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The effectiveness of the web accessibility audit as a motivational and educational tool in inclusive web design

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Thank you all.

Declaration by the Candidate

I declare that I am the author of this thesis; that, unless otherwise stated in the text, all references cited have been consulted by me; that, except for those parts of work which are declared in this thesis to be based upon joint research, the work which this thesis records is mine; and that it has not been previously presented or accepted for a higher degree.

David Sloan

April 2006

Declaration by the Supervisor

I declare that David Sloan has satisfied all the terms and conditions of the regulations made under Ordinances 12 and 39; and has completed the required 9 terms of research to qualify in submitting this thesis in application for the degree of Doctor of Philosophy.

Dr Peter Gregor

April 2006

Summary

The importance of Web sites that can be accessed and used regardless of an individual's disability is critical. One barrier to improved accessibility of Web sites relates to the gap between Web authors' technical knowledge of Web accessibility guidelines and a broader understanding of the challenges facing disabled people when interacting with Web sites.

This thesis describes the development and evaluation of a Web accessibility auditing methodology with the dual aims of accurately identifying accessibility barriers present in a Web site, and presenting the audit findings and recommended actions in a way that informs, educates and engenders an improved understanding of accessibility amongst the audience.

The methodology was piloted amongst a sample of Web sites, validated against other published accessibility evaluation methodologies, and adopted for subsequent audits carried out on a commercial basis. The impact on recipient organisations and individuals of a sample of 14 commercially commissioned audits was then evaluated. Audit recipients were surveyed, and each Web site audited evaluated to identify any changes to accessibility, and the presence of evidence of changes or improvements to accessibility strategy.

Strong indications were found that the audits had a positive impact both on individuals and on the commissioning organisations. The audits were identified as having a particularly positive educational and motivational impact on recipients who did not identify themselves as having expertise in Web accessibility. There was also evidence that the design approach promoted by the audits had been adopted and applied by some of the commissioning organisations.

The majority of respondents cited the recommendations for improvement as the most valuable feature of the audit. This illustrates a tension between the importance of presenting specific recommendations for actions and providing richer narrative accounts of evaluation stages to encourage a more holistic appreciation of accessibility.

The particular benefits of the study are found in the identification of evidence of impact of commercially-commissioned Web accessibility audits over a period of time to recipients of varying characteristics. A number of areas for further investigation have been identified, focusing on investigating the potential value of the accessibility audit in providing more ‘experiential’ evaluation stages.

Associated Publications

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Sloan D. (2006) Two cultures? The disconnect between the Web standards movement and research based Web design guidelines for older people. Gerontechnology Journal. Accepted for publication.

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1 Introduction

The importance of Web site accessibility for disabled people is widely accepted, given legal and moral obligations to avoid unjustified discrimination, allied to the financial and technical benefits that may accrue from inclusive Web design.

Many studies have been carried out of the accessibility of Web sites to disabled people, and these studies overwhelmingly show that levels of accessibility are disappointingly low, despite the increasing number and quality of tools and resources available to support accessible Web design. These studies have generally concentrated on the Web sites of large corporate and public organisations, whereby the sites under analysis are most likely to have been created by an in-house Web development team, or contracted to a professional Web design agency. In either case they are likely to be the result of a significant amount of investment by the organisation represented by the site. Thus, awareness of accessibility issues appears deficient even in what can be considered the professional Web design industry.

The impact of this issue is exacerbated when one considers the democratic nature of the Web. As a publishing medium, it enables anyone with the desire – or responsibility – to create and publish Web content to do so without the need to undergo formal training, reach a specific level of expertise or accreditation, or engage professionals to carry out the task on their behalf. The prevalence of Web site authoring software tools specifically designed to allow those without a detailed knowledge of Hypertext Markup Language (HTML) and other Web technologies to rapidly create and publish Web content further promotes the Web as an egalitarian publishing environment.

This means that many Web authors may be unaware of the need to consider accessibility in the creation of Web content, let alone know the specific techniques required to avoid introducing accessibility barriers. Others may assume that the use of a commercial authoring tool will output Web content without any flaws.

There are many sound initiatives to promote awareness of Web site accessibility, in particular to disseminate knowledge of accessible design techniques. Despite this, there remains a clear challenge in engaging and educating Web designers and content authors not only in adopting these techniques, but developing a wider awareness of the issues facing Web access to disabled people. This is illustrated by many designers who do invest time in improving awareness and knowledge in accessible design, but consider accessibility as a technical skill, at the expense of gaining a greater understanding of the challenges people with sensory, physical or cognitive impairments face when accessing and using the Web.

To support awareness-raising of Web accessibility, much attention has been paid to evaluation of existing Web sites for accessibility. Research has also taken place into devising and harmonising Web site assessment methodologies, and assessing these methodologies based on their accuracy in identifying true accessibility barriers.

Regarding Web site accessibility evaluation, far less effort has gone into the **delivery** and **format** of the message given by evaluators to those who receive the resulting report, and its **impact** on the recipients – in terms of motivation, education and understanding. Yet this is particularly significant, given on the one hand the lack of awareness or true understanding of the issues, and on the other hand possible hostility, inertia or indifference of potential recipients to the audit and its results, and thus the effect on the quality of accessibility improvements made to the site.

Therefore there is a pressing need to understand the impact of Web accessibility audits on the target audience. This thesis presents an exploration of the impact of Web accessibility audits on the recipient organisations and individual readers. The rest of this thesis is organised as follows.

Chapter 2 provides a background review of Web accessibility research, focusing on the challenges of raising awareness and encouraging a true understanding of accessible Web design beyond a basic technical knowledge of guidelines, and reviews how attempts have been made to encourage a more holistic approach to understanding of accessibility.

Chapter 3 sets out the aims of the research, identifying the specific research questions the research activities sought to answer.

Chapter 4 describes the development of the Web accessibility auditing methodology that is the focus of the research. It outlines the creation and evolution of the methodology, its key objectives, a description and justification of each audit stage, and a description of the presentation to the commissioning organisation of the audit findings and recommendations.

Chapter 5 discusses the validation of the audit methodology through a comparison with other accessibility evaluation methods and methodologies identified from a literature review.

Chapter 6 describes the evaluation of the audit impact on recipient individuals and organisations, including the sample of audits used in the evaluation, the methods used to survey audit recipients and independently assess impact. The results of the evaluation stage are presented in **Chapter 7**.

Finally, a discussion of the results, including implications on and directions for future research directions and a critique of the research, is presented in **Chapter 8**.

2 Background

2.1 The importance of Web accessibility

The World Wide Web Consortium (W3C) has long recognised the need to ensure that the Web evolves as an information and communication space that can be accessed by anyone, regardless of disability. This was recognised by the formation by the W3C of the Web Accessibility Initiative (WAI) in 1997 to oversee education and awareness-raising of accessibility as an issue, and also to ensure that accessibility has been considered in the development of Web technology standards and tools.

The WAI resource *Developing a Web Accessibility Business Case for Your Organisation*, (W3C 2005a) summarises four key arguments for developing optimally accessible Web sites:

- **Social factors:** given that Web accessibility, if fully achieved, allows disabled people to experience the full potential of the Web, it can significantly help to reduce levels of social exclusion amongst disabled people by narrowing the "digital divide" (Waddell 1999; Shneiderman 2000). A commitment to Web accessibility is thus a demonstration of an organisation's social responsibility.
- **Technical factors:** accessible design techniques can lead to more efficient presentation of online information, while making sites easier to use, and with a resultant decrease in server load. Accessible design also encourages adoption of design techniques, standards and technologies that promote interoperability across diverse browsing environments, from older and limited functionality browsers to emerging browsing platforms.

- **Financial factors:** while implementing accessibility can incur initial costs, it is likely to have a positive long-term cost-benefit on an organisation. In particular, accessible design makes a Web site available to a wider audience, and hence potential increase in market share; while the technical changes made can lead to reduction in maintenance and development costs.

- **Legal and policy factors:** many countries around the world have introduced legislation aimed at protecting the rights of disabled people, legislation that either directly or indirectly places a responsibility on organisations with Web sites to take steps to ensure that disabled people can access and use the Web site for its intended purpose. In the UK, the legislation in question is the Disability Discrimination Act (DDA 1995) (Sloan M. 2001). Recognising this responsibility, increasingly specific sectors – for example local and national government - and individual organisations are introducing policy requiring a minimum level of accessibility to be achieved by Web sites.

As alluded to in the technical and financial factors noted above, Web accessibility is not limited to supporting people who may fall within a conventional notion of "disability". In addition to barriers encountered as a result of a person's sensory, cognitive and/or physical impairments, accessibility barriers may be encountered by people who are effectively disabled by the environment in which they are using the Web site. Newell and Cairns (1993) drew a comparison between the similar design attributes of a system that can be accessed and used by an "extra-ordinary" (i.e. disabled) user in "ordinary" environments (the user's home or work, for example) and a system usable by an "ordinary" user (i.e. with no significant impairments) in an "extra-ordinary" environment. Vanderheiden (2000) further noted that:

> "for every type of disability there are situational constraints which would provide the same requirements (in system design)".

Situational constraints may be introduced by the physical environment - for example excessive noise reducing hearing ability; impact of the physical environment on the user - for example extreme cold requiring gloves to be worn, thus reducing manual dexterity; or technology available - for example a hand held device with small, monochrome display effectively introducing significant visual impairment. The implication follows that if Web resources can be made accessible to disabled people, they will also be accessible to those browsing in non-standard conditions, or using a device with limited capabilities.

2.2 Accessibility problems outlined

Barriers to access and use of Web content may be experienced by Web users with:

- sensory impairments, primarily visual, ranging from no functional vision to reduced visual acuity or colour perception, or hearing;
- physical impairments, primarily ranging from reduced manual dexterity to loss of the use of the hands;
- cognitive impairments, including reduced short term memory, reduced reading skills, specific learning difficulties such as dyslexia, and severe learning disabilities.

In most cases, an individual's impairments will have been acquired over time, rather than present at birth; an individual will experience a combination of relatively minor impairments, rather than a single, but severe impairment; and impairments will tend to fluctuate in severity, although with a gradual decline over time (Gregor *et al.* 2002, 2005; Carey 2005). This phenomenon, and the resulting difficulty in

classifying disabled people into discrete groups has been termed ‘dynamic diversity’ (Gregor *et al.* 2002).

Access barriers may occur when the design and functionality of Web content does not accommodate these impairments, for example by:

- providing information in a way that requires a specific sensory capability to access that information;
- failing to allow interaction via a range of input devices;
- failing to allow customisation of display or behaviour;
- failing to support efficient navigation and cognitive processing of information presented.

Appendix 1 provides an overview of accessibility barriers that may be encountered by disabled Web users.

2.3 Research and development in Web accessibility

As awareness of the importance of Web accessibility continues to grow, there has been development in technologies both allowing disabled people increased ability to access and browse Web content, and in supporting Web authors in creating optimally accessible content. Research to date has largely concentrated on two key areas:

- **Supporting disabled Web users:** through the development of solutions that ameliorate or remove the adverse impact of a particular disability on the ability to access and use Web sites. These include *access solutions*, allowing individuals to make adjustments at the operating system or application level to behaviour or display characteristics, and *assistive technologies* – additional hardware and software that in combination with standard browsing

technology can improve accessibility. Other solutions have concentrated on the transformation of existing Web content in order to improve its accessibility for specific groups.

- **Supporting Web developers and content authors:** through the development and publication of design guidelines and best practice in accessible Web design, and other supporting literature. This has been matched by activity in developing software tools to support accessible design, from authoring tools to accessibility checking tools to simulations of specific impairments.

A more detailed review of research in these areas is provided in **Appendix 2**.

2.4 Promoting accessible Web design

There has been significant research activity into the development of tools and techniques available to support Web developers in creating optimally accessible Web content. However, there are more fundamental challenges, firstly in persuading organisations and individuals of the benefits outlined in **Section 2.1** of accessible Web design, and secondly in education of accessible Web design techniques. It is argued that the latter requires not just promotion of guidelines and best practice, but also an exposure to the way in which disabled people access and use the Web.

2.4.1 Improving attitudes to accessibility

Despite the increase in prominence of Web accessibility as a serious issue to be addressed, and the resulting increase in levels of discussion and activity (e.g. Seale 2004), studies of Web site accessibility indicate that levels of Web site accessibility continue to be disappointing (see **Section 5.2** for discussion of some recent studies). Furthermore, a number of surveys of Web site developers indicate that there is still a

widespread lack of awareness of Web site accessibility issues amongst those responsible for providing Web content, in terms of benefits and obligations, and in knowledge of how to effectively implement accessible design techniques.

2.4.1.1 Industry attitudes

Lazar *et al.* (2004) surveyed 175 Webmasters on attitudes, perceptions and activities relating to Web accessibility. While many of the survey questions concentrated on accessibility to people with visual impairments, the responses indicated that awareness and experience of Web accessibility was lower than hoped for; furthermore attitudes towards accessibility were not always positive. For example Lazar *et al.* found that 36% of respondents (63) were not aware of the World Wide Web Consortium (W3C) Web Content Accessibility Guidelines (WCAG), while 41% (72) indicated their organisation did not have firm plans for improving accessibility. Survey results also indicated perceptions that accessibility was difficult to achieve while preserving graphical design objectives; it was too expensive; it was difficult to convince clients or senior management of the importance of accessibility; and that legislation would ultimately be the single persuading factor in considering accessibility.

In a survey of 453 organisations found to have Web sites with accessibility problems (Milliman 2002), 42% (191) reported that the main reason for the low level of accessibility of their site was that disabled people were not part of the site's target audience; while 25% (115) cited a lack of necessary skills or awareness of either accessible design guidelines or techniques. Respondents also revealed that the most compelling incentive for them to improve their site's accessibility was demonstrable evidence that the improvements would lead to increased traffic (247 respondents - 59%) (Milliman 2002).

In investigating attitudes to accessibility, Knight (2003) found a significant proportion of developers who thought that there was a conflict between accessibility for disabled people and usability for others – a potential barrier to effective implementation of accessibility features.

The issue of education and awareness was also emphasised in an investigation by the UK's Disability Rights Commission (DRC), which not only evaluated Web sites for accessibility, but also interviewed Web site developers and commissioners about attitudes towards accessibility (DRC 2004). The research found that of small businesses (less than 250 employees), 71% did not take accessibility into account when developing a Web site, and 31% appeared not to be aware of accessibility as an issue (DRC 2004, p36). Amongst Web site commissioners who were interviewed as part of the study, over two-thirds of large (over 250 employees) companies had taken accessibility into account during Web design, but this was not reflected in the quality of accessibility of the sites evaluated:

> "if 68% of Web site commissioners from large organisations do indeed take accessibility into account, their concern to meet the needs of disabled people is, sadly, not being turned into good enough practice on the ground." (DRC 2004, p37)

More generally, amongst those who might be assumed to be enthusiastic advocates and practitioners of user-centred design, of which accessibility should be an important aspect, studies have indicated that best practice is not always followed. Gould and Lewis (1985) identified a lower than expected uptake of user-centred design principles amongst system designers, while a more recent survey suggested that user-centred design methods are not always used even by individuals with a strong interest or involvement in user-centred design (Vredenburg *et al.*, 2002).

The specific tension that accessibility can engender amongst design professionals may also lead to a variety of adverse reactions that demonstrate the difficulty in promoting accessibility. This was illustrated in a recent project, in which the present author was involved, to create a Web resource focused on techniques for developing accessible educational multimedia. During the requirements gathering stage of the project, it became apparent that the subject of accessibility was a highly emotive one amongst media producers, some of many years' experience. Reactions related to the significant impact accessibility might have on their working practices, and in some cases there was the perception that, in coming under an 'accessibility microscope', the quality, legality and ethical value of their work was in question (Sloan *et al.* 2006a).

2.4.1.2 Barriers to uptake

Industry attitudes towards accessibility and action in relation to improving accessibility have been shown to be disappointing. This indicates the presence of a number of barriers to uptake of accessible Web design.

The challenges in successfully advocating accessible Web design reflect the wider challenge facing the movement promoting what is variously known as Universal Design, Design for All or Inclusive Design of consumer products, including communication and information technology (Keates and Clarkson 2004). Projects in North America and Europe have sought to promote uptake by industry of inclusive design through exploring attitudes towards inclusive design and identifying key motivators and barriers to uptake (Vanderheiden and Tobias 2000; Keates and Clarkson 2004).

A key identified obstacle to uptake of inclusive design has been a common perception by industry that it is difficult and expensive. This is illustrated by

indications that inclusive design would be adopted by some organisations only if it was "easy", or if it could be achieved through external consultants, and did not add to production costs or extend production time (Keates *et al.* 2000; Vanderheiden and Tobias 2000). Velasco and Verelst (1999) put this another way:

> "The concept Design for All is misleading…it gives to the designers the idea of a highly sophisticated and not cost-effective design process by which their products will reach a wider hypothetical market (the strength of which) has not been shown to them."

Keates *et al.* (2000) also identified an issue relating to stereotyping of inclusive design as "designing for the institutionalised" - products that would look obviously as if they had been designed for a small minority, and thus repellent to the rest of the market. In the Web design field, this has been mirrored in widely quoted perceptions that accessible Web sites must by their nature compromise on aesthetic appeal, and are therefore at odds with the goals of many designers (Zeldman 2003; Petrie *et al.* 2004; Dodd 2005)

The economic business case for accessible design, in the form of potential increase in custom/sales, may also be presented from a legal perspective, in the form of increased likelihood of avoiding financial or social penalties resulting from unlawful practice. Thus there is an important difference between accessibility related legislation that requires industry to act over accessibility or face legal action - 'push' legislation - and legislation that is not a universal demand for accessibility but rather influences market trends by mandating the *purchasing* of accessible products - 'pull' legislation (Vanderheiden and Tobias 2000; Keates and Clarkson 2004).

As an example, the legislation of Section 508 of the Rehabilitation Act requires US federal agencies to procure and provide accessible technology, but does not require

industry to produce it. Those organisations that do, of course, will stand to gain from access to the significant market of US federal agencies (Vanderheiden and Tobias 2000; Keates and Clarkson 2004); those that do not are not in breach of the law, but deny themselves access to a potentially lucrative market. In contrast, there is particular opposition to 'push' legislation if it is seen by industry as restricting freedom in product design by specifying features that must be included or avoided; this opposition extends to some advocates of inclusive design who feel that legislation may encourage organisations to design to a 'legal minimum' rather than pursue true accessibility (Vanderheiden and Tobias 2000).

In considering a lack of success in convincing clients of a Web design agency of the benefits of accessibility, Heilmann (2005) identified the lack of case law in many countries as a barrier to wider uptake of accessible design. He argued that in countries like the UK, where no case law exists at the time of writing, and where the relevant legislation (the DDA) gives no specific technical guidance as to a minimum level of accessibility, it may be difficult to persuade some organisations that Web accessibility is necessary. The significance of this was emphasised by independent surveys of Web designers by Lazar *et al.* (2004) and Milliman (2002), both of which indicated that a clear legal mandate to provide accessible Web sites may be the only factor in influencing some developers in adopting accessible design techniques.

In considering the impact of legislation, it is important to note that in many countries, disabled people are not specifically protected against discrimination by law, and therefore there is no legal mandate for developers in such countries to consider accessibility. Where legislation does exist, the penalties for non-conformance may be unclear, and may depend on the nature of a specific case. This may again make it

difficult to make a case for accessibility, especially if non-compliance seems worth the apparent risk (Gregor *et al.* 2005).

Lack of organisational support has also been cited as a reason for lower-than-expected levels of support for accessibility. In terms of evaluation personnel, the W3C has recommended that a multi-skilled team, rather than an individual, should carry out a Web accessibility review (W3C 2005d). In addition to Web accessibility principles and guidelines, recommended expertise includes knowledge of general Web design techniques, Web technologies and assistive technologies – and should ideally include people with a range of disabilities. With these demands, an accessibility evaluation as recommended by the W3C may demand significant resources, in terms of personnel, time, and financial investment, which may make comprehensive evaluation of every page impractical for large Web sites (King *et al.* 2005).

An effective strategy for ensuring a long term commitment to Web accessibility requires regular and co-ordinated involvement from senior management, sales and marketing, legal affairs, IT provision and disability groups as being necessary, led by an "accessibility champion" (Urban, in Thatcher *et al.* 2002, pp283-303). WebAIM (2003) defined essential elements of an organisational accessibility strategy as including a definition of who is responsible for creating accessible content; training and support frameworks; a definition of 'accessible', and how, when, and by whom that condition may be assessed; a timescale for meeting minimum standards verification programmes, and consequences for failing to meet the defined level of accessibility within the defined time.

Evidence indicates that such strategies are, however, uncommon. The survey by Lazar *et al.* (2004) indicated that a need for additional organisational support,

particularly amongst senior management, was an essential requirement for many Webmasters in implementing accessibility, while Knight (2003) and Alexander (2005) reported resourcing issues and lack of upper management support as being barriers to implementing accessibility.

In proposing the concept of 'user-sensitive inclusive design', Newell and Gregor (2000) acknowledged the limitations of trying to pursue and promote a design methodology that appears to promise 'universal design' but requires significant involvement of an extremely wide range of users. Instead they promote a more pragmatic approach whereby a fundamental aspect is to consider the needs of people with 'extreme' needs, and the implications of meeting these needs on other members of the target audience.

Even with what may seem compelling arguments for accessibility, the challenges of 'selling' accessibility to some may be insurmountable – particularly in trying to persuade organisations to invest in retrofitting of legacy Web content. In such cases, research focus may be best concentrated on developing better tools to enable users to improve accessibility of existing resources (Hanson and Richards 2004).

2.4.2 Developing and promoting an understanding of Web accessibility

Related to, but separate from, advocacy of accessibility is the issue of education – once the importance of accessibility has been 'sold' to a Web author, how do they acquire the necessary skills to implement a truly accessible design? Training is necessary to raise awareness of the issues and develop knowledge of how to avoid introducing accessibility barriers, but it can take some time for designers to develop the necessary skills in accessibility (Regan 2004). Further, it has been demonstrated (for example Thatcher 2003, Newell *et al.* 2006a) that while some developers can be

convinced of the importance of accessibility to the point that they are familiar with accessibility guidelines, they may fail to successfully interpret and implement accessibility guidelines in their work without a broader understanding of the issues. The result is that significant barriers for disabled people may remain.

2.4.2.1 Limitations of a technical approach to accessibility

It is widely acknowledged that the development and promotion of guidelines for Web accessibility has been fundamental to the increase in prominence of Web accessibility (Thatcher *et al.* 2002, Kelly *et al.* 2005; Sloan *et al.* 2006b). Guidelines can be particularly effective as a basis for automated assessment of those accessibility barriers that do not require human inspection – those that Thatcher refers to as 'algorithmic' rather than judgemental (Thatcher *et al.* 2002, p165).

A guidelines-based approach to accessible interface design in general and Web accessibility in particular has, however, been criticised for having significant shortcomings (e.g. Winberg 1999; Akoumianakis and Stephanidis 2003; Hudson 2004; Milne *et al.* 2005; Nielsen 2005). A key issue is that such an approach may encourage designers to assume accessibility is a technical attribute of a system that can be addressed in isolation, distinct from contextual features such as purpose or target audience.

The presence of Web accessibility guidelines, in particular the Web Content Accessibility Guidelines (WCAG) produced by the W3C (W3C 1999), may lead to their perception as a set of instructions which, if followed, will result in universal accessibility in its truest sense – for all potential users. This then implies a binary state of either 'WCAG-conformant and accessible to *all* disabled people' or 'not WCAG- conformant and therefore accessible to *no* disabled people'. One unfortunate effect of this perception, particularly if guideline conformance is seen as - or

becomes in reality - a legal requirement, is the withdrawal of potentially valuable Web resources that particularly enhance accessibility for some groups of disabled people but not others - resources rejected as not being 'fully' or 'universally' accessible (Kelly *et al.* 2005; Sloan *et al.* 2006b).

Another failing of a guideline-based approach is that it tends not to encourage the consideration of the context in which a system such as a Web interface will be operated, identified as a critical aspect of effective design (Beyer and Holzblatt 1998). Aspects such as target audience characteristics, context of use and available browsing technology may all influence the effective application of accessible design techniques (Akoumianakis and Stephanidis 2003; Kelly *et al.* 2005; Sloan *et al.* 2006b), and appropriate judgment of the existence and severity of a *judgemental* accessibility barrier (Thatcher *et al.* 2002, p165).

As an illustration, the W3C Web Accessibility Initiative (WAI)'s tripartite approach to accessibility may inadvertently be responsible for exacerbating this issue (Kelly *et al.* 2005; Sloan *et al.* 2006b). The W3C WAI approach is founded on a need to ensure that: i) Web content, ii) browsing technology and iii) Web content authoring tools each conform with relevant accessibility guidelines (Chisholm and Henry 2005). Thus, WCAG-conformant Web content may not reach optimal accessibility unless users access the content using browsers that also comply with W3C accessibility guidelines in order to ensure accessibility – and at the time of writing there is no compelling evidence to indicate that any such browser exists.

The aim of the WAI model is commendable, in that it places responsibility on manufacturers of browsing technologies to ensure these technologies support the rendering of accessible Web content by conforming to relevant accessibility guidelines (Chisholm and Henry 2005; see also **Appendix 2**). This is, however, also

the limitation of this model in terms of its use in practice - it relies on *end-user uptake* of conformant browsing technology, something that is beyond the control of Web site designers. For disabled people who do not use such technology, some accessibility features may be of little benefit, as most potential beneficiaries will not be using browsing technology that can take advantage of them (Kelly *et al.* 2005; Sloan *et al.* 2006b).

Given the role in the WAI model of conformant browsing technologies, it is unsurprising that there has been criticism of the limitations in the capabilities of widely-used browsing and assistive technology in taking advantage of the features offered by Web sites designed with accessibility in mind (Meyer 2005; Clark 2005b). Further, there is evidence of a perception amongst some advocates of a general lack of proactivity amongst disabled people in acquiring and using the most appropriate access technology (Meyer 2005; Clark 2005a). This perception may trickle down to less capable Web site developers, with a resultant failure to understand more fully the need to apply accessibility guidelines in the context of the site in question.

Previous studies have indicated that many disabled people are unaware of the most appropriate access technology for their specific needs (DRC 2004; Microsoft 2004). Czaja (1997) notes that while there is little evidence to indicate that older people are by nature averse to using technology, they may have greater difficulty acquiring and retaining technical skills – which may impact on their ability to apply appropriate accessibility solutions. There is certainly a pressing need for user education in the uptake of appropriate browsing and access technologies, and initiatives by organisations such as the UK-based charity AbilityNet[1] are addressing the issue of

[1] AbilityNet: http://www.abilitynet.org.uk

awareness by assessing disabled people for the most appropriate access technology solution that would support them in their use of a computer. However, given that most impairments affecting an individual's ability to access and use a Web site are acquired and are dynamically changing in their impact (Gregor *et al.* 2002), it is likely that many people will encounter accessibility problems having hitherto been unaware that they have become "disabled" in a Web context, and therefore in need of accessibility support. This makes it highly unlikely that they will independently and immediately identify the most appropriate access solution for their needs.

In addition to the shortcomings of the WAI model of accessibility, there have also been criticisms of the nature and content of the WCAG themselves, despite the guidelines' status as a *de facto* standard for Web accessibility. This has resulted in challenges for Web developers trying to interpret the guidelines, exacerbated for people without a significant level of technical knowledge (Colwell and Petrie 1999, Donnelly and Magennis 2002; Clark 2003a, Kelly *et al.* 2005; Sloan *et al.* 2006b). While the W3C has taken steps to address some of the limitations identified above in the development of version 2.0 of the WCAG, there have been concerns that development of version 2.0 of the WCAG may preserve many of these problems (e.g. Clark 2003b). Additionally, even with improved guidelines, their misuse by other policymakers in adopting WCAG conformance as part of standards or legislation may continue to see guideline conformance as the only indication of legislative compliance (Kelly *et al.* 2005; Sloan *et al.* 2006b).

The limitations of relying on guideline conformance to measure Web accessibility was illustrated by the findings of the DRC Formal Investigation (DRC 2004), where the researchers found Web sites that rated highly on user performance and acceptance measures, yet which did not conform to some high-priority WCAG

checkpoints (Petrie *et al.* 2004). Conversely, there is evidence that accessibility guidelines can be applied literally without consideration of the impact of the solution on usability for disabled people (for example Thatcher 2003). An investigation of museum Web sites in the UK showed that some Web sites analysed to have a high level of conformance to WCAG were also found to be "unusable by disabled people" (Petrie *et al.* 2005).

Despite this, some Web developers appear to place greater emphasis on guideline adherence as a measure of accessibility than evidence that a site can be successfully used for the intended purpose by disabled users. This was illustrated by some reaction to the DRC investigation findings - reaction that criticised the promotion of sites as 'accessible' when they did not conform with some core WCAG checkpoints (for example WebCredible 2004).

2.4.2.2 Usability for disabled people

The technical knowledge and skills in accessible Web design of many accessibility advocates and design experts is clear, as demonstrated by the activities of the Web Standards Movement (see **Appendix 2**). However, it has been shown that this may be accompanied by a relatively narrow awareness of the issues, marked by expressions of frustration that the technical aspect of accessible design may not be effective on its own to ensure equitable access for disabled people.

From a Web content authoring perspective, this may manifest itself in a number of tangible ways. For example, a lack of understanding of how people using screen reading technology receive page content may lead to an inappropriate provision of text alternatives for images, guided by an assumption that all images must be given a detailed description, but severely reducing usability for screen reader users. This is powerfully illustrated by the example described by Thatcher (2003). Others may

attempt to provide seemingly beneficial solutions for accessibility, such as extensive provision of keyboard shortcuts through HTML “access keys”, without taking into account the potential adverse impact these can have on the ability to operate an assistive technology or browser (Foliot 2005).

This reliance on guidelines for accessibility is, it is argued, a symptom of attempts to distinguish between accessibility and usability for disabled people, particularly where the former may be seen as a legal obligation and the latter as a separate matter for the developers to address as they see fit. There is evidence to indicate a positive correlation between levels of Web site accessibility and levels of usability (Sullivan and Matson 2000). However, the relationship between accessibility and usability in general has been a source of significant debate (Alexander 2004a), and ultimately for some commentators is of limited worth:

> “…it is rarely useful to differentiate between accessibility and usability…the distinction between accessibility and usability is especially hard to define when considering cognitive and language abilities.” (Lawton Henry, in Thatcher *et al.* 2002)

> “What we have learned…is that the key issue for those experiencing problems with digital information systems is the unified concept of task completion whose use of time and success rate can be measured, as opposed to much more abstract measurements of accessibility and usability. Only those who seek grants to split hairs will quarrel with the fundamental premise that what matters is the system's fitness for purpose which allows, for example, box offices to issue tickets, shops to sell goods and information systems to inform.” (Carey 2005)

Yet, because of the presence of legislation introducing responsibilities for ensuring that organisers do not unjustifiably discriminate against disabled people, it is easy for developers to conclude that 'accessibility' exists as a legal minimum in terms of technical status, while usability is a characteristic that will play a factor in the relative commercial success of one system or service over another. Thus, accessibility may be seen as a highly objective technical condition - divorced from the degree to which a disabled person can successfully use, in comparison to someone without a disability, a Web site for its intended purpose.

Nielsen (2005) describes this assumption as an "accessibility fallacy":

> "…the assumption that accessibility exists in a vacuum and can be scored without considering users and their tasks. Yes, there are technical criteria for supposedly making a website accessible. But even if you meet every high-priority checkpoint, users with disabilities might still be completely incapable of using your site." (Nielsen 2005)

From a legal perspective, the text of the UK's Disability Discrimination Act (DDA 1995) defines examples of unjustified discrimination as including (in § 19 (3)) (emphasis added):

> "(b) access to **and use of** means of communication;
>
> (c) access to **and use of** information services;"

This text indicates that, in the UK, an ability to use a service is also a legal requirement, and effectively validates Nielsen's assertion of an "accessibility fallacy".

From a user perspective, there are also indications that 'accessibility' is an artificial construct. Research by Microsoft into usage of access technology found evidence

that people with specific impairments who used accessibility options and assistive technologies often did not consider that they used these technologies because of their impairment (Microsoft 2004). Instead, these people considered that they used access solutions to make their computer easier to use:

> "From trackballs to screen magnifiers, participants frequently reported that these products make computers "easier to use", "more comfortable" and "more convenient". (Microsoft 2004)

This strongly suggests that access technologies may in fact perceived by users as **usability** features, rather than accessibility features (Gregor *et al.* 2005).

So, acknowledging that there are limitations in a model that distinguishes between accessibility and usability, some researchers have explored methodologies for assessing usability for specific disability groups, rather than "accessibility" *per se*. Leporini and Paternò (2002; 2004) and Fukuda *et al.* (2005) have proposed criteria for assessing the usability of Web sites for screen reader users; while Di Blas *et al.* (2004) identified limitations in current accessibility guidelines and argue that a linguistic approach to Web accessibility for blind people is necessary - one where interaction between a human and a Web site can be interpreted in terms of a dialogue.

This work is important in that it considers the context surrounding disabled users' interaction with Web sites, including individual differences in capabilities, knowledge and available technology. This pragmatic approach is reflected in the nature of research-based Web design guidelines for specific groups such as those developed by Coyne and Nielsen (2001, 2002), Theofanos and Redish (2003) and Morrell *et al.* (2004), which frequently are more prescriptive than WCAG in terms of page design, visual appearance and behaviour (see **Appendix 2** for more details).

This leads in places to contradictions with the platform- and individual access needs-independent design approach promoted through the WCAG.

It is therefore unfortunate that as yet, the prominence and influence of work such as this remains relatively low amongst the Web design industry, as found in a survey by the present author (Sloan 2006). This suggests an apparent tension between a philosophy that promotes "accessibility-conformant" design that relies on the use of "accessibility-conformant" browsing technology, and a more pragmatic approach to accessible design that takes into account limitations in current browsing technology, and knowledge and attitudes of disabled people when accessing and using Web content (Sloan 2006).

2.4.2.3 Encouraging a true understanding of accessibility - the "Eureka moment"

There is a significant risk that technically-capable developers may neglect the more 'human' aspect of accessibility, underpinned by a knowledge of how people with varying disabilities access and use Web sites. The outcome will be more frequent occurrences of "accessible but unusable" Web sites such as that described by Thatcher (2003), and a failure to use technology in an imaginative and creative way to enhance accessibility of information, services and experiences (Slatin 2002, Regan 2004).

At the same time, for someone who publishes Web content but is significantly less motivated to develop skills in Web design, accessibility may be treated as something that should be taken care of by an automated tool, and therefore something that is irrelevant to their work. Also, for those involved in defining standards, policy and legislation to be adhered to by others when developing Web sites in terms of accessibility, there is a danger that if this definition over-relies on conformance with

technical guidelines, increasingly inappropriate solutions may be developed (Kelly *et al.* 2005; Sloan *et al.* 2006b).

For all these groups, there is a need to engender an improved consciousness and understanding of the challenges facing disabled Web users, in order that accessible design techniques can be applied appropriately. One challenge is to convey to Web designers and authors the current problems of the W3C WAI model outlined in **Section 2.4.2.1**, and the limitations of relying on the uptake by the target audience of standards-conformant browsing and access technology.

Various approaches have been taken to encourage Web developers and authors to develop a more thorough understanding of accessibility and the issues facing disabled and older Web users. For example, Velasco and Verelst (1999) describe how the accessibility knowledge of Web developers was enhanced by introducing them to various assistive technologies, and encouraging the designers to access their own Web sites using these tools. In a separate initiative, the concept of the Accessibility Internet Rally (AIR) was developed in Austin, Texas, whereby accessibility awareness raising amongst Web developers is stimulated through a single-day competition that partners developers with non profit organisations and disabled people to create accessible Web sites. The AIR concept has successfully been rolled out to other parts of the US (Slatin and Rush 2002).

In proposing the concept of 'universal access assessment workshops', Akoumianakis and Stephanidis (2003) describe how face-to-face discussions between developers, usability experts, project managers and disabled end-users can stimulate the effective adaptation and application of inclusive design principles to a particular design project, taking into account contextual issues such as target audience and access environment.

In educational institutions, novel approaches to the teaching of accessibility as part of ICT and Web design courses have also been taken. Harrison (2005) describes how students on a Web page design course were exposed to the issues surrounding accessibility by asking them to use assistive technology to complete simple browsing tasks, before introducing them to key accessible design strategies and requiring them to create an accessible Web site. Slatin (2002) recommends class exercises that encourage Web design students to imagine accessibility, by spending time browsing through simulated restricted browsing situations such as mouse-free and graphics-free. Building on the AIR concept described above, a Web design course taught by Lazar (2003) involved the partnering of Web design students with local non-profit organisations; each student group was required to produce an accessibility report of the partner organisation's Web site, and encouraged to maintain an interest and involvement in the development of the site in light of the report.

The present author and colleagues have been involved in the teaching of accessibility considerations within various undergraduate computer science courses at the University of Dundee (Gibson *et al*. 2003; Sloan and Gibson 2003). Here, teaching of inclusive design principles is supplemented by involving students in ongoing research projects within the Division of Applied Computing relating to developing technology for disabled and older people, requiring students to develop systems with disabled and older people in mind, and by inviting older people to evaluate systems developed by student projects. In this way, throughout the degree course, students are encouraged to apply accessible design principles and are also exposed to situations where they can directly interact with people with specific access needs.

This type of exposure to 'real users' has been identified as an essential part of instruction in accessible design, in that to truly understand accessibility, Web authors

of all types must experience what Petrie *et al.* (2006) have called a 'Eureka moment'. In other words, there is a need for Web authors to reach a point where an awareness of theory and acquiring of technical skills becomes crystallised by an understanding of how people with different disabilities interact with Web content, the range of skills, attitudes and coping strategies that may be adopted, and the effect that design decisions can have on this interaction.

Newell *et al.* (2006a) described in detail one such experience, during a development project involving academia, industry and government, where the application under development was an email interface for older people new to the Internet. Problems emerged when the academics' initial advice on the limited technical skills and knowledge of the target audience did not sufficiently influence the interface design, despite the industrial developers' awareness of user-centred design issues. Only when a member of the development team facilitated a structured walkthrough of a prototype with some older users did the developer experience first-hand the issues that had previously been unsuccessfully conveyed to him through advice from the academics. This observational experience was critical in understanding more about the target audience, changing assumptions, and thus clarifying the challenges facing the interface designers – changes that would not have happened had a separate usability team produced a report for the developers (Newell *et al.* 2006a)

The 'eureka effect' may most obviously be created when Web designers directly observe a disabled person attempting to use a system interface or Web site (Petrie *et al.* 2006). One example is that of UK retailer Tesco, which acted to address accessibility problems present in its Web site after its developers were invited to watch a screen reader user attempt with great difficulty to access and use the site (RNIB 2005b). Additionally, usability companies may offer video-taped sessions of

usability or accessibility evaluations on a commercial basis, which offer the potential of creating a similar impact.

2.4.2.4 Challenges in involving disabled people in Web design

The involvement of disabled people in the design and development is clearly a high impact means of helping designers to understand accessibility problems and the effectiveness of particular design solutions, and is recommended as a valuable aspect of accessible Web design and evaluation (e.g. Slatin and Rush 2002; Clark 2003a; DRC 2004; Wattenberg 2004). The W3C promotes the involvement of disabled people in accessibility review teams (W3C 2005d) and as subjects in user evaluations (W3C 2005e); the Information Technology Technical Assistance and Training Center (ITTATC) at the Georgia Institute of Technology provides advice on involving disabled people in the design and analysis phase of product development (Georgia Tech Research Corporation 2004).

However, there can be significant difficulties in successfully involving disabled people in design (Newell and Gregor 2000). In the context of Web site design, challenges in carrying out user evaluations with disabled people may include sourcing and recruitment of sufficient numbers and range in specific impairments of evaluators (Coyne and Nielsen 2001; Mankoff *et al.* 2005a; Petrie *et al.* 2006), and in finding an accessible evaluation environment (Clark 2003a). The issue on their eligibility for state benefits of any financial reward received by disabled evaluators for their involvement paid to the evaluator may be a specific problem in recruitment of disabled people (Newell and Gregor 2000).

It is perhaps unsurprising, then, that in a survey of 98 Web developers and their approach to accessibility evaluation, Alexander (2005) found that manual evaluation methods were appreciably more favoured (61% of respondents always used manual

inspection methods when carrying out evaluations) than user evaluations with disabled people - 7% of respondents claiming to always include user evaluations, and 41% rarely or never included user evaluations. In general, accessibility guidelines such as WCAG may also be perceived by some developers to provide such a solid framework for designing a Web site without accessibility barriers that following the guidelines obviates the need for user-testing with disabled people.

While the involvement of even one disabled person may provide a valuable experience for designers, there is also a danger in assuming that person is representative of a particular disability when in fact they may be a 'wildcard' with particularly extreme skills or attitudes (Gray and Salzman 1998; Lang 2003). In reality there are many variables within a specific 'disability group', including browsing and assistive technology available to them, and experience in using that technology; prior experience in accessing and using the Web; and existence of other impairments (W3C 2005e). Depending on recruitment methodology, there is a possibility that only "expert" or extremely able disabled subjects may be recruited – evaluators who are experienced in identifying and describing problems, yet potentially less likely to find problems that less experienced users may encounter (Mankoff *et al.* 2005a). In other cases, excessively optimistic results may arise from evaluations with disabled and older people, who may give overly positive feedback about a system that they had been observed to have difficulty using (Waller *et al.* 2005; Eisma *et al.* 2004).

Remote accessibility evaluation is possible, whereby disabled people perform the evaluation without the evaluator being present and send their results to the evaluation team. This avoids the need for the evaluation team to expend resources on bringing the evaluator to a suitable evaluation venue (or the evaluation team to the evaluator)

in order to conduct an evaluation, and allows for flexibility in time and location of evaluators (Mankoff *et al.* 2005a; Petrie *et al.* 2006). A Web site launched in the UK in March 2006 enables disabled people to register as Web site evaluators, and invites organisations seeking feedback from disabled people to use the service to contract the registered evaluators in assessing their Web sites (BBC 2006). However, studies have found the quality of data gathered through remote evaluations may not be comparable to local observations (Mankoff *et al.* 2005a; Petrie *et al.* 2006; see also **Section 5.1**).

Rudimentary accessibility evaluation methods can be used to substitute involvement of disabled people (Sloan *et al.* 2000; Law *et al.* 2000; Clark 2003a; Lauke 2005); discussed further in **Sections 4** and **5**. These methods generally involve progressively removing or degrading specific sensory channels (for example turning off a monitor and relying on a screen reader or viewing a page in monochrome) or limiting physical mobility (for example unplugging the mouse and using the keyboard). This can quickly provide useful feedback, particularly when multiple evaluators independently evaluate the interface and compare results (Mankoff *et al.* 2005a).

While the use of 'non-disabled' people in research as surrogates for disabled people may have attractions in terms of costs and convenience, and may overcome a scarcity of available evaluators, the issue is however a matter of some debate (Higginbotham and Bedrossian 1995). Aside from the ethical issues of 'simulating' the experiences of disabled people, the quality of the interaction is likely to be degraded - as Clark (2003a) puts it:

> "non-disabled people are not very good at pretending to be disabled" (Clark 2003a, p343).

Perhaps most significantly, from the perspective of the Web developer/author and from the perspective of this thesis, the loss of direct observation of disabled people interacting with an interface, may not create the 'eureka moment' (Petrie *et al.* 2006).

The potential of video and theatre to engage designers in the challenges facing people with specific impairments has also been identified as having significant potential in changing designers' attitudes and perceptions in relation to inclusive design. With the former, the experiences of disabled people interacting with technology can be captured and shown to design teams at a later date; the nature of video also allows control over the interaction - such as pausing the video to allow discussion of a particular action - that would not be possible in a 'live' evaluation.

Newell *et al.* (2006b) have explored the potential of theatre to provide a similar experience to an audience of designers. They created dramatisations of the experiences of older people using technology, based on observations and discussions, and employed professional actors to produce performances that were captured on video to be shown to technology developers. Newell *et al.* found evidence that designers changed perceptions of and attitudes towards older people as technology users after watching the video, and suggest that live theatre could have even greater potential as an intermediary between designers and end users (Newell *et al.* 2006b).

2.4.2.5 Communicating the results of accessibility assessments to Web authors and designers

The methods of enhancing understanding of accessibility and inclusive design described by Newell *et al.* have a drawback in that the logistics and resources required to produce theatre or video-based scenarios may eliminate them as a viable stage in the development of a Web site or, more generally, as part of an education and awareness-raising programme. Given these challenges of creating a scenario that

may result in the 'Eureka moment' described by Petrie *et al.* (2006) taking place, there is a potentially valuable role for Web site audits provided by usability and accessibility experts to recreate this experience.

In some cases, audits will be commissioned by, and/or read by individuals and teams who already have a high level of awareness and expertise in accessibility, but it is also quite possible that readers who consider themselves experts may in fact be examples of those who may particularly benefit from experiencing the 'Eureka moment'. This is equally so for those designers or content providers whose levels of accessibility knowledge and awareness are much lower.

However, recalling the problems experienced by Newell *et al.* (2006a), the situation was not solved by academics (inclusive design experts) explaining to developers the particular problems facing the target user group – and thus a report or audit produced by experts may not seem the most effective way of genuinely changing attitudes. This suggests a clear need for accessibility and usability professionals to improve the way in which they communicate their findings and recommendations to those responsible for the Web site reviewed.

The Human Computer Interaction (HCI) community has long sought to find the most effective way of communicating best practice in user-centred design through education of developers and designers, and in particular through the findings of usability evaluations. This has proved challenging. Jeffries (1994) described the challenges of reporting usability problems to design teams in such a way that the developers can identify and implement an effective solution. Wixon (2003) highlighted a related problem by identifying limitations in research into usability evaluation methodologies in terms of their applicability in real-world design and development scenarios.

It has been pointed out (Jarrett, 2004) that most usability evaluation reports are documents from ‘outsiders’, pointing out shortcomings of the current status of the subject interface (or Web site) and listing necessary changes – the same can be said for accessibility reviews. These reports thus have the potential to be perceived negatively by those involved in developing the system, and by extension as an attack on their professional skills. The format and tone of the report, and the way in which the findings are conveyed can have a significant impact on the reaction of the recipients to the report, and hence the likelihood that recommendations for changes will be followed (Tognazzini 2001; Jarrett 2004; Theofanos and Quesenbery 2005).

There are also specific challenges from an accessibility perspective, given the added moral and legal obligations that surround the issue, and the resultant possible misunderstandings between accessibility expert and audit recipient. Bartlett (2001) identified a tendency amongst accessibility advocates to report accessibility barriers through an unsolicited and hostile approach to a Web site owner, which may lead to the effect of antagonising the site owners. He stressed the need for a positive tone in approaching Web site designers to report accessibility problems:

> “We can't afford to alienate anyone who could make a difference, and the old saying tells us that ‘you attract more flies with honey than vinegar.’” (Bartlett 2001)

Thus, there is a danger that not only may a Web accessibility audit fail to truly support the reader in gaining a rich understanding of accessibility that has been identified as being so important, it may result in a negative reaction that may be reflected in the amount and quality of work that is carried out in response to the audit’s recommendations.

A standard has been developed for summative usability report structures – the Common Industry Format (CIF) for Usability Test Reports (ANSI/NCITS 354-2001). In contrast, there has been a paucity of research in effective communication of *formative* usability studies (Theofanos and Quesenbery 2005). It would appear to be a similar case for accessibility. The W3C WAI provides a template for accessibility reports (W3C 2002b), but while this advises on the content and structure of the report, it does not provide advice on effective communication with designers in terms of style of writing or presentation of results and recommendations; neither does it appear to be evidence-based.

Assuming the level of accessibility of the subject Web site is sub-optimal, a Web accessibility audit will normally present recommendations to make changes to the site based on the findings of the review. However, presentation of a general list of findings, for example in the form of unmet guidelines or checkpoints may not be helpful to the designers and developers charged with improving the site in terms of understanding the problems and prioritising actions for overcoming them (Law *et al.* 2005). Some researchers have attempted to provide the information contained in accessibility in a more meaningful and supportive way, with the aim of supporting busy developers in the task of implementing the recommendations.

For example, Petrie *et al.* (2005) developed the concept of classifying accessibility barriers found in a Web site in two distinct groups:

- Designer measure – the number of different checkpoints not met by a Web site; and
- User measure – the number of instances of a specific checkpoint being violated.

In this way, Petrie *et al*. aim to show designers how many techniques need to be adapted or adopted, while also indicating the extent to which each unmet checkpoint impacts on a disabled user's ability to use the site as intended.

Law *et al.* (2005) describe a Streamlined Evaluation and Reporting Process (SERPA), which acknowledges the challenges that may be faced in persuading Web developers - or 'programmers' - in taking the action recommended in an accessibility audit and attempts to present information in a way that is aimed at supporting developers in making the required changes. Rather then highlighting conformance levels or checkpoints not met, Law *et al.* recommend presenting lists of actions first, separated into content-related and presentation-related issues, and identifying the level of difficulty of the action.

While these methods may help to present recommended changes in a manner more likely to ensure that developers take the action recommended, they do not directly address the more fundamental issue of changing attitudes and sensitivity that was successfully achieved in exposing Web designers and content authors to real (Newell *et al.* 2006a) or simulated (Newell *et al.* 2006b) scenarios involving disabled people interacting with the subject Web site.

This means there is an apparent gap in current knowledge in the most effective techniques for conveying, though accessibility reports or audits, not just accessibility problems present within a Web site and the design changes necessary to overcome them, but more generally to promote an understanding amongst the organisation commissioning the report and amongst individual readers of how disabled people access and use Web sites, such that accessible design guidelines can be applied appropriately and sympathetically in future work.

3 The research aim: studying the impact of accessibility audits on attitudes and perceptions

It has been demonstrated that published research activity indicates that little is known about how to effectively produce a Web site accessibility report that achieves the *dual* aims of:

1. accurately reporting accessibility barriers present in a Web site and how to overcome them; and
2. enlightening the commissioning organisation and individual readers as to how disabled people interact with the site and therefore how best information, functionality and intended experience of the site can be provided to people with specific impairments.

The work described in the remainder of this thesis therefore covers three main activities:

1. The development and implementation of a Web accessibility evaluation methodology devised by the present author and colleagues (**Chapter 4**)
2. Validation of that methodology through comparison with other published Web accessibility auditing methodologies (**Chapter 5**)
3. Evaluation of the impact and effectives of the developed methodology, and the resultant audit reports providing the findings of audits using the methodology (**Chapter 6**).

The primary aim was to explore the extent to which the accessibility audit can become an effective tool in changing perceptions and attitudes towards, and

understanding of the issues facing disabled Web users, at an organisational and individual level.

Specific areas of attention were identified as including:

- Given the costs and time required to arrange more ‘human’ experiences such as theatre performances or video presentations, or even to arrange for an entire design team to observe user evaluations, can the accessibility audit serve as a cost-effective surrogate in creating the ‘Eureka experience’ amongst designers, identified as being so crucial to true understanding of accessible design?
- Can the nature and format of the Web accessibility audit help to address the perceived problem that an audit may be commissioned by one person or department, and passed on to another – who may have been unaware that the audit had been commissioned - to carry out the necessary repair work?

4 Developing a Web Accessibility Audit Methodology

4.1 The Digital Media Access Group

The present author was employed between 1999 and 2001 by the Disability and Information Systems in Higher Education project (DISinHE) project, run by the University of Dundee's Department of Applied Computing from 1998 -2001. DISinHE's remit was to provide a focal point for information relating to technology and disability for the Higher Education community in the UK. Its success in achieving this goal was illustrated by the establishment in 2001 of a national (UK-wide) service (Techdis[2]) which has continued to develop as a source of advice and information for the tertiary education community.

While DISinHE's remit did not extend to providing resource-specific advice or reviews, nevertheless project staff received many requests for evaluations or audits of the accessibility of Web sites and other resources. Given this demand, and given that Applied Computing had separately been commissioned by the Joint Information Systems Committee (JISC[3]) around the same time to audit the accessibility of the Web sites of a number of JISC-funded UK Higher Educational Web resources, the

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[2] Techdis: http://www.techdis.ac.uk

[3] The Joint Information Systems Committee (JISC) "works with further and higher education (in the UK) by providing strategic guidance, advice and opportunities to use ICT to support teaching, learning, research and administration." It is funded by the UK Further and Higher education funding councils. About JISC: http://www.jisc.ac.uk/index.cfm?name=about

Digital Media Access Group (DMAG)[4] was established by the author and colleagues in 1999 as a dedicated consultancy and research unit devoted to accessibility assessment of digital resources.

At that point in time, little guidance or research was available in terms of effective methods of evaluation of a Web site's accessibility, and the WCAG (W3C 1999) was a matter of weeks old. Similarly, awareness of accessibility as an issue amongst Web site developers and commissioners was extremely low. In order to carry out their work, the present author and colleagues developed a Web accessibility audit methodology combining automated inspection methods and manual evaluations to produce an evaluation report that was:

- Informative, identifying as many as possible of the true potential accessibility barriers present within the subject site, and;
- Educational, both in providing advice for the site developers in fixing or removing existing barriers, and avoiding the introduction of future barriers; and in providing any reader of the report (regardless of technical expertise or involvement in the site) with a solid and easy to understand account of the importance of Web site accessibility, the barriers that disabled people may face when accessing Web sites, and the steps that can be taken to avoid them, using the site under review as a case study.

The creation of the initial evaluation methodology and construction of the audit report was strongly influenced by the assumption that most recipients of the report, while possibly aware that Web site accessibility was an issue, would be unlikely to

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[4] Digital Media Access Group: http://www.dmag.org.uk

be knowledgeable about the ways in which disabled people may access the Web, or in accessible design techniques.

Additionally, the initial programme of audits was commissioned by JISC, the funders of the projects providing each subject Web site, rather than the development team themselves. The fact that the site developers had not commissioned the audit was therefore seen as a possible source of hostility by audit recipients - who may not take kindly to receiving an unsolicited report that may be perceived as being highly critical of the subject site, and by extension calls into question their own competence as developers. Diplomacy and clear explanation and justification of findings and recommendations, were therefore key objectives in presenting the findings of the audit report.

4.2 Methodology aims and development

In autumn 1999, the author and colleagues developed one of the earliest methodologies for evaluating Web site accessibility (Sloan *et al.* 2000; Rowan *et al.* 2000; Gibson *et al.* 2001; Sloan *et al.* 2002). In devising the methodology, a review was conducted by the present author and colleagues of methods that had been documented to support assessment of Web site accessibility. In addition to the WCAG, and supporting documentation available at that time from the W3C WAI, the review uncovered the presence of a number of automated assessment tools, alternative browsing technologies and tools for simulating specific browsing conditions, many of which remain in use at the time of writing (see **Chapter 5**).

The benefits and limitations of automated assessment were recognised early in the methodology development. The use of automated tools to assess accessibility has

some clear attractions. These include (Sloan *et al.* 2000; Killam and Holland 2001; Thatcher *et al.* 2002; Lang 2003):

- Automated evaluation tools enable rapid reporting of accessibility problems – whether of a single page, selection of pages, an entire Web site, or multiple Web sites;
- Automated tools perform a task (code inspection and analysis, often very repetitive) more accurately and effectively than a human;
- Automated tools do not require the levels of accessibility expertise that other assessment methods may require;
- Automated tools enable benchmarking of sites against accepted best practice, and allow repeatable comparison between sites, or of a single site's accessibility over time.

At the same time, several drawbacks of relying on automated tools were also apparent. The most fundamental problem is that any automated tool can positively identify the presence only of those accessibility barriers that do not require human inspection and judgement (Thatcher *et al.* 2002; O'Grady and Harrison 2003; Faulkner and Arch 2003; Thompson *et al.* 2003). This leaves many potentially significant barriers undetected.

Additionally, even of the barriers that *are* detected, automated tools are unable to identify the impact of a specific barrier on the overall accessibility of the site (Thompson *et al.* 2003; Spindler 2004). The algorithms used by the tools when analysing HTML content can also lead to problems, resulting in reporting of false negatives (failure to identify accessibility barriers present) and false positives (reported errors that are not in fact accessibility barriers), leading to variations in

how different tools - and versions of the same tool - will assess the same page (Ivory and Hearst 2001; Diaper and Worman 2003; Faulkner and Arch 2003; Thompson *et al.* 2003; Brajnik 2004). Lack of configurability of the tool logic in terms of the set of guidelines used to assess the subject Web site (Vanderdonckt and Beirekdar 2005) and difficulty in combining results from different tools (Englefield *et al.* 2005) have also been cited as problems.

From an educational and motivational perspective, a significant drawback relates to the way in which results are presented by automated tools to users. While a tool may be designed to be educational, and encourage manual checking of checkpoints that cannot be assessed by automated means (Cooper and Rejmer 2001), this does rely on the user's ability to read and understand the tool's output. However, the often detailed and highly technical output generated by the tools may limit the user's ability to make practical use of the results presented (Sloan *et al.* 2000; Cooper and Rejmer 2001).

Thus, the importance of manual inspection methods was also recognised early in the methodology development, in particular involvement of disabled people in the evaluation. Therefore the applicability of evaluation techniques more commonly associated with usability evaluation were also investigated. At the same time, every effort was made to achieve a balance between ensuring that as many as possible true accessibility barriers were found, wherever they may be in the subject site, and a methodology that allows a manageable and digestible audit to be completed in a reasonable amount of time by a small team of evaluators. Nielsen's "pragmatic approach" of prioritising repair work based on page significance and significance of a particular accessibility barrier was used to guide both evaluation and presentation of recommendations (Nielsen 1999).

Methodology stages are discussed in more detail in **Section 4.4**; in summary, the first iteration of the methodology involved a general manual exploration of the subject site, automated evaluation with an accessibility checking tool, manual assessment of selected pages against the WCAG checkpoints, manual assessment of selected pages against various browsing conditions and in different browsing technologies; a heuristic evaluation of the site's usability, and user evaluations with disabled people.

4.3 Initial evaluation

4.3.1 Evaluation procedure

Since the methodology had been developed in order to carry out a programme of accessibility reviews of a series of Web sites, this work was an obvious basis for initial evaluation of the usefulness of the methodology. The methodology was used to assess 11 Web sites, each of which provided information and services to the UK Higher Education sector, and each funded by JISC. The resources provided by each site included online academic data repositories, library catalogues and other gateways to information; the target audience of each site was primarily academic staff and students.

As each site was provided by and for UK academic institutions, it was anticipated that, in comparison to commercial Web sites, a high standard of technical quality and usability would be apparent throughout, and that use of new technology and graphic design techniques would be applied sensibly. The level of accessibility of the sample was therefore expected to be of a reasonably high level.

4.3.2 Problems uncovered by the methodology

In summary, the overall level of accessibility of the Web sites assessed was found to be reasonable (Sloan *et al.* 2002). In most cases, clear evidence was found that the

site developers had attempted to improve the accessibility of their Web sites. At the same time, though, the presence of several accessibility barriers indicated a misunderstanding of the principles of accessible design. While some barriers were peculiar to specific sites, in many cases, instances of the same accessibility barrier were found across all sites.

Barriers commonly found included:

- Failure to provide equivalent alternatives to graphical information;
- Lack of consistent and efficient navigational systems, including inconsistent provision of navigation bars, lack of internal page links, and link text that did not clearly indicate the destination page;
- HTML code that did not validate to recognised standards;
- Limited, or no, ability to change visual appearance;
- Poor information layout, including excess content on pages, and inappropriate use of lists.

One interesting outcome of this evaluation programme was the realisation that there was often a discrepancy between the priority level of a specific unmet WCAG checkpoint and the level of impact on disabled evaluators of the unmet checkpoint. The synthesis of evaluation stage findings indicated some situations whereby the frequency and location of an unmet WCAG checkpoint was judged – or observed in user evaluations – to influence the impact of that barrier on the accessibility and usability of the site to disabled evaluators to a greater or lesser degree than the checkpoint's WCAG priority indicated. This observation led to the rejection of WCAG priorities as the primary means of grouping recommendations in future audit reports.

4.3.3 Feedback from site administrators

Following the audit of their Web site, each site administrator[5] was contacted by email in order to obtain feedback regarding the usefulness of the audit in helping to address accessibility issues present in the site. Feedback received is summarised in **Table 1**.

Statement	**Rating** scaled from 1 (total disagreement) to 7 (total agreement)
I found the audit to be informative	4.83
I found the audit to be useful	5.17
The recommendations were easy to follow	3.67
I intend to follow the recommendations detailed in the audit	4.67
I agreed with the findings of the audit	4
I am pleased the audit was conducted	5.33

Table 1: Feedback on initial accessibility evaluation programme

The results shown in **Table 1** indicate that recipients of the audit were generally welcoming of the audit, and found it of use in helping them develop their sites. However, **Table 1** also indicates that there was scope for improvement of the presentation of recommendations. The feedback received included some additional suggestions for improvements of the auditing procedure, such as the presentation of recommendations in a clearer and more easily digestible way. In addition, feedback indicated that the manner in which the auditing procedure was conducted could be

[5] 'Site administrators' were those people who had been identified by the project funders (JISC), as key contacts for each site - with whom DMAG liaised during the audit of the site. These people would most likely have been managers of the service, or site developers, but this data was not formally collected during the survey.

improved, supported by increased communication between the auditors and the site administrators, over:

1. The timing of the audit; and
2. The purpose of the site.

The problem of timing was not unexpected, given that the programme of audits had been commissioned and overseen by a third party, and did not take into account any planned redevelopment of the subject sites. It might be assumed that any direct request from a Web site developer or owner for an accessibility audit of that site would be timed to coincide with a period of redevelopment. In some cases, however, the timing of an audit commissioning may be influenced by other factors, such as budget availability or request from senior management, who may not be aware of the plans of the site developers. Thus, advance consultation with audit recipients would ensure that firstly, the audit was timed as best as possible to coincide with a site overhaul or redesign project.

Additionally, the need to be aware of the purpose of the subject site – its target users and intended functions – when carrying out the audit and presenting results was clearly conveyed in feedback. An increased understanding of the aims and objectives of the site was therefore identified as being necessary for auditors to better evaluate its effectiveness in terms of the context in which it was used.

This increased understanding of the context and purpose of the site was accompanied by a request for increased understanding of the financial and human resource constraints under which the Web site development team worked. There was also a general plea for more pragmatic advice in terms of recommending improvements and how they should be implemented.

In some cases, feedback indicated that there was an impression amongst respondents that implementing changes to sites would lower accessibility, as they interpreted the audit recommendations as a request that certain features with accessibility barriers be withdrawn or reduced in functionality. This appears to be a common misunderstanding amongst designers, despite the fact that increasing accessibility should not result in the removal of features but instead seek to provide alternatives. On reflection, though, this was treated as a call to clarify recommendations presented in the audits, emphasising the need for a greater understanding of the context of each subject site, in terms of its aims, target audience and usage scenarios.

It was also noted by some respondents that the issue of third party provision of Web site content was a significant barrier to implementing accessibility improvements across the entire subject site. Some subject sites mirrored the content of other sites, or provided access to content that was created by third parties. While site administrators and developers may have no control over such content, the issue of potential discrimination remains a responsibility of the site provider. It was realised that future audits would need to consider how best to advise on this issue.

4.3.4 Impact of the audit on subject sites

In addition to feedback from audit recipients, the impact of the audits was further investigated by revisiting each subject site several months after the audit was completed. This inspection was carried out by DMAG as an independent piece of research, and not as part of the original agreed auditing work. The aim was to identify the extent to which each site and its level of accessibility had changed since receipt of the audit. It should be noted that this initial evaluation of the audit methodology did not include a formal re-audit stage using all stages of the methodology, partly due to limitations in time, and partly because it was not clear

whether some audit recipients planned to use the audit document to repair the subject site, or to use it to guide a site redesign. Thus, this stage was limited to an informal, brief inspection of each subject site, with the relevant audit as a reference.

Of the 11 sites audited:

- One site had implemented a small number of changes suggested in the audit, but retained the appearance and structure;
- 6 sites had undergone extensive redesign;
- 4 sites appeared not to have changed at all in terms of accessibility.

For the sites that had undergone extensive redesign, a brief inspection indicated that all sites had eliminated most of the accessibility problems highlighted in the site audit, although in some cases new accessibility problems had been introduced as part of the redesign. This gave some indication that the audit document had been of practical use to the recipients when looking to address the barriers identified as being present in their site.

4.4 Description of DMAG accessibility audit methodology

Following feedback from the initial evaluation, the second iteration of the methodology took place, resulting in a multi-stage Web accessibility evaluation methodology, described in this section. This methodology has been used as a basis for all Web accessibility audit work carried out since 2001 by DMAG, although minor changes have been made to specific audit stages over time, to reflect developments of new tools and in new techniques.

4.4.1 Stages of the methodology

4.4.1.1 Testing with automatic validation tools

Recognising the advantage of automated tools in rapidly generating an assessment of each page of the site, the subject site is passed through two automatic validation tools:

1. An automated accessibility validation tool is used to check the whole site for the subset of accessibility barriers that can be uncovered by automated means. The results report generated by the tool is inspected, and summarised in the audit report. When the audit methodology was developed, the tool used was the freely available downloadable Bobby tool provided by the Centre for Applied Special Technology (CAST). As discussed in **Section 4.4.4**, however, the choice of tool used changed over time.

2. The W3C MarkUp Validation Tool[6] is used to evaluate a selection of pages of the site for any errors in the HTML code of each page. While the MarkUp Validation Tool is not specifically an accessibility evaluation tool as such, it enables checking of a key aspect of optimally accessible Web design - use of HTML code that validates as far as possible to a "published formal grammar"[7].

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[6] W3C MarkUp Validation tool is available at: http://validator.w3.org/

[7] The Priority Two checkpoint 3.2 of WCAG states: "Create documents that validate to published formal grammars" See: http://www.w3.org/TR/WAI-WEBCONTENT/wai-pageauth.html#tech-identify-grammar

It should be noted here that a selection of pages is required as the MarkUp Validation Tool does not run automatically across all sites. Also, given that for a large site to validate every page would take a large amount of time, a selection of site pages is used for this stage.

4.4.1.2 Manual Evaluation with Accessibility Guidelines

The same set of pages used in the HTML Validation stage is also used to perform a manual check against each checkpoint of the WCAG. In doing so, this stage takes into account those guidelines and checkpoints that automatic tools cannot validate, such as the contrast of a page's background and text colours, and appropriateness of alternative text provided for graphic features.

Each checkpoint not met in the pages reviewed is noted and presented in a table of all WCAG checkpoints. From this, an early indication of the site's likely level of WCAG conformance can be obtained – with the proviso, of course, that this evaluation stage concentrates on only a sample of the full site.

4.4.1.3 Inspection under different browsing conditions

Using the same graphical browser throughout, the subject site is accessed under various browsing conditions that, in the model of Newell and Cairns (1993), result in an 'ordinary' user (the evaluator) accessing the site under 'extraordinary' conditions. Any accessibility problems experiences are noted. These conditions include:

- viewing the site with graphics turned off;
- style sheets turned off;
- scripts disabled;
- using only the keyboard, in order to identify any content or functionality that cannot be accessed without using the mouse.

4.4.1.4 Expert inspection

A detailed exploration is then carried out of the site, which involves an attempt to visit every page of the site. In this way, each site page can be assessed as a discrete entity, and at the same time its relationship with other pages and context within the site as a whole can be considered. Thus, quirks of individual pages can be discovered along with an analysis of levels of consistency of appearance, content and structure of the site. This approach also allows assessment of the availability and adequacy of navigation features – a particularly important aspect since many disabled people may be arriving at pages deep within the site, accessed for example from a search engine results page or a hyperlink in an email.

The results of this exercise are presented as a narrative piece, discussing in turn the site's layout and appearance, navigation, and content, plus any accessibility features provided. Screen shots are used to illustrate key issues where appropriate. A useful side-product of this stage is the identification of examples illustrating specific barriers – or examples of good practice, which can be cited in the recommendations produced based on the audit findings.

4.4.1.5 Viewing with browsers and assistive technologies

Contrasting with the **Inspection under different browsing conditions** stage, the subject site is viewed using different browsing technologies, such that any browser-specific accessibility problems can be highlighted. This again requires a manual inspection of selected pages of the site. As new browsers and new versions of existing browsers emerge, so the selection of browsers used has evolved over time to include:

- Lynx: a freely available text-only browser that does not support JavaScript.
- Internet Explorer, versions 4.x – 6.x.

- Netscape Communicator, version 4.x;
- Opera, versions ranging from 5.x to 8.x;
- Mozilla and Firefox browsers (various versions)
- A dedicated speech browser – originally pwWebSpeak, and latterly IBM's Home Page Reader (HPR)[8]

The site's performance is also monitored when accessed using Freedom Scientific's JAWS for Windows: a widely used screen reading application used by blind and partially sighted people, running in conjunction with Internet Explorer and an 80 character Braille Display. Here, a visually impaired user of JAWS explores the site, observed by a DMAG evaluator, and any problematic area is jointly explored in more detail.

The subject site is also viewed at various screen resolutions, in particular low resolutions, simulating the experience of accessing the site using a browsing device with limited screen size, for example a television based browsing set-up. The Size-O-Matic tool from Pythonsoft[9] is used as a simple tool for resizing browser windows to specific resolutions.

4.4.1.6 Usability Evaluation

A core aspect of the evaluation methodology was to ensure that a user-centred approach was taken, and so task-based evaluation of the subject site with disabled evaluators is carried out. This was strongly influenced by the nature of relevant legislation in the UK, the Disability Discrimination Act (DDA 1995), which, rather

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[8] IBM Home Page Reader (HPR) available at: http://www-3.ibm.com/able/solution_offerings/hpr.html

[9] Pythonsoft Size-O-Matic tool available at: http://www.pythoness.com/

than setting in law a minimum technical level of accessibility, requires that disabled people be able to access **and use** services without facing unjustified discrimination (discussed in **Section 2.4.2.2**). Additional user evaluations with able-bodied people, carrying out the same tasks as the disabled evaluators, allow identification of the existence and nature of barriers to use by all people, regardless of disability.

This evaluation stage was never, however, intended to be a rigorous empirical evaluation with the aim of producing statistically significant quantitative data; rather it was primarily intended to provide additional qualitative information about the site's performance in terms of how well it supported users in carrying out a set of tasks. In line with the view that quality of interaction extends beyond a basic level of usability to more subjective aspects of pleasure (Jordan 2000), an important aspect of the evaluation was to observe the impact of a barrier on the evaluator, and note any divergence between assumed impact (through relating a barrier to a corresponding WCAG checkpoint priority) and actual impact on the evaluator's progress and attitude.

The ideal scenario identified is that at least five evaluators covering a range of visual, mobility and cognitive impairments be engaged to carry out task-based evaluations, along with five evaluators with no significant impairments for each site, as recommended for 'discount' usability evaluation purposes by Nielsen (2000). However, in practice the number of evaluators involved in this audit stage is governed by the client's budget, and in audits carried out by DMAG, this has ranged from none to eight disabled people, while the use of non-disabled people as part of accessibility audits has been extremely rare.

In the user evaluations, evaluators each carry out a number of sample tasks, and whilst evaluators are encouraged to think aloud, an observer records evaluator

comments plus additional observations on task completion, route taken through the site and barriers encountered along the way. Further qualitative information, in terms of each evaluator's opinions of aspects the site, is also obtained via a semi-structured questionnaire on completion of the evaluation, where ratings are measured on a Likert scale.

4.4.1.7 Recommendations

Following synthesis and analysis of the findings of each evaluation stage, recommendations for improving the site's accessibility are presented. These are prioritised according to the assessed impact of the relevant accessibility barrier on the site in question:

1. Recommendations that should be followed as soon as possible.
2. Recommendations that should ideally be followed in time, but are of less significance than the higher priority tasks, or may require significant effort to implement.
3. Examples of good practice, and which should be continued.

Along with a generic description of the work required to address the barrier, the following are provided for each recommendation:

- a rationale justifying why the recommendation should be applied;
- example(s) of where the recommendation should be applied;
- any examples of where the recommendation has already been followed in the site.

The recommendations presented in the report will, in many cases, closely resemble WCAG checkpoints. In other situations, they may combine several WCAG

checkpoints or may not be directly mapped to a WCAG checkpoint, but which may nevertheless be related to an issue that had a significant impact on usability of the subject site for some disability groups. Similarly, there may be a discrepancy between the priority allocated to the audit recommendations and the priority allocated by WAI to any corresponding WCAG checkpoint(s). This is because the priority of the audit recommendations takes into account a number of factors:

- the frequency of discovery of the related accessibility barrier across different evaluation stages;
- the frequency and location of occurrence of the barrier within a page and across site pages; and
- the degree to which the barrier was observed to cause problems in user evaluations.

In this way, the audit does not present a formal WCAG compliance report. Rather it attempts to overcome some of the identified limitations of the guidelines (see **Section 2.4.2.1**) by tailoring the recommendations to the site in question, presented in a set of easy to follow instructions that can be understood by technical and non-technical readers alike. It also aims to support pragmatic prioritising and scheduling of tasks required to raise accessibility of the subject site – often a challenge to site owners, particularly in large, complex sites (Theofanos *et al.* 2004), as well as to provide a general educational resource in Web accessibility.

4.4.2 The audit document

The audit report document given to recipients provides a description and findings of each evaluation stage used, followed by recommendations for improving the subject Web site's accessibility. At all times, best efforts are made to present evaluation

stage findings in a narrative, easy to read style, with the aim of allowing readers of varying technical levels of expertise to understand not only the key accessibility problems identified in the site, but also gain an idea of how disabled people use the Web and the impact of specific barriers on their ability to access and use sites in general. Screenshots illustrating specific problems are provided where appropriate.

The audit document commences with an Executive Summary, briefly outlining the aims and methodology of the audit, plus key findings, and is supported by Appendices containing supplementary information, such as a completed WCAG checklist and a sample evaluation questionnaire, if user evaluations have been carried out. The main body of the document includes three sections:

- **Background and Aims** – this includes an overview of the importance of Web accessibility, highlighting the benefits arising from designing with accessibility in mind, in line with those identified in **Section 2.1**, and outlining legal obligations[10]. The aims of the report are also stated, stressing that the audit is written to support future development, rather than as a direct criticism of the awareness, attitudes and capabilities of the site owners and developers. An overview of the audit methodology is also provided.
- **Evaluation findings:** for each of the evaluation stages applied, a brief description of the evaluation method and role of the evaluation stage in the audit process is provided. This is followed by a narrative description of the findings.

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[10] For UK-based sites, the Disability Discrimination Act (DDA 1995) is the most relevant legislation. Additional focus on DDA Part IV is included in the audit reports of Web sites of educational institutions.

- **Recommendations:** A summary table of recommendations precedes the detailed presentation of each recommendation as described in **Section 4.4.1.7**. Advice on an appropriate recovery strategy, in terms of prioritisation of the recommended repair work is also given. This generally recommends an approach that addresses high priority barriers on high traffic pages first, leaving less high impact problems and barriers on rarely visited pages for later, in line with the approach recommended of Nielsen (1999).

The length of the audit document is dependent on two factors: the number of evaluation stages carried out, and the level of accessibility of the subject site. An audit report of a site with significant accessibility barriers will by its nature include a longer Findings section and a greater number of Recommendations for improving the site's accessibility than would a site with a higher level of accessibility. The length of DMAG Web accessibility audit reports therefore have ranged from 50 to 90 pages.

4.4.3 Defining scope of the review

For most audits, definition of the scope of the site under review is straightforward – defined by the entire collection of pages residing under a particular URI domain or subdomain, unless otherwise specified by the audit commissioner. In this case, the whole site would be analysed using an automated accessibility checking tool; the Detailed Manual Exploration attempts to visit as many pages as possible. For those audit stages that cannot realistically be applied to every page of the subject site, efforts are made to analyse at a minimum a sample set of pages from the site, including:

- the Home page;

- a ‘typical’ page representative of each layout and presentation ‘style’ used throughout the site;
- a page with a form requiring users to enter data;
- the results page of a site search facility;
- a page containing a data table;
- a page containing multimedia, for example video or Macromedia Flash; and
- a page providing contact information.

In some cases, where very large sites have been subject to audit, the scope of the audit has not been defined by URI domain or subdomain, but rather by the set of pages required to be visited *en route* to completing a set of tasks provided in advance by the audit commissioners. This approach was developed when DMAG was commissioned to evaluate a very large university Web site. A task-based sampling technique was used to define the scope of four separate audits, each one concentrating on the accessibility of tasks that a defined stakeholder group would be expected to complete using the site. In this instance, the university identified stakeholder groups as prospective students, current students, staff, and other visitors, and also provided DMAG in advance with a list of eight typical tasks that each group would be expected to be able to complete using the site. Thus the areas of the site under review were defined as the pages that would be most likely to be visited by each stakeholder group when carrying out these 8 tasks.

The rationale behind this task-based approach is twofold:

- For very large sites, the content of which may be under ownership of many different groups within a large organisation, an audit that attempted to assess every page would either be so large and take so long to complete as to be

impractical, or be so generalised as to be worthless. Instead, a pragmatic approach is required that provides an audit that can usefully identify the greatest possible number of problems that may exist, and which can be digested and acted upon by many different groups within the organisation.

- The task based approach is in line with the principles of the UK Disability Discrimination Act (DDA 1995), which requires that organisations take reasonable steps to avoid unjustified discrimination against disabled people when providing goods, facilities and services. In other words, disabled people should not encounter unjustified accessibility problems when attempting use the Web site for its intended purpose, and concentrating on the accessibility of *tasks* rather than pages helps measure the extent to which the site meets this requirement.

4.4.4 Changes made to the methodology

As noted, the methodology presented in **Section 4.4.1** is the second iteration of the methodology. Two evaluation stages were dropped from the first iteration of the audit methodology shortly after the pilot study. In neither case was the decision a direct result of feedback from the pilot study audit recipients. The stages dropped were:

- The **Initial Impressions** stage. This was an introductory stage involving all members of the evaluation team sitting together to browse the site, pointing out areas of potential concern. The value of this stage had been the presence of multiple experts together looking at the site and discussing possible issues requiring further investigation. The stage was dropped, partly due to scheduling difficulties in arranging for all team members to be present at the same time to carry out this stage, which by its nature had to be the first

evaluation stage carried out. There was also a realisation that presentation of the results of this stage as part of the audit report may cause undue confusion to readers, given that further reading would reveal findings of more in-depth manual inspections.

- The **Heuristic Evaluation** stage. This involved at least two of the evaluation team carrying out independent heuristic evaluations using Nielsen's 10 usability heuristics (Nielsen 1994), adapted for the Web by Instone (1997). This stage was also dropped due to the time required for each team member to complete an evaluation and for the results to be synthesised. The stage had been considered valuable in that it forced a more usability-centred view of the site. However, as many audit clients were working to a limited budget, this was also seen as the least 'accessibility focused' stage, and therefore one that could be sacrificed with least impact on the ability of the methodology to uncover as many potential accessibility barriers as possible.

Other changes made focused on the presentation and content of the audit document, reflecting the feedback of the initial evaluation stage. This included the addition, at the start of the Recommendations section, of a summary table presenting each recommendation in succinct form, grouped by priority, thus enabling readers to quickly gain an idea of the scope of the repair work recommended. The presentation of user evaluations was also enhanced, changing from a combined report of all evaluations to a report for each individual evaluator, presented task-by-task.

Over subsequent audits, other minor modifications were made, primarily in terms of tools used to aid manual and automated inspections, as new and more accurate and effective accessibility assessment and simulation tools and browsing technologies became available. Significantly, the Mozilla Firefox browser, with the Web

Developer ToolBar extension[11] installed, replaced Internet Explorer as the primary evaluation browser, the toolbar allowing more efficient evaluation of issues such as performance with style sheets and JavaScript disabled.

The automated assessment tool used was also changed. After technical problems with the standalone Bobby application, which ceased to work after an upgrade of the PCs used by the evaluation team, the online version of Bobby was adopted – the standalone version no longer being free. This version of Bobby was latterly replaced by the Cynthia Says online tool[12]. The unfortunate result of this was that a tool that could crawl an entire site had been replaced by one that could evaluate only one page at a time, and even then at a rate of only one page per minute[13].

IBM Home Page Reader replaced pwWebSpeak as the standard speech browser used to listen to the site content, while the version of the JAWS screen reader used underwent a number of upgrades. In 2005, the Colour Contrast Analyser (see **Appendix 2**) was also adopted as a tool for assessing potential problems relating to colour contrast.

One of the most significant developments of the audit process based on feedback received from the initial evaluation stage was an increase in advance consultation with the audit commissioner(s) wherever possible. This was a logical step given the situation in which the pilot study audits were commissioned (see **Section 4.3**).

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[11] Web Developer Toolbar for Firefox – available from http://www.chrispederick.com

[12] Cynthia Says accessibility evaluation tool available at: http://www.contentquality.com/

[13] Purchase of a more advanced tool has been considered, but at the time of writing no decision has been made to buy a tool for use in auditing work.

This advance exchange of information included a request for contextual information about the site:

- the intended aims of the site;
- intended target audience;
- a list of typical tasks that the target audience might reasonably be expected to complete using the site.

Technical information was also requested, including details of:

- the authoring tools used to create the site and its content;
- the number of authors likely to be maintaining the site or adding and editing content;
- any reliance on non-HTML formats to present content development environment;
- any reliance on third-party content, the nature of which was beyond the control of the development team.

The primary aim of this modification was to ensure that the advice presented in the audit was sympathetic to the aims of the site and the circumstances under which it was created and maintained, with the intention that the audit presented information that was more site-specific, and at the same time more pragmatic.

4.4.5 Usage of the methodology

The DMAG methodology combines a number of specific evaluation methods. This has allowed a flexible approach to costing audits provided on a commercial basis - the cost of an audit is related to the number of audit stages applied. This allows clients with smaller budgets and/or requiring a rapid turnaround of work to receive a

reduced-stage impact for reduced cost. The choice as to which audit stages are not included is made through consultation between the client and DMAG; but for many clients the additional costs of user evaluations with disabled people in particular mean that this stage is omitted.

The impact of this is that not all Web accessibility audits conducted by DMAG apply the full methodology outlined above. As discussed in **Section 6.1**, certain stages are carried out less often than others.

5 Investigation into usage of other Web accessibility evaluation methods

The DMAG methodology was developed and evaluated in the period 1999-2000, and has been used by the present author and colleagues since then. In this time, there has been a noticeable increase in research activity in studying and implementing Web accessibility evaluation methods. Most of this work appears to have concentrated on the effectiveness of individual evaluation methods in uncovering the largest possible proportion of true potential barriers that exist in a Web site, rather than measuring the audit's impact on the recipients. Even more common has been the publication of the findings of programmes of Web accessibility audits, where the primary goal has been to report on the levels of accessibility of a sample of Web sites, and the methodology(ies) used were a means to achieving this objective.

In order to assess the validity of the DMAG methodology in terms of its similarity to other published Web accessibility evaluation methods, an investigation was conducted into accessibility evaluation methods published since 2000, including those used in published surveys of Web site accessibility.

5.1 Published accessibility evaluation methods

In general, published methods can be grouped into three categories:

1. automated methods, aimed at inspecting the underlying HTML code of a Web page for potential barriers;
2. manual inspection methods to identify accessibility barriers (which may in turn use tools to aid inspection for specific barriers);

3. Involvement of disabled people in evaluating the site.

Automated tool inspections generally involved assessment with one or more of the many automated accessibility checking tools available (Ivory and Hearst 2001; Witt and McDermott 2004). Manual accessibility inspection methods include evaluation with a variety of browsing and assistive technologies, guideline checks and observation of site performance when using simulation tools to assess for example colour contrast or page display in low-resolution displays (Smith and Bohman 2004; RNIB 2005a; Lauke 2005; Arch *et al.* 2003; Clark 2003a).

Scope/Audit Stages	**Preliminary Review**	**Conformance Review**
Scope	Selection of pages, including: • Home and other 'entry' pages; • pages with different layouts and functionality (e.g. with tables, forms, or dynamically generated results; informative images such as diagrams or graphs)	• For manual evaluation stages: Selection of pages as for Prelim review; • For automated and semi-automated evaluation stages: the entire Web site under review (unless logistically or technically unfeasible)
Examine pages using graphical browsers under different conditions	Yes (graphics off; audio off; monochrome; changing screen resolution; changing font size using browser; navigate using the keyboard)	Yes (conditions as for Preliminary review plus check when style sheets, scripts and applets are not loaded)
Manual inspection of selected pages using WCAG checklist	No	Yes
Examine pages using specialized browsers (speech and/or text)	Yes (using a text-to-speech solution or a text browser)	Yes (using a text-to-speech solution and a text browsers)
Read and evaluate page content	No	Yes
Use at least two automated assessment tools	Yes	Yes (at least one of which is applied across entire site)
Use automated code validation tools	No	Yes

Table 2: Comparison of WAI Preliminary and Conformance review methodologies (from W3C 2005f; W3C 2005g)

The W3C's Web Accessibility Initiative notes that the evaluation method used is dependent on the aim of the evaluation, and outlines two separate methodologies for accessibility evaluation - one for a preliminary (formative) evaluation (W3C 2005f), and a more comprehensive methodology for a conformance (summative) evaluation against the WCAG (W3C 2005g). **Table 2** provides a comparison of the two methodologies. The W3C notes that the methodologies presented in **Table 2** can be further strengthened by the addition of user evaluations with disabled people – resulting in what is referred to as 'comprehensive evaluations' (W3C 2005g).

However, others have expanded the accessibility evaluation methodology to include more of a usability focus. Winberg (1999), Lang (2003) and Brajnik (2005b) have independently noted the close relationship between many accessibility evaluation methods and usability evaluation methods. Reflecting this, Brajnik (2005b) listed key accessibility evaluation methods as:

- Conformance review – assessing performance against a standard or set of guidelines;
- Automated test – using tools to report performance against a subset of guidelines;
- Heuristic evaluation – a pool of expert evaluators use their knowledge of different ways in which a site may be accessed to evaluate the performance of the subject site against design heuristics or principles, and compare assessment of severity of any breaches found;
- Heuristic walkthrough – scenario-based application of design principles by evaluators;

- User testing – observation and recording of performance of disabled people interacting with the site through attempting pre-set tasks.

Brajnik (2005b) then proposed the accessibility walkthrough method as a method of particular value. He argued that it is more sympathetic to the context in which a site may be used, and hence more likely to identify barriers that will have measurable impact on users, and also that, by its nature, the method does not require the expertise of other evaluation methodologies, in particular heuristic evaluation.

Paddison and Englefield (2003) developed a set of nine accessibility heuristics, to support accessibility evaluation. Their aim was to ease the task of carrying out an accessibility review of a Web site, but tests with usability specialists revealed that in comparison with a usability heuristic evaluation, usage of the accessibility heuristics demanded a significant degree of background knowledge (in accessibility).

Work has also been carried out to compare the relative effectiveness of specific evaluation methods, most notably between 'remote' evaluations with disabled people and other accessibility evaluation methodologies. Mankoff *et al.* (2005a) compared remote evaluations with local observations of disabled evaluators, use of an automated tool and expert reviews. They found that combinations of evaluators independently reviewing the subject site and combining their results was a particularly successful means of identifying actual barriers, while remote evaluations were markedly less successful. Petrie *et al.* (2006) concentrated on local versus remote evaluations with disabled people, and found that while quantitative data collected from remote and local evaluations was comparable, remote evaluations were less effective at generating qualitative data – fewer problems were reported, and those that were reported were less descriptive in terms of nature and cause than those identified in local evaluations.

The existence of different accessibility assessment methodologies, which can lead to different definitions of an 'accessible' Web site, has been identified as being potentially confusing to Web developers and authors (Brajnik 2005a; Witt and McDermott 2004). This has been acknowledged by the European Commission in moves towards harmonisation of accessibility assessment and accreditation. Co-ordinated under the Web Accessibility Benchmarking Cluster (WAB)[14], this work has included exploration of the development of a European Union-wide charter mark, accompanied by development of a harmonised evaluation methodology used to assess Web sites for accessibility. A draft of the Unified Web Evaluation Methodology (UWEM) was released in October 2005 (WABCluster 2005).

The UWEM includes advice on:

- Scope of the Web site under evaluation and sampling of pages;
- Test procedures (automated and manual) for evaluation of conformance to each Priority One checkpoint of WCAG 1.0;
- Aggregation of test results;
- Conformance levels
- Scoring and reporting of results,
- User testing protocols.

However, at the time of writing, the UWEM and other methods discussed appear primarily focused on conformance and performance evaluation, rather than fostering an awareness and understanding of the problems present such that the site developers

[14] Web Accessibility Benchmarking Cluster: http://www.wabcluster.org

can take the necessary steps to improve both their understanding and the site's accessibility.

5.2 Published Web accessibility surveys and methodologies used

Since publication of the DMAG audit methodology, several investigations into the accessibility of Web sites have been carried out across the world, where the findings of which are publicly available. From a literature review, 20 key surveys published since 2000 were identified, and each of these surveys was examined in order to establish the range and popularity of evaluation methods used.

Table 3 lists the 20 Web accessibility surveys examined and **Table 4** outlines the evaluation methods adopted by the surveys. More in-depth details of each survey are provided in **Appendix 3**, including the stated motivation or aims of the survey, nature of the sample of sites surveyed, the scope of each site included in the review, and more details of the methodology used.

Overwhelmingly, these studies had been carried out of multiple sites (ranging[15] from 6 to 1080), with the aim of assessing their performance against recognised standards (i.e. the WCAG) or an indication of their performance with respect to relevant legislation (such as Section 508 of the Rehabilitation Act in the US, or the UK's Disability Discrimination Act). In terms of the scope within each site, over one-third

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[15] This range does not include the study of Coyne and Nielsen, which uniquely of all the studies reviewed sites with the aim of generating design guidelines, not to report accessibility levels. Neither does it include the study of Zaphiris and Zacharia, which specified 18096 *pages*, but did not specify the number of *sites* evaluated.

of the surveys (n=7, 35%) limited their investigation to the Home page of each subject site.

Author(s)	Year of Publication of Study
1. Alexander	2004
2. Cabinet Office	2005
3. Coyne and Nielsen	2001
4. Davis	2002
5. Disability Rights Commission (DRC)	2004
6. Ellison	2004
7. Jackson-Sanborn *et al.*	2001
8. Kelly	2002, repeated in 2004
9. Lazar *et al.*	2003
10. Loiacono	2004
11. McMullin	2002
12. Milliman	2002
13. Pennell	2005
14. Petrie *et al.*	2005
15. Sloan and Sloan	2003
16. Spindler	2004
17. Thompson *et al.*	2003
18. Williams *et al.*	2004
19. Zaphiris and Zacharia	2001
20. Zeng and Parmanto	2004

Table 3: Summary of published Web accessibility surveys

Whilst together the studies used a broad range of the evaluation methodologies used in the DMAG methodology (see **Section 4.4**), **Table 4** indicates that automated accessibility checking tools were overwhelmingly the most popular evaluation tool, used in 19 studies (95%), and in 8 studies (40%) was the *only* evaluation technique used. In contrast, the use of alternative manual inspection methods was far less common (n=8, 40%); similarly the use of alternative browsing technology, such as the Lynx text-only browser (n=3, 15%), assistive technologies (n=2, 10%). Involvement of disabled people in evaluations was also low (n=3, 15%). 2 (10%)

surveys included automated validation of HTML code; 2 (10%) involved additional surveys of Web site commissioners and providers.

Evaluation method	Number of surveys (n=20)
Manual accessibility check	8 (40%)
Check using alternative browsers	3 (15%)
Automated accessibility evaluation	19 (95%)
Assistive technology check	2 (10%)*
Task-based user evaluation with disabled people	3 (15%)
Other	4 (20%)
* 2 additional surveys did not explicitly mention an assistive technology check as part of the methodology used, but did include user evaluations with disabled people, which involved people using assistive technologies.	

Table 4: Evaluation methods used by published Web accessibility surveys

It is also interesting to note that very few of the surveys employed a multi-stage evaluation methodology or *meta-method* such as that used by DMAG or promoted by the W3C. Pennell (2005) used a variety of evaluation methods, but his study was largely limited to the Home page of each site. The author and a colleague based their assessment method on the DMAG methodology, but this was limited to a few pages of each subject site (Sloan and Sloan 2003). In outlining their survey approach, Thompson *et al.* (2003) noted the limitations of automated methods, and also emphasised their aims of assessing accessibility of site *functions*, rather than producing an arbitrary mark of accessibility for individual pages or sites. Their study also aimed to compare the performance of two independent manual expert evaluations, and to compare the manual evaluations with an automated evaluation.

The relative unpopularity of the meta-method in the studies above cannot be taken to mean that meta-methods are not used. However, it does suggest that they are not popular when the primary goal of an evaluation programme is to present a state–of-play report on accessibility of a large number of Web sites – even when most of the

studies acknowledge the limitations of relying on a single evaluation methodology. In the sample studied, 7 of the 8 surveys relying only on the use of automated tools admitted the weakness of relying on automated methods – but nevertheless continued to report the results of the study based on this evaluation method alone. This is a phenomenon also noted by Thompson *et al.* (2003).

Of particular interest to this research is the observation that none of these studies provided any evidence of efforts made to monitor impact assessment – the effect of the study on the sites reviewed. Indeed, most studies provide no evidence that the site administrators or developers were contacted during or after the research.

Thus, while the surveys may have benefit as benchmarking exercises and in raising awareness more generally, it is impossible to establish the impact of the report on the owners of each subject site. A potential exception is Kelly's study (Kelly 2002, Kelly 2004), which was repeated two years after the original survey of UK university Web 'entry points' took place. While some conclusion may be drawn as to changes in activity in relation to Web accessibility over time, the influence of the published survey on these changes cannot be established. While improvements in reported accessibility were found, the survey did not explore reasons for improvement, or the influence of the original survey on each university and their approach to Web design.

More fundamentally, most surveys did not document any involvement of the organisations providing each site under review - before, during, or subsequent to the evaluation. A notable exception was the survey of Milliman (2002), who followed up an automated survey of Web sites with a questionnaire emailed to each site administrator asking for feedback on the level of accessibility of their site. The DRC survey did also include a survey of Web site designers and commissioners – although there is no indication as to whether this contact took place with owners of the sites

evaluated. The surveys of Coyne and Nielsen (2001) had the primary objective of generating design guidelines rather than establishing accessibility levels of the sample surveyed, and as such the performance of sites was reported only in the context of justification of a design guideline. Even so, no contact with the site owners was documented.

It is possible that organisations whose Web site was included in an accessibility survey such as those listed in **Table 3** may take or have taken steps to improve their site's accessibility as a direct reaction to the publicity. In such a case the absence of contact by the researchers cannot have influenced the action taken by the organisations. In other cases, the reaction of an organisation to a survey that they did not commission and were not invited to provide contextual information about the site's development lifecycle, purpose and target audience, may be one of indifference or denial. However, understandably, given the sensitive nature of the situation, evidence supporting these scenarios is scarce.

5.3 Accessibility auditing in practice

The surveys described above are each assumed to have been carried out as 'uninvited' accessibility surveys for research or benchmarking purposes. There is though a very visible market for commercial accessibility audits in the UK and elsewhere[16], and along with DMAG, many organisations now offer Web accessibility audits as a service (e.g. Dodd 2005; RNIB 2005a). Part of the service offered may

[16] The accessibility and usability market in the UK was valued at £115 million according to a report released in February 2006: http://www.usabilitynews.com/news/article2981.asp

include follow-up or long-term support that can effectively measure the impact of an initial audit.

By their nature, these accessibility evaluations are most likely to have been actively requested by organisations seeking to improve accessibility. Therefore it is also assumed that recommendations arising from the evaluation are more likely to be acted upon than the findings of an uninvited large scale surveys. However, it is also possible that an audit may be commissioned by one department of a large organisation without the knowledge or support of those expected to implement the recommendations, and this may have a negative effect on the impact of the accessibility report. Additionally, since such audits are commissioned on a commercial basis, the results – and indeed the methodology – may be considered commercially sensitive by both the organisation commissioning the audit and the auditors themselves. This makes it unlikely that the audit findings, impact and any follow-up dialogue will be made publicly available.

It is also very likely that, in practice, many organisations carry out Web accessibility audits of their own sites, and in some cases the audits will be conducted by the developers themselves. Again, in such a case publication of the methodology used or the audit's results is likely to be scarce. However, two separate publications shed some light on methodologies used.

King *et al.* (2005) describe the approach used by IBM to monitor accessibility of their Web presence, estimated at 30 million Web pages, whereby regular automated inspection of pages was combined with human inspection of a sample of pages. The sample of pages chosen for manual inspection was based on page location within the overall site structure, structure of the page, and number and type of errors found through automated means (or "error profile"). Human checking was carried out with

the aid of ‘favelets’ or ‘bookmarklets’, each of which highlighted a specific page area to inspect for potential barriers (see **Appendix 2** for more details).

Separately, research by Alexander (2004a) gives an insight into the evaluation methodologies adopted by individual developers. Alexander surveyed 98 people on their evaluation practices, and found that:

- 78% of respondents spent no more than half of their working role on Web accessibility related matters.
- 56% based their evaluations on the WCAG, with a further 16% basing evaluations on WCAG and the Section 508 Standards.
- 45% usually or always used automated tools in assessment; 26% rarely or never used automated tools.
- 90% usually or always used manual inspection methods; 2% rarely or never used manual inspection methods.
- 27% usually or always used user testing; 41% rarely or never used user testing.
- For respondents that did conduct user testing, 87% included evaluators who were blind; 80% included evaluators with low vision; 54% included evaluators with mobility impairment and 26% included evaluators with cognitive impairments.

The findings of this survey indicate that given the dominance in popularity of manual inspection over other evaluation stages, meta-methods for evaluation are comparatively rarely used amongst the respondents.

5.4 Comparison of DMAG methodology with other methodologies

The limitations of relying on automated tools have been widely recognised, particularly where there is a need to identify as many accessibility barriers as possible in a **single** Web site, and an integrated approach that combines automated testing with manual methods is more effective (Diaper and Worman 2003; Lang 2003; W3C 2005f; W3C 2005g). There are close similarities between the DMAG methodology, developed in 2000, and based partly on advice provided by W3C WAI at that time, and the current methodology recommended by W3C WAI (as shown in **Table 2**).

The DMAG methodology also reflects the 'programmer-friendly' approach recommended by Law *et al.* (2005), particularly through Law *et al.*'s principles of effective presentation of recommendations for action:

- Provide a list of fixes as a primary output;
- Separate content-related from presentation-related findings;
- Give evaluation results in a form that programmers can use;
- Identify easy fixes versus more difficult fixes;
- Keep in mind the end users are programmers.

Jeffries' recommendations for effective usability reports also contains a number of features present in DMAG audits (Jeffries 1994, pp288-289):

- Separate descriptions of each problem and its solution;
- Justifications for the solution – and for existence of the problem, if appropriate;

- Assessment of severity of the problem.

Other researchers have recommended the DMAG methodology as the most effective means of evaluating a Web site for accessibility (Lang 2003; Diaper and Worman 2003) – as the latter note:

> "The only way to properly assess a Web site's accessibility is to undertake some approach like Sloan *et al.*'s" (Diaper and Worman 2003, p13)

Thus, the validity of the DMAG evaluation methodology appears sound. Yet there is little published evidence of the widespread usage of such a methodology, and in particular measures of its effectiveness. Indeed, the methodologies used in published Web accessibility surveys of multiple sites, discussed in **Section 5.2**, clearly show that the meta-method as developed by DMAG is unpopular, particularly for large scale evaluation studies. This means, of course, that there is also a scarcity of research relating to the effectiveness of the methodology on the audit recipients in terms of awareness raising, motivation and understanding of accessibility.

6 Evaluation of audit impact

Given the lack of publicly available research into the impact of Web accessibility audits on the recipients, and with the DMAG accessibility audit methodology now established, the next stage of the research addressed a more extensive and detailed evaluation of the DMAG methodology and its impact on recipients' awareness, attitudes and knowledge of accessibility matters.

6.1 Audit sample

Evaluation of the impact of the audit methodology involved studying the impact of a sample of 14 audits carried out as a commercial service by DMAG for a range of clients in the UK. The audits were delivered to clients over a timespan of approximately 39 months, the first being completed and delivered in August 2002, the most recent in October 2005.

Audit	Category	Date of Delivery
1a, 1b, 1c, 1d	Academic	Feb 2004
2	Public Sector	Sep 2002
3	Public Sector	Dec 2004
4	Academic	Aug 2002
5	Academic	Sep 2005
6	Academic	Aug 2004
7	Academic	Sep 2004
8	Academic	Sep 2005
9	Academic	Sep 2005
10	Academic	Dec 2004
11	Health	Oct 2005

Table 5: Audits sampled - category and delivery date

Table 5 summarises the 14 audits that made up the sample used in this study, including category of site and the date the audit was received by the recipient client.

Note that for commercial confidentiality reasons, the name of some of the subject Web sites cannot be revealed.

Table 6 shows the DMAG methodology stages used in each audit, and illustrates that there were differences in the extent of the audit methodology applied amongst audits. As noted in **Section 4.4.5**, the Web accessibility audits supplied by DMAG on a commercial-in-confidence basis are priced on a charging scale, and clients choose a solution that best meets their own needs, budget and timescale. This, along with the adoption of new tools discussed in **Section 4.4.4**, means that the methodology applied in the sample of audits used was not completely consistent from audit to audit in terms of stages applied, a matter beyond the control of the present author.

Some commissioning organisations received more than one audit in the sample used in the study:

- Audits **1a, 1b, 1c and 1d** were all carried out on the Web presence of a large UK university, and commissioned as one piece of work by that university. The extent and variation in the appearance, functionality and ownership of sections of the overall site under review meant that a full audit was impractical, and a stakeholder approach was taken, as described in **Section 4.4.3**. Thus, audits 1a, 1b, 1c and 1d refer to audits focusing on current students, staff, prospective students and external groups respectively.
- Audits **2 and 3** were delivered to the same recipient organisation, but were commissioned separately, covered two related but different Web sites and were delivered approximately 27 months apart. Therefore it was anticipated that the audits would be read by different audiences.

- Audits **5, 6, 7, 8, 9 and 10** were commissioned by the University of Dundee as part of a programme of Web site accessibility audits of a pre-selected group of sites of University academic and support organisations. They were carried out by DMAG independent of any consultation with those involved in the subject Web sites, and therefore the vast majority of the audit recipients did not know that the audits had been commissioned until they were given a copy. Additionally, Audits **9 and 10** covered different sections of the same Web site, an academic Faculty and School respectively. Some recipients were given copies of both audits.

NB The present author, along with colleagues in DMAG, conducted the evaluation and write-up stages of most of the subject audits,. The exceptions were Audit 5 and Audit 9, in the production of which the author had no involvement.

In most cases, the contractual agreement to provide an audit report to a client includes the provision by DMAG of a limited amount of follow-up support via telephone or email. In the sample of audits chosen for the study, face to face presentations of results were also provided.

- Audits 1a, 1b, 1c, 1d – one on-site presentation of general findings;
- Audit 4 – two on-site workshops on Web site accessibility following delivery of the audits. Additional documents providing general advice on accessibility issues were also provided along with, but separate to, the audit.
- Audits 5, 6, 7, 8, 9, 10 – 1 hour face-to-face meetings with recipients to discuss the findings of each audit, plus general Web accessibility issues. Note that in each case, recipients had been unaware that the audit had been

commissioned, and as such this was the first direct contact between DMAG and the recipients.

The present author played an active role in all of the above meetings and presentations, other than the presentation given to the recipients of Audits 1a, 1b, 1c and 1d.

Audit	Evaluation Stages								
	Aims and Background	Expert inspection	Evaluation with Automated Tools	Manual Guideline check with W3C WCAG	Check with different browsing conditions	Check with Browsers and Assistive Technology	Heuristic Evaluation	User Evaluations	
								Able-bodied (n=5)	Disabled [a]
1a - 1d	Y	Y	Y	Y	Y	Y	-	Y	1 B
2	Y	Y§	Y	Y	Y	Y	Y	Y	1 B
3	Y	Y	Y	Y	Y	Y	-	-	5 (1 B, 2 VI, 1 D, 1 MD)
4	Y	Y§	Y	Y	Y	Y	Y	Y	2 B
5	Y†	Y	-	Y	Y	-	-	-	3 (1 B, 1 D, 1 MD)
6	Y†	Y	-	Y	Y	-	-	-	3 (1 B, 1 D, 1 MD)
7	Y†	Y	-	Y	Y	-	-	-	3 (1 B, 1 D, 1 MD)
8	Y†	Y	-	Y	Y	-	-	-	3 (1 B, 1 D, 1 MD)
9	Y†	Y	-	Y	Y	-	-	-	3 (1 B, 1 D, 1 MD)
10	Y†	Y	-	Y	Y	-	-	-	3 (1 B, 1 D, 1 MD)
11	Y	Y	-	Y	Y	-	-	-	3 (1 B, 1 D, 1 MD)

† Aims and background presented in a separate document.

§ Initial inspection also carried out.

[a] abbreviations used for specific impairments of evaluators as follows:

B – blind (relies on text-to-speech); VI – other visual impairment; D – Dyslexia; MD – reduced manual dexterity.

Table 6: Subject audits and evaluation stages used

6.2 Survey of audit recipients

In order to establish the degree to which the audits served their intended purpose, audit recipients were contacted and asked to provide feedback on a variety of aspects relating to the audit, including the circumstances behind its commissioning, its distribution, and impact on individual recipients.

In the period November 2005 to February 2006, recipients of audits were contacted by email requesting them to provide feedback about the audit and audit impact by completing an online questionnaire.

6.2.1 Survey design

A secure Web questionnaire was developed using the Participating in Consultation Online (PICO) Web-based questionnaire system successfully developed by colleagues of the author at the University of Dundee (Milne *et al.* 2003) and used primarily for enabling remote and anonymous consultation with secondary school pupils. A Web based questionnaire was chosen over a paper-based or telephone-based approach for a number of reasons:

- Speed and range of distribution;
- Ease of completion and submission;
- Ease of collecting and analysing results;
- Accuracy of information collected.

The PICO system allowed conditional questions, enabling a questionnaire to be developed that could cope with a diversity of users. It also enabled a variety of type of question to be asked; as such, the questions included were a mixture of multiple choice and free text. Multiple choice questions included questions requiring ranking

of a selection of options, selecting one option from a choice of several, and selecting multiple options from a list. The questionnaire structure is provided in **Appendix 4**.

6.2.2 Survey aims

The questionnaire sought to elicit data from individual recipients about a number of aspects of the audit and its impact. Specifically, it was hoped to establish patterns relating to:

- the distribution of the audit amongst the recipient organisation;
- the circumstances and motivations behind the audit's commissioning;
- the relative worth of specific stages of the audit to individual recipients, and in particular the relative value of stages describing human interaction with the site (expert inspection or user evaluation) versus automated tool evaluation or guideline conformance;
- the impact of the audit on the recipients (individuals and organisations), in terms of understanding the issues present in the subject site, and in their attitudes to, awareness of and knowledge of Web accessibility in general.

6.2.3 Survey distribution

An initial email was sent to key contacts – people with whom DMAG had originally liaised over commissioning and delivery of a particular audit. Key contacts were asked to forward the invitation to complete the questionnaire to as many as possible of their colleagues who may have read the audit.

An exception to this approach was for Audits 5-10. As explained in **Section 6.1**, the audit commissioner made a decision not to notify the audit recipient organisations in advance, nor to enable consultation between the recipients and DMAG. However, each recipient organisation was invited, after receipt of the audit, to nominate

recipients take part in a consultation with DMAG. During this face to face consultation, attendees were made aware of the questionnaire, encouraged to complete it and to pass on details of absent colleagues who had also read the audit.

6.2.4 Survey responses

Over a period from November 2005 to February 2006, 16 responses were received. It is impossible to estimate the response rate in terms of number of responses received as a percentage of those who had read each audit in question. Firstly, the total number of audit recipients within any one recipient organisation could not be known, as it was assumed that audits would be circulated to varying extents amongst the staff of each client organisation. Secondly, initial approaches to key contacts encouraged forwarding the invitation to complete the questionnaire to anyone who had received a copy of the audit, or otherwise read it. Publicity of the existence of the survey was therefore dependent on the degree to which the key contact forwarded the survey invitation.

For some organisations, a significant amount of time had elapsed between receipt of the audit and notification of the survey – at most, potentially 39 months. This was an unavoidable aspect of the nature of the research project in question. It was therefore accepted that some recipients of the audit may have since left the organisation, while others may have chosen to ignore the request for feedback.

6.2.5 Analysis of data

The PICO system used to capture responses also enabled some immediate analysis of data. Using the system, it was possible to group responses by individual respondent, and also collate responses for individual questions. Comparisons between groups of users, based on answers provided to specific questions, were also carried out.

Quantitative data was exported to a spreadsheet package for calculation of basic statistical values; additional statistical tests were performed using the VassarStats Web site for Statistical Computation[17] Online.

Results are presented in **Section 7.1**.

6.3 Evaluation of evidence of impact

An additional stage of the research sought to gather evidence to identify the degree to which the audit recipients had:

1. Taken the appropriate steps to improve the accessibility of the subject Web site; and
2. Shown a public commitment to promoting Web accessibility throughout the organisation.

Therefore the subject Web sites of each audit were reviewed during the period March 20th to April 5th 2006. For reasons of limited time and resources available, it was not possible to apply the same methodology used in the original evaluation across each subject site. Instead, a streamlined checklist of key features was used to guide evaluation.

The original audit documents were consulted, and for each audit a selection of examples of where accessibility issues were present were extracted from the Recommendations for Immediate Action. The selection of examples focused, where possible, on the following generic issues, chosen as particular examples of where a

[17] VassarStats: http://faculty.vassar.edu/lowry/VassarStats.html

true understanding of the context of accessibility can be distinguished from a rigid guideline-based approach:

- Quality of alternative text provided for graphics;
- Quality of hyperlink text;
- Quality of keyboard access, including presence and extent of internal page navigation;
- Quality of structural HTML used, in particular the use of headings and table headings.

These instances of key accessibility barriers were then revisited in order to assess the degree to which they had been addressed.

In addition, a small selection of pages of the subject site were accessed and reviewed for performance with respect to the same points as above, using the following techniques:

1. Browsing the site using Firefox version 1.5 with the Web Developer's Toolbar (see **Section 4.4.4**), running on Windows XP.
2. Browsing pages in text-only linear form, using Lynx 2.8.5 running on Windows XP.

NB For audits 1a, 1b, 1c and 1d, where the reviews concentrated on the same overall Web site but from different perspectives, a single review took place, but included checking examples of accessibility barriers extracted from each of the four audit documents.

Appendix 5 summarises the Recommendations for Immediate Action that were provided as part of each audit. Note that while **Appendix 5** provides summary

recommendations, the audit document expands each recommendation in terms of specific actions to follow, plus a rationale for carrying out the actions, and examples of where the recommendation should be followed (see **Section 4.4.1.7**).

During the review, specific attention was also paid to the presence and extent of accessibility information provided within the subject site. This included general policy and strategy on Web accessibility, advice supporting disabled users in accessing and using the site, resources supporting organisation staff in developing accessible Web content and mention, if any, of the DMAG audit procedure and impact.

Results are presented in **Section 7.2**.

7 Results

7.1 Survey of audit recipients

NB Raw data from individual recipients is available on request.

7.1.1 Coverage of audits

Table 7 outlines the audits read by respondents, and shows the interval between audit delivery dates and audit reading dates for each respondent.

Respondent	Audit	Date audit delivered by DMAG	Date audit read by recipient	Approximate time interval between delivery and reading
1	1a-1d	Feb 2004	April 2005	14 months
2	1a-1d	Feb 2004	Not known	-
3	2, 3	Sep 2002 (2); Dec 2004 (3)	Oct. 2002 (2); 2004 (3)	< 1 month (2); immediate (3)
4	3	Dec 2004	Jan. 2005	1 month
5	4	Aug 2002	Sep. 2004	25 months
6	4	Aug 2002	July 2004	23 months
7	4	Aug 2002	Oct. 2004	26 months
8	5	Sep 2005	Oct. 2005	< 1 month
9	6	Sep 2004	Estimated within 1 week of audit delivery	1 week
10	7	Sep. 2004	Feb-March 2005	5.5 months
11	8	Sep 2005	September/October 2005	< 1 month
12	9, 10	Nov 2004 (10), Sep 2005 (9)	Feb 2005 (10), Sep 2005 (9)	3 months (10), immediate (9)
13	10	Nov 2004	16th January 2006	2 months
14	10	Nov 2004	March 2005	4 months
15	5	Sep 2005	October 2005	< 1 month
16	11	Oct 2005	October 2005	Immediate

Table 7: Audit coverage, delivery date and date read by respondents

The 16 respondents had collectively received 14 separate audits, giving a spread of just over one respondent per audit. In addition to respondents 1 and 2, who were

from the institution that received four audits (1a, 1b, 1c, 1d), two other recipients had received more than one audit.

7.1.2 About the respondents

7.1.2.1 Employment and interest in Web design

The 16 respondents came from various backgrounds, shown in **Table 8**. 10 (62.5%) either managed a Web development team or developed Web sites, while 6 (37.5%) were not involved in Web design on a professional basis.

Identified Job description	Number of respondents
Manager of a Web design/development team, and Web site design is also a significant part of my job	2
Manager of a Web design/development team, but Web site design is not a significant part of my job	4
Web designer/developer	4
Lecturer/researcher	2
Supporting disabled staff/colleagues, and/or disabled customers, clients and/or students	1
Other: Web administrator assistant	1
Other: Faculty Secretary	1
Other: Project co-ordinator	1

Table 8: Job descriptions of respondents

Those who specified a job description that was not either Web design/development or management of a Web design/development team were asked about their professional or personal interest in Web design. Their responses are presented in **Table 9.**

7.1.2.2 Involvement in the audited site

Respondents were asked about the extent of their involvement in the audited Web site. Responses are given in **Table 10**.

Stated Job description	Interest in Web design
Lecturer/Researcher	1. Web Representative responsible for one of the School Web sites (of the organisation that commissioned the audit).
	2. Academic e-learning manager for the school (whose site was audited) with responsibility for quality of e-learning.
Supporting disabled staff/colleagues and/or disabled customers, clients and/or students	1. IT Disability Support Specialist, with a specific interest in Web standards and accessibility.
Other	1. Web Administrator Assistant
	2. Faculty Secretary – involved in the design of the audited site, along with the Faculty Web Development Team; provided material for the site.
	3. Project co-ordinator of a project to develop a website based on identified information needs of patients/carers/health care professionals. Works with the users to identify these needs but does not carry out the actual Web development.

Table 9: Respondents' identified interest in Web design

7.1.2.3 Accessibility expertise of respondents

Respondents were asked to indicate on a 7 point Likert scale their level of knowledge about Web accessibility before they read the audit. Results are presented in **Table 11**.

7.1.3 Audit commissioning and distribution

Respondents were asked to indicate their involvement, if any, in the commissioning of the audit. Of the 16 respondents, 13 (81%) had not been involved in the commissioning of the audit; 3 (19%) had been involved.

Those who **were involved** in commissioning the audit were asked for:

- An indication of the people to whom the audit was distributed or otherwise made available (results presented in **Table 12**); and
- The reasons behind the commissioning of the audit. They were asked to rate in order of importance, to the best of their knowledge, a selection of potential

reasons, and then invited to present additional reasons. The rated reasons are presented in **Table 13**.

Respondents' description of involvement in subject Web site	
Manager, but I was not around at the time	None
Managing software houses to ensure compliance with customer's requirements	The website is an application to be used internally and externally. I wrote the specification for the application.
The audit was carried out prior to my employment at the University. However, as the University's Web Accessibility Officer, the audit was an invaluable source of information to me and was widely used within my team to improve and change the University Web site.	Content editor and graphic designer
None. I am responsible for a School Web site within the main University site.	Designed and developed the website
A little input, but not a lot	I am responsible for the uploading and creation of the Department's Web content
Navigation Structure; Implementation of the content; Maintenance of the site	Web designer & developer
I was part of the team that designed its precursor. I am part of the review team for the site; I am a user of the site	I had no involvement prior to the audit.
Contributed to the consultation on the design of the site and provided information for inclusion on the site.	I identified the user needs, worked with the Web developer to agree layout and functional requirements for the website, developed/re-formatted information for the website. I also work with users to demonstrate the website and gain their feedback.

Table 10: Respondents' involvement in the audited Web site

Level of Web accessibility knowledge	Number of respondents
1 - No knowledge whatsoever:	0
2:	2
3:	4
4 - A working knowledge:	2
5:	5
6:	1
7 - Expert in Web accessibility:	2

Table 11: Respondents' levels of Web accessibility expertise

NB For ease of interpretation of **Table 12** and **Table 13**, the three respondents who were involved in commissioning the audit are referred to as A, B and C.

Audit made available to:	**Respondents**
All people involved in developing the subject Web site.	A, B, C
All people involved in providing content for the subject Web site.	A
All people involved in developing Web sites in general.	-
Senior management.	A, B
Staff responsible for supporting disabled staff/employees and/or disabled customers, clients or students.	B
Legal advisors.	A
Other (owners of some of the original website content).	C

Table 12: Audit distribution within recipient organisation

Reason	**Importance** (1 most important, 5 least important)				
	1	**2**	**3**	**4**	**5**
To provide an independent assessment of the level of accessibility of the subject site.	B, C	A			
As part of steps taken towards ensuring compliance with the Disability Discrimination Act (DDA).	A*	B	C		
To establish the extent to which the subject site conforms to the W3C Web Content Accessibility Guidelines (WCAG).			A, B	C	
To establish how well disabled people can use the subject site for its intended purpose.		C		A	B
To provide an educational resource in Web site accessibility.				B	A, C
Additional stated reasons:	*To ensure that the software houses complied with customer requirements. This reason was identified as top priority by Respondent A.				

Table 13: Ranked reasons for commissioning the audit

Those who were not involved in the commissioning of the audit were asked to identify the circumstances under which they received or obtained a copy of the audit. These responses are presented in **Table 14**.

Circumstances surrounding receipt of audit	Number of respondents
Respondent was given a copy of the audit to read and act upon its findings.	8
Respondent was given a copy of the audit for reference.	1
Respondent specifically asked for a copy of the audit.	2
The audit was made available to all staff within the respondent's organisation (for example published on an intranet).	2
The audit was distributed at an internal training event (or similar).	0
None of the above.	0

Table 14: Circumstances under which respondents received audits

7.1.4 Effectiveness and impact of the Audit

Respondents were asked to rate the impact of the audit on a variety of issues, using a Likert scale to indicate their level of agreement with a number of presented statements. Responses for each statement are presented in **Table 15**.

Impact Statement	**Respondent Rating** (n=16) (1 = strongly disagree – 7 = strongly agree)						
	1	**2**	**3**	**4**	**5**	**6**	**7**
1. "The audit gave me a good idea as to how well the subject site performed against best practice in accessible Web design."	0	0	0	3	2	4	7
2. "The audit highlighted the degree to which disabled people were able to use the subject site for its intended purpose."	0	0	0	2	6	5	3
3. "The audit made me more aware of the importance of the issue of Web site accessibility to disabled people."	1	1	0	1	2	4	7
4. "The audit made me more aware of the problems that disabled people can encounter when accessing Web sites."	1	1	1	2	1	4	6
5. "The audit and its findings motivated me to further my knowledge of Web accessibility issues and the role I can play in improving the accessibility of Web sites."	0	1	3	2	2	3	5
Totals:	2	3	4	10	13	20	28

Table 15: Respondents' rating of statements about the audit impact

Preferred Evaluation stage	Respondents (n) and reasons given
Performance under different browsing conditions.	(n=1) “Because of the inconsistent way in which browsers render Web pages.”
Performance when accessed using different browsing and assistive technologies.	(n=1) “As there are so many different browsers and assistive technologies in use by students, it is important to clearly understand and appreciate how easy/difficult it is for them to access information on our Web site.”
User evaluations with disabled people.	(n=3) “I knew about most of the rest of the findings before - and it was great to see how actual users dealt with the site - better than just my preconceptions of how they would cope.” “At the end of the day theory and academic opinion is only useful if it can be tested and put into practice. A user who has no specific interest in either but has opinion based on their own personal experience can give a broader and rounder picture of what is what.” “Gave an indication of what REAL people felt the issues were - IT personnel sometimes can't appreciate what these issues are as they are too close to the subject.”
Recommendations for improving the subject site's accessibility and usability.	(n=11) “Because it looked into the issues faced across a number of discrete sites, rather than sites in isolation. Highlighted some useful issues for us here, and given that it was external helped with political neutrality too.” “Because it is possible to apply these recommendations to sites and materials where I am responsible for their production. Useful lever to use with staff and in reports for committees.” “It provided the evidence we required that the site did not comply with some of the customer's requirements.” “Summary of what needed to be done in the different areas.” “As it contained pointers on changes that I could also make to my site, of which I was previously unaware of their importance.” “The recommendations provided a list of points which I could easily go through and pin point where in the site I had to make amendments I was able to create action points for these and organise myself to meet these recommendations. It was also useful to have the recommendations divide into sections of what was really a necessity and some things that could improve the site.” “So we could monitor the progress of improving the site.” “It provided a sense of direction which I could act in order to improve accessibility.” “The information provided helped me to improve our websites for all users and gave guidelines on how to proceed with the recommendations.” “Clearly identified the action required to implement enhancements. We used this to identify additional actions to be taken in response and the timeline within which this would be required.”

Table 16: Respondents' preferred evaluation stages

7.1.5 Effectiveness of specific audit stages

Respondents were asked to identify the one evaluation stage that they considered to be most useful to them, and to explain in their own words their choice. Responses are presented in **Table 16**.

The following stages were not rated most useful by any respondent:

- Detailed manual accessibility inspection of the subject site.
- Report of the subject site's performance when assessed by automated accessibility and HTML checking tools.
- Assessment of selected pages of the subject site against the Web Content Accessibility Guidelines.

As noted, some audits did not include all stages of the DMAG methodology described in **Section 4.4**. Recipients of these audits were presented with those evaluation stages of the methodology that were **not** included as part of the audit they received, and asked to indicate their opinion as to the perceived usefulness of these stages. Responses are presented in **Table 17**.

Additional Audit Stage	**Respondent rating of anticipated usefulness** (1 = not at all useful – 7 = very useful)							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**Mean rating**
Report of the subject site's performance when assessed by automated accessibility and HTML checking tools. (n=8)	0	0	1	4	1	1	1	4.625
A review of the performance of the subject site when accessed using different browsing and assistive technologies. (n=8)	0	0	0	2	3	1	2	5.375

Table 17: Respondents' anticipated usefulness of additional audit stages

7.1.6 Statistical analysis

The data collected from respondents allowed for a degree of in-depth analysis. Firstly, an investigation was carried out to establish whether a correlation may exist between a respondent's identified level of expertise in Web accessibility and audit impact.

Secondly, respondents were divided into groups for comparison, based on specific characteristics, and statistical tests performed to establish whether or not any significant difference in audit impact existed between the two groups. This was carried out three times, focusing respectively on:

1. level of involvement of the recipients in Web design and development – comparing respondents who were primarily Web developers with those who were not.
2. circumstances under which the audit was received – comparing respondents who were given a copy of the audit and told to act on it with those who acquired the audit under other circumstances.
3. relationship of the audit recipients to the auditors (i.e. DMAG) – comparing respondents who were based at the University of Dundee, and hence colleagues of the auditors, with those who were based elsewhere, and had no such relationship with the auditors.

The respondent pool was therefore subdivided into three separate pairs of groups, each pair distinguished by a specific characteristic as listed above. In two of the comparisons (audit receipt circumstances and relationship of recipients to the auditors), the number of respondents in each group was equal (8 each); in the remaining group pair (involvement in Web development), the split was 7-9. Non-

parametric statistical significance tests were performed for each group on each audit impact statement rating, to assess whether there was any significant difference in impact rating.

7.1.6.1 Audit impact and level of accessibility expertise

Appendix 6 shows respondent ratings for each impact statement based on respondent expertise in Web accessibility. Given that each respondent's level of expertise and statement rating were both identified by an ordinal value, a Spearman's rank correlation co-efficient test was carried out for each of the 5 impact statements as shown in **Table 15**. The hypothesis was that those with greater expertise in Web accessibility would identify the audit as having less impact than those whose expertise in Web accessibility was low. Results are presented in **Table 18**.

Audit Impact Statement	rs	T	P(1)	P(2)
1	-0.3194	-1.26	0.1141	0.2283
2	-0.0766	-0.29	0.3880	0.7761
3	-0.493	-2.12	0.0261	0.0524
4	-0.4145	-1.7	0.0556	0.1112
5	-0.3069	-1.21	0.1232	0.2463
For all tests, n=16 and df=14.				

Table 18: Spearman's rank correlation co-efficient test – audit impact and expertise in Web accessibility

At the 95% confidence level, a significant negative correlation was indeed found between expertise in accessibility and level of agreement with Impact Statement 3 "The audit made me more aware of the importance of the issue of Web site accessibility to disabled people" (Spearman rs = -0.493, df = 14, P(1) = 0.026). Additionally, a negative correlation approaching significance was found between expertise in accessibility and level of agreement with Statement 4 "The audit made me more aware of the problems that disabled people can encounter when accessing

Web sites" (Spearman rs = -0.4145, df = 14, P(1) = 0.056). No significant correlations were found for any of the other statement ratings.

7.1.6.2 Audit impact and level of involvement in Web development

A comparison was made between audit impact on respondents who indicated through their chosen job description that Web design formed a major part of their day-to-day job, and on those for whom Web development was less significant as a daily task. The Web Developer group included all those respondents who indicated their job was "Web developer" or "manager of a Web design/development team and Web site design is also a significant part of my job", plus one respondent who described her job as "Web admin assistant" (see also **Table 8**). There were 7 respondents in the Web Developer group and 9 in the 'non developer' group.

The ratings given by the two groups for each audit impact statements are shown in **Table 19**, and **Table 25** compares the two groups in terms of preferred audit stages.

Mann-Whitney U-tests were performed to establish the level of significance in differences between the two groups' ratings for each of the 5 impact statements. There was no significant difference between the two groups in any of the statement ratings, although the difference in ratings of Impact Statement 1 "The audit gave me a good idea as to how well the subject site performed against best practice in accessible Web design." approached significance at the 95% confidence level (Ua = 47, Z = -1.59, P(1) = 0.0559) (see **Table 20**).

Audit Impact Statement	Groups (n_a=9; n_b=7)	Rating (Level of agreement)		
		Maximum	Minimum	Median
1. "The audit gave me a good idea as to how well the subject site performed against best practice in accessible Web design."	Web developers	7	4	5.5
	Other	7	5	6.5
2. "The audit highlighted the degree to which disabled people were able to use the subject site for its intended purpose."	Web developers	7	4	5.5
	Other	7	4	5.5
3. "The audit made me more aware of the importance of the issue of Web site accessibility to disabled people."	Web developers	7	1	6.5
	Other	7	4	6
4. "The audit made me more aware of the problems that disabled people can encounter when accessing Web sites."	Web developers	7	1	6.5
	Other	7	2	5.5
5. "The audit and its findings motivated me to further my knowledge of Web accessibility issues and the role I can play in improving the accessibility of Web sites."	Web developers	7	2	6
	Other	7	3	4.5

Table 19: Audit impact and level of respondent involvement in Web development

Audit Impact Statement	Ua	Z	P(1)	P(2)
1	47	-1.59	0.0559	0.1118
2	36	-0.42	0.3372	0.6745
3	37	-0.53	0.2981	0.5961
4	29.5	0.16	0.4364	0.8729
5	31.5	0.05	0.4801	0.9601
For each test N_a = 7; N_b = 9				

Table 20: Mann-Whitney U scores for impact versus level of involvement in Web development

7.1.6.3 Audit impact and circumstances under which audit was received

A second comparison was made based on the circumstances under which the recipient received or acquired the audit. The comparison was made between audit impact ratings given by those who identified that they were given a copy of the audit and told to act on its recommendations and by those who had received it under different circumstances. The latter group included those who had been responsible for commissioning the audit, those who had been given a copy for reference, and those who proactively sought a copy of the audit either by asking for a copy or finding a copy made available internally within the organisation (see **Table 14**). Both groups consisted of 8 respondents.

Table 21 compares results between these two groups in terms of how they rated each audit impact statement, and **Table 25** compares the two groups in terms of preferred audit stages.

A Mann-Whitney U-test was performed to establish the level of significance of the difference between the two groups' ratings for each of the 5 statements. At the 95% confidence level, there was no significant difference between the two groups in any of the five impact statement ratings (see **Table 22**).

7.1.6.4 Audit impact and relationship of recipients to DMAG

The final comparison was made between those respondents who were employees of the University of Dundee, and thus effectively colleagues of the audit team, and those who belonged to organisations independent of the University. The justification for this comparison was to explore whether there was a difference in attitudes and impact between recipients who were aware that the auditing team was part of the same institution – even though DMAG was commissioned as an external service provider; and those for whom the auditing team was completely independent.

Audit Impact Statement	Groups (n_a=8; n_b=8)	Rating (Level of agreement)		
		Maximum	Minimum	Median
1. "The audit gave me a good idea as to how well the subject site performed against best practice in accessible Web design."	Given audit to act on findings	7	4	6
	Other	7	4	7
2. "The audit highlighted the degree to which disabled people were able to use the subject site for its intended purpose."	Given audit to act on findings	7	4	5
	Other	7	4	6
3. "The audit made me more aware of the importance of the issue of Web site accessibility to disabled people."	Given audit to act on findings	7	1	6.5
	Other	7	2	6
4. "The audit made me more aware of the problems that disabled people can encounter when accessing Web sites."	Given audit to act on findings	7	3	6.5
	Other	7	1	5.5
5. "The audit and its findings motivated me to further my knowledge of Web accessibility issues and the role I can play in improving the accessibility of Web sites."	Given audit to act on findings	7	3	6
	Other	7	2	4.5

Table 21: Audit impact and audit receipt circumstances

Audit Impact Statement	Ua	Z	P(1)	P(2)
1	43	-1.1	0.1357	0.2713
2	39.5	-0.74	0.2297	0.4593
3	27.5	0.42	0.3372	0.6745
4	32	1.05	0.1469	0.2937
5	24.5	0.74	0.2297	0.4593
For each test N_a = 8; N_b = 8				

Table 22: Mann-Whitney U scores for impact versus audit receipt circumstances

It should be stressed that the number of respondents from the University of Dundee who had prior knowledge of DMAG and the work carried out by the group is

unknown; however the present author had a prior professional relationship with two of the respondents. Additionally, the circumstances under which the programme of audits (Audits 5 to 10 in the sample) was carried out was made clear to each recipient organisation in a covering letter provided along with the delivery of the audit.

Audit Impact Statement	**Groups** (n_a=8; n_b=8)	**Rating (Level of agreement)**		
		Maximum	Minimum	Median
"The audit gave me a good idea as to how well the subject site performed against best practice in accessible Web design."	Univ. of Dundee	7	4	6
	Other	7	4	6.5
"The audit highlighted the degree to which disabled people were able to use the subject site for its intended purpose."	Univ. of Dundee	7	4	5.5
	Other	7	5	5.5
"The audit made me more aware of the importance of the issue of Web site accessibility to disabled people."	Univ. of Dundee	7	1	6
	Other	7	2	6.5
"The audit made me more aware of the problems that disabled people can encounter when accessing Web sites."	Univ. of Dundee	7	2	6
	Other	7	1	6
"The audit and its findings motivated me to further my knowledge of Web accessibility issues and the role I can play in improving the accessibility of Web sites."	Univ. of Dundee	7	3	6
	Other	7	2	4.5

Table 23: Impact of audit: comparison between respondents from the University of Dundee and others

Table 23 compares results between these two groups in terms of how they rated each audit impact statement, and **Table 25** compares the two groups in terms of preferred audit stages.

A Mann-Whitney U-test was performed to establish the level of significance of the difference between the two groups' ratings for each of the 5 statements. At the 95% confidence level, there was no significant difference between the two groups in any of the statement ratings (see **Table 24**).

Audit Impact Statement	Ua	Z	P(1)	P(2)
1	32	0.05	0.4801	0.9601
2	34	-0.16	0.4364	0.8729
3	37.5	-0.53	0.2981	0.5961
4	33	-0.05	0.4801	0.9601
5	24.5	0.74	0.2297	0.4593
For each test $N_a = 8$; $N_b = 8$				

Table 24: Mann-Whitney U scores for impact versus recipient location

Groups	Preferred audit stage			
	Performance under different browsing conditions	Performance when using different browsing and assistive technologies.	User evaluations with disabled people.	Recommendations for improving accessibility and usability.
Web developers (n=7)	1	1	1	4
Other (n=9)	0	0	2	7
Given audit to act on findings (n=8)	1	0	1	6
Other (n=8)	0	1	2	5
Univ. of Dundee (n=8)	0	n/a	2	6
Other (n=8)	1	1	1	5

Table 25: Comparison of preferred audit stages

7.1.7 Other feedback

Respondents were also invited to provide free text responses on any other aspect of the audit that they had not provided in previous questions. Additional responses were received from 7 respondents (44%). These comments are presented in **Table 26**.

Free text responses

1. “In some ways (and I wasn't around at the time) it seems that the audit is 'yet another thing for Web managers at our institution to read', when it's difficult enough already to get them to read/adhere to WCAG and our own Standards documentation. In other ways it marks out some crucial checkpoints which (if they were followed by all sites at our institution) would make for improved usability across the sets of content. In future it is likely to be used in best practice discussions, but removed from the 'bottom line' material for this reason.”
2. “In both cases, the software houses involved went on to modify the sites to comply with the requirements. They have also now included these as part of their standard approach to Web design for all their customers (subject, of course to specific requirements).”
3. “The audit has been an excellent resource in making major changes to the *(name removed to preserve commercial confidentiality)* University Web site. It also led to my employment as my team were not fully aware of Web accessibility and it's consequences before reading the audit report.”
4. “I now try to make any new pages I develop using semantic HTML and CSS for presentation, as this automatically deals with most Accessibility issues.”
5. “Excellent resource.”
6. “Really feel privileged to have such an audit on our website. It's never easy to get an evaluation of your Web work from people who actually know what they are talking about. I think it has also highlighted for me the resources within the university and possibly the lack of knowledge and communication between staff who are working in Web design within the university.”
7. “The report could have been better structured and written with an understanding of who might be reading it, i.e. people who perhaps are not fully aware of disability/accessibility issues and who may have little or no IT understanding. Considering your user doesn't just apply to computers but to anyone reading your documentation too!”

Table 26: Additional comments from respondents on the audit and audit impact

7.2 Evaluation of evidence of impact

Evaluation of evidence of the impact of each audit on the subject site concentrated on changes made to the subject site’s accessibility and to publicly available evidence of the recipient organisation’s accessibility strategy and policy.

7.2.1 Changes in accessibility of the subject site

Based on the brief evaluation method outlined in **Section 6.3**, the cumulative performance of each subject site, with respect to the level and quality of repairs made following the audit delivery, was graded on a five point scale: 4 (Excellent), 3 (Good), 2 (Adequate), 1 (Poor) and 0 (Very Poor). This rating, along with comments on changes made, is presented for each audited site in **Appendix 7**. Also presented in

Appendix 7 for each audit is the time lapse between audit delivery and subsequent review of the subject site. In all cases the latter review took place between 25 March and 5 April 2006.

7.2.2 Impact on accessibility strategy and policy

7.2.2.1 Audits 1a, 1b, 1c, 1d

For the large university site reviewed by Audits 1a, 1b, 1c and 1d, significant evidence was found of a proactive and widespread approach to accessibility, directly influenced by the audits provided by DMAG. In particular, a number of publicly available pages focusing on Web accessibility were found on the subject Web site. Most of the following pages were interlinked, allowing users to navigate directly between them.

- **Web Accessibility Statement:** a page providing information on the accessibility policy for the institution's central Web site, including details of alternative formats of information provided on the site, steps taken to enhance accessibility, and also justified instances of where WCAG checkpoints had not been met. This page was linked through an "Accessibility Statement" link present on the Home page and on all other pages visited of the institution's central Web site.

- The **University Accessibility Standard**: this page specified a minimum level of accessibility – with which "each page published by or hosted by the University" should comply. It also mandates a published accessibility statement for all university Web sites.

Accessibility related information was also provided within the university's online *Starting out with Web Communications* guide, written for Web managers, publishers

and content providers. Accessibility-related information included advice on: *Making Accessible Web Pages* – outlining legislative obligations, and introducing the University Standard mentioned above; *Writing Accessibility Statements*; *Usability Testing*; and a *Recommended Reading* list, including several books and Web resources on accessibility.

Specific mention was made of the DMAG audits on the Making Accessible Web Pages page. The accompanying information provided stated that the University Accessibility Standard was produced as a direct response to the recommendations contained in the audits. The audits, executive summary, and presentation given by a DMAG staff member after delivery of the audit were all made available for download on this page.

7.2.2.2 Audit 2

No mention was found on the subject site of any accessibility strategy adopted by the organisation providing the site; there was no information on the site accessibility, and no mention was made of the audit procedure.

NB This audit was delivered before the provision of prominent accessibility advice as part of site content was adopted as a high priority recommendation, so no explicit recommendation to provide an accessibility page had been made.

7.2.2.3 Audit 3

No mention was found on the subject site of any accessibility strategy adopted by the organisation providing the site; there was no information on the site accessibility, and no mention was made of the audit procedure.

7.2.2.4 Audit 4

This audit covered the extensive Web presence of a large university, which included a central institutional site and a number of sub-sites of varying appearance and functionality. The audit was delivered before the provision of prominent accessibility advice as part of site content was adopted as a high priority recommendation, so no explicit recommendation to provide an accessibility page had been made. Despite this, though, a link to an Accessibility Statement page was provided at the bottom of each page of the central institutional site, though a brief inspection of the sites of some University organisations indicated an inconsistent provision of an Accessibility page.

The Accessibility Statement page outlined the university's general commitment to Web accessibility and sets out technical standards that site Web pages should meet in terms of WCAG conformance. It also provided links to specific accessibility advice to site users through a page listing access key mappings and a page providing instructions on using browsers to change appearance of pages. Separate links, aimed at Web content providers, gave access to an outline of key accessibility issues, and technical guides on accessibility, including information on assistive technologies and accessible Web design. Much of this information was restricted to registered users, and was password-protected, so could not be reviewed[18].

A final link on the Accessibility Statement page led to a list of links to further information, both internal and external locations. This list included a link to a page providing a downloadable PDF copy of the DMAG accessibility audit plus

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[18] It is possible, but could not be confirmed, that the additional documents provided by DMAG as part of the delivery agreement would be available in this restricted-access area of the site.

supporting presentations given by DMAG staff. Other than this, no information about the audit process or its influence on institutional accessibility strategy was provided.

7.2.2.5 Audit 5

Audit 5 focused on a specific site within the University of Dundee's Web presence. When the site was audited, a Text only version of the site was noted. When the site was revisited, this remained the only accessibility related feature of the site – no information was a provided about the site's accessibility, or any accessibility policy, and no mention was made of the DMAG audit process.

7.2.2.6 Audit 6

Audit 6 focused on a specific site within the University of Dundee's Web presence. While the audit recommended provision of a dedicated accessibility page for the site under review, at the time of checking no such page was provided, and no other mention was made of the accessibility review process.

7.2.2.7 Audit 7

Audit 7 focused on a specific site within the University of Dundee's Web presence. The subject site did not have an Accessibility page at the time of audit; however the follow-up review found that one had been added, linked from each other site page visited during the review. The page concentrated on information supporting users in accessing and using the site, and identified the technical accessibility level to which site pages were expected to reach (WCAG Priority One). It did not mention the audit process.

7.2.2.8 Audit 8

Audit 8 focused on a specific site within the University of Dundee's Web presence. A link was provided to the main University accessibility statement at the bottom of each page in this site. This page outlined the general aims with respect to

accessibility of the University's Web pages. It also provided advice on optimising accessibility of site pages, access-key mappings, and also a generic list of known issues within the overall University Web presence. Mention was made on this page of the DMAG accessibility audit process, although no information was provided of actions taken as a result of the audit, nor was the audit document itself available.

7.2.2.9 Audits 9 and 10

Audits 9 and 10 were delivered at different time intervals to different (but related) organisations within the University – and the scope of the audits focused on different parts of what is effectively a single Web site. In terms of accessibility advice, the sites audited by Audits 9 and 10 shared a single Accessibility page, added after the audits had been delivered. This page was available from all other pages within the site; although since the link to the Accessibility page was provided in a frame separate to the main navigation frame and the main content frame, access to this page may be difficult in a browser that does not support frames

The information in the Accessibility page was a mixture of advice supporting users - including access-key listings and a link to a separate Web resource providing advice on using the browser to configure display; technical information on the site design. There was also an acknowledgement of the DMAG auditing process in evaluation and monitoring of the site's accessibility.

7.2.2.10 Audit 11

As recommended by the audit of the subject site, the existing Accessibility page was made more prominent, and was noted to be available on the Home page of the site. This page provided advice on navigating the site, accessing information in alternative formats and adjusting the size of the text, using the bespoke text size changing feature present on all pages.

A general statement was provided outlining a commitment by the organisation providing the site to “take the accessibility of this website seriously and aim to make it as easy to use as possible for all users”. However there was no mention of the audit process having taken place, nor was mention made of action taken as a result of the process.

8 Discussion

8.1 General summary of results

The survey of audit recipients indicated a generally favourable response to the audits, in terms of its perceived usefulness as an informative document, its impact in raising awareness of the issues surrounding Web accessibility, and as a motivational tool. Moreover, as would be expected, there was evidence of changes having been made to the vast majority of audited sites, and also evidence of increased prominence of organisational approach and improved policy relating to accessibility. However, there were several situations where recommendations presented by audits had not been followed, in some cases many months after the audit had been delivered.

8.2 Impact of audits and audit stages

A number of trends were identified from evaluation of the audit impact, both from survey responses and from action observed to have been taken in terms of changes to each audited Web site. These trends have implications on the nature and format of the audit and its delivery, but also offer insight into areas of further research with respect to education and awareness-raising of Web accessibility.

8.2.1 Preferred audit stage

Overwhelmingly, respondents' feedback indicated that the Recommendations were the most valued audit stage (11 out of 16 respondents, 69%). At first glance this would seem logical, given the role of the audit as a document describing problems with the subject site. The Recommendations, being a list of prioritised actions to be followed in order to overcome the problems, would therefore likely be seen by many respondents as being the indispensable section above all others of the audit report.

This is illustrated in the comments given to support the identification of the Recommendations as the most valuable stage:

> "Summary of what needed to be done in the different areas."
>
> "…provided a list of points which I could easily go through and pin point where in the site I had to make amendments. I was able to create action points for these and organise myself to meet these recommendations…also useful to have the recommendations divide into sections of what was really a necessity and some things that could improve the site."
>
> "It provided a sense of direction (in) which I could act in order to improve accessibility."
>
> "The information provided helped me to improve our websites for all users and gave guidelines on how to proceed with the recommendations."
>
> "Clearly identified the action required to implement enhancements. We used this to identify additional actions to be taken in response and the timeline within which this would be required."

These comments appear to reinforce the advice presented by Law *et al.* (2005, p24) – "give evaluation results in a form that programmers can use". It is noted, though, that not all recipients of the audits could be classified as "programmers".

The importance of the Recommendations as evidence to present to third parties with responsibility for the subject site or other resources under the control of the commissioning organisation was also clear from comments:

> "Useful lever to use with staff and in reports for committees."
>
> "It provided the evidence we required that the site did not comply with some of the customer's requirements."

The recommendations were presented with a rationale and selected instances of the accessibility barrier in question. However, recipients who have the perception that the crux of the audit document is the list of actions to be carried out may give less attention to, or even ignore, the rich narrative information presented prior to the recommendations. The likelihood that a "Eureka moment" may occur through reading a set of recommendations is expected to be low, in comparison to exposure to a real-world account of a disabled person interacting with a Web site.

The reasons given by respondents who valued other audit stages are revealing in this respect, particularly those who rated the User Evaluations with Disabled People stage:

> "At the end of the day theory and academic opinion is only useful if it can be tested and put into practice. A user who has no specific interest in either but has opinion based on their own personal experience can give a broader and rounder picture of what is what."

> "Gave an indication of what REAL people felt the issues were - IT personnel sometimes can't appreciate what these issues are as they are too close to the subject."

These responses indicate an appreciation of exposure to an account of the interaction of "real people" with the site; and in doing so expose an apparent lack of confidence in the ability of experts (the site developers *and* the auditors!) to comprehensively identify all actual problems present.

Survey respondents who received audits that did not include all DMAG audit stages were asked to indicate the likely value of the audit stages that had not been used in the audits they read. **Table 17** indicates a level of ambivalence towards the value of a

report of an automated accessibility assessment, and only a slightly higher value of the usefulness of a review of the site performance under different browsing and assistive technologies. This may be indicative of the relative ease with which the respondents feel they could have carried out these audit stages themselves, in particular the automated tool review.

8.2.2 Perceived role of the audit

The popularity of the Recommendations section amongst recipients is a clear indication of the perceived role of the audit, both by commissioners and readers. It is also illustrative of the potential conflict between the arguably idealistic approach of the audit providers as accessibility advocates and the understandably more pragmatic approach of the commissioning organisation (the customer) and the audit recipients. The latter group-includes those tasked with making the necessary fixes to bring the site up to an acceptable level, half the respondents (8) having been given an audit and expected to act on its findings (see **Table 14**).

The audit provider, as an accessibility advocate, would anticipate and expect the audit to engender long-term positive change in attitudes and approaches amongst Web site designers and content providers. On the other hand, the commissioning organisation is most likely to see the audit as an externally commissioned report listing actions to be carried out to improve the site in focus, such that it can reach a particular level of accessibility. As noted in **Section 8.2.1**, there was evidence to indicate that, for many respondents, one important attribute of the audit was that it was an externally produced, independent report on the subject site, and therefore "politically neutral", to paraphrase one respondent (see **Table 26**). Where rapid-impact evidence is required, a report that accentuates a list of required changes is

likely to be seen as more powerful than one where the list of recommended changes is less prominent than accounts of disabled people's interactions with the site.

For the commissioning organisation, and for many recipients, the long term impact of the audit as an educational and awareness-raising tool is likely to seem significantly less important than a list of required actions. As outlined in **Table 13**, the most important reasons for commissioning the audits were "to provide an independent assessment of the level of accessibility of the subject site" and "as part of steps taken towards ensuring compliance with the Disability Discrimination Act (DDA)". Actual understanding of the problems facing disabled people, and the value of the audit as an educational tool were seen as less important, although one would hope that these are recognised as integral to the audit by the audit commissioners.

8.2.3 Comparison of different groups of respondents

The comparison between groups of respondents in terms of perception of audit impact revealed some interesting trends.

8.2.3.1 Audit impact and level of accessibility expertise

It was hypothesised that audit impact would be greater on those with less expertise in Web accessibility than those with a higher level of expertise. Indeed, a significant negative correlation was found between expertise and impact rating on one of the five measures of audit impact - Impact Statement 3, relating to recipients' increased awareness of the importance of accessibility (see **Section 7.1.6.1**). This indicates that the audits were successful in their aim of raising awareness of accessibility particularly amongst those without significant accessibility knowledge.

This negative correlation between expertise and impact of the audit on awareness of accessibility issues is unsurprising if one considers the audit findings confirmed what

recipients with accessibility expertise already knew, rather than revealing novel observations. One respondent quote illustrates this neatly:

> "I knew about most of the rest of the findings before - and it was great to see how actual users dealt with the site - better than just my preconceptions of how they would cope."

As expected, the audits did appear to have been genuinely insightful to those without significant knowledge of accessibility, but perhaps more surprisingly also a number of respondents who considered themselves to have a degree of expertise in accessibility.

For all other measures of audit impact, however, no significant correlation was found between accessibility expertise and rating – measures that were generally more focused on awareness of specific attributes of the site, such as performance against best practice and in supporting usability for disabled people. This could be seen as an illustration of the phenomenon identified by Newell *et al.* (2006a, 2006b) whereby a technically capable Web developer may consider themselves a relative expert in accessibility through familiarisation with accessibility guidelines and design techniques, yet on reading the audit receives an exposure to a more 'human' insight into the issues present, in a way very similar to that received by a non-expert.

It should be stressed that this comparison used self-identified rating of expertise, and therefore there is a possibility that there may be a higher than apparent variation in actual - as opposed to assumed - expertise in Web accessibility amongst recipients. The level of accessibility for a particular respondent may therefore be over- or under-estimated, in absolute terms or relative to other respondents. It is also possible that for some respondents identifying themselves as having a high level of expertise, this level of expertise may have increased significantly since reading the audit, meaning

that its impact may have been more extreme than a respondent expert whose level of expertise has remained consistently high since receipt of the audit.

8.2.3.2 Audit impact and level of involvement in Web development

The second comparison involved dividing respondents into two groups, characterised by their level of activity in Web development. No significant difference was found between ratings of any of the 5 measures of audit impact given by Web developers and ratings given by 'non-developers' (see **Section 7.1.6.2**). This indicates that level of activity in Web development was not a significant factor in the impact of the audit.

Amongst Web developers, there was a large range in rating of the impact of the audit both on Impact Statement 3: awareness of the problems facing disabled Web users, and Impact Statement 4: awareness of the importance of Web accessibility in general. In both cases, the highest rating was 7 (totally agree) and the lowest 1 (totally disagree), although the median value for both statements was 6.5. This indicates a general trend towards a high positive impact in terms of awareness-raising even amongst full-time developers, with a small number of exceptions.

It should be noted that the group of Web developers was not identical to the group of accessibility experts discussed in **Section 8.2.3.1**. The findings above provide a reminder that expertise in Web accessibility should not yet be assumed to be a characteristic of all full-time Web developers.

The impact statement ratings of those who did not identify themselves primarily as Web developers were generally high (medians ranging from 4.5 to 6.5), the lowest median rating being that of Impact Statement 5, relating to motivation to further one's knowledge in Web accessibility. Given relative lack of involvement of this group of respondents in Web development, they may be less inclined to devote time

to research the subject further. Interestingly, despite the high ratings given by non-developers, one Web developer who also identified themselves as having expertise in accessibility, indicated their belief that the audit could be improved in presentation of information to non-experts (see comment in **Table 26**).

8.2.3.3 Audit impact and circumstances under which audit was received

The third comparison considered circumstances under which the recipient received or acquired the audit, in particular whether they were expected to implement the recommendations present, or whether they were more likely to receive or acquire the audit as a document for reference.

It had been anticipated that those audit recipients who were given the audit and told to act upon its findings and recommendations may have a particularly negative reaction towards the audit, viewing it with suspicion or hostility, given the nature in which they came to be aware of its existence. For some recipients, it was thought that there may even be the possibility that the audit was seen to be attacking the quality of their work and, by extension, their professionalism. However, the results presented in **Section 7.1.6.3** show that, between the two groups, there was no significant difference in impact ratings for any of the 5 impact statements.

This could be taken as a positive reflection of the nature of the audit, in that it overcame any potentially adverse impact that might have been expected from a report produced by an external agency, without the knowledge of those recipients expected to deal with its findings.

8.2.3.4 Audit impact and relationship of recipients to DMAG

The final division of respondents compared those who were employees of the University of Dundee, and therefore effectively colleagues of the audit team, and those who belonged to organisations independent of the University. Once again,

there was no significant difference between the two groups in any aspect of audit impact rating (see **Section 7.1.6.4**).

This suggests that relationship of the auditors to the recipient organisation does not significantly influence the impact of the audit on individuals. So, whether the auditors are part of the same overall organisation as that of the recipients, or whether the relationship of the auditors to the recipients is that of a service provider and customer, audit impact would not be significantly different.

8.2.4 Comparison of preferred audit stages

Table 25 summarises the preferred audit stages of respondents from each group discussed in **Section 8.2.3**. Results indicate that for each group chosen for comparison, there is little difference in preferred audit stage. As noted in **Section 8.2.1**, the Recommendations for improvement was the most favoured audit stage across all groups.

8.2.5 Impact on individuals

In additional to general indications of impact with respect to awareness of, and approach to Web accessibility, several individuals gave specific examples of where the audit had influenced their approach to Web design. These included an adjustment to technical approach to accessible design:

> "I now try to make any new pages I develop using semantic HTML and CSS for presentation, as this automatically deals with most Accessibility issues."[19]

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[19] This comment appears to betray the very assumption the audits are intended to challenge – namely that application of specific technical approaches is sufficient to ensure optimal accessibility.

Additionally, 4 (25%) of the respondents to the survey had actively sought out the audit, either by requesting a copy (2 respondents), or finding and reading a copy that was published on an organisation intranet (2 respondents). One such recipient explicitly indicated that the audit was of use in informing their work on other sites:

> "(the audit)…contained pointers on changes that I could also make to my site, of which I was previously unaware of their importance."

The value of the audits in providing generic advice that could be applied in other situations was echoed by another comment outlining the usefulness of the recommendations:

> "…it is possible to apply these recommendations to sites and materials where I am responsible for their production."

Despite this positive feedback indicating that most recipients considered the audit had had a positive impact on their awareness and approach to accessibility, particularly those identified as non-experts, it is difficult to judge whether any recipient could have experienced a "eureka moment" as described by Petrie *et al.* (2006) and Newell *et al.* (2006a).

8.2.6 Impact on organisations

Both the survey of audit recipients and the review of subject sites revealed that the audits appeared to have instigated some changes in approach to accessibility by the recipient organisation. Specific examples of where there is evidence of the impact of the audit on organisational approach and strategy include:

- The provision of a dedicated Accessibility page or pages on the subject site (7 sites)

- The influence of the audit recommendations on the creation of an in-house Web accessibility standard to which all internal material published online should conform (1 site);
- Presentation of audit findings by the recipients to third party development teams for action; these development teams had subsequently adopted the recommendations as in-house standards (2 sites)
- The creation of a dedicated staff position dealing with Web accessibility (1 site).
- The use of the audit to generate a staged action plan for improving the subject Web site, and/or for monitoring progress. (2 sites)
- Publication of the audits on the organisation Web site as part of resources supporting development of optimally accessible Web sites (2 sites).

This is encouraging, given that for most audits in the sample, the provision of information relating to the accessibility of the subject site was presented as a high priority recommendation. The exceptions were Audit 8, where the subject site already provided an Accessibility page; and Audit 2 and Audit 4, both of which were delivered before the recommendation to include an accessibility page, if one was not provided, became standard practice in DMAG audits[20]. Even so, the subject site of

[20] The provision of an accessibility page providing support for people who may need accessibility related advice, such as help on changing the appearance of the site for accessibility reasons, plus an outline of organisational accessibility strategy, is not a W3C WCAG checkpoint. Nevertheless, the anticipated positive benefits of such a page on usability for disabled people justifies its inclusion as a DMAG recommendation.

Audit 4 provided a series of pages focusing on accessibility, despite the absence of this action as an explicit audit recommendation.

One respondent, from the University of Dundee, also noted the potential impact of the audit on current organisational support for accessibility:

> "Really feel privileged to have such an audit on our website. It's never easy to get an evaluation of your Web work from people who actually know what they are talking about. I think it has also highlighted for me the resources within the university and possibly the lack of knowledge and communication between staff who are working in Web design within the university."

Contrasting with the positive measures of impact described above, the review of subject sites also found areas where accessibility barriers remained, despite the explicit identification of these barriers as specific points for action by the audit. In some cases, the barriers appeared to have had no attention, while in others, attempts had been made to address the barriers, but in the judgement of the present author had fallen short of a true accessibility fix. In particular, despite the recommendations of the audit, there were several instances of alternative text supplied for graphics where the text did not enhance non-graphic usability, as it either failed to convey the meaning of the graphic, or added unnecessary repetition to adjacent text on the page.

Surprisingly, some of the sites in question were identified in survey responses as being examples of where positive action had taken place. The most extreme examples were Audits 2 and 3, where the review of progress found very little evidence of positive changes having taken place. Yet one survey respondent responsible for commissioning Audits 2 and 3 stressed the role of the audits in conveying to the site developers that the sites were deficient at the time of the review, and indicated that action had been taken to address these deficiencies:

> "In both cases, the software houses involved went on to modify the sites to comply with the requirements."

This finding is of some concern. It may be seen as a sign that, despite best efforts, the audit content did not adequately explain the work required to implement the recommendation. Alternatively, it is possible that the respondent was not in a position to confirm that claimed improvements had in fact been satisfactorily made, when evidence indicates that they had not.

While some audits appear to have been commissioned for formative purposes, before or early in the redevelopment or replacement of a site, to allow identification and correction of accessibility problems before repair becomes too costly, others were commissioned for summative purposes, for example the University of Dundee audits (Audits 5-10). In the latter case, the timing of the audit would be independent of any redesign or development work planned by the recipients, and therefore action may be delayed until a suitable time unless action was mandated by the commissioning organisation – it was not known whether this scenario applied to any of the audits in the sample.

A final explanation may be that for some Web developers, accessibility remains of lower priority than competing objectives. The challenge of persuading busy Web developer colleagues to take note of the audit and its recommendations is highlighted by the response of one recipient:

> "In some ways (and I wasn't around at the time) it seems that the audit is 'yet another thing for Web managers at our institution to read', when it's difficult enough already to get them to read/adhere to WCAG and our own Standards documentation. In other ways it marks out some crucial checkpoints which (if they were followed by all sites at our institution) would make for improved

usability across the sets of content. In future it is likely to be used in best practice discussions, but removed from the 'bottom line' material for this reason."

8.3 A critical assessment of the study

8.3.1 Strengths

The particular strength of this research, it is argued, is in its nature as a study of the impact of a series of commercial accessibility audits, each commissioned on a contractual basis by an organisation actively seeking information on the accessibility of their Web content, and each generated using a methodology that has been acknowledged as being sound and appropriate for purpose (as discussed in **Section 5**). A literature review revealed no comparative study of audit impact over time.

Thus, in contrast to a formal experimental investigation that might involve the tracking of a set of artificially-generated audits distributed to a sample of recipients, each audit in this study has been commissioned, delivered and received in a genuine commercial context. It would therefore seem reasonable to argue that the circumstances under which the audits were requested and their impact on the recipient organisation is a genuine representation of the way in which audits may be requested and received within the sectors represented by the organisations who received the audits in the study.

The diversity of backgrounds of respondents, circumstances behind the audit's commissioning, and the variations in time interval between audit delivery, receipt by respondent, and period of research all add to the richness of data collected in the survey. This diversity is reflected in the variations in impact, in terms of actions taken and identified changed in knowledge and awareness of recipients.

8.3.2 Constraints

Gray and Salzman (1998) notably identified a number of significant challenges to the validity of the findings of several previous prominent studies of usability evaluation methodologies. It is therefore necessary to emphasise that the very nature of this research did not lend itself to the production of data on which statistically significant and generalisable conclusions on methodology effectiveness can be drawn. In particular, the commercial nature in which the work was carried out not only meant variations in application of the methodology across different audits, but also that once audit delivery and any other contractual commitments were complete, the dialogue between DMAG and the client tended to cease, as both parties moved on to other activities.

A measure of impact at an organisational level has been established through recipient feedback and from a *post hoc* inspection of the subject Web site and other sites representing the organisation commissioning the audit. It was not possible to empirically measure the change in knowledge and understanding of accessibility amongst recipients since they read the audit or to confidently isolate and quantify the influence of the audit on subsequent work carried out by individual audit recipients.

Some specific limiting factors on the generalisability of the research findings were also identified.

8.3.2.1 Survey distribution and response

Although the total number of survey respondents was small (n=16), it was not possible to know the total number of individuals who read each audit, and thus not possible to calculate or even estimate the response rate. A specific limitation was the reliance on the initial key contact to forward to all potential recipients in the commissioning organisation the invitation to complete the survey.

8.3.2.2 Bias amongst respondent organisations and individuals

The majority of sites reviewed were those of academic organisations; the remainder were public sector initiatives (one relating to motor insurance, the other a public health information site). Two major DMAG clients did not respond to the survey invitation - one was a large university and the other a Web design agency producing Web sites for private and public sector organisations.

Thus, the sample size and nature does not allow for formal comparisons across different sectors, and it is also possible that this introduces bias into the sample of audits and audit recipients. Surveys have found that public sector, governmental and academic Web sites have on average reached higher levels of accessibility than those of private sector commercial organisations (for example as reported by Jackson-Sanborn *et al.* 2001; Loiacono and McCoy 2005; and Hackett *et al.* 2005). The influence of legislation and policy relating to the avoidance of undue discrimination within the public sector has been cited as the main reason for this difference in performance.

It is also possible that individual audit recipients most likely to respond were those who have a particularly strong interest in accessibility, and thus be more positive in reporting impact of the audit. However, they may also be more likely to provide a critical assessment of the audit, rather than praise it unreservedly.

8.3.2.3 Variation in time between audit delivery and impact assessment

The time lapse between audit delivery and impact measurement allows a longer-term analysis of the impact of the audit over time, in contrast to a more immediate follow-up that may not allow the organisation to implement planned changes. However, it also increases the likelihood that other factors may also have influenced approaches and attitudes to accessibility.

8.3.2.4 Influence of other accessibility awareness-raising activities

Some recipient organisations commissioned DMAG to give on-site presentations relating to Web accessibility soon after audit delivery; others arranged for face-to-face consultations between the recipients and DMAG. This may have had an influence on the awareness and understanding of accessibility amongst those survey respondents who did attend.

In addition, during the period in which the study took place, the prominence of accessibility as an issue has increased. This has led to been an increase in availability and quality of other instructional resources, which may also have influenced knowledge of survey respondents. It should be noted, however, that no mention was made of the influence of other resources by any respondent.

8.3.2.5 Subsequent activity of audit recipients

Not all survey respondents were directly involved in the development, management or content provision of subject site. This was anticipated to a certain extent, as audits are written to be of interest to readers with a general interest in accessibility as well as specifically supporting those involved in the subject.

The impact of the audit on individual readers may vary from respondent to respondent, depending on their involvement in the subject design. Additionally, some respondents may not have carried out any Web development work, or otherwise had a chance to demonstrate any increased awareness or understanding, between reading the audit and completing the survey.

8.4 Changes to Evaluation Design

Reflection on the research described above has led to the identification of a number of changes to the evaluation methodology which would facilitate more formal evaluation of the audit impact. These are outlined below:

- **Formal monitoring of audit distribution.** This could be recorded by asking the key contact of the recipient organisation to explain the internal dissemination strategy of the audit. This could include an estimate of the number of potential individual recipients of the audit (including those to whom the audit was given and those who would otherwise have access).

- **Scheduled surveys of audit recipients.** Again, through the key contact, a formal invitation could be issued to audit recipients to complete a short survey similar to that described in **Section 6.2**. To enable maximum return, this could be repeated, for example one month after audit delivery, and then again one year after audit delivery. This would enable a longitudinal measure of impact and distribution for each audit.

- **Monitoring of impact on individuals.** An obvious activity, but likely to be impractical in most commercial situations, would be to test recipients' acquired awareness and skills in accessible design, for example through an on-line quiz. Another option would be to ask audit recipients to nominate another Web site, the appearance and functionality of which they had had a significant influence upon. Even so, there is a possibility of bias in that respondents may nominate a site they consider to have the most obvious accessibility 'qualities'.

Such changes would not, however, clearly identify any occurrence of a "Eureka moment" and its influence on an individual. This can only be identified through respondent feedback combined with an assessment of the progress made by the respondent in work carried out since the "moment", as was performed in this research.

8.5 Areas for further research

There has been an ongoing debate about the relative merits of different accessibility evaluation methodologies, and the impact of multiple, diverse methodologies for assessing and declaring accessibility. Unlike the present research, this work has generally focused not on the impact of the findings, but on the degree to which a particular methodology or combination of methodologies successfully identifies the greatest proportion of the true accessibility barriers that exist in a site. It is suggested that more attention on optimising the effectiveness of audit impact on recipients is required, and this research indicates a number of possible areas of investigation.

8.5.1 Audit Reports without Recommendations

The proposals of Law *et al.* (2005) laid bare the conflict between the accessibility evaluation report as a set of 'quick-fix' instructions that programmers may actually be able and willing to act upon, and the educational and experiential potential as proposed by the current author. In discussing usability reports, Jeffries (1994) similarly emphasised the importance of providing the information that those developing the resource need in order to make the necessary changes.

While Law *et al.* imply that the rich observational material from which recommendations are generated should be omitted from the report given to

developers[21], this is diametrically opposed to the concept proposed by Newell *et al.* (2006b) that assumes a true understanding of accessibility can only be achieved through a more qualitative exposure to disabled people's interactions with a Web site. More generally, there is also debate as to whether the generation of recommendations should be the outcome of a usability evaluation method (Karat 1994).

Taking the position of Newell *et al.* to an extreme, the recommendations arising from an accessibility audit become the *least* significant and least powerful aspect of the document, as they may be treated as a short term solution. Instead, a report that concentrates on the experiences of disabled evaluators and experts in using the site in context gives the programmer an opportunity to gain an insight into accessibility to the extent that they can use their design expertise to apply the necessary changes, with guidelines to help them, rather than instruct them. At the same time, for less experienced Web developers and content providers, exposure to these experiences will also enable more informed application of accessibility guidelines.

Such a review may be impractical for some situations, particularly when an audit is commissioned with the explicit aim of providing a summative evaluation of an interface, such as a conformance review. User evaluation with disabled people is a slow way of informing a design team of the issues present in a system (Coyne and Nielsen 2001; Mankoff *et al.* 2005a; Petrie *et al.* 2006). However, in more formative environments, where the design team may benefit from a general improvement in understanding of the issues, the recommendation-free audit may have a more positive impact. Thus, a possible extension of the work described in this thesis could be to

[21] Law *et al.* do suggest that this material be made available should the recipients request it.

compare the impact of accessibility audits provided with and without recommendations.

A suggested methodology might be:

1. Carry out an accessibility review of a Web site, using the DMAG methodology described in **Section 4.4**.
2. Provide an audit report consisting only of recommendations to a group of *n* developers.
3. Provide an audit report consisting of evaluation stage findings but with no recommendations to another group of *n* developers.
4. Ask each developer to improve the accessibility of the Web site that was the subject of the audit.
5. Assess the quality of changes made by each developer.
6. Repeat Steps 1, 4 and 5 after a period of time, using a different subject Web site (this time developers are not provided with an audit).
7. Assess the quality of changes made by each developer.
8. For each developer, compare the results of Step 5 with Step 7.
9. Compare performance of the two evaluator groups.

Given the multi-faceted nature of 'Web development', of particular interest would be comparisons of audit impact between those whose primary role is in traditional 'development'- i.e. using programming skills to create applications, those whose role is more oriented towards graphic design and visual identity, and those whose role is to provide content for online publication.

8.5.2 An evaluation method for non-experts

Comprehensive accessibility auditing methodologies such as the DMAG methodology can require time and expertise which may make them challenging to apply for many individuals and organisations (Diaper and Worman 2003; Paddison and Englefield 2003; Brajnik 2005a). Yet there is value in supporting non-experts in conducting usability and accessibility evaluations that can help to improve the quality of their work (Chevalier and Ivory 2003).

In the DMAG methodology, the two evaluation methods most likely to result in a "Eureka moment" are observation of disabled evaluators interacting with the subject Web site, and to a lesser extent exploration of the site under specific restricted browsing conditions using simulation tools such as those suggested by, for example, Lauke (2005). In each case, the key to effective data gathering is to record the experience, and only then should guidelines be consulted to establish what design decisions are required in order to make the necessary changes. However, each stage has significant educational value to a reader, merely as stand-alone accounts of experiences in using the site, rather than precursors to a set of required design decisions.

This is in line with the argument presented by Wixon (2003), who argued that a realistic approach to researching effective usability evaluation is to develop methods that maximise the use of an organisation's available resources; and that a case study approach is the most practical and effective way of applying usability. In their book on Web accessibility, Slatin and Rush (2002) use case-studies in the form of 'user experiences'. Chapters on the arguments for accessible design are interspersed with real-world accounts of experiences of accessibility problems encountered by one of the authors, Slatin, who is visually impaired.

By emphasising the experiential methods within the DMAG methodology, the case-study approach can be applied, and the resultant audit can serve as a case study. The audit thus has long term value even for readers who were not involved in the site under review, or who joined the design team at a later date. Therefore there is potential value of an investigation into the effectiveness of using reports generated by non-experts and consisting of the two audit stages mentioned above. The addition of the accessibility walkthrough proposed by Brajnik (2005b) may also be considered as a third audit stage. This may, in a way similar to the research outlined in **Section 8.5.1**, establish the cost-benefit of in-house accessibility reviews in which the primary aim is to raise awareness amongst all those responsible for developing and authoring Web content.

8.5.3 Using audit findings as a basis for theatrical representation of results to Web authors

Continuing the "audit as a case study" concept, the experiences documented in audits may have potential as the basis for dramatisation, for presenting to audiences of Web developers and content providers as a theatrical presentation. Newell *et al.* (2006b) discussed the impact of the Utopia Trilogy of videos, each based on observed experiences of user/technology interaction. The suitability of a Web accessibility audit as a similar source of material, and the challenges of turning that into a theatrical production that can genuinely aid understanding amongst Web authors within an organisation, could provide the basis of another research study.

This production could then accompany other audit stage findings in a multimedia Web accessibility audit report, supplementing or even replacing the traditional textual report provided to subjects in this research.

8.6 Conclusion

The study assessed the Web accessibility audits produced using the DMAG methodology and found evidence that they:

1. accurately reported accessibility barriers present in a Web site and described how to overcome them;
2. improved the understanding of commissioning organisation and individual readers as to how disabled people interact with the site, and how information, functionality and intended experience of the site can best be provided to people with specific impairments.

The study focused on a series of commercially-commissioned accessibility audits, and produced a very rich set of data taken from a real world context. In contrast, a more academic study may have produced more statistically robust data but may not have accurately reflected the true impact of the audit when received by an organisation as part of a genuine business-to-business transaction.

There is clear evidence that individual recipients of the audits have valued its contribution to their awareness and understanding; there is also clear evidence of action being taken by commissioning organisations after the audit was received. This has included the formulation by one organisation of an internal Web standard based on the audit recommendations, and the creation by another organisation of a specialised Web accessibility post.

A significant negative correlation was found between respondent expertise in Web accessibility and audit impact in terms of awareness of accessibility as an issue, providing evidence that the audit was of particular educational value to non-experts. Other than that, no significant correlation was found between any aspect of audit

impact and expertise in accessibility. Likewise, when respondent impact ratings were compared based on respondents' levels of involvement in Web development, circumstances under which they received the audit and relationship with the auditors (DMAG), no significant differences were found in terms of audit impact.

While responses from recipients indicated a positive impact on awareness and knowledge, an independent assessment of impact would be extremely difficult, particularly in establishing the extent to which an individual may have encountered what Petrie *et al.* (2006) referred to as a "Eureka moment". The popularity of the Recommendations section, at the expense of sections describing the experiences of disabled people interacting with the site in particular, suggest that the perception of the accessibility audit remains that of an external review, listing problems and solutions, rather than as a rich, educational resource.

A number of possibilities for future work have emerged. An engaging and illustrative account of an accessibility evaluation could have potential in raising awareness and understanding of accessibility, as a cost-effective surrogate of richer, but more difficult to arrange experiences such as video presentations or theatre performances. A combination of both, possibly delivered as a multimedia audit report, could be particularly powerful. These activities seek to explore how the apparent demands of audit recipients for a "list of things to be done" could be balanced with a document that would be a cost-effective - if less high-impact - method of creating the "Eureka moment" amongst designers, which appears so crucial to true understanding of accessible design.

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Appendix 1: Common Accessibility Barriers

The following general Web accessibility barriers are based on the checkpoints of the W3C Web Content Accessibility Guidelines (W3C 1999).

- Failure to provide information or functionality in equivalent alternative formats for graphics or multimedia.
- Functionality such as navigation or data input that makes operation with an input device other than a mouse difficult or impossible.
- Reliance on colour as the only way of presenting information.
- Use of text and background colour combinations with insufficient colour contrast.
- Provision of flickering or flashing content at a frequency between 2 and 59Hz.
- Failure to allow user-control over page display or behaviour.
- Failure to provide information in a way that supports easy access to and understanding of page content by the intended audience.
- Failure to use appropriate structural HTML to enable alternative browsing devices to effectively represent page content.
- Failure to use appropriate graphic or multimedia content to enhance and illustrate textual content.
- Failure to identify the natural language of pages, and any changes in natural language within page content.
- Failure to use appropriate Web technologies and to meet appropriate Web standards.

Appendix 2: Research and development in Web accessibility

Supporting disabled Web users

Work in developing tools to enable and enhance the browsing experience for disabled people has concentrated on two key areas – developing assistive technologies to enable access, and developing solutions to transform Web content into the most appropriate format for a disabled person's specific needs.

Access technologies

Much activity has taken place in developing solutions that, in combination with or in place of 'conventional' applications required to access the Web, can reduce or remove the impact of a disability on the ability of the user to access and process online information (Paciello 2000, Clark 2003a). This can range from access solutions provided at operating system or application level, such as controlling on-screen text-size or configuring mouse behaviour (Gregor *et al.* 2005), to dedicated software and hardware solutions that work alongside or instead of 'conventional' browsing technology (Paciello 2000; Clark 2003a).

Much activity has focused on developing browsing technology for enabling audio output of Web content, supporting access for people who have severe visual impairment or who are blind. This has generally been achieved either through the combination of a generic screen reader (Thatcher 1994; Raman 1996), such as JAWS from Freedom Scientific or GW Micro's Window Eyes (Thatcher *et al.* 2002), with a standard browser; or the creation of a dedicated speech browser for enhanced non-visual interaction (Asakawa and Itoh 1998; Morley *et al.* 1998; Zajicek *et al.* 1998;

Ramakrishnan *et al.* 2004). Other research has concentrated on enhanced audio output of complex features within Web pages, such as data tables (Pontelli *et al.* 2002; Yesilada *et al.* 2004).

The potential of text-to-speech output of Web content for people who can see but have difficulty reading on-screen text has also been identified. Several applications exist specifically to extend a 'standard' browser's functionality by offering on-the-fly text-to-speech conversion – saving authors from recording audio versions of their Web pages. Readspeaker[22] and Browsealoud[23] are examples of commercial solutions that allow Web site providers to enable users to listen to an entire page or selected page text. The Web Adaptation Technology (Hanson 2004; Hanson and Richards 2004; Richards and Hanson 2004; Hanson *et al.* 2005), and the Accessibar extension[24] for the Firefox browser both allow user access to audio with no requirement of the content author to adapt their pages. Some browsers, such as Opera[25], now offer a text-to-speech solution as standard, or part of a browser's functionality.

Real-time tactile representation of Web content is also possible through for example refreshable Braille displays (Paciello 2000), tactile browsing devices (Rotard *et al.* 2005) or force-feedback pointing devices (Yu *et al.* 2005).

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[22] Readspeaker: http://www.readspeaker.com

[23] Browsealoud: http://www.browseealoud.com

[24] Accessibar extension for Firefox: http://accessibar.mozdev.org/

[25] Opera: http://www.opera.com

The use of speech as a means of **input** has been identified as having potential for enhancing navigation of Web content for people with low vision or with severely limited manual dexterity (Curran *et al.* 2004), or access to and interaction with Web content is possible via a telephone (Zajicek *et al.* 2004). Many other alternative input devices have been developed to support people who because of severe physical disability find it impossible to use a conventional keyboard and mouse set-up and (Doherty *et al.* 2000; Paciello 2000; Mankoff *et al.* 2002; Clark 2003a).

Tools for transforming Web content

Even with the presence of the necessary assistive technology or accessibility solutions at the user end, the design of Web resources may cause significant problems. The obvious solution is to redesign the Web site to improve its accessibility. This however requires the site providers to be aware of the issues and to take the necessary steps to resolve them, which may in some cases require significant amounts of time and expense that may result in the task being seen as undesirable (Richards and Hanson 2004), despite the benefits outlined in **Section 2.1**. Consequently, some researchers have looked to provide a more immediate means of addressing this problem by developing tools that bypass the page author or developer, and ultimately aim to improve the accessibility of the page by restructuring or repurposing the HTML content.

Some work has concentrated on automating the task of repurposing or adding to existing Web content (alternatively referred to as ‘transcoding’ or ‘transforming’). This generally involves an intermediary (proxy) server which analyses the underlying HTML of the page requested by the user, and may remove non-essential code or potentially problematic features, add new code, alter the page’s visual

appearance and/or reorder content, before returning the page to the browser (Brajnik *et al.* 2005). As they may improve a page's display, navigation, information flow, logic or orientation, transformations may be aimed at a range of users, but are often specifically targeted at people browsing with a limited, or no visual channel, in particular for people with no functional vision (Brajnik *et al.* 2005).

For example, Asakawa and Takagi (2000) described the use of a proxy server to process structural and descriptive annotations, labelling areas of page content to enhance non-visual understanding, while Mirabella *et al.* (2004) proposed a system to allow teachers to annotate Web-based learning resources to facilitate accessibility transformations. Others have looked to support the use of real world navigation techniques used by blind people to improve mobility online, through adding cues to pages to aid navigation and orientation (Goble *et al.* 2000; Yesilada *et al.* 2004).

Researchers at IBM have also explored ways in which a proxy server can be used to apply transformations of Web content for enhanced accessibility (Fairweather *et al.* 2002). More recent work has refocused on extending browser functionality to enable direct transformation of the page's display for example by adjusting text size and hyperlink appearance (Richards and Hanson 2004; Hanson and Richards 2004; Hanson *et al.* 2005).

The concept of the Semantic Web has moved from a vision (Berners-Lee 1999) into an active area of research and development, "provid(ing) a common framework that allows data to be shared and reused across application, enterprise, and community boundaries" (W3C 2004). It has also been the motivation behind extending the principle of transformation of Web content for accessibility purposes to enhancing the accessibility of knowledge and concepts present online (as opposed to simple page content). For example Huang and Sundaresan (2000) developed a system to

allow transcoding of Web content "based on semantic rather than syntactic constructs", supporting consistency of common task completion across multiple sites, while Mukherjee *et al.* (2004) discussed a system to enable *semantic bookmarking* – bookmarking of concepts and tasks in a domain rather than a specific page. Harper and Bechhofer (2005) proposed a system, using Semantic Web technologies, that supports designers in adding semantic information necessary to enable visually impaired users to gain effective access to the meaning of a Web page.

Seeman (2004) outlined the potential of using Semantic Web technologies to enhance access for people with learning disabilities, by providing annotations to Web content to enable transformations of information and concepts present to a more accessible format for those who may have difficulty processing written content. People with communication difficulties, who may use symbol-based augmentative and alternative communication (AAC) systems, may benefit from effective translation of textual content marked up in HTML content into a specific AAC system, such as the Concept Coding Framework project, which is investigating how RDF (Resource Description Framework) can be used to provide a common framework to facilitate translation of content between AAC systems (Judson *et al.* 2005).

In an alternative approach to supporting Web access for blind people, James (1998) described efforts at developing audio HTML interfaces to enhance the quality of non-visual browsing – augmenting text-to-speech output of page content with appropriate sounds to facilitate browsing and feature recognition.

Some work has looked at supporting accessibility through user-profiling, where a user's accessibility requirements are stored in a machine-readable format and used to influence the output of the requested Web page (for example Dhiensa *et al.* 2005).

Nevile (2005) outlined the potential of a standardised way of describing a user's accessibility needs and a similar standardisation of the description of a resource's accessibility features and limitations in ensuring users receive resources appropriate to their needs. A collaboration led by the IMS Global Learning Consortium have produced AccessForAll metadata specifications[26] for user needs and resource features, and work is ongoing on developing this framework into a formal set of standards (Nevile 2005).

Supporting Web designers, developers and content authors

From the perspective of Web designers, developers and content authors, significant developments have taken place in the number and capability of tools and resources available to support the provision of optimally accessible Web content. These have ranged from the production of design guidelines, promoting best practice in accessible Web design to development of tools supporting authoring of accessible Web content and tools to aid accessibility evaluation.

Guidelines

The most prominent set of guidelines supporting Web designers and authors in creating optimally accessible Web content, and providing a *de facto* standard against which accessibility can be measured, is the World Wide Web Consortium (W3C) Web Content Accessibility Guidelines (WCAG). Version 1.0 of the WCAG was published in 1999 (W3C 1999), and version 2.0 remains in draft at the time of writing. The W3C's approach to accessibility recognises that Web content authors

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[26] IMS Global Learning Consortium AccessForAll metadata specifications: http://www.imsglobal.org/accessibility

and designers cannot be solely responsible for ensuring optimal accessibility (Chisholm and Henry 2005), and the W3C's Web Accessibility Initiative has thus developed additional sets of accessibility guidelines:

- for developers of browsers, assistive technologies and media players, the User Agent Accessibility Guidelines (UAAG) (W3C 2002a).
- for developers of the tools used to create Web content , the Authoring Tool Accessibility Guidelines (ATAG) Version 1.0 was published in 2000 (W3C 2000); Version 2 is in development at the time of writing.

The WCAG maintains the highest profile of all Web accessibility guidelines, and is directly referenced to, or influences, accessibility legislation and standards around the world (Thatcher *et al.* 2002; W3C 2005c), and in specific sectors – for example in the e-learning sector, the IMS Accessibility Guidelines apply the WCAG accessibility principles to the design of e-learning resources (IMS 2002). The UK's Royal National Institute of the Blind (RNIB) developed the See it Right Standard against which it audits Web sites for accessibility, using what is effectively a subset of the WCAG checkpoints:

> "set(ting) a standard of accessibility exceeding WAI single 'A' and close to WAI 'AA'. As well as requiring compliance with WAI priority one checkpoints, the requirements for gaining our Accessible Website logo incorporate a range of priority two and three checkpoints which have particular relevance to users with sight problems." (RNIB, 2005a)

Other relevant standards also exist. In the United States, the Section 508 Electronic and Information Technology Standards include §1194.22, *Web-based intranet and internet information and applications*, the standard used to define compliance by

Web sites with Section 508 of the Rehabilitation Act. The content of §1194.22 is similar to, but not identical to WCAG (Thatcher et al. 2002, pp345-349).

The international standard ISO/TS 16071 deals with accessibility of human-computer interfaces, defining accessibility as the "usability of a product, service or environment or facility by people with the widest range of capabilities" (ISO 2003). In March 2006, the British Standards Institute published a Publicly Available Specification (PAS 78) on commissioning accessible Web sites – targeting the procurement of accessible Web sites rather than the design process (BSI 2006).

Alternative guidelines to WCAG also exist, and these are commonly more explicitly research-based - often presenting the evidence behind each guideline as part of the guideline document, and introducing guidelines addressing usability issues relating to the user group under observation. For example, Coyne and Nielsen developed guidelines generated from observations of user trials with disabled people (Coyne and Nielsen 2001) and similarly with older people (Coyne and Nielsen 2002); Theofanos and Redish generated guidelines based on observation of screen reader users working with Web sites (Theofanos and Redish 2003); while work by the same researchers, observing people with low vision, identified a more diverse set of needs and hence a more fluid set of design requirements for this user group (Theofanos and Redish 2005). Morrell *et al.* (2004) used a literature review to generate a set of accessibility guidelines for the design of Web sites for older people, arguing as they did so that existing accessibility guidelines such as WCAG were overly generalistic. Kurniawan and Zaphiris (2005) produced guidelines for accessible Web design for older people, first based on a literature review and then evaluating the relevance of each guideline with a group of older Web users. The US Department of Health and Human Service's National Cancer Institute produced a set of research-based Web

design and usability guidelines, including a section specifically devoted to accessibility, with each guideline present ranked based on an expert review of the strength of existing evidence supporting each guideline (Koyani *et al.* 2003).

Resources and tools

The profile of accessibility within the Web design industry has been raised, particularly at grassroots level, through its adoption as a core part of the "Web Standards" movement (Zeldman 2003). This has led to an injection of innovative practice in Web design techniques that attempt to maintain accessibility while enhancing visual look and feel (Regan 2004, Meyer 2005).

These developments have been diverse in nature and goal, for example:

- methods to enhance intra-page navigation for people unable to use a mouse, through "skip links" (Thatcher 2002);
- display customisation to enable large print styling of pages (Clark 2005a);
- the provision of extra text to aid page understanding, intended only to be spoken by screen-readers, and invisible to sighted users (Bohman and Anderson 2004).
- the use of Macromedia Flash to provide enhanced typographic quality while maintaining structural validity and accessibility in non-visual browsing environments (Davidson 2005).

The growing importance of accessibility as an issue in Web design is shown by the increase, in the last 6 years, of printed and online resources devoted to the subject. Several books deal specifically with Web accessibility, bringing together arguments for implementing Web accessibility with background information on how disabled

people use the Web, and accessible design techniques and evaluation strategies (for example Paciello 2000; Thatcher *et al.* 2002; Slatin and Rush 2002; Clark 2003a). There are many Web sites, Web logs, email lists and online discussion fora devoted to accessibility, and a wide range of events on Web accessibility, from seminars to multi-day conferences, targeted at industry and the public sector as well as academia.

Several tools have been developed to support Web site creators and usability and accessibility experts, both in developing sites with accessibility in mind and in evaluating for accessibility (W3C 2005b). For developers, significant progress has taken place in the extent and quality of the support provided by popular Web site authoring software to aid designers in creating accessible Web content. It is widely accepted that this has been driven in part by legislative obligations of the Section 508 legislation (Gregor *et al.* 2005), and supported by the development of the W3C ATAG. A review of a number of authoring tools found that while support varied in quality, there has been a noticeable trend in improvement of accessibility support in newer versions of specific tools (Thatcher *et al.* 2002).

For developers of multimedia, software such as the Media Access Generator (MAGpie)[27] from the National Centre for Accessible Media (NCAM) has emerged, supporting the authoring and synchronising of caption and audio description files with video content. Macromedia has also taken steps to improve the accessibility of its Flash and Shockwave technologies, in particular in the accessibility of such technologies to people with no functional vision (Regan, in Thatcher *et al.* 2002). Similarly, steps have been taken to improve the accessibility of Adobe Portable Document Format (PDF) documents (Clark 2005b).

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[27] MAGpie: http://ncam.wgbh.org/webaccess/magpie/

Tools have been developed to improve the accessibility of the HTML output of other applications frequently used to rapidly generating Web content by converting documents to HTML format. As an example, the Illinois Accessible Web Publishing Wizard[28] aims to enhance the HTML output of Microsoft Office applications, so improving accessibility.

To ease the task of accessibility evaluation, automated tools take advantage of the fact that some accessibility barriers result from incorrect HTML coding practice. Such tools can be set to access a Web page, parse the page's HTML code and check that code for the presence or absence of specific qualities that are required in order to ensure conformance with a specific set of accessible design criteria, normally selected checkpoints of the WCAG. More advanced tools can then spider an entire site by following hyperlinks on the initial starter page, much in the same way that a search engine indexing robot does.

An increasing number of automated tools, some of which are freely available, exist that check either specifically on accessibility, or on accessibility issues along with other aspects of page and site performance such as file size, download time and validity of the HTML code (Ivory and Hearst 2001; Ivory *et al.* 2003). In each case, the tool will output the results of the analysis as a report, in varying levels of detail, identifying for each page those checkpoints that have been deemed not to have been met, and the location of the breach(es).

As Web browser functionality develops, so the browser can be configured to be an increasingly powerful accessibility evaluation tool in its own right. For example, the

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[28] Illinois Accessible Web Publishing Wizard: http://cita.rehab.uiuc.edu/software/office/index.php

Opera browser includes voice recognition and speech output capabilities[29], which as well as enhancing accessibility can act as an accessibility evaluation tool. Freely downloadable browser toolbars such as the AIS Accessibility Toolbar for Internet Explorer (King *et al.* 2005) and the Web Developer's Toolbar for Mozilla/Firefox (Lauke, 2005) support developers in conducting evaluations through the use of small scripts known as bookmarklets or favelets , and stored in the browser's bookmarks folder. These scripts can be used to quickly transform or analyse a specific aspect of the page appearance or code, enabling specific accessibility evaluation techniques to be performed. These include turning style sheets off, linearising tables, outlining specific HTML elements, or passing the page URI to a Web based HTML or accessibility validation tools.

Tools also exist to allow simulation of, or a measure of the quality of, the output of Web pages as might be experienced by someone with a specific impairment. For example, the Vischeck Web site[30] simulates the visual appearance of a site when viewed by someone with a particular colour deficit. The Colour Contrast Analyser tool[31] developed by Vision Australia allows comparison of the hue and brightness levels of text and background colour pairs, and uses an algorithm to test whether contrast levels are appropriate, while the Juicy Studio Readability Test[32] is an example of a tool that can analyse the text of a Web page for readability levels against recognised reading level algorithms.

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[29] Opera browser – speech output: http://www.opera.com/voice/

[30] Vischeck: http://www.vischeck.com/

[31] Colour Contrast Analyser: http://www.visionaustralia.org.au/info.aspx?page=628

[32] Juicy Studio Readability Test: http://juicystudio.com/services/readability.php

The value of accessibility-focused simulation tools in early design stages by catching potential accessibility problems at a point where remedial steps are still possible is pointed out by some researchers. For example, Takagi *et al.* (2004) describe the development of aDesigner, a tool aimed at supporting designers by visualising usability of a Web page for blind people by, for example, using colour shades to indicate the approximate time it will take for a screen reader to read content in various areas of the page. This then enables the designer to quickly implement and evaluate changes to the navigability of the page without requiring to learn how to use a screen reader – or seek screen reader users for evaluation purposes. Similarly, the EASE simulator described by Mankoff *et al.* (2005b) allows designers to experience a software interface or Web page through a variety of visual impairments; it can also alter input device behaviour to simulate a variety of motor impairments.

Appendix 3: Published Web Accessibility Surveys

Further details are provided of published Web accessibility surveys discussed in **Section 5.2**.

Table A outlines for each survey the aims of the study, the nature of the sites in the survey sample and the scope of each site included in the review.

Table B gives details of the methodology used for each survey.

Table A: Web accessibility surveys - nature of sampled sites, aims and scope

Author(s)	Sites reviewed plus stated circumstances/motivation behind commissioning	Scope (number of sites reviewed and extent of individual sites reviewed)
1. Alexander (2004b)	Assessment of all Australian tertiary education Web sites for compliance with "basic accessibility standards".	n=45; 4 pages for each site: Home page, prospective students page, orientation page and a student accommodation page.
2. Cabinet Office (2005)	Evaluation commissioned by UK government of Web sites "owned by public administrations of the EU's 25 Member States and several sites owned by the EU"	n=436 (Automated testing); scope unclear from report. n=31 (Manual testing of a subset of the above sample); scope unclear from report
3. Coyne and Nielsen (2001)	Commercial research – evaluating selected US and Japanese sites with the aim of generation of guidelines for designers based on qualitative and quantitative analysis of user evaluation of Web sites, rather than reporting levels of accessibility of the subject sites.	n=3 (Quantitative analysis); Scope - effectively all pages visited by an evaluator in an attempt to complete the tasks allocated them. n=16 (Qualitative analysis); Scope - effectively all pages visited by an evaluator in an attempt to complete the tasks allocated them.
4. Davis (2002)	Investigation into accessibility of health information Web sites to visually impaired people.	n=500; Home pages only.
5. Disability Rights Commission (DRC 2004)	A Formal Investigation commissioned by the UK Disability Rights Commission (DRC) to gather "authoritative data" from a "large and representative sample of Web sites used by the British public". (DRC 2004, p6). Carried out by researchers at City University London. The DRC is given the power by UK legislation (the Disability Rights Commission Act 1999) to conduct a Formal Investigation "for any purpose connected with the performance of its duties under…the Act."	n=1000 (automated testing); Home pages only n=100 (task-based evaluation of a subset of the above sample); Scope - effectively all pages visited by an evaluator in an attempt to complete the tasks allocated them.
6. Ellison (2004)	Evaluation of accessibility of selected US Federal agency Web sites.	n=50; Home pages only

Author(s)	Sites reviewed plus stated circumstances/motivation behind commissioning	Scope (number of sites reviewed and extent of individual sites reviewed)
7. Jackson-Sanborn *et al.* (2001)	Study looking at the accessibility of popular US and international Web sites of various categories (government, college, clothing, international, job sites, "the percentage of Web sites currently on the Internet that would be accessible to those considered disabled under the Americans with Disabilities Act."	n=549; scope unclear – described as "first layer" of each site
8. Kelly (2002); Kelly (2004)	A report on the accessibility of "entry points to UK University Web sites". First carried out in 2002, and repeated in 2004.	n=163 (2002); n=161 (2004); Home pages only
9. Lazar *et al.* (2003)	Investigation into accessibility of Web sites of major organisations in the Mid-Atlantic area of the US.	n=50; Home pages only
10. Loiacono (2004)	Evaluated the Web sites of Fortune 100 companies "to investigate how well corporate America has dealt with the issue of Web accessibility"	n=97; Home pages only (97 sites reviewed "due to company mergers and bankruptcies")
11. McMullin (2002);	Project carrying out "an automated baseline survey of WCAG compliance of Web sites based in Ireland", with the objective to "inform and promote Web accessibility policy in Ireland."	n=159; Home page and pages up to three links from Home page.
12. Milliman (2002)	Investigation into accessibility of private sector organisation Web sites in the US.	n=1080; Home pages only
13. Pennell (2005)	A study of the accessibility of UK bank and building society Web sites - to assess impact and reaction to the DRC Formal Investigation.	n=19; "the majority of the analysis focuses on the Home page"
14. Petrie *et al.* (2005)	An audit of the accessibility of museum Web sites in England and elsewhere.	n=125; Home pages only (automated evaluation) n=12; unspecified pages required to be visited to complete pre-determined tasks (in-depth evaluation of a subset of the original sample of 125 sites)
15. Williams *et al.* (2004)	Audit of the accessibility of tourist information Web sites in the UK and Germany.	n=100; Home pages and the "first two logically linked pages within the site" (50 UK sites, 50 German sites)

Author(s)	Sites reviewed plus stated circumstances/motivation behind commissioning	Scope (number of sites reviewed and extent of individual sites reviewed)
16. Sloan and Sloan (2003)	Study carried out of the Web sites of the main political parties in Scotland, in run-up to 2003 Scottish Parliament Election, to identify level of accessibility of online manifesto information.	n=6; Home page plus page(s) giving access to the online party manifesto and manifesto information on the economy.
17. Spindler (2004)	Investigation into the accessibility of library Web pages of mid-sized (student population 5,000-10,000) US colleges and universities.	n=190; Home pages only
18. Thompson *et al.* (2003)	Study evaluating key sites of 102 US university Web sites to assess "functional accessibility" of various categories of Web content.	n=1013; Scope varies from site to site. Some "sites" in this sample were in fact single pages, others multiple pages.
19. Zaphiris and Zacharia (2001)	Investigation into an entire country's Web presence (that of Cyprus). Specific research aims: To what extent is the Cyprus Web accessible? Are there significant differences between the accessibility rating of different domain categories of Web site?	n=18,096 Web pages.
20. Zeng and Parmanto (2004)	Investigation of accessibility of consumer health information Web sites. Research also investigated relationships between accessibility and other attributes such as function, popularity and importance.	Home pages and pages up to two levels below Home page of sites listed in Google subdirectory "Health/Consumer/Resources" (n=108)

Table B: Evaluation methods used in published Web accessibility studies

Survey	Evaluation stages					
	Manual accessibility check	**Check with alternative browsers**	**Automated accessibility evaluation**	**Assistive technology check**	**Task-based user evaluation with disabled people**	**Other**
1. Alexander	Manual check using browser to simulate different conditions.	Lynx, v 2.8.4	The WAVE			
2. Cabinet Office	Manual check of pages against validity list based on of WCAG checkpoints		Unspecified tool. Used “in-house suite of software tools” developed by an external Web consultancy.			Also included a survey of policy advisers for each EU member state and the EU itself on accessibility policy (n=26).
3. Coyne and Nielsen				No specific stage; however user evaluations with disabled people may have uncovered issues relating to assistive technology performance	104 people. 84 with disabilities, 20 non-disabled as control group. 44 disabled people took part in qualitative study; 60 (inc 20 non-disabled) took part in quantitative study.	
4. Davis	Manual check of “Bobby-identified potential problem areas”.		Bobby			

Survey	Evaluation stages					
	Manual accessibility check	**Check with alternative browsers**	**Automated accessibility evaluation**	**Assistive technology check**	**Task-based user evaluation with disabled people**	**Other**
5. Disability Rights Commission (DRC)			Watchfire WebXact	No specific stage; however user evaluations with disabled people may have uncovered issues relating to assistive technology performance	50 disabled people. Also focus groups and interviews	
6. Ellison			Bobby			
7. Jackson-Sanborn			Bobby			
8. Kelly (2002); Kelly (2004)			Bobby			
9. Lazar *et al.*	Manual check using guidelines developed by researchers, based on Section 508 standard and WCAG.		InFocus (set to test against Section 508 standard) A-Prompt (set to test for WCAG compliance)			
10. Loiacono			Bobby Worldwide			
11. McMullin			Bobby Worldwide			

Survey	Evaluation stages					
	Manual accessibility check	**Check with alternative browsers**	**Automated accessibility evaluation**	**Assistive technology check**	**Task-based user evaluation with disabled people**	**Other**
12. Milliman			Bobby (version unspecified)			Email questionnaire sent to Webmasters of the subject sites asking for reasons of inaccessibility and incentives for improving accessibility
13. Pennell	Manual check using browser to simulate different conditions and test for presence of specific features and barriers. Used Colour Contrast analyser to check contrast issues. Linearisation checked using Firefox Web Developer Toolbar.	Viewed pages in Lynx Viewer (simulator of Lynx).	Cynthia Says			HTML and CSS validation.
14. Petrie *et al.*			Watchfire WebXact		Task-based evaluation with 15 disabled people.	

Survey	Evaluation stages					
	Manual accessibility check	**Check with alternative browsers**	**Automated accessibility evaluation**	**Assistive technology check**	**Task-based user evaluation with disabled people**	**Other**
15. Williams *et al.*	"Usefulness" of alternative text for graphics manually assessed; manual check for presence of alternative language versions of subject sites also carried out.		Bobby			
16. Sloan and Sloan	Manual inspection for specific barriers; check for colour contrast issues.	Lynx (version unspecified)	Cynthia Says (online version)	IBM Home Page Reader		HTML Validation
17. Spindler			Bobby 3.2			
18. Thompson *et al.*	Manual inspection with images turned off; font size changed; low screen resolution; use of colour; keyboard accessibility		Bobby	JAWS		
19. Zaphiris and Zacharia			Bobby (version unspecified)			
20. Zeng and Parmanto			Bobby 4.0.1			

Appendix 4: Survey Questionnaire

The following questions were presented to survey respondents through the PICO online survey tool. Where conditional questioning was used to ask further questions based on responses to previous questions, this is clearly identified.

Q1: Firstly, for confirmation purposes, what was the name of the Web site that was the subject of the audit report you read? *(Question Type: Free Text)*

Q2: The audit report was written with the aim of being useful to a number of different groups of people. Which of the following best describes your job? *(Question Type: Multiple Choice)*

- Manager of a Web design/development team, and Web site design is also a significant part of my job.
- Manager of a Web design/development team, but Web site design is not a significant part of my job.
- Web designer/developer
- Lecturer/Researcher
- Senior management
- Advertising/marketing
- Supporting disabled staff/colleagues and/or disabled customers, clients and/or students
- Legal
- Other

The following questions (Q2A1 and Q2A2) were presented to those who answered Q2 with **Lecturer/Researcher**, **Senior management, Advertising/marketing**, **Supporting disabled staff/colleagues and/or disabled customers, clients and/or students**, **Legal**, **Other:**

Q2A1: Please briefly describe your professional or personal interest in Web site design/development. *(Question Type: Free Text)*

Q2A2: What, if any, was your involvement in the Web site that was the subject of the audit? *(Question Type: Free Text)*

Q3: On a scale of 1 to 7, where 1 means 'no knowledge' and 7 means 'expert', please indicate what you consider was your level of awareness and knowledge of Web accessibility for disabled people before you first read the audit report. *(Question Type: Scale Rating)*

- 1 - No knowledge whatsoever
- 2
- 3
- 4 - A working knowledge
- 5
- 6
- 7 - Expert in Web accessibility

Q4: Were you involved in commissioning the audit? *(Question Type: Yes/No)*

The following questions (Q4A1, Q4A2 and Q4A3) were presented to those who answered **Yes** to Q4.

Q4A1: To understand a little more about the distribution of the audit report document within your organisation, please select all those groups to whom - to the best of your knowledge - a copy of the audit report was sent or made available?

Select one or more options from the list, or leave this question blank if you were the only person who read the audit. *(Question Type: Multiple Selection)*

- All people involved in developing the subject Web site.
- All people involved in providing content for the subject Web site.
- All people involved in developing Web sites in general.
- Senior management.
- Staff responsible for supporting disabled staff/employees and/or disabled customers, clients or students.
- Legal advisors
- Other

The following question (Q4A1A) was presented to those who answered **Other** to Q4A1.

Q4A1A: You selected 'other' as one of the groups to whom the audit report was made available. Please provide brief details here. *(Question Type: Free Text)*

Q4A2: Please rank in order of importance - most important first - the following possible reasons as to why the audit was commissioned. (You'll then be asked if there were any other reasons that are not listed here). *(Question Type: Ranking)*

- To provide an independent assessment of the level of accessibility of the subject site.

- As part of steps taken towards ensuring compliance with the Disability Discrimination Act (DDA).
- To establish the extent to which the subject site conforms to the W3C Web Content Accessibility Guidelines (WCAG).
- To establish how well disabled people can use the subject site for its intended purpose.
- To provide an educational resource in Web site accessibility.

Q4A3: If there were any additional reasons as to why the audit was commissioned, please note them here, along with an indication of the importance of these additional reasons. *(Question Type: Free Text)*

The following question (Q4B1) was presented to those who answered **No** to Q4.

Q4B1: So that we can understand more about how our audits are circulated, please select the option that best describes the circumstances under which you read the audit report. *(Question Type: Multiple Choice)*

- I was given a copy of the audit to read and act upon its findings.
- I was given a copy of the audit for reference.
- I specifically asked for a copy of the audit.
- The audit was made available to all staff within my organisation (for example published on an intranet).
- The audit was distributed at an internal training event (or similar).
- None of the above.

The following question (Q4B1A) was presented to those who answered **None of the above** to Q4B1:

Q4B1A: Please briefly explain how you came to read the audit. *(Question Type: Free Text)*

Q5: Approximately when did you first read the audit report? (specify the year and month, if possible) *(Question Type: Free Text)*

Informative message: The next few questions ask you to rate your agreement with some statements. A 7 point scale is used, where 1 means total disagreement and 7 means total agreement.

Q6: The audit gave me a good idea as to how well the subject site performed against best practice in accessible Web design. *(Question Type: Scale Rating)*

- 1 - Strongly Disagree
- 2
- 3
- 4 - Neither agree nor disagree
- 5
- 6
- 7 - Strongly Agree

Q7: The audit highlighted the degree to which disabled people were able to use the subject site for its intended purpose. *(Question Type: Scale Rating)*

- 1 - Strongly Disagree

- 2
- 3
- 4 - Neither agree nor disagree
- 5
- 6
- 7 - Strongly Agree

Q8: The audit made me more aware of the importance of the issue of Web site accessibility to disabled people. *(Question Type: Scale Rating)*

- 1 - Strongly Disagree
- 2
- 3
- 4 - Neither agree nor disagree
- 5
- 6
- 7 - Strongly Agree

Q9: The audit made me more aware of the problems that disabled people can encounter when accessing Web sites. *(Question Type: Scale Rating)*

- 1 - Strongly Disagree
- 2
- 3

- 4 - Neither agree nor disagree
- 5
- 6
- 7 - Strongly Agree

Q10: The audit and its findings motivated me to further my knowledge of Web accessibility issues and the role I can play in improving the accessibility of Web sites. *(Question Type: Scale Rating)*

- 1 - Strongly Disagree
- 2
- 3
- 4 - Neither agree nor disagree
- 5
- 6
- 7 - Strongly Agree

Q11[33]: The findings of a number of different evaluation stages were provided as part of the audit report. Which stage did you consider to be the most useful to you? (please select one only) *(Question Type: Multiple Choice)*

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[33] The list of answers for Q11corresponded to the list of stages in the audit received by the survey respondent, so answers available in this question varied from respondent to respondent, depending on the audit they received.

- Detailed manual accessibility inspection of the subject site.
- Report of the subject site's performance when assessed by automated accessibility and HTML checking tools.
- Assessment of selected pages of the subject site against the Web Content Accessibility Guidelines.
- Performance of the subject site under different browsing conditions
- Performance of the subject site when accessed using different browsing and assistive technologies.
- User evaluations with disabled people.
- Recommendations for improving the subject site's accessibility and usability.

Q12: Please briefly explain why you felt the **(answer to Q11)** was the most useful section. *(Question Type: Free Text)*

The following question was given to respondents who received audits that did not include all DMAG audit stages. It was repeated for each audit stage not included.

Q13: The audit you read did not include some evaluation stages which have been included in other accessibility audits carried out by the Digital Media Access Group. For each of the following stages listed, please indicate the extent to which you think the stage would have added value to the audit.

(Audit stage name) *(Question Type: Scale Rating)*:

- 1 - Not at all useful.
- 2

- 3
- 4 - Moderately useful.
- 5
- 6
- 7 - Very useful.

Q14: The questionnaire is almost complete - but before finishing, if you have any other comments you'd like to make about the audit, its contents and its impact, please do so here. *(Question Type: Free Text)*

Q15: Thank you very much for your help! If you would like to take part in a further survey of the audit's impact on your perception of Web accessibility, please enter your email address here, and I will contact you shortly. Many thanks again, David Sloan. *(Question Type: Free Text)*

Appendix 5: Audits and Recommendations Provided

The following table presents the list of Recommendations for immediate action given as part of each audit in the study sample.

Recommendation	Audit													
	1a	1b	1c	1d	2	3	4	5	6	7	8	9	10	11
Provide an accessibility page for the subject site.	Y	Y	Y	Y	N/A	Y	N/A	Y	Y	Y		Y	Y	Y
Provide every graphic with an appropriate text alternative.	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y
Provide each page with a title that succinctly and clearly identifies the page content.	Y			Y	Y		Y	Y	Y	Y	Y	Y		Y
Ensure hyperlinks clearly indicate the destination page.	Y	Y	Y	Y	Y	Y	Y	Y	Y		Y			Y
Avoid providing recursive links.	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y			Y
Optimise page content for browsers that linearise the content.	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
Identify row and column headings for all data tables.	Y	Y			Y	Y	Y		Y	Y	Y		Y	
Make sure as far as possible that all pages validate to a formal HTML or XHTML specification.	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Recommendation	Audit													
	1a	1b	1c	1d	2	3	4	5	6	7	8	9	10	11
Avoid the use of frames; if they must be used provide each with an appropriate title and explain the relationship between frames.		Y	Y			Y							Y	
Avoid using images of text when styled HTML could be used instead.					Y		Y				Y	Y	Y	
Make sure there is sufficient contrast between text colour and background colours					Y		Y							
Enable users to adjust text to suit their own requirements.					Y									
Use appropriate HTML elements to identify page structure					Y	Y	Y			Y	Y	Y	Y	Y
Make sure that link text is consistently presented, and distinguish between link text and non-link text.					Y		Y	Y						
Avoid unnecessary duplication of page content.										Y				
Avoid changing page content without warning the user.					Y								Y	
Ensure that page content can be viewed at low resolutions without requiring horizontal scrolling.					Y									
Ensure information and functionality is accessible through the keyboard.						Y	Y			Y			Y	
Provide a link to the Home page from other pages.						Y	Y							
Avoid links that open the destination page in a new browser window without warning the user.						Y		Y		Y		Y	Y	

Recommendation	Audit													
	1a	1b	1c	1d	2	3	4	5	6	7	8	9	10	11
Identify the primary natural language in which the site content is written, and any changes to that language within pages.						Y	Y							
Avoid relying on JavaScript for functionality.						Y	Y	Y						
Where a limited time is placed on viewing a page, warn the user and if possible allow users to adjust the length of the time limit.						Y	Y							
Optimise the accessibility of forms.						Y	Y						Y	Y
Where multimedia content is provided, make sure it is provided with appropriate accessibility features.							Y							
Correct spelling errors; limit the use of inappropriate terminology.							Y							Y
For information presented in complex graphics, provide this information in text form on a separate page, clearly linked from the page containing the corresponding graphic.									Y					
Improve the ease of navigation through the consistent provision of navigation bars.												Y		

Appendix 6: Audit Impact Ratings and Level of Accessibility Expertise

Respondents: N=16	Impact Statement (1 - strongly disagree; 7 – strongly agree)				
Level of Accessibility Expertise (1 - least; 7 – most)	**1. Awareness of performance against Best Practice**	**2. Degree to which disabled people could use site**	**3. Awareness of importance of Accessibility**	**4. Awareness of problems disabled people face**	**5. Motivation to further knowledge of Web accessibility**
7	4	5	2	1	2
7	7	6	7	7	6
6	4	5	1	3	3
5	5	6	6	5	4
5	7	7	7	7	7
5	7	4	6	2	7
5	5	4	5	6	5
5	6	7	4	6	3
4	6	6	7	7	6
4	6	5	6	4	6
3	7	6	5	6	4
3	4	5	6	6	7
3	7	7	7	7	7
3	7	5	7	4	5
2	6	5	7	7	3
2	7	6	7	7	7

Appendix 7: Changes made to the accessibility of subject sites following the audit

Audit	Time interval (months)	Rating	Specific comments on progress
1a, 1b, 1c, 1d	26	4	There was evidence of a partial redesign of the Home page and some other pages since delivery of the audit. Of the pages visited, most significant accessibility barriers identified in the audits had been removed. The majority of pages accessed had no significant accessibility problems, other than occasional instances of inappropriate alternative text. Skip links were consistently provided, making keyboard access logical and efficient. No access keys were provided, and a justification for this decision was given in the Accessibility Statement page of the site. Where improvements to accessibility recommended by the audit had not been made, this tended to be within sites that appeared peripheral to the central University site, and were of a more commercial nature. Here, consistent missing alternative text and lack of internal page navigation were particularly prevalent
2	43	1	The site appeared not to have been redesigned since audit delivery. Of the pages visited, some of accessibility barriers had been addressed, but many remained. There were still instances of missing and inappropriate alternative text for images; plus an image map missing alternative text for the main image and for one of the hotspots. Link text was generally adequate, but structural HTML elements were not used, and no internal page navigation was provided.
3	27	1	Some accessibility barriers had been removed, including the addition of alternative text to images. However, other barriers that had been identified in the audit were still present, including navigation bars that could not be activated using the keyboard, an absence of internal page navigation links, and an absence of appropriate structural HTML elements. NB Only a subset of the original site could be reviewed, due to lack of authentication details necessary to access secure areas.
4	44	3	Much of the audited site had undergone a significant redesign, and many of the examples of barriers identified in the audit had been removed. Extensive access keys had been provided. However some issues remained, although the likely impact of these was judged to more of a hindrance than a barrier to access to information for some groups. Remaining issues included some images with inappropriate alternative text, inefficient keyboard navigation, including absence of internal page navigation, and inconsistent use of appropriate structural HTML.
5	7	1	Of the examples of accessibility barriers selected, most remained in the subject when revisited. These included – graphics missing alternative text, inappropriate link text, an absence of internal page navigation, and instances of missing structural HTML.

Audit	Time interval (months)	Rating	Specific comments on progress
6	20	4	The audited site had been assessed as reaching a high level of accessibility so the recommendations presented were relatively low-impact in comparison to other audits. Further inspection of specific issues identified in the audit revealed that action had been taken for most. This included the provision of suitable alternative text for image links, and the addition of internal page navigation features – although the effectiveness of the latter could further be improved by moving the location of the internal page link. Also, in one example of a complex data table, column headings had been provided for the main table, but not for nested tables. In discussions after the audit delivery, the possibility was explored of providing complex tables with a textual description of the data presented, but this had not been implemented.
7	19	4	The subject site had undergone minor redesign, and as a result site accessibility had significantly improved. Specified instances of inappropriate alternative text for images had been addressed, and navigational features causing problems for keyboard accessibility had been removed. The use of structural HTML had improved, and a 'Skip to main content' link had been added to each site page visited.
8	7	3	The site had originally reached a high level of accessibility, and when reviewed some outstanding barriers identified in the audit had been addressed, including the provision of a 'skip to main content' link, and the improvement of some previously inappropriately worded hyperlinks. However, some barriers had not been addressed, and instances were found of graphics with inappropriate alternative text, and inconsistent use of structural HTML to mark up lists.
9	7	2	Audit 9 and 10 covered separate areas of a site sharing a common look and feel. The site acts as an intranet application, enabling document sharing and management for staff, as well as providing a public face to the particular academic organisations represented by the site. The site's design which has not significantly changed since delivery of the audits, is complex, using multiple frames. Therefore while some accessibility recommendations presented in the respective audits have been carried out, in particular the provision of more alternative text to graphics, the complexity of the site means the overall impact on accessibility has remained limited.
10	15		
11	5	2	Some examples of accessibility barriers identified by the audit as being present in the site had been removed. In particular, images appeared to have been provided with appropriate alternative text, and link text appeared to be appropriate. However, some issues remained. For example, internal page navigation remained as an access-key shortcut rather than a visible 'skip to main content link', despite the audit recommending the latter. Additionally, the use of structural HTML remained inconsistent.