

Definitely got lost! I ended up in haberdashery or something. I got stuck in a loop and couldn't get out, so that's not good (sighted user).

No, I didn't have a clue, I didn't know what to do with the suits and jackets (sighted user).

Not lost, I just didn't know where I was going, I didn't feel I could go beyond suits, my confidence ran out (visually impaired user).

More lost than any other others – pages seemed to take a long time to load as well (visually impaired user).

10.5.4 OPAC

Twenty users (fourteen sighted, six visually impaired) said that it was clear to them where they were at each stage of the OPAC task. Comments included:

It was clear to me and I didn't get lost – but I know the interface (sighted user).

You just go step by step, it is very hierarchical (sighted user).

Fairly clear, also I am familiar with the interface (visually impaired user).

It was quite obvious I had got the right title etc (visually impaired user).

I thought that was a pretty straightforward search (visually impaired user).

Only three users (all visually impaired) said they got lost and three (one sighted, two visually impaired) said that they felt confused. Comments included:

Needed to use a bit of ingenuity, couldn't find anything using the links so tried it in navigation mode (visually impaired user).

When I first did the search and brought up the first page of results, I thought that was all the information, I didn't realise that there would be more levels such as a Title Details link (visually impaired user).

> **I definitely got lost, it's one of those sites which you need to keep using to get familiar with (visually impaired user).**

> **The distinction between what information would be displayed in Recent Issues and Title Details was not clear (sighted user).**

> **When I clicked on things I sort of expected all the information to come up, not have to follow more links (visually impaired user).**

Twelve users (five sighted, seven visually impaired) expressed mixed feelings - saying that at times they felt lost and at other time it was clear where they were. Comments included:

> **Not lost, just lost faith! The interface is not untidy, but I couldn't be sure what I was hearing was what was actually going on (visually impaired user).**

> **I got a bit lost when I was looking for what it was called before (former title) but with a bit of thinking you realise that there has got to be a link somewhere (sighted user).**

> **A little lost, it was the last ditch effort to go for the Title Details, it wasn't telling me what I was going into (visually impaired user).**

10.6 How satisfied are you with the task performed?

Users were asked how satisfied they were with the task performed. Based on the comments given, answers were grouped into positive comments, neutral comments and negative comments.

10.6.1 Search Engine

Ten users responded in a positive way to the Search Engine task (eight sighted, two visually impaired). Comments from both samples included:

> **Yes, satisfied, although I would have liked the Met Office link to be on top, but it wasn't really far away. (Sighted user)**

> **I view it as a sense of achievement, but I wouldn't have done it at all given the choice. (Visually impaired user)**

Eighteen of the users (eleven sighted, seven visually impaired) responded neutrally to the Search Engine task, comments included:

Quite satisfied, I think if I had spent more time I could have found more general forecast, with temperatures etc. (Sighted user)

Fairly satisfied. If the connection had been quicker it would have been better. (Sighted user)

OK, but it took a lot lo nger that I would have wanted it to. (Visually impaired user)

50%, well I found the Manchester forecast, I didn't expect to do that. So, reasonably successful as I have never used (this search engine) before. (Visually impaired user)

Fairly. I wouldn't use (this search engine). (Visually impaired user)

Negative comments were made by twelve of the users (one sighted, eleven visually impaired). Comments included:

Not very (satisfied), I couldn't find the information and some of the sites seem to have some problems. (Sighted user)

Well, for me it was a lot of action for something very simple! UK national weather - I should have found more easily really.(Visually impaired user).

Not very (satisfied), it was spoilt by the fact that I couldn't find the UK weather (Visually impaired user).

No, frustrated (visually impaired user).

10.6.2 Directory

Twenty-six of the users made a positive response to the Directory task (twelve sighted and fourteen visually impaired). Comments included:

100% (satisfied) (Sighted user)

Very satisfied. (Sighted user)

Yes, more than average. (Sighted user)

Very happy, it was easy and there were no "accidents". (Visually impaired user)

I was satisfied in the end with what I got. (Sighted user)

Yes, I think that was a good one. (Sighted user)

Yes, fine, no problem.(Visually impaired user)

That was good. (Visually impaired user)

Neutral comments were made by eleven of the users (seven sighted, four visually impaired). Comments included:

I am happy with the result, but getting there was a bit hit and miss. (Sighted user)

Well, I found some information relating to the Solomon Islands so I could have used that as a grounding to look for further information. (Sighted user)

The task itself wasn't too bad, but I was guessing all the way through really. There was nothing I could really say yes, that's what I want. (Visually impaired user)

Only two of the users made negative comments (one sighted and one visually impaired). A comment by one user was:

It just takes so long – sighted people just go click, click, click, and there's the answer, what else do you want to know? While I'm still looking for the first bloody link, it's very frustrating! (visually impaired user)

10.6.3 Online Shopping

Thirteen users made positive responses to the Online Shopping task (five sighted, nine visually impaired) Comments included:

Yes, that was ok really. Some of it was irritating, but with the Search I was able to find what I wanted. (Sighted user)

Yes, happy. (Visually impaired user)

Fine, although I won't be coming back to the site! (Visually impaired user)

Neutral comments were made by nine users (six sighted, three visually impaired). Comments included:

Task was alright, but not happy with the information they gave me. (Sighted user).

It was ok, it wasn't too hard. (Sighted user)

Medium – I got what I wanted but it took time and most was unreadable. The nice clear text didn't have the information that I wanted. (Visually impaired user).

Seventeen of the users made negative responses (nine sighted, seven visually impaired). Comments included:

I would have been happier with a search option rather than me doing all the work. (Sighted user)

I'm not satisfied, I'm disappointed. In a way I'm more disappointed because it started off so well. (Visually impaired user).

No, I'm not happy with that one. (Sighted user)

Very unsatisfactory – I'm dissatisfied. (Visually impaired user).

10.6.4 OPAC

Positive responses were made by twenty-one of the users (fifteen sighted and six visually impaired. Comments included:

Definitely satisfied! (Sighted user)

Completely (Visually impaired user)

I wish I was a student here! (Visually impaired user)

Neutral comments were made by twelve of the users (four sighted and eight visually impaired). Comments included:

That was ok, it was quite quick and there were no errors with the software, so it was quite good. (Sighted user)

With a bit of help it was alright. (Visually impaired user)

It'll do! (Visually impaired user)

Quite satisfied ironically – the main reason is that I found what I wanted. (Visually impaired user)

Six users made negative responses to the OPAC task (one sighted, five visually impaired). Comments included:

Not very at all (sighted user)

I can't really say that I was satisfied because I didn't complete it (visually impaired user).

10.7 Were any error messages or pop-up windows explained?

10.7.1 Search Engine

During the Search Engine task, two users experienced error messages (one sighted, one visually impaired). Both users said that they just ignored them because they didn't know what they meant. Both users backed out of that page and tried again.

10.7.2 Directory

One user (sighted) had a pop-up window appear during the Directory task, the user just **"clicked on x"** to close it.

10.7.3 Online Shopping

Six users (four sighted, four visually impaired) experienced error messages or pop-up message windows during the Online Shopping task. Comments about error messages included:

> **Didn't know what they meant, I have seen them before but don't understand them (sighted user).**

> **I just leave alone messages such as the proxy server message – I might just turn it off and wait for a bit, it means nothing to me (visually impaired user).**

Comments about pop-up message windows included:

> **Pop-up menus are informative, but not always easy to close (visually impaired user).**

> **I just closed it, didn't read it! (sighted user).**

10.7.4 OPAC

No error messages or pop-up message windows occurred during the OPAC task.

11 SUMMARY OF FINDINGS

11.1 General observations of searches

During the Search Engine task, eleven of the sighted users chose to use the search facility only, two just followed links on the page and seven followed links and performed searches. Nine of the visually impaired users chose to use the search facility only, six just followed links on the page, four tried a combination of following links and searching and one user abandoned the task before trying either.

In both cases (sighted and visually impaired), users who opted to use the search facility were able to execute the task more quickly than those who followed hypertext links from the Home Page. This was particularly true for the visually impaired sample, as the link to the weather provided by the Search Engine was towards the bottom of the Home Page, which contained around 180 hypertext links followed by a second page containing around 200 hypertext links to specific cities. The sighted users were able to browse through the links faster than the visually impaired users because they could quickly scan a page visually and pin-point relevant links. However, presentation of the links was rather cumbersome and not particularly user friendly for either of the samples.

During the Directory task, seven of the sighted users chose to use the search facility only, ten just followed links and three chose a combination of following links and searching. Five visually impaired users chose to use the search facility, twelve chose to follow links on the page, two followed links and performed a search and one user abandoned the task without following any links or performing any searches .

Observations of the Directory interface revealed that those using a screen reader were able to complete this task more efficiently than some of the sighted users. This seemed to be because, if using a screen reader, options such as "Search", "A-Z" and "Countries" which were offered on the top menu were read out at the start of the task. When users chose to follow one of these options they generally got to the required information fairly directly (although not necessarily quickly as they were required to listen to long lists of countries or alphabetical listings). On the other hand, users who surveyed the page visually were often drawn to the middle screen which had a collection of subject categories presented in slightly larger text than the top menu bar. This route took users on a more complex journey to the information, requiring them to think a little more laterally about which link to follow and certainly taking a less direct route.

As well as offering a search option to follow, the Directory offered a search box directly from the Home Page. This also took users on a fairly direct route to the information but it was presented at the bottom of the page in small text and was not always obvious to the users as it required them to either scroll down to the bottom of the page to locate it, or wait for the screen reader to read out the whole page to them.

For the Online Shopping task, ten of the sighted users chose to use a combination of following links and searching, seven just followed links and three tried to follow links but were forced to abandon the task because of problems with the site. Two of the visually impaired users chose to follow links and to search and three just used the search facility. Fourteen of the visually impaired users followed links on the page (one user was forced to abandon the task before following any links or trying a search due to software compatibility problems).

Users from both samples were able to use the search facility on the Online Shopping site without too much of a problem. The results returned, however, were not always very comprehensive and sometimes completely confusing (at one stage the site was promoting a sale and returned other items as well as items defined by the search). Users (both sighted and visually impaired) at times seemed unsure that the items returned were a true reflection of what was actually available. The visually impaired users tended to stop more readily once they had found at least one relevant item, whereas the sighted users were more inclined to look further. The reason for this may be due to the fact that sighted users could see a lot of other potentially relevant items on screen whereas the visually impaired users were listening item by item and may not have been aware that ten other possible items were displayed. For the visually impaired users it might have been useful to hear how many items were displayed.

All users (sighted and visually impaired) had to perform an initial search for the OPAC task. Both samples had similar problems with this task, mainly relating to the layout of the screen and the terminology used, which was ambiguous at times.

Overall, users who performed a search looked at only the first page of returned results - usually just the first two or three hits - before pursuing one of these links further or reformulating the query. Users who were using magnification generally located the results without too much of a problem as long as the text had not become "pixelated" when enlarged. However those using speech technology (the majority) found that because a screen reader generally starts reading from the top of a page it took a while to reach the results and it was not always obvious if there were any results displayed, or whether the search had even been activated successfully. Users commented that they found the results "difficult to find" and "hard to read", also "not sure if results are there, the top of the page is the same as the last one".

11.1.1 Time spent searching

Overall, visually impaired users took longer to complete each task although the amount of time taken varied between tasks. Completion of the task was counted when the user indicated this to the observer. Users were told that it was up to them to decide when they had found the required information – or when they wanted to stop searching.

The Search Engine and OPAC tasks took visually impaired users between three and five times longer to complete than the sighted users. There were exceptions of course, one visually impaired user completing the Search Engine task in two minutes using the search facility. In this case he/she only had to listen to part of a sentence being read out by the screen reader to be able to understand and move on. (It should also be noted that the user's search terms were very specific and thus quickly retrieved relevant results). The visually impaired users were generally more efficient at completing the Directory and Online Shopping tasks, but it still took them longer to complete than the sighted users.

Further investigation is needed to examine the depth of searching undertaken by both samples in order to ascertain whether users stopped searching once they had found something reasonable or whether they tried other searches or features to check that they had found all the available information. For example, some users (from both samples) indicated they had completed a task even if they had searched no further than a hypertext-linked list of headings and descriptions, whereas others continued to follow one or more of the headings before they indicated they had completed the task. This could be seen as more of a user behaviour issue than a usability one, although for some users (specifically users in the visually impaired sample) it had taken them a considerable amount of time to just retrieve a list of headings. In these cases comments suggest that users may have been more inclined to stop searching at this point because "it just takes so long" and it is "a lot of action for something very simple". Previous studies of user behaviour with search engine tasks (including both visually impaired and sighted users) suggest that on average users search for around 16 minutes before stopping and they often rate success and satisfaction levels with the ease of retrieval rather than information provided in the results (Craven and Griffiths, 2002).

11.1.2 Surveying the page

Comparisons of surveying between the sighted users and visually impaired users (i.e. sighted users who looked at pages and visually impaired users who had text read out) show that there are similarities between the two groups. All users need to spend some time surveying a page or pages before deciding how to proceed, and the layout of the page affected their efficiency in surveying. However, the time spent on surveying differed between the two groups – for example a sighted person often only had to glance at a page, quickly scanning it for relevant information or links. Visually impaired users with screen magnification or who could look at a standard screen at close

proximity could also scan pages to some extent, being able to control which part of the screen they surveyed. In contrast, visually impaired users with screen readers had to listen to text read out and this tended to take considerably longer. Although some of the visually impaired users were able to listen to text read out at high speed, listening to just the beginning of a sentence before tabbing to the next block of text, others had to spend much longer surveying before they were able to proceed. This suggests that there are a higher number of variables impacting on visually impaired users' efficiency in surveying a page. Variables include the type of assistive technology used, how compatible this is with the pages surveyed, levels of expertise in using assistive technologies and familiarity with the layout of the screen and terminology used. (The last two variables will also impact on sighted users' efficiency).

During the Search Engine and OPAC tasks the sighted users surveyed pages on fewer occasions than the visually impaired users. Reasons derived from the visually impaired users' comments suggest that all the Search Engine pages contained too much information to enable rapid surveying, and that terminology used on the OPAC site was unfamiliar to many of the visually impaired users, causing them to listen (or look at) pages several times before deciding how to proceed.

In contrast, the visually impaired users surveyed pages on fewer occasions than the sighted sample during the Directory and Online Shopping tasks. Comments from the visually impaired sample suggest the information provided on these sites enabled them to find their way around without having to spend as much time surveying. The Directory, for example, had less information on its home page and although subsequent pages sometimes contained a large number of links, users seemed able to navigate through them quite easily (if not quickly). Similarly although the Online shopping pages contained a lot of distracting graphical information, relevant links were read out in a fairly logical way.

11.1.3 Keystrokes

Keystrokes per task were logged according to serial steps taken (clicking on, clicking back) and parallel steps (including typing in, tabbing down and up, clicking on enter). In most cases visually impaired users took more steps (using keystrokes or mouse clicks) per task, and used a greater combination of keystrokes than the sighted users. Keystrokes logged for each task reveal that visually impaired users used a combination of around sixteen different keystrokes, whereas the sighted users consistently used the same six. Differences between keystrokes used by the visually impaired users compared to the sighted users mainly related to the assistive technologies used, which offered a variety of ways to navigate a page using keystrokes such as the up and down arrow, the tab key, the return key and specific control keys. Users interacting with standard PCs, however, tended not to use control keys, relying instead on scrolling up and down the page, typing in terms, selecting options and clicking on the return key.

11.1.4 Serial and Parallel Steps

Differences between the two samples were found according to steps taken during the four tasks. In total, visually impaired users took more steps (serial and parallel) than the sighted users. The Search Engine and OPAC tasks revealed the greatest difference where visually impaired users took almost twice as many steps overall as the sighted users. The Online Shopping task shows that visually impaired users took more parallel steps than the sighted users, but took fewer serial steps (i.e. movement within pages), indicating that the visually impaired users could locate a relevant page quite efficiently but had to spend more time navigating within a page in order to find the information.

The only task where visually impaired users took fewer steps overall (both serial and parallel) was the Directory task, indicating that for this task visually impaired users were able to locate the required information with a more efficient use of steps than the sighted users. As mentioned previously, a possible reason for this, derived from observations and comments, was because those using a screen reader (the majority of visually impaired users in the sample) had potentially relevant links such as "search", "A-Z" and "countries" read out to them from the top menu almost as soon as they started the task.

The findings show that whilst movement serially from page to page (or between web sites) varies to some extent between the sighted and visually impaired users, the main differences occur when moving around, or within a page (parallel). This suggests that the more choices provided on a page and the more complex the design of the interface, the longer a visually impaired person must spend trying out different options before finding the information they want or moving on to use another resource. This was particularly true for users who were listening to screen readers, as they were to some extent forced to navigate the page serially when it had actually been designed for parallel navigation (e.g. a page containing frames).

11.1.5 Search Terms

Similarities occurred between the two samples in the type of search terms used and in the type of search. Almost all of the users who searched applied simple search terms and did not make use of the advanced function. These findings are in line with previous research into user searching behaviour (Craven and Griffiths, 2002), indicating that in general all users whether they are blind, visually impaired or sighted want to be able to perform quick and simple searches.

Differences did occur in the reformulation of searches and search terms. Both samples reformulated searches to include new terms or to add to existing ones. However, the visually impaired users also reformulated their search because they had mis-spelled terms, which meant no results were retrieved.

Sighted users also mis-spelled terms, but they could generally spot their mistake and correct it fairly quickly, whereas this was often chance or guesswork for the visually impaired users. Another reason that visually impaired users reformulated a search was when the results were displayed half way down the screen and the screen reader starting reading out from the top. Users assumed the results would be read out first, so were unsure if any results had been retrieved or whether their search had been activated and therefore re-submitted the search.

11.2 General questions

General questions included aspects of using the web and the chosen resources. Users from both samples mentioned using various methods to tell them that a page was loading or that it had loaded. The main methods mentioned by the sighted users were visual ones such as looking at the page loading on-screen or at the various clues provided on screen such as the browser icon moving around, the status bar or messages such as "Document Done". For visually impaired users these types of clue were only useful if the user had enough sight to be able to decipher icons or messages, or if they could use screen magnification. For those using a screen reader, the user had to rely on aural clues such as listening to noises from the hard drive, or waiting for the screen reader to start reading out from the top (which most automatically do once the page has loaded), or for "Document Done" to be read out. Most used a combination of clues rather than relying on one, and a degree of patience and chance seemed to be part of the process, suggesting that even before they have started to interact with a web page a number of barriers to their success already exist.

Before commencing a task, users were asked to comment on the interface of each resource, describing their first impression of the interface and what sort of information they thought it was providing. Generally, both samples commented favourably if the information provided on screen was presented in a clear and logical way (whether to look at in standard size, magnified or read out). One of the visually impaired users commented that when listening to a page read out it appeared to him/her as one long list, and therefore it was more helpful if the list followed a logical order and was not too overbearing in terms of the number of links per page. Clarity of background and text was mentioned by users from both samples but had more of a bearing on visually impaired users, especially those who were using screen magnification as the text from some sites became "pixelated" when enlarged and therefore difficult, if not impossible, to read ("smoothing" of text could help improve this to some extent, but only if the user was aware of this function).

Users from both samples were less happy with pages that provided them with too much information. The sighted users commented that pages with a large number of links, graphics and repeated menus sometimes appeared "cluttered" or "busy" to them, which was annoying. For visually impaired users such pages were time consuming and overbearing and could discourage the

user from proceeding. If a page contained duplicate menus and/or repeated links it was not always clear to them if they would take the user to the same place (as well as having to listen to the link read out twice if using a screen reader). Interestingly, pages that were full of graphical links were not necessarily a problem for the visually impaired users as long as appropriate alternative text was provided clearly describing where the link would take them.

Pages that included logos were a problem if the logo was not properly explained, and pages that had ambiguous descriptions to links presented potential problems to users (from both samples). Similarly, large block of text were not favoured by either the visually impaired users or the sighted users and most said that they would not bother to read this type of information.

Users were required to use a stated resource for each task, the aim being to ensure valid and reliable comparisons between the users and the tasks. At the end of each task users were asked what resource they would have chosen to search for the information. For each task, a few users said that they would have chosen to use the stated resource. However the majority suggested other resources such as bookmarked or favourite sites, other search engines, or even non-web-based resources. The visually impaired users tended to have their own bookmarked or favourite sites. Generally the sites they mentioned were ones that they found accessible, which was an important factor for them. Of other search engines mentioned, the most popular with visually impaired users were Google and AlltheWeb. For the visually impaired users who said they would not have used the web at all for one or more of the tasks, alternatives mentioned were CD-Roms, ringing up the library, asking someone, listening to the radio, or (in the case of the Online Shopping task) just going to the shop.

11.3 Usability questions

Users were asked to describe their experience of undertaking each of the tasks, including ease of navigation, executing searches and following links, and overall satisfaction levels.

11.3.1 Navigating around the resource

Visually impaired users found navigation of the Search Engine more of a problem than the sighted users. In general the visually impaired users found it to be "unpleasant" and with "too much information", whilst the sighted users found it quite easy and straightforward to navigate (even if they did not like it). Overall, both samples seemed to either like it or loathe it, with only five of the users overall expressing neutral feelings relating to navigation of this site.

Navigation of the Online Shopping site was less problematic for visually impaired users than the Search Engine, with just under a half expressing positive feelings about navigation. However, the site still had its frustrations,

the main problems being the amount of duplicated information, the rather inflexible search facility and presentation of the "results" (which proved confusing both for the visually impaired and sighted users).

Sighted users found navigating the OPAC site easier than the visually impaired users, describing it as "simple" and "intuitive" whereas comments from the visually impaired users described it as "quite confusing" and spoke of having to "use a lot of guesswork". One reason for this was that many of the sighted users were familiar with the layout of the site, whereas visually impaired users were less familiar, although some commented that it was an interface they could get used to if necessary.

The most popular site in terms of navigation was the Directory. Around th ree quarters of the users (from both samples) expressed either positive or neutral feelings about navigation of this site. The main problems expressed related to ambiguous or unclear descriptions (comments from both samples) and pixelated text when using screen magnification.

11.3.2 Locating hypertext links

In general, most of the sighted users had little or no problems locating hypertext links, which were in a "different colour", or "underlined", or when the cursor "turned into a hand", or they just assumed it was a link. In general the visually impaired users also had few problems locating the hypertext links (even if there were too many), because they were read out by the screen reader as a "link" (or could be seen in similar ways to the sighted users).

Some problems locating hypertext links did however arise. During the Search Engine task, location of links was described as confusing if plain text was presented amongst a long list of hypertext links, because to the user it seemed logical that this was also a link. This was particularly problematic if using a screen reader, as it was not always easy to decipher which bit of text the "link" prompt was referring to.

Problems with links were also experienced by the visually impaired users during the Online Shopping task, where some of the links were graphical ones and not obvious, while others were too close together, not separated by anything, or "all higgledy-piggledy".

In general, both samples found links on the OPAC and Directory sites easy to locate. The main problems experienced with both of these sites (again, for both samples) was that it was not always obvious what the terminology meant or where the link would take them, examples being what the A-Z link was referring to or what a link to "R eference Details" meant.

11.3.3 Locating the search box

If a search box was provided on the screen most of the sighted users were able to locate it, particularly if it was placed in a prominent place. Similarly, the visually impaired users were able to quickly locate search boxes if they were prominently placed (such as near the top of the page). Visually impaired users also preferred to be provided with a search box rather than a link to a separate search page, as this was just one more step for them to take.

During the Search Engine task, around half of the visually impaired users and almost all of the sighted users found it reasonably easy to locate the search box. However once located it was not always obvious to some of the visually impaired users where they had to enter search terms, or how to activate the search. This was a particular problem when using a screen reader and some users thought they had entered terms and activated the search, but in fact had not. This confusion continued when no results were returned, as it was unclear to the user whether there were no resources available or whether they had not properly activated the search.

The OPAC home page provided links to various search options such as Title Search, Keyword Search or Title/Author Search. On selecting a search link, users were taken to a separate search page. Once in the search page the search box could be clearly seen together with some extra options and an example of how to enter terms. The cursor was automatically set in the search box ready to type in terms. This was very useful for users who were able to look at the screen (standard size or magnified), but was sometimes confusing for users with screen readers as they were not always aware that the cursor was set ready for typing in terms. Although some of the visually impaired users were able to use a keystroke to place them directly into the search box, not all users seemed be aware of this option and in some cases "just guessed" how and where to enter terms.

The Online Shopping site provided a separate search page with simple search box, plus several drop-down combination boxes. This did not prove a particularly successful experience for either of the samples, for although locating the search box or combination boxes was not too problematic, once found it was not always obvious what to do next or how to enter terms. A help screen was provided, but only a few users activated this.

The Directory site provided a link to a separate search screen from the home page and also provided a small search box at the bottom of the home page. Not all the users (from both samples) were aware a search facility was provided, either because the search option was hidden amongst the other links, or because users had to scroll down the page to locate it or have to "go all the way down reading everything to find it".

11.3.4 Understanding the results

Once results from the Search Engine had been returned users from both samples found them reasonably easy to understand. However, the main problem for the visually impaired users was actually locating the results, as they were presented part of the way down the screen and, if using a screen reader, they would have to listen to the top part of the screen read out first. When this happened it was not always obvious whether they had retrieved any results at all. Another problem experienced was that if the search returned a large number of results it was not initially clear to the visually impaired user that only the first ten were displayed, the worry being that they may have to listen to hundred of results being read to them. Although in reality most users rarely went past the first three or four results, it was still off-putting to be faced with a large number of results.

Overall, visually impaired users seemed to find the Online Shopping results easier to understand than the sighted users. This was mainly the case for users with screen readers: reasons for this may have been that they were listening to the results read out to them item by item rather than looking at items on what was a rather cluttered and distracting page.

The visually impaired and sighted users generally found the Directory results easy to understand, although some users (from both samples) said that they only looked at or listened to the headings rather than the whole description, or just clicked on a link without thinking about it. Problems experienced with the Directory results were pixelated text (when using screen magnification) which was hard to read, and the amount of detail given which was "a bit too much at one stage".

As mentioned previously, many of the sighted users were familiar with the terminology used on this site and therefore nearly all the sighted users said they were able to understand the results. The visually impaired users expressed mixed feelings about the OPAC results, but almost half of them also said they could easily understand the results. The remaining visually impaired users (and a few of the sighted users) either found the results confusing or found them hard to read (i.e. some of the text appeared pixelated when magnified). An example of confusion was when the results returned informed the user that they had one result, but proceeded to read out a long list of titles (including the title searched for). Some users said they found the terminology confusing because they were unused to it but given time would be able to use the site more efficiently.

11.3.5 Getting lost

Many of the users experienced times when they were either not sure where they were during a task or were unsure how to continue. This did not necessarily cause users to give up on a task (unless it kept happening or if they could not get back on track after several attempts), the main strategy

being to "go back" a stage or even to "start again". This strategy was used by both the sighted and visually impaired users.

During the Search Engine task visually impaired users had more problems telling where they were than the sighted users. Over half said that they had moments during the task when they felt partially or totally lost, compared to just a quarter of the sighted users.

Sighted users also seemed slightly better able to tell where they were during the Online Shopping task (although the only two users to feel completely lost were sighted). The visually impaired users expressed mixed feelings about this task, one commenting that he/she was "not lost, just didn't know where I was going" and another "more lost than any of the other (tasks)".

During the OPAC task most of the users from both samples knew where they were and did not express feelings of getting lost. However some were unsure how to find the information required and were not always sure how to proceed. Terminology rather than getting lost seemed to be the main stumbling block during this task which, and as one visually impaired user commented, "needed a bit of ingenuity" to complete.

The Directory was probably the most successful site in terms of users knowing where they were during the task. More sighted users expressed feelings of getting lost orfeeling confused than the visually impaired users, of whom only around a quarter expressed any feelings of getting lost. The remaining visually impaired users said it was clear where they were up to and they simply back-tracked if they were unsure at any time.

11.3.6 Error messages

Any error messages that appeared during a task were generally ignored and backed out of or closed (by both samples). Pop-up windows were also often ignored and closed, although one of the visually impaired users commented that these can be good for information, even if they are sometimes hard to close.

11.3.7 Levels of satisfaction

Satisfaction levels relating to the Search Engine task were mixed. Sighted users generally seemed happier with this task than the visually impaired users. The visually impaired users tended to respond in either a neutral or negative way to the task, expressing feelings of frustration about the length of time it took them to find "something very simple". This feeling is reflected in the number of users who cited searc h engines with simpler interfaces such as Google or Alltheweb as their preferred method of searching.

Satisfaction of the Online Shopping task was again mixed, although the visually impaired users were generally more positive than the sighted users. Sighted users tended to express more neutral comments relating to satisfaction with this task, and both samples expressed feelings of dissatisfaction. A general feeling seemed to be that even if they were satisfied with the task it was not necessarily a good experience, or as one of visually impaired users who was satisfied with the task commented: "I won't be coming back to the site". However, perhaps this is more a reflection of attitudes to online shopping in general than of the site itself.

Sighted users were more satisfied with the OPAC task, although both samples were generally happier with this task compared to the Search Engine and some responses given were extremely positive. The majority of neutral or negative responses came from the visually impaired users and this seemed to relate more to a lack of familiarity with the site and the terminology used, which seemed to hamper users' success with this task.

The Directory task was again the most successful in terms of satisfaction levels with nearly three quarters of the visually impaired users giving positive responses (and over half of the sighted users). Neutral responses generally related to the fact that, although the required information was retrieved, it was "a bit hit and miss" or that the user was "guessing all the way through". Only two negative responses were made relating to this task, the main problem being that some of the information and links provided were in very long lists which meant that it could take a visually impaired user a lot longer to find the information.

12 CONCLUSIONS

NoVA's observations and other analyses of users searching for information on the web reveal that, unsurprisingly, people who are sighted find searching the web much easier than visually impaired people. Furthermore, people who are visually impaired, but possess enough sight to be able to see part of the screen (either up close or using magnification), find searching the web easier than those whose sight is severely impaired (i.e. those who are either totally blind or have very limited sight). These results confirm the findings of a parallel study conducted by Coyne and Nielsen, which estimated that "the Web is about three times easier to use for sighted users than it is for users who are blind or who have low vision" (Coyne and Nielsen 2001 p 5), although we would not make such explicit claims. Again, as with NoVA, findings from this study also revealed that people using screen magnification appeared to have a higher success rate than those using a screen reader, although the difference was not statistically significant.

Comparisons of time spent searching during the NoVA usability tests showed that visually impaired people have to spend more time searching for information than sighted people (again this concurs with findings of Coyne and Nielsen, 2001). However, times can vary considerably. The design of a site can considerably reduce the time needed if a number of simple design features are included. These would include a logical and meaningful menu, a search facility and a strict limit on the number of links per page (as well as other accessibility design features such as those recommended by the W3C/WAI).

The acceptable (to the user) length of time spent searching for information may have an impact on the success of a search, as users tended to stop after an average (mean) of about 16 minutes whether they had found all, some or none of the information they were looking for. Logging the number of keystrokes (or the number of steps) people have to take whilst undertaking a search shows that visually impaired people take more than twice the number of steps and have to interact with more than twice the number of keystrokes than sighted users. The steps taken for the NoVA tests were broken into "serial" and "parallel", enabling comparisons to be made between the number of times people moved from page to page (or site to site) with the number of times they have to move around a page. The studies show that visually impaired users have to spend much more time navigating around a page than sighted users, and have to use a greater variety of keystrokes to do so. Even if the page is accessible it may have been designed in a parallel way (i.e. with frames and tables), so that a visually impaired user (particularly someone using a screen reader) may have to spend more time navigating around each page. This can lead to frustration and fatigue, and may cause them to stop altogether, which may in turn result in users missing out on potentially useful information. At the extreme it could discourage them from using the web altogether and thus contribute to social exclusion.

It should be noted that users in the NoVA usability tests were looking for information prescribed by the task. Clearly this could have influenced their motivation to stop (i.e. the importance of finding the information may not have been as great as when information was needed for other, personal reasons). However, it is clear that, in a real information searching situation, pages that cause people to stop searching because they are complex or cumbersome to navigate will still be a serious problem. One example could be a user in higher education researching a topic for a piece of coursework using a screen reader to access web-based resources. The user may find a site with resources of a highly academic nature, relevant to their topic and of sound quality, but then miss important documents or references because they give up searching. The site may not necessarily have been inaccessible, but simply designed in an inflexible way. Web designers need to be aware that people will not carry on searching or browsing a site if they have to spend too long or find it too complicated - they will simply go elsewhere.

The type of assistive technology used had a bearing on the search process. Visually impaired users who were able to read a standard size screen up close were better able to browse through non-serial information because they could scan the page rather than try to navigate it line by line. A similar comment applies to those using magnification packages as they could interact with the page in a similar way to someone using a standard size screen, with an element of control over which section to look at - although clearly there were more problems where it was necessary to scan between frames. The main problem observed with magnification packages was that the text on screen could appear very broken or "pixelated" when enlarged, and in some cases this rendered text completely unreadable. Users sometimes had to activate speech (if that was possible) in order to proceed, or to highlight the text to enhance its appearance (although this could be viewed as more of a problem relating to inaccessible web design than a problem relating to user behaviour). While a possible solution is for users to override font/size settings, in reality most users do not do this (and it can have unpredictable effects with all too many pages).

Observations indicated that screen readers forced users to navigate pages in a serial way, which was not always appropriate for the design of the page. For example, pages with a large number of links are designed for quick scanning, but a screen reader is not able to do this and will read out each link one by one. It is also difficult to remember the contents of a page containing a large number of links, and users often have to go back and listen to all the links again in order to find (or not find) a suitable one. This makes the navigation process considerably longer and users expressed feelings of frustration - especially if they were looking for something fairly simple. Similarly, pages that contain duplicate menus (i.e. one at the top and one at the side) force the user to listen to links being read out more than once, which again is time consuming.

For successful browsing of sites the observations identified that hypertext links need to be placed in a logical order and given meaningful titles. Ideally the page should not contain a long list of links, but if this is absolutely necessary then it should at least be in alphabetical order (or offer an alternative list in alphabetical order). The number of links also had a bearing on success, as the greater the number of links per page the longer it took someone to browse, particularly if using a screen reader. Ideally pages should not be cluttered with links (except perhaps for something like a site map) and for reasons explained it is better to adopt the shallow and deep approach which has been identified in previous research as being the preferred approach for someone who is blind or visually impaired. For web sites where it is not possible or practical to offer this approach, for example with very large sites, it is important to provide a search facility as an alternative to browsing through links.

For users who prefer to search a page rather than browse through it, a search box should be placed in a prominent place (such as near to the top of the screen). This is preferred to providing a link to a separate search page as users were sometimes confused by this, assuming "search" would be a search box and not a hypertext link. The search box should be simple and not too small (an option to go to an advanced search may also be offered, along with tips on formulating search terms and queries) and if the search facility is available on all pages it should always be placed in the same position.

Even if a web page passes all the automated accessibility checks and/or adheres to recommendations by bodies such as the W3C, this does not always mean it will be problem-free for users. An example is given by the user who tried to tab quickly through links but missed important information because the screen reader paused before reading out some of the text (e.g.. "Link, Image" (pause) "perform a Title search") and the user had moved on before the link was fully read out. Therefore, the importance of using people for accessibility checking cannot be stressed too much.

Observations during the NoVA usability testing highlighted the fact that expertise with the assistive technology used also had a big impact on the success of the task. Users who were aware of the different options offered by some of the more advanced screen reading technology were able to have a greater degree of control in the way they interacted with a page. For example, they could search within the page for specific information, sort alphabetically, navigate through tables and frames and set preferences to avoid repeated reading out of navigational links at the top of the page. This may have implications for training programmes for people with visual impairments.

It is also important to check web pages using different types of assistive technology. Observations of the NoVA usability testing showed that

performance varied between assistive technologies and, as mentioned previously, not everyone uses the most up-to-date versions, perhaps because they cannot afford to keep upgrading their software, or because they feel comfortable using a particular version (much like someone who drives the same car or has been using the same camera for years). It may also be that they are using a public access terminal where the assistive technology has been chosen for them.

Different types of assistive technology present different solutions and problems to accessing a web page. Observations identified problems with screen magnification such as pixelated text (the main problem in the usability tests), but enabled users to search a page that had been designed in a parallel way with relative ease. Screen readers presented many problems for users, such as not always reading out every link (for no particular reason it seems, although this needs further investigation), therefore potentially missing important information. Similarly, partially minimised pages or pages that opened as a new window could also be confusing or misleading because the screen reader would just read what is on screen.

Older screen readers did not work well with frames. Whilst trying to navigate between two frames, one user got stuck in the contents frame and took some time to get back to the main frame. Compatibility can also be a problem. One user, for example, had problems with the screen reader reading out what seemed to be the HTML of the page rather than the page itself. The user had recently upgraded his/her PC and felt that this could have been the cause of the problem rather than the screen reading software.

Some of the more advanced screen readers do allow a degree of user control regarding navigation. However success in using some of the more advanced features of a screen reader seemed to depend on awareness and experience. Those who were quite experienced and made use of elements such as the Links List, Sort Alphabetically and Search in Page options were able to reduce the time spent browsing by eliminating the need to tab back and forth through each link. Use of the Virtual PC key (or the Braille Bar) enabled users to move around the page and pinpoint areas of text or spellings that were not immediately clear to them.

13   RECOMMENDATIONS

13.1 Web page design

The design of web pages critically affects their accessibility. Even those which pass all the standard automatic checking services and adhere to the Web Accessibility Initiative Guidelines may still be difficult to access by those with visual impairments. Designers need to be much more aware of how *layout* and *content* considerations affect accessibility, and need to consider the navigational practices of users in their designs. We **recommend** that additional guidance be developed to encapsulate the lessons from the NoVA project and elsewhere, including the following:

Accessibility should be understood as requiring a number of different responses, such that sighted, partially-sighted and blind users can all use their choice of technology to access services.

Web pages should use a simple and logical structure, and this should be consistent throughout the site.

Web pages designed for enabling access to a variety of sources through a list of links (e.g. gateways to resources) should also provide a search facility, which should be available at the *top* of the page.

Such web pages should follow a logical order and the logic should be explicit (i.e. not just "A-Z" but "alphabetical by explicit criterion").

The number of links per page should be such that a user who has to listen to them being read out will be able to retain all in memory. Although we cannot recommend an exact limit (though it would be nearer 10 than 100), since this will vary from application to application, this test gives a useful rule of thumb for developers.

While WAI Guidelines advise on the use of frames, it should be understood that the critical issue tends to be the *complexity* of pages and the logical *relationship* between areas on the page. Thus a page containing frames may not itself be problematic; a page containing a number of frames which require a user to make mental links between them will be inaccessible. Designers should consider the steps needed to navigate *within* pages since this is the most crucial determinant of accessibility.

13.2 Assistive technology

Access to the most up-to-date software enables greater control: we **recommend** that libraries and museums should for this reason invest in up-to-date technology. However, not everyone has that access and many users may be using an older version or an obsolete browser, for example at home. Older versions should not be discarded without an audit of user requirements in each service. Thus providers need to be aware of the trade-off between

functionality and familiarity. Web designers must also be aware of these issues and must not assume that everyone has the latest version of software available.

13.3 Staff training

We **recommend** that the findings of NoVA and parallel research should be used to inform accessibility training issues relating to assistive technology, for example in training library and museum staff in relation to open access computers with assistive technology. An accessible web-based tutorial, with examples of good and poor practice, might be an appropriate way forward.

13.4 User training

Experience of using assistive technology enhances performance: many of the features offered by assistive technologies provide short-cuts to help reduce the amount of time spent navigating or searching for information on the web. Not all users are aware of the features offered, and those that are may sometimes be unsure how to operate them. We **recommend** that greater emphasis is therefore given to the provision of training for both users and trainers.

13.5 Universal design

Some of the similarities between the two samples confirm the need for universal design rather than separate systems. The comment by a visually impaired user that text only options tend to be out of date reinforces this view. We therefore **recommend** that unless there are pressing reasons not to do so, all developers should adopt universal design as their underlying aim.

13.6 The appropriateness of digital approaches

Accessible gateways and portals such as those in development at the National Library for the Blind could pave the way forward for people with visual impairments. However mainstream portals also need to be addressing accessibility issues so that people with visual impairments are not forced to rely on "specialised" services alone, but are able to use the services and resources of choice.

It remains the case, however, that the Web will have to be made much more user-friendly to attract more visually impaired people to use it - for many it will still present too many barriers to be an attractive option. Service providers need to beware of making electronic access the only option. We **recommend**

that service providers, in auditing the accessibility of their web pages, should explicitly consider whether non-Web alternatives - including human intermediaries - are needed.

13.7 Further research

We **recommend** that studies should be undertaken in the following areas:

Studies of how learning and cognitive styles impact on visually impaired users' access to information resources.

Research into the effects of the usability of a web site or other online resource on the users' motivation to continue searching, i.e. why does one user stop as soon as they find a reasonable answer, while another user continues to look further? Is this a usability or a user behaviour issue, and how does task impact on it?

The performance of screen reader technology should be assessed independently. It appeared during the NoVA tests that different screen readers performed differently on real-world web pages for reasons that were not immediately apparent. We were also surprised that screen readers do not provide effective spell-checking tools.

The feasibility of developing a software checking tool which provides a map of the stages necessary for searching by a user with screen reader technology (i.e. examining *process* issues) should be investigated.

A short study is needed to determine the effects of screen magnification on common character sets and to develop suitable advice both for web designers and for users, taking into account existing "smoothing" technology.

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APPENDIX ONE: SHORT DESCRIPTION OF CODES

AA: 'Arrow Around'

AD: 'Arrow Down'

AU: 'Arrow Up'

BACK: 'BACK key'

CH: 'Control Home'

CI: 'Click In'

CO: 'Click On'

CU: 'Click Up (scroll bar)'

CD: 'Click Down (scroll bar)'

RO: 'Read Out'

LA: 'Look At page'

PD: 'Page Down key'

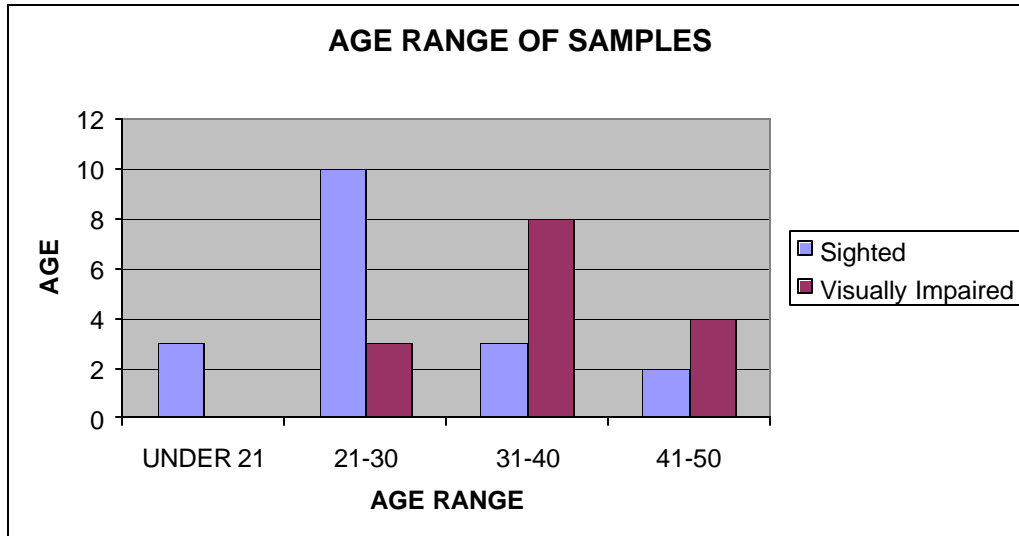PU: 'Page Up key'

TD: 'Tab Down page'
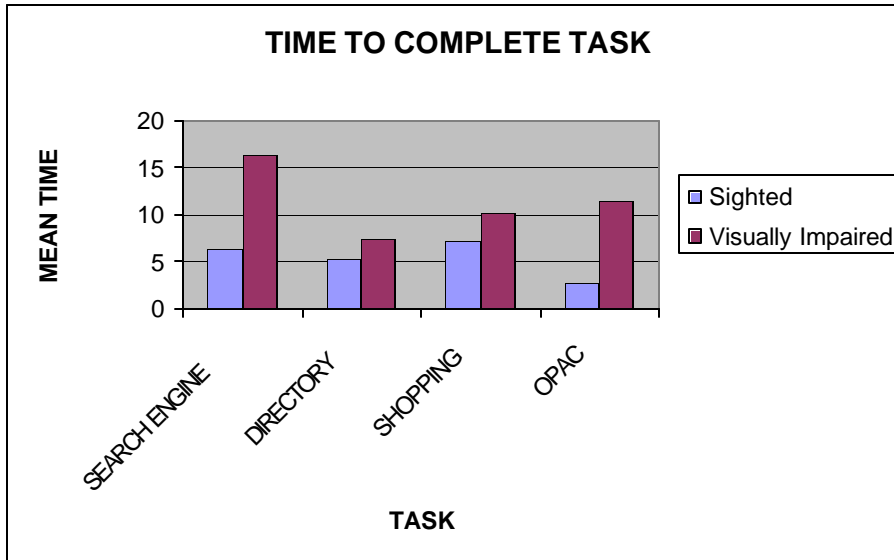
TI: 'Type In'

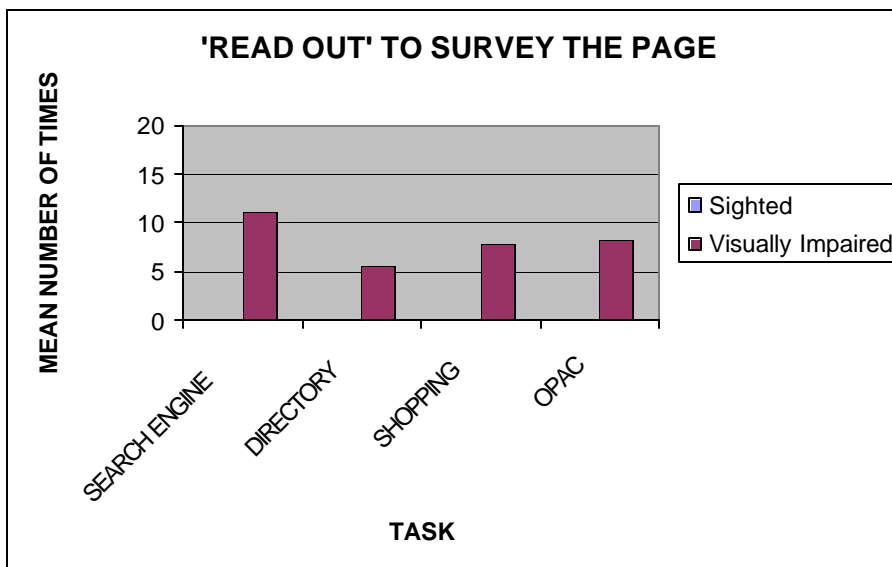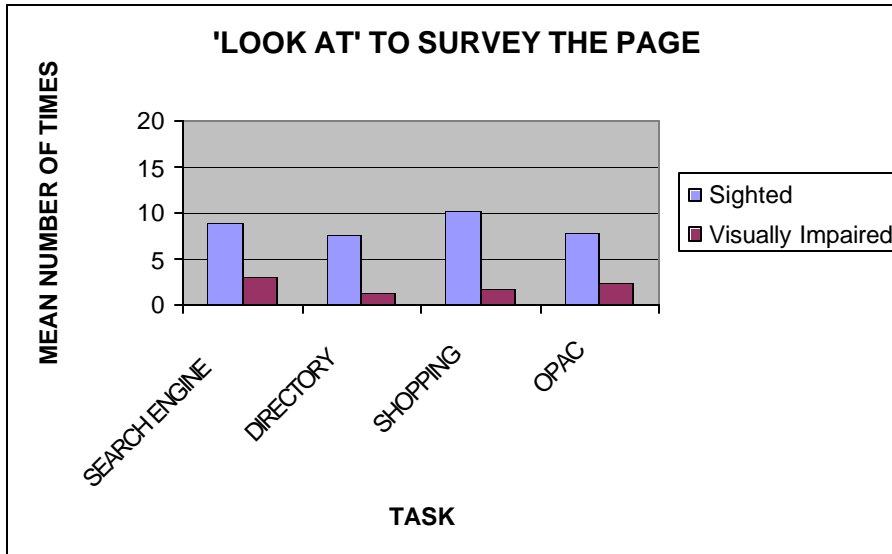TU: 'Tab Up page'
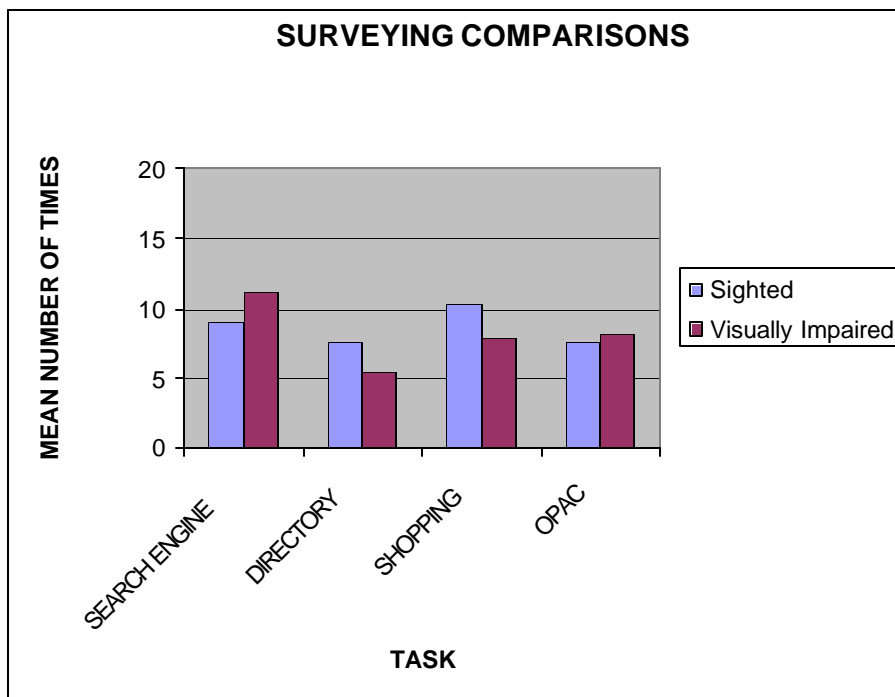
ZI: 'Zoom In'

ZO: 'Zoom Out'

APPENDIX TWO: AGE RANGE OF SAMPLES

AGE RANGE OF SAMPLES

APPENDIX THREE: MEAN TIME TAKEN TO COMPLETE TASKS

TIME TO COMPLETE TASK

APPENDIX FOUR: SURVEYING DURING A TASK

'LOOK AT' TO SURVEY THE PAGE

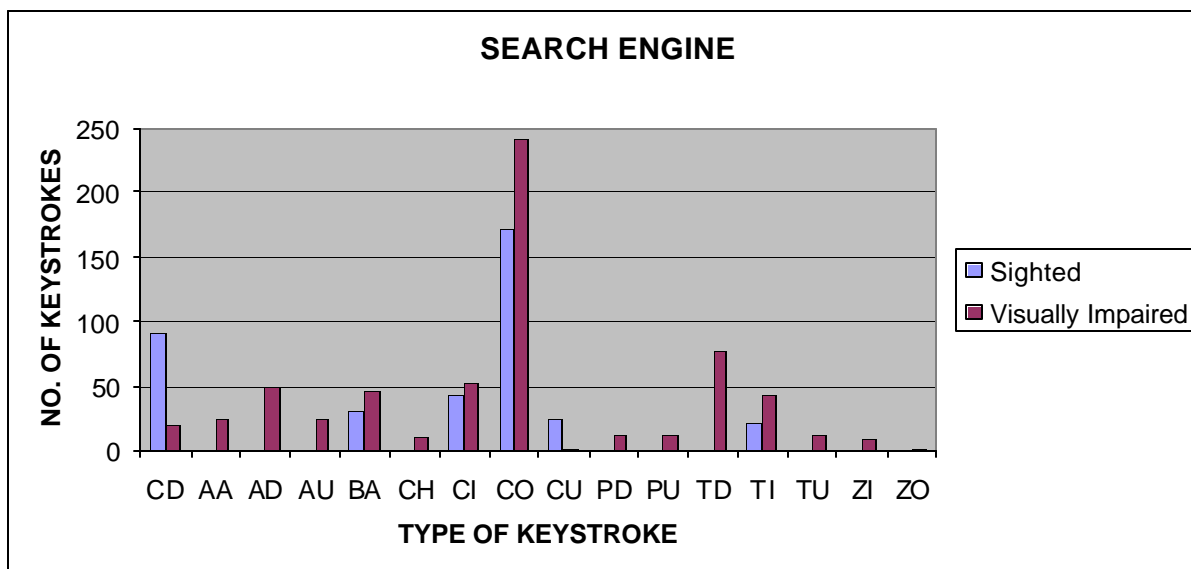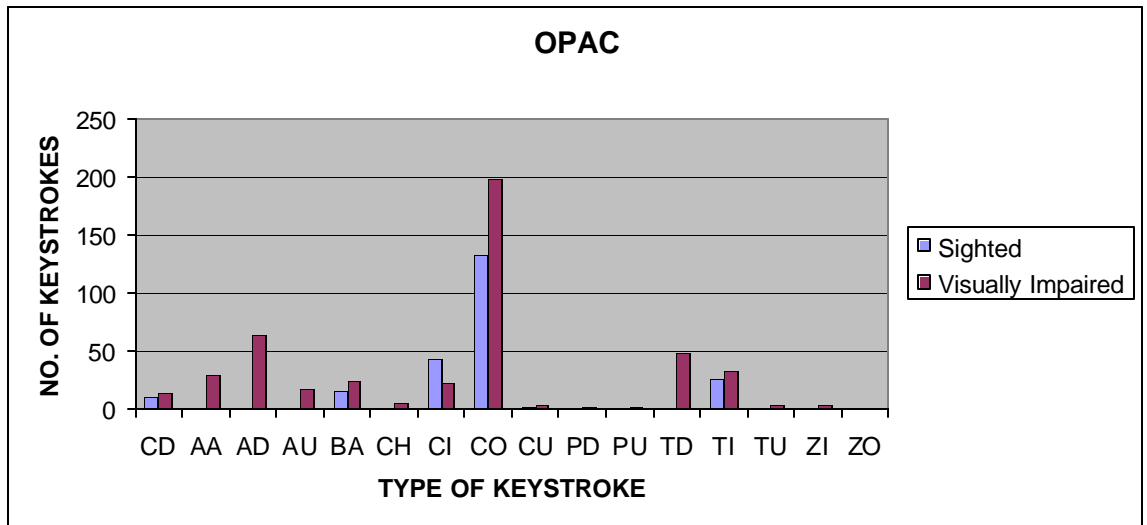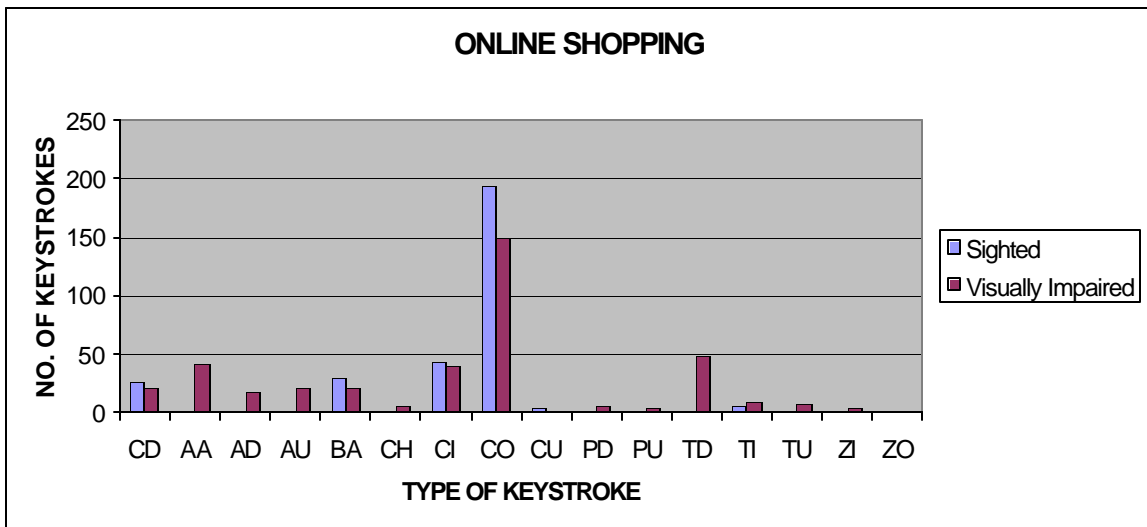'READ OUT' TO SURVEY THE PAGE

APPENDIX FIVE: COMPARISONS BETWEEN LOOK AT CODE (SIGHTED USERS) AND READ OUT CODE (VISUALLY IMPAIRED USERS).

SURVEYING COMPARISONS

APPENDIX SIX: KEYSTROKES PER TASK

SEARCH ENGINE

DIRECTORY

ONLINE SHOPPING

OPAC
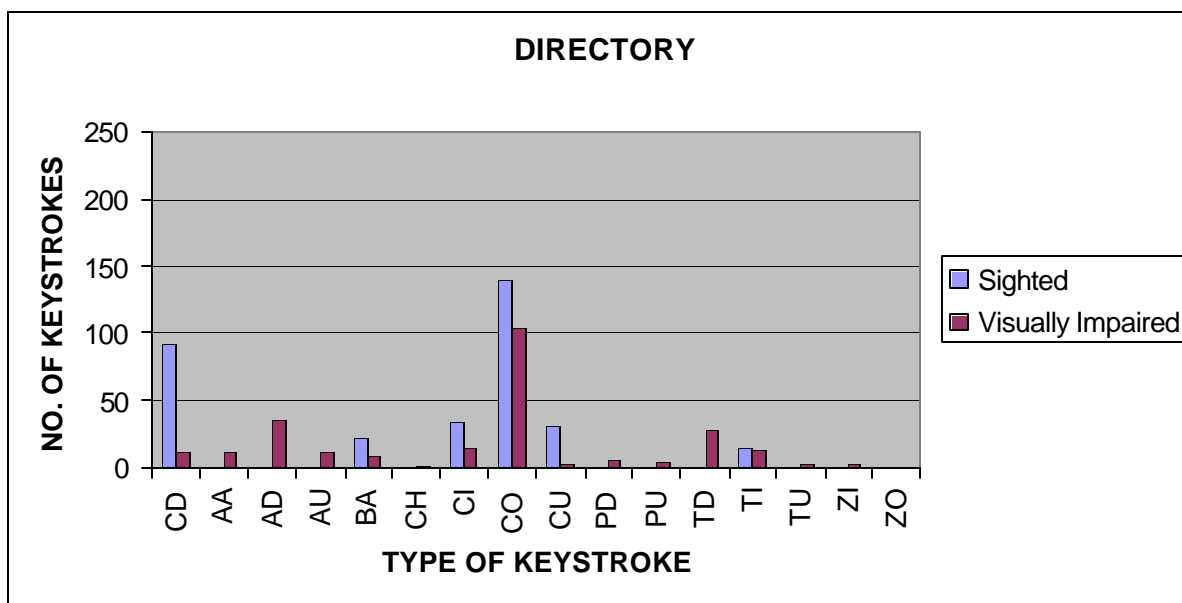
APPENDIX SEVEN: TOTAL STEPS TAKEN

TOTAL STEPS

Legend: ■ Sighted ■ Visually Impaired

Y-axis: STEPS (0, 100, 200, 300, 400, 500, 600, 700)

X-axis (TASK): SEARCH ENGINE, DIRECTORY, SHOPPING, OPAC
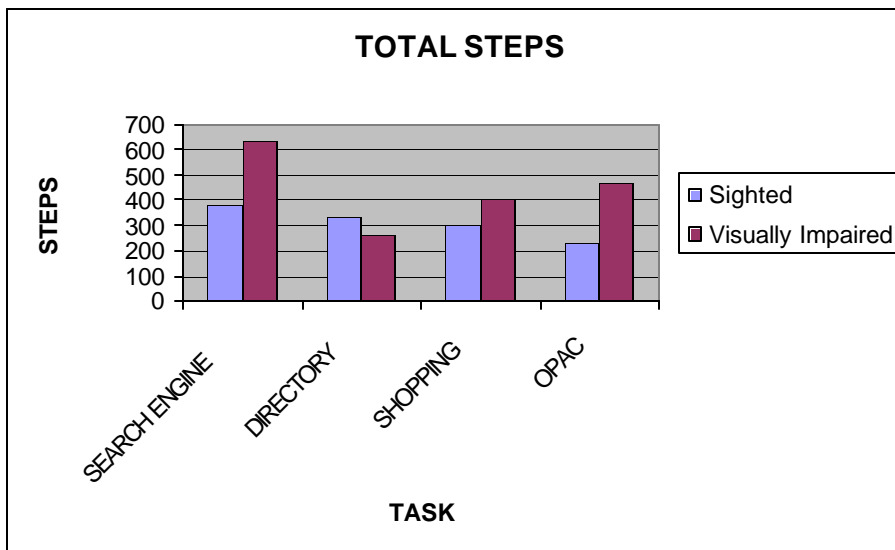
APPENDIX EIGHT: SERIAL AND PARALLEL STEPS

TOTAL PARALLEL STEPS

Chart showing STEPS (y-axis, 0–400) versus TASK (x-axis: SEARCH ENGINE, DIRECTORY, SHOPPING, OPAC) with two series: Sighted and Visually Impaired.

TOTAL SERIAL STEPS

Chart showing STEPS (y-axis, 0–400) versus TASK (x-axis: SEARCH ENGINE, DIRECTORY, SHOPPING, OPAC) with two series: Sighted and Visually Impaired.