AN EXPLORATION INTO TWO SOLUTIONS TO PROPAGATING WEB ACCESSIBILITY FOR BLIND COMPUTER USERS

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AN EXPLORATION INTO TWO SOLUTIONS TO PROPAGATING WEB ACCESSIBILITY FOR BLIND COMPUTER USERS

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A model is presented depicting the driving forces (Web industry, consumers, U.S. federal government, and technology) promoting an accessible Web and potential solutions within those forces. This project examines two distinct solutions, lawsuits (a consumer-driven solution) and AcceSS 2.1 transcoder (a technology-driven solution) to provide more information on two under-researched methods that could have far-reaching impacts on Web accessibility for the blind.

First, an evaluation of the intraclass correlation (ICC) between homepage Web Accessibility Barrier (WAB) scores and WAB scores of levels 1-3 found that the homepage is not sufficient to detect the accessibility of the website. ICC of the homepage and average of levels 1-3 is 0.250 ($p=0.062$) and ICC of levels 1, 2, & 3 is 0.784 ($p < 0.0001$). Evaluating the homepage and first-level pages gives more accurate results of entire site accessibility.

Second, an evaluation of the WAB scores of the homepage and first-level pages of websites of five companies sued for alleged inaccessible websites found mixed results: lawsuits worked in two cases, but didn't in three. This is seen through an examination of accessibility and complexity of the websites for years surrounding the lawsuits. Each sued website is compared to a control website within the same industry and to a random group of websites representing the general Web.

Third, a usability study of the AcceSS 2.1 transcoding intermediary found that technology can increase users' efficiency, effectiveness, and satisfaction in Web interaction, regardless of universal design. The study entails a within-subject cross-over design wherein 15 users performed tasks on three websites: one universally designed, one non-universally designed, and one reference site. Paired t-tests examine the effect of AcceSS 2.1 on time, errors, and subjective satisfaction and mixed-model analysis examines the effect of study design on outcomes. Results show that users perform tasks faster, with fewer errors, and with greater satisfaction when accessing pages via AcceSS 2.1, but users where less satisfied with the universally designed website and significant differences were found in the universally designed website and not the non-universally designed website. Website usability and ease of navigation are more important to users than simple accessibility.

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1.0 INTRODUCTION

In this age of information technology, the Internet is a resource that has quickly become an integral part of people's lives. People of all ages, races, and ethnicities are moving more and more of their activities online (NTIA, 2002). For those with disabilities, the Internet can bring a sense of community that hasn't been experienced before (Hillan, 2003; Ritchie & Blanck, 2003; Sanyal, 2006). Early studies on information technology for persons with disabilities found that computer and Internet access can increase levels of independence and have a positive impact on the academic progress and career success of individuals with disabilities (Burgstahler, 1992; Coombs, 1991). However, Web content must be accessible to persons with disabilities if it is to have positive outcomes. Currently the Web is three times less usable by persons with disabilities than those without (Nielsen, 2001). The objective of this dissertation is to evaluate two approaches to mitigating Web accessibility barriers, specifically for persons who are blind.

The term accessibility, as applied to the Internet, means that anyone can equally access the information presented, regardless of device and/or personal limitations. Persons with disabilities, however, often find that the Web is far from accessible. Some persons with disabilities use assistive technologies to aid them in accessing Internet information. Web designers must take into consideration both the limitations experienced by individuals with disabilities and the limitations that coincide with their use of computer-related assistive technologies.

The model below (Figure 1) presents a visual representation, adapted from force field theory, of the driving forces promoting an accessible Web. Force field analysis is a technique, developed by social science pioneer Kurt Lewin (Lewin, 1951), for diagnosing situations by graphically depicting the driving forces and restraining forces affecting a particular situation at a given time (Witkin & Altschuld, 1995). Figure 1 shows the driving forces and the potential solutions to an accessible Web that fall within those forces. The forces presently pushing for increased accessibility for blind Web users are the Web industry, consumers, the U.S. federal government, and technology.

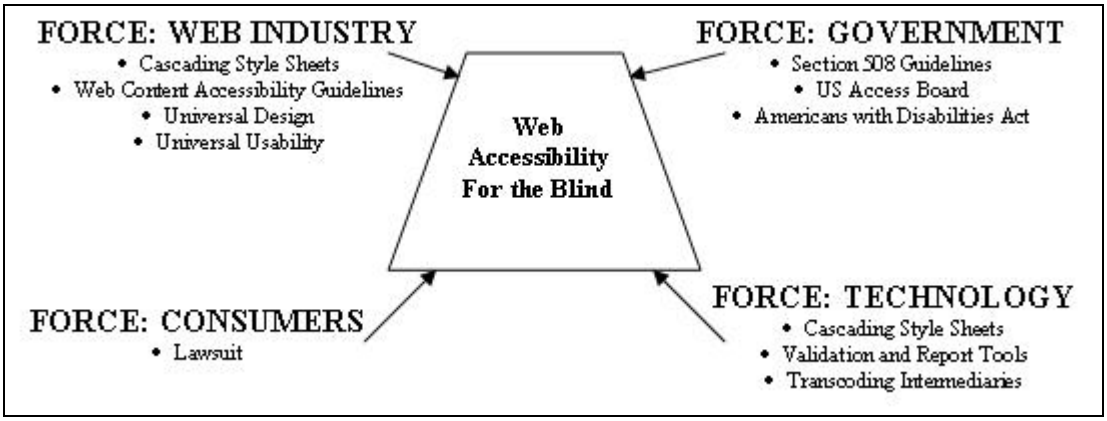

Figure 1. Model of the Driving Forces on Web Accessibility

The potential solutions within each force, such as Cascading Style Sheets (CSS), can be influential in multiple forces. CSS, a Web design technology that separates content from style, appears as a component of two forces because it is a Web design technology and also a World Wide Web Consortium (W3C) recommendation (W3C, 2006b), meaning that it has the

endorsement of the W3C members and director for wide deployment. It would make sense that many industry solutions are also technology-related solutions.

No discussion involving force field analysis is complete without mention of the restraining forces favoring equilibrium. The force field diagram (Witkin & Altschuld, 1995) is a useful tool in force field analysis. Force field diagrams show the driving and restraining forces on a situation at a given time and also depict the relative strength of the forces. This allows one to see how the current situation can be upset by increasing or decreasing the strengths of the various forces.

The force field diagram for Web accessibility is presented in Figure 2. The driving forces have already been mentioned. The restraining forces are less concrete than the driving forces and include: 1) the habits of Web designers to not include accessibility features, 2) lack of awareness surrounding Web accessibility, 3) the cost of redesigning websites to be accessible, and 4) technology. By examining the force field diagram of Web accessibility, one can see how change can occur by either increasing the driving forces, decreasing the restraining forces, or a combination of both. Technology is both a driving and a restraining force since many of the complex design elements incorporated into websites (multimedia, scripts, etc.) are the very elements that post barriers to persons with visual disabilities.

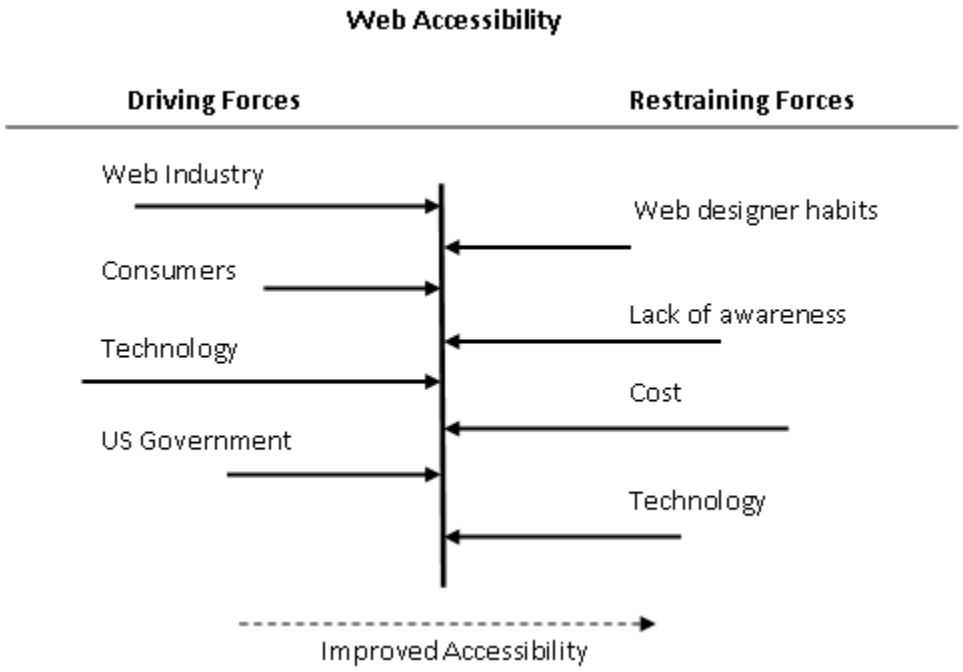

Figure 2. Force Field Diagram for Web Accessibility

Solutions within the different forces on Web accessibility can be employed together for the greatest impact on Web accessibility, as a solution in one force may not be enough to cause change. The passage of the Rehabilitation Act Amendments of 1998 (P.L.105-220, 1998), known as Section 508, is an example of a solution that, alone, was not enough to change the current situation of Web accessibility. Section 508 requires that all electronic and information technology developed or purchased by the U.S. federal government are accessible by persons with disabilities, except where this would cause an "undue burden." These amendments apply to (though not exclusively) federal pages on the Internet and the World Wide Web. The Section 508 mandate is a solution that brings slow success (Stowers, 2002) and does not apply to the popular Web. Government websites are still the only websites mandated to be accessible nine years following the passage of Section 508.

Another solution for a more accessible Web was initiated by consumers. Blind consumers and their advocates are suing large companies for having alleged inaccessible websites, stating that this inaccessibility is discrimination under the Americans with Disabilities Act (ADA) (42U.S.C.§§12101etseq., 1990). These lawsuits are an attempt to make a court precedent and extend the ADA to include the Internet. One point of interest in this dissertation is how effective these cases prove to be. The end result of these lawsuits, if positive, has the potential to set legal precedent and have a major impact on disability policy.

Technology is a driving force that could provide a faster and more efficient transition to an accessible Web for blind computer users. Technology can be invaluable in the interim period, between the signing of legislation and when change is readily apparent. Technology should not be the only solution sought, however, because the extension of the ADA to include the Internet is of great importance within the realm of disability policy.

Web accessibility for the blind computer user is worsening over time (S. Hackett, 2004). While there are several forces working in its favor, a totally accessible Web is far from existent. Each of these non-mutually exclusive forces (Web industry, technology, government, and consumer) contains several solutions to mitigating Web barriers. Some of the solutions have been extensively studied and analyzed. An example of one such solution is Bobby, a popular error-detection tool which is prevalent in the literature (Brajnik, 2004; Diaper & Worman, 2003; Ivory & Chevalier, 2002; Witt & McDermott, 2004). Other solutions, such as transcoding intermediary technologies, have been developed but not tested with real users (Brown & Robinson, 2001; Liu, Ma, Schalow, & Spruill, 2004; Maeda, Fukuda, Takagi, & Asakawa, 2004; Hironobu Takagi & Asakawa, 2000; Hironobu Takagi, Asakawa, Fukuda, & Maeda, 2004).

This project examines two distinct solutions, lawsuits (a consumer-driven solution) and AcceSS transcoder (a technology-driven solution) to provide more information on two under-researched methods that could have far-reaching impacts, both in the short-term and the long-term, on Web accessibility for the blind. Using a transcoding intermediary, a website can be transformed from its original form into one that is accessible and usable to blind persons and their assistive technologies being used to access the Web.

The remainder of this chapter will describe the motivation behind this research and the research questions to be answered by the studies.

1.1 MOTIVATION

Prior research done by the author led to the questions being addressed in this project. The author completed a longitudinal examination of accessibility and complexity of random and Government Internet websites for the years 1997-2002 (S. Hackett, 2004) with the primary objective of determining how technological advances in Web design have affected accessibility over time. The Web Accessibility Barrier (WAB) (Bambang Parmanto & Zeng, 2005) score was the metric used to assess accessibility and a complexity algorithm was used to assess complexity of the website. Both metrics are described in detail in chapter 2. Government websites provided a baseline in this study, as they are currently the only websites that require conformance to guidelines and therefore provide a reasonable benchmark. A random sample of 40 websites per year was examined. The random websites were obtained from the Top 500 ranked websites from www.alexa.com on July 28, 2003.

The study found that, in the random websites, there was a statistically significant increase in mean WAB scores throughout the years studied (F[5,234]=7.246, p<0.001) (Figure 3). A WAB score of zero means that there are no barriers to accessibility. Increasing WAB scores indicate increasing barriers. Complexity scores of the random websites also showed a statistically significant increase throughout the years (F[5, 234] = 16.52, p<0.001) (Figure 4).

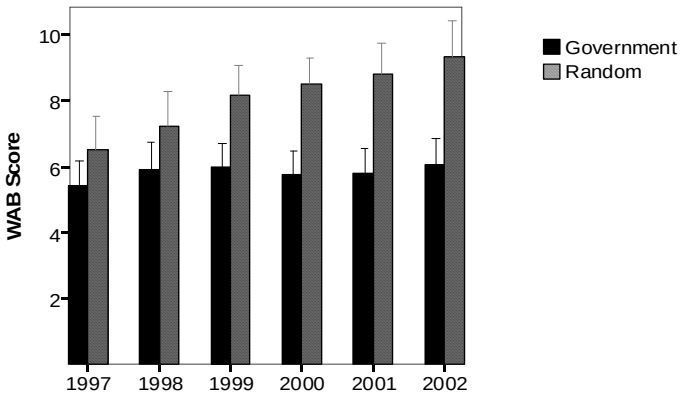

Figure 3. Comparison of Mean WAB Scores for Government and Random Websites

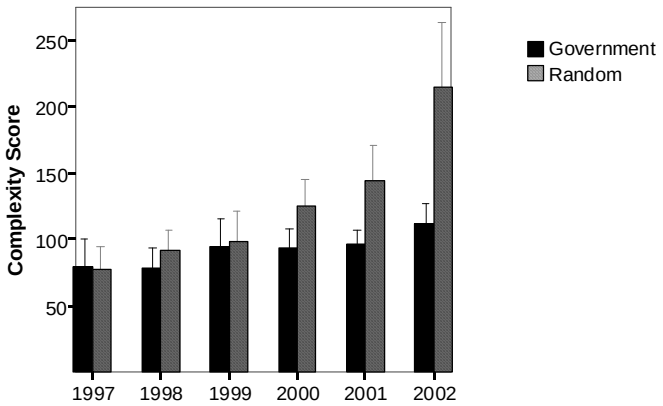

Figure 4. Comparison of Mean Complexity Scores for Government and Random Websites

Government websites were also evaluated because they serve as a strong basis for comparison. The study found that mean WAB scores for government websites remained fairly unchanged through the years (Figure 3), with no statistically significant differences found (F[5,105]=1.148). Scores of government websites remain close to the accessible threshold line of 5.5 (Bambang Parmanto & Zeng, 2005). Interestingly, similar to the random websites studied, the complexity of government websites showed a statistically significant increase through time (F[5,105]=3.758, p<0.01) (Figure 4). There is also a significant linear trend in the data (F[1,21]=9.926, p<0.005), indicating a tendency for complexity scores to increase each year.

Pearson correlation coefficients were computed to evaluate the relationship between WAB scores and complexity scores without regard to year for both categories (Figure 5) and a significant positive correlation was shown between the two in the random category (r=0.485, p<0.0001): as complexity scores increase so do WAB scores. There is little relationship between the two in the government category (r=0.21).

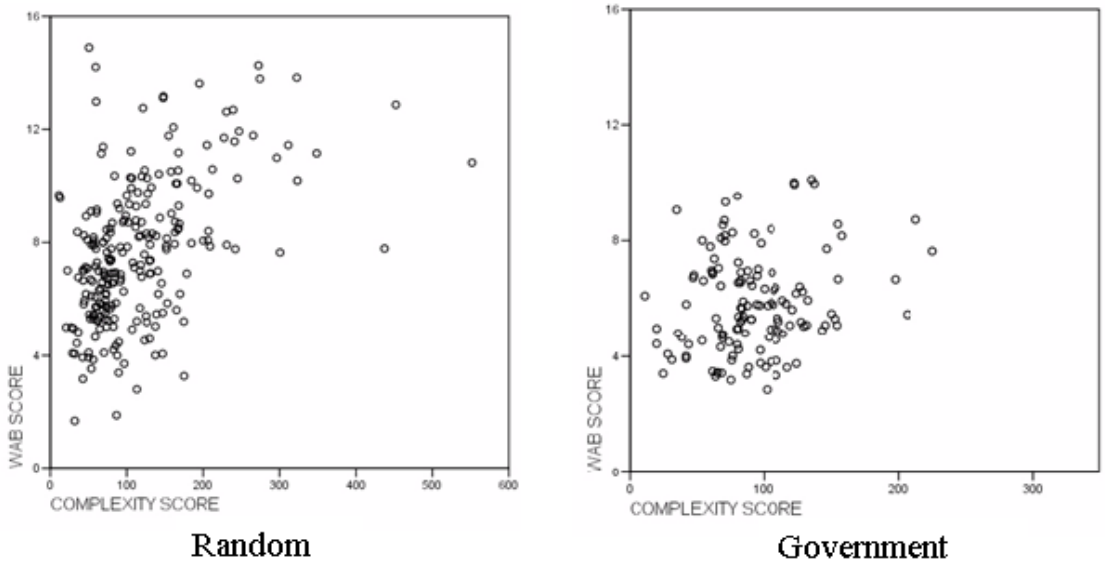

Figure 5. Scatter Plot of Correlation between WAB and Complexity Scores 1997-2002

The findings of this study show that, along with a statistically significant increase in accessibility barriers, there has been a concurrent statistically significant increase in complexity in the random websites studied. As Web designers have added increasingly complex components to the design of their Web pages for the purposes of creating aesthetically appealing and interactive websites, they have inadvertently added barriers to accessibility for persons who are blind. The design elements that become barriers if not properly used are images (for both categories the use of images has been increasing rapidly), image-type buttons, image maps and frames.

The most important finding from this study is that, while websites from both the random and government samples had increasing complexity, government websites had WAB scores that remained consistently close to 5.5. This is evidence that increasing complexity for purposes of aesthetics or consumer-driven design does not have to equate to inaccessibility for blind Web users.

1.2 RESEARCH QUESTIONS

The author's previous research found that the general trend is for new technology to lead to increasing complexity which, in turn, leads to increasing barriers to blind persons. With new technologies being created constantly, one can assume that unless there is a paradigm shift the Web will continue on this trend and persons with disabilities will be left facing more and more barriers. Although some designers are aware of accessible design and the need for an accessible Web, it is a matter of competing innovations, with the complex technology winning. However, not all new technology and added complexity in website design leads to an increase in the

number of accessibility barriers, as evidenced in the author's previous research. The reason for this is that, by law, government websites have to conform to Section 508 guidelines. This results in better design, allowing new technology and complexity to be incorporated into websites without jeopardizing accessibility.

While there is not yet a mandate for non-government websites to comply with any type of standard for website design, there are other methods to achieving an accessible Web. These can be seen in Figure 1. One of the solutions, falling within the force of industry, is through the use of universal design principles. This solution is prevalent in the literature (V.L. Hanson, 2004; Keates et al., 2000; Leporini & Paterno, 2004; Perlman, 2002; Ben Shneiderman, 2000; B. Shneiderman, 2003; Vanderheiden, Scholtz, & Thomas, 2000). Universal design can be seen as the "gold standard" in Web design and the principles upon which every site should be designed to allow for maximum accessibility. These principles take into account accessibility and usability of the users whereas accessibility guidelines, such as the government-mandated Section 508, primarily address accessibility.

Government mandates, such as Section 508, are one way to mitigate barriers. The ADA (42U.S.C.§§12101etseq., 1990) could implement such a mandate on a national level in the U.S. The literature (Jaeger, 2002; J. Lazar, Beere, Greenidge, & Nagappa, 2003; Stowers, 2002) also presents this solution. While case law mostly determines the ADA, the U.S. Department of Education and the Department of Justice have the responsibility of enforcing it. Therefore, consumer lawsuits filed against companies by individuals and organizations can have an impact on the future of the ADA. The possibility of an eventual general mandate for all websites, not just those of government-funded agencies, exists.

Technology is another force offering solutions to Web accessibility. Many solutions fall within the realm of technology. Bobby has been used extensively in studies assessing Web accessibility (Jackson-Sanborn, Odess-Harnish, & Warren, 2002; Loiacono, 2004; Loiacono & McCoy, 2006; Mankoff, Fait, & Tran, 2005; Paris, 2006; Ritchie & Blanck, 2003; Rowan, Gregor, Sloan, & Booth, 2000; Rowland, 2000; Spindler, 2002). Unfortunately, Bobby only provides a final diagnosis of "approved" or "not approved." This means that a site can fail to meet Bobby approval if one image is missing ALT text, which is additional information provided in the HTML to describe the image. Bobby, as a fast and efficient solution, is not as promising as transcoding intermediary technology because the responsibility still lies with the site designer to correct all errors and provide a barrier-free presentation of the website. When Web designers follow design standards and guidelines they address accessibility from the design or re-designing (retrofitting) phases. Transcoding intermediaries have the unique ability to change existing websites without the Web designer making the modifications, reducing the time and cost to the onset of an accessible Web.

This dissertation evaluates two under-researched approaches to mitigating barriers to accessibility for persons who are blind. These approaches fall within the forces of consumers and technology. Specifically, the approaches being researched are: 1) consumer activism in the form of lawsuits and 2) utilizing a transcoding intermediary to transform inaccessible Web pages into ones without barriers.

1.2.1 Research Question 1a

If every website met the "gold standard" and was designed using universal design principles, which take into account Web accessibility and usability, far fewer accessibility problems for visually impaired users would exist. Instead, blind persons and their advocates have taken action by suing large consumer websites for allegedly maintaining inaccessible websites. Is it possible to force these companies to comply with accessibility standards through the use of lawsuits? The first method to mitigating barriers evaluated in this project is consumer activism in the form of lawsuits. The research question, therefore, is:

Do consumer-driven lawsuits, claiming discrimination under the ADA, cause changes in the websites of the companies being sued?

This study aims to identify the impact that lawsuits have on the accessibility of company websites. The ADA does not specifically mention Web accessibility, but some persons with disabilities and organizations representing persons with disabilities have sued companies for allegedly having inaccessible websites under the ADA, stating discrimination. Furthermore, the ADA is ruled by case law so these lawsuits can set a precedent for future cases and can have a major effect on Web accessibility, with the possibility of eventually leading to a universal mandate of Web accessibility under the ADA.

The ADA (42U.S.C.§§12101etseq., 1990) prohibits discrimination based on disability; however, since its passage came before mainstream use of the Internet there is no mention of the Internet in this legislation. Controversy over whether or not the ADA does apply to the Internet exists. Consumers and their advocates have filed various civil suits in the U.S. against

corporations regarding inaccessible websites and the courts appear to be split on the issue. The companies involved in the civil suits include America Online, Barnes and Noble, Inc., Southwest Airlines, Claire's stores, Priceline.com, Ramada.com, Metropolitan Atlanta Rapid Transit Authority, and Target Corporation. The literature details the major lawsuits and the supporting arguments for applying the ADA to the Internet (P. D. Blanck & Sandler, 2000; King, 2003; Kretchmer & Carveth, 2003; Noble, 2002; NYStateAttorneyGeneral, 2004; Out-Law.com, 2006; M. Sloan, 2001; Yu, 2002).

A limitation in the data collection method was revealed while the author was conducting a preliminary study to support Research Question 1a: the Internet Archive's Wayback Machine[1] poses problems when collecting data from dynamically-generated pages. While websites' homepages are often archived, dynamically-generated pages, are not. Dynamically-generated pages, which are quite common, are created "on the fly" from one or more templates and a database or content management system (W3C, 2006a). This limitation makes it difficult for the author to obtain a good sample of pages for accessibility trending purposes and leads to Question 1b.

1.2.1.1 Research Question 1b.

Because the archiving of dynamic pages is not optimal, can the homepage alone be used for data collection?

[1] http://www.archive.org

The specific aim of the study is to determine if the homepage of a website is representative of the whole site with respect to accessibility. If homepages are a good indication of website accessibility and only homepages need to be evaluated, the limitation posed by the archiving methods of the Wayback Machine can be avoided, leading to a better examination of the impact of lawsuits on Web accessibility. The purpose of Research Question 1b is methodological.

1.2.2 Research Question 2

Unfortunately, even if lawsuits do work and new websites from this point forward were designed to accessibility guidelines, millions of inaccessible Web pages already exist. When Web accessibility is not taken into consideration from the planning phase of website development, it is necessary to change the website after-the-fact. This is known as remediation and retrofitting. Remediation occurs after a website has already been developed and needs to be retrofitted to comply with accessibility guidelines. It can entail rewriting the HTML or redesigning the site. Transcoding, one form of remediation, is the process of adapting document contents so that they may be viewed on diverse devices or accessed by users with disabilities.

Many designers and companies, such as Target Corporation (Brodkin, 2007), are not willing to put in the time and money necessary to redesign or retrofit existing inaccessible Web pages and the effort that this would require may be a prohibiting factor for a smooth and fast transition to an accessible Web. Even Section 508 proved to make slow progress (Stowers, 2002), with legislation passing in 1999 and compliance required in mid-2001; yet, come 2002 many sites still were not compliant. While the researcher's assumed "gold standard" for website design is universal design, with Web design technology advancing at lightning speed, it is

reasonable to think that there will never be a time when every page on the Web is universally designed. How is an accessible Web achieved in the absence of legislation or in the interim period?

As shown in the model in Figure 1, another force against Web accessibility is technology. While technological solutions have been used to assist in accessibility and computing for the blind (e.g.: cascading style sheets, validation and repair tools such as Deque Ramp[2], Bobby[3], A-Prompt[4], the WAVE[5], and LIFT[6]), none has proven to be a potential panacea like transcoding intermediaries.

Can transcoding technology be used to mitigate the problem of increasing accessibility barriers for the blind?

To determine the answer to research question 2, the author conducted a summative comparative usability study on two websites. This study aims to analyze the effects of a transcoding intermediary, built to maximize Web usability for persons with visual impairments, on a website designed following universal design principles and on a website that was not designed following universal design principles. The study hypothesizes that the transcoding intermediary will have less effect on usability when transforming a website that was designed *with* universal design considerations and will have more effect on usability when transforming a website that was designed *without* these considerations.

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[2] http://www.deque.com/products/ramp/index.php
[3] http://www.watchfire.com/products/webxm/bobby.aspx
[4] http://www.aprompt.ca/
[5] http://www.wave.webaim.org/index.jsp
[6] http://lift.american.edu:8080/tt/index.html

Transcoding intermediaries are able to reformat a Web page into one that is accessible even when a designer has not taken accessibility into account. The adaptation can range from simple Web clipping, where images are discarded from the Web page (BBC, N.D.), to ones with various services for the blind and visually impaired (Brown & Robinson, 2001; Liu et al., 2004; Maeda et al., 2004; Hironobu Takagi & Asakawa, 2000), to advanced content summarization and page reconstruction based on complex algorithms (Jatowt & Ishizuka, 2004; Hironubi Takagi, Asakawa, Fukuda, & Maeda, 2002). Transcoding intermediary systems reformat materials that would otherwise have to be developed separately for display on different devices. Transcoding occurs at the point between the user and the browser to transform the contents of the Web page into a form accessible to the viewer (B. Parmanto, Saptono, Ferrydiansyah, & Sugiantara, 2005). Transcoding tools allow virtually any website to be accessible to the end user and frees individuals with disabilities from the expense of software and the learning curve of additional assistive technologies (Liu et al., 2004). It also takes the responsibility away from the Web designer to retro-fit all existing pages of a website and makes the application platform-independent. Most importantly, this technological solution to Web accessibility is readily achievable in the here and now.

One could see universal design as the mitigation technique to support because universal design takes into consideration elements of Web accessibility along with elements of usability and addresses the largest population. In this project it is even referred to as the "gold standard." However, for optimal usability, persons with disabilities require separate designs aimed specifically to their mode of access (Nielsen, 2003). For example, an interface for blind users would be designed keeping in mind that one-dimensional auditory presentation is most favorable for screen readers (Nielsen, 2003), while users with cognitive disabilities would benefit from an

interface that contains more graphics and images to portray meaning. Technology will best allow for multiple presentations for varying audience needs, and a website presented through a transcoding intermediary, such as the one used in this project, has the potential to meet the needs of blind users better than universal design.

The author measured the usability, not just the accessibility, of the websites. Usability pertains to the quality of the user's experience when interacting with a product or system. Usability should not be confused with accessibility, as many researchers feel that accessibility alone is not enough (Hudson, 2004; Jaeger, 2006; Leporini & Paterno, 2004; Milne et al., 2005; Nielsen, 2005). Differing implementation methods are proposed to incorporate usability and Web accessibility in tandem (Keates et al., 2000; Leporini & Paterno, 2004; Vanderheiden et al., 2000). Other approaches include making the website customizable by the user (Vicki L Hanson, 2004; V.L. Hanson, 2004; Hanson et al., 2005; Hanson & Richards, 2005; B. Shneiderman, 2003), making changes easy to integrate (Perlman, 2002), and making standards more usable for designers (Thovtrup & Neilsen, 1991; Vanderheiden et al., 2000).

In this project, the author conducted a usability study on the AcceSS 2.1 Web transcoding gateway. Version 1.0 of the transcoding gateway was designed for accessibility purposes for persons with visual impairments. Version 2.1 implements special simplification and summarization techniques meant to increase usability for the blind user. Preliminary usability studies reveal that Version 2.1 shows promise in increasing usability for this target audience.

Figure 6 is a graphical depiction of the sequence of the studies comprising the project.

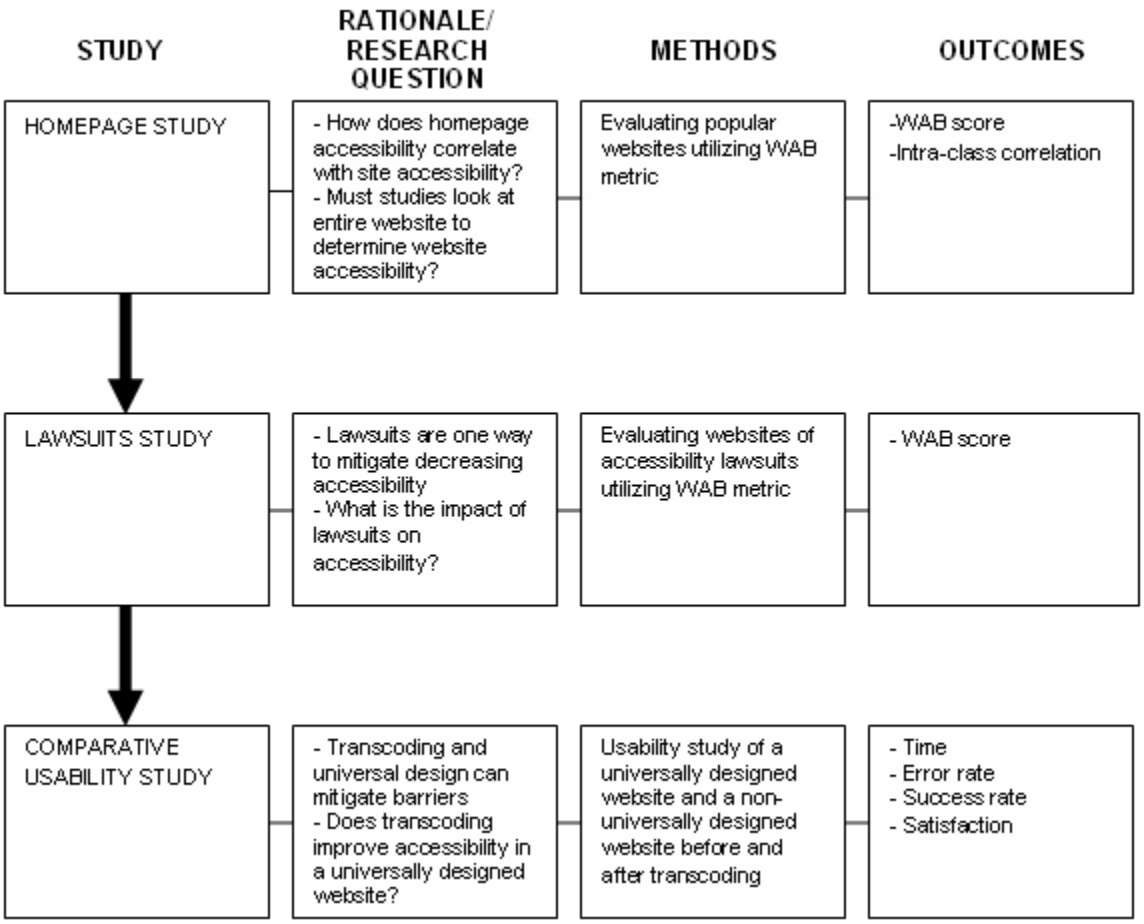


Figure 6. Outline of Studies

1.3 RELATED WORK

This project examines two methods to mitigating barriers to Web accessibility for the blind that have not been investigated in depth. Although literature analyzing the applicability of the ADA to the Internet (P. Blanck, Hill, Siegal, & Waterstone, 2004a, 2004b; P. D. Blanck & Sandler, 2000; Cavaliere & Williams, 2002; Crawford, 2004; King, 2003; Kretchmer & Carveth, 2003) exists, there are presently no empirical studies searching the effects of lawsuits on accessibility

and, while there is much work being done in the area of transcoding system development, little has been done to test the benefits of usability of these systems for persons with visual impairments. This section discusses the work being done to gauge the benefits of transcoding systems.

Zeng (Zeng, 2004) performed a study to examine the benefits of the accessibility transformation provided by the AcceSS 1.0 software. Participants were asked to perform information gathering and online shopping tasks on both the original and transcoded websites. The results of the study were promising: when performing tasks using the transcoder, users accomplished more tasks with greater efficiency and fewer errors while feeling more satisfied, less frustrated, and with increased confidence. However, a common theme noted among the participants in the study was that they cared more about usability than accessibility. Iterative design was employed to enhance the AcceSS software to incorporate usability features and, therefore, the focus in this project is on usability.

Brajnik (Brajnik, Cancila, Nicoli, & Pignatelli, 2005) performed a usability study on commercially available LIFT Text Transcoder[7] by asking subjects to perform information finding tasks on the original and the transcoded versions of an Italian government website. The participants included 17 blind, 7 with low vision, and 5 with motor disabilities. The study found that a text transcoder can improve user effectiveness, productivity, and satisfaction. From the results presented it was not possible to separate the individual disabilities, making it unclear the effects of the system on blind users in the study.

[7] http://lift.american.edu:8080/tt/index.html

1.4 CONTRIBUTIONS

The work in this project contributes to the field of Web accessibility for the blind in the following ways:

- A model for looking at the forces on Web accessibility for persons who are blind is presented
- The lawsuits study is the first empirical exploration of the impact of lawsuits on websites
- The comparative usability study (looking at universally designed and non-universally designed websites):
    - evaluates accessibility AND usability
    - includes only participants who are blind and using screen readers.

2.0 BACKGROUND

This chapter provides background to the reader on the various topics pertaining to driving forces on Web accessibility introduced in chapter 1. The forces on an accessible Web (Web industry, government, consumer, and technology) are presented after a section describing Web accessibility and its beneficiaries. A section on usability is also included in this chapter because of the emphasis in chapter 5 on the usability of websites with and without the use of transcoding intermediary technology.

2.1 WEB ACCESSIBILITY

This section describes the beneficiaries of an accessible Web, assistive technology for visually-impaired computer users, and accessibility evaluation and measurement.

2.1.1 Web Accessibility for Disabilities

Accessibility, when pertaining to a Web page, means that information has been made available for use by almost everyone, including persons with disabilities. This accessibility may be direct or through the use of assistive technologies, various technologies used by persons with

disabilities to access the Internet. This section will briefly describe the beneficiaries of an accessible Web.

According to the U.S. Census Bureau (U.S.Census, 2003), 49.7 million persons have some type of long lasting condition or disability, of which 9.3 million have a sensory disability involving sight or hearing and 12.4 million have a physical, mental, or emotional condition causing difficulty in learning, remembering, or concentrating. More than half of Americans without disabilities have access to a computer at home compared to less than 24% of people with disabilities (Kaye, 2000). A 2-phase study conducted by Forrester Research and commissioned by Microsoft Corporation (ForresterResearch, 2003, 2004) found that the rate of computer use is lower among persons with mild and severe impairments: 74% use computers compared to 84% of individuals without impairments. The study results also indicate that among working age computer users in the U.S. (18 to 64 years old), approximately 25% have a visual difficulty or impairment.

The gap in Internet usage is even greater: 10% of people with disabilities use the Internet compared to 38% of persons without disabilities (Kaye, 2000). Among the elderly, computer and Internet use is much lower. Only 26% of elderly persons without disabilities own a computer and 9% use the Internet, while only 11% of those with disabilities have a computer in their home and 2% use the Internet (Kaye, 2000). However, according to an NTIA report (NTIA, 2004), from 2001 to 2003 all groups of persons with disabilities increased their usage of Broadband Internet connections. The 25-60 year-old age group representing those in the labor force had greater Broadband use than the same age group not in the labor force and the 25-60 year-old age group not in the labor force had higher Broadband use than those over 60 years of age (NTIA, 2004).

2.1.1.1 Vision

In its infancy, the World Wide Web was primarily text-based and a blind person could access most of it easily through text-to-speech software. The Web has become less accessible for users with disabilities (Amtmann, Johnson, & Cook, 2000; Bucy, Lang, Potter, & Grabe, 1999; S. Hackett, 2004; Heim, 2000; USDOJ, N.D.) as Web page design has evolved and Web designers have started to include images, frames, tables, animated Java applications, and streaming audio and video to organize information in more complex ways.

Individuals with visual disabilities include those who are blind, colorblind, or have low vision. A person with low vision can use a screen magnifier to enlarge the text on the computer, use a larger font, or increase the contrast between background and foreground colors (Godwin-Jones, 2001). A person who is blind can use a text-to-speech program that reads aloud the text on the screen via a voice synthesizer or use a refreshable Braille display to obtain a tactile output of the information.

HTML standards guide designers to assign meaningful alternative text (ALT text) labels to non-text elements (such as images, multimedia objects, logos, Java applets, or other types of Web page content that cannot be reduced to ASCII text) to support non-visual content understanding because images and image-related Web content are not yet directly interpretable by assistive technology. ALT text can be provided by making a simple modification to the HTML. Without alternative text to describe images or links, a blind person using text-to-speech software will simply hear “image, image, link”, etc. as the software reads through the Web page. Persons who are print disabled and those who experience difficulty with reading can access the information when screen readers are able to read Web pages (Waddell, 1999).

2.1.1.2 Other Disabilities and the Aging

Persons with mobility or dexterity limitations have a wide range of functional variation so that they may have limited or no ability to interact with a computer using a mouse or a keyboard, the two primary human-computer interfaces. There are various other ways in which a person can interact with the computer and the Internet, including track balls, on-screen keyboards, mouth sticks, head controls, switches, speech recognition, and alternative augmentative communications (AAC) devices. Persons with mobility or dexterity limitations can also use a feature called Sticky Keys. This feature is commonly present in Microsoft Windows and MAC OS X operating systems and allows the user to press keys sequentially instead of simultaneously to perform an action.

Users with cognitive disabilities may have trouble navigating the Web when presented with textual information. Difficulties in using the Internet can occur while having to type in the URL, typing a word in a search engine page, or identifying and clicking on the appropriate subsequent results when doing a search.

Individuals who are deaf or hard of hearing have a hearing range which may include deafness to mild hearing loss. For many persons who are deaf or hard of hearing, visual representations are needed for any information that is presented in an auditory fashion. This can include synchronized closed captioning of video clips, blinking text for alert messages, and transcripts of the auditory information.

Accessibility is not just for persons having an obvious disability or functional limitation. It also benefits those using low-end technology with lower modem speeds, persons utilizing wireless Internet connections, and the aging. The average age of the world population is rapidly increasing (Mynatt, Essa, Rogers, Scholtz, & Thomas, 2000) and, as we age, our chances of

developing a mild or moderate disability increases. By age 65, most persons have lost at least some of their ability to focus, resolve images, distinguish colors, and adapt to changes in light (Lescher, 2000). According to an NTIA report (NTIA, 2002), almost 30 percent of the population aged 65 and older has at least one of the limitations they were examining, while only 1.3 percent of children under 15 has one.

2.1.2 Assistive Technology for Visually-impaired Computer Users

This section is provided to inform the reader of the various devices used to access the computer and the Internet by persons with visual impairments. Persons with blindness and low-vision either have trouble seeing information on the computer screen or cannot see it at all. Assistive technologies, such as screen readers, screen magnifiers, and Braille display, can aid these persons in attaining the information they cannot see.

According to a 2004 study conducted by Forrester Research and commissioned by Microsoft Corporation (ForresterResearch, 2004), among U.S. 18- to 64-year old computer users with mild or severe impairments, 16% were aware of screen readers, however only 1% used them in the work or home setting. Similarly, 8% were aware of refreshable Braille displays but less than 1% used them in the work or home setting. Awareness of screen magnifiers was much greater, 36%, with home use being 4% and work use being 3%.

2.1.2.1 Screen Readers

Screen readers are text-to-speech software that read aloud the text on the computer screen via a voice synthesizer. The screen reader is the interface between the user and the Internet. The human-computer interaction is successful based upon the success of the screen reader when

reading the website. A user can have a successful experience with a website if the site is designed in such a way that it is compatible with a screen reader.

The most well-known screen readers are Freedom Scientific's JAWS for Windows and GW Micro's Windows-Eyes. IBM's Home Page Reader (HPR) is a text-to-speech browser that many users with visual impairments use when accessing the Internet. It is not a screen reader but a Web browser and it is commonly used by persons with visual impairments to access the Internet. HPR also provides Web developers with the ability to identify accessibility problems and provides assistance with accessibility compliance testing (IBM, N.D.-a). As with most types of software, new versions of screen readers are developed continuously. This allows for newer versions of screen readers to support more types of documents and multimedia. APPENDIX A provides details on the features and system specifications of IBM Home Page Reader, GW Micro's Windows-Eyes and Freedom Scientific's JAWS for Windows.

2.1.2.2 Screen Magnifiers

Screen magnifying software enlarges a portion of the screen and is a common technology used by persons with low vision. The screen magnification program enlarges a section of the screen to fit the entire display screen (Cook & Hussey, 2002). ZoomText by AiSquared[8], Lunar by Dolphin[9], and MAGic by Freedom Scientific[10] are examples of screen magnifiers. These screen magnifiers are priced around $350-400 for the standard version. Some operating systems, including Windows XP[11] also have built-in magnifying features.

[8] http://www.aisquared.com/index.cfm
[9] http://www.dolphincomputeraccess.com/products/lunar.htm
[10] http://www.freedomscientific.com/fs_products/software_magic.asp
[11] http://www.microsoft.com/windowsxp/using/accessibility/magnifierturnon.mspx

2.1.2.3 Braille Display

Braille display is a technology that allows an individual who is deaf and blind to receive a tactile display of the information presented on the screen. By use of a translator program, text characters from the screen are converted to Braille cell dot patterns (Cook & Hussey, 2002). Users are able to run their fingers along the refreshable display and read the dynamically-generated Braille cell dot patterns. Braille displays range in price from $1400 to upwards of $10,000[12].

2.2 GOVERNMENT

This section details the U.S. federal agencies and legislation addressing Web accessibility pertinent to this dissertation.

2.2.1 U.S. Access Board

The U.S. Access Board, an independent U.S. federal agency, was created by Section 502 of the Rehabilitation Act of 1973 (29U.S.C.§792, 1973) and issued its standards on December 21, 2000. Although originally the emphasis was solely on the physical environment, its breadth spread to making rules concerning the electronic information environment under the ADA and Section 508. The mission of the U.S. Access Board is to increase accessibility for people with disabilities and, as a result, is a leading source of information on accessible design (USAccessBoard, N.D.). Website compatibility with the adaptive equipment used by people

[12] http://www.nanopac.com/Pricelis.htm#Blindness%20Products:%20Braille%20Displays

with disabilities for information and communication access is an important feature of the standards issued by the U.S. Access Board (Cavaliere & Williams, 2002). To date, there is no mandate for private websites that mirrors the requirement that Section 508 places on U.S. federal government websites.

2.2.2 The Americans with Disabilities Act of 1990

The Americans with Disabilities Act (42U.S.C.§§12101etseq., 1990) prohibits discrimination based on disability. Since the passage of the ADA came before mainstream use of the Internet, there is no mention of the Internet in this legislation. This makes the law subject to judicial interpretation as to whether or not Title II and Title III of the ADA apply to this medium (Kretchmer & Carveth, 2003). Title II of the ADA (42U.S.C.§§12101etseq., 1990) states that "no qualified individual with a disability shall, by reason of such disability, be excluded from participation in or be denied the benefits of the services, programs, or activities of a public entity." A public entity is a state or local government and instrumentalities thereof. Title III of the ADA (42U.S.C.§§12101etseq., 1990) mandates that persons with disabilities be able to participate in "the full and equal enjoyment of the goods, services, facilities, privileges, advantages or accommodations of any place of public accommodation by any person who owns, leases (or leases to), or operates a place of public accommodation."

2.2.3 Section 508 of the Rehabilitation Act Amendments of 1998

Section 508 of the Rehabilitation Act of 1973 (29U.S.C.§794d, 1986) was first added to the Rehabilitation Act in 1986. Section 508 of the Rehabilitation Act (29U.S.C.§794d, 1986) in its

current state was amended by the Workforce Investment Act of 1998 (P.L.105-220, 1998) on August 7, 1998 and is probably the most important piece of legislation regarding accessibility for persons with disabilities and the Internet. Section 508 requires all electronic technology developed or purchased by federal agencies to be accessible to persons with disabilities as of June 2001, unless this would pose an undue burden. In the event of an undue burden, the agency must provide alternative access to the information. Section 508 requires that federal agencies and departments follow accessibility regulations when procuring, developing, using, or maintaining electronic and information technology (USAccessBoard, 2004), however it does not require manufacturers to develop accessible technologies.

2.3 TECHNOLOGY

Technology is an important force on Web accessibility. Technology can allow for accessibility evaluation and also plays roles in the authoring of accessible websites. Tools are available for use during site repair and retrofitting. Transcoding intermediaries are also a solution that holds much promise. This section describes some of the technological solutions to an accessible Web.

2.3.1 Accessibility Evaluation

Technology provides one with a way in which to assess accessibility of websites. In order to test hypotheses it must be possible to evaluate websites. Evaluating Web accessibility can be done for purposes of developing accessible websites and, for research, to determine the state of accessibility of the Web. Evaluation tools are useful to Web designers because they provide

feedback to the designer on the accessibility of the site and some provide detailed descriptions of problems and solutions to making the site more accessible. Measuring Web accessibility determines the state of accessibility and allows one to compare accessibility between websites, over time, or between different genres.

2.3.1.1 Accessibility Evaluation, Repair, and Authoring Tools

There are various tools available that Web page designers can utilize when authoring a site or during evaluation or repair of a site to make it more accessible. Bobby may be the most well-known accessibility tool. Originally developed by CAST, Bobby is now developed and distributed by Watchfire Corporation. WebXACT is a free online service from Watchfire that allows one to test a single page for quality, accessibility, and privacy issues (Watchfire, 2006b). Bobby 5.0 is also available for a 10-day trial offer or to purchase for $299 for more in depth evaluation purposes (Watchfire, 2006a). Other tools are listed in Table 1 and a complete listing of Web accessibility evaluation tools can be found on the WAI website[13].

[13] http://www.w3.org/WAI/ER/tools/complete

Table 1. Web Accessibility Evaluation Tools

Product	URL	Description	Cost	Company
Bobby	http://www.watchfire.com/products/webxm/bobby.aspx	Accessibility validation that uses WCAG 1.0 to evaluate Web pages for errors and ranks them in order of priority	Free to evaluate 1 page/ $299 to purchase	Watchfire Corp.
LIFT	http://lift.american.edu:8080/tt/index.html	UsableNet's LIFT™ for Macromedia Dreamweaver is an extension set for Macromedia®'s WYSIWYG editor. Its aim is to allow users to make sites accessible under Section 508 and compliant with W3C standards through retrofitting, automatically repairing, and fixing ALT tags		UsableNet
Lynx Viewer	http://www.delorie.com/web/lynxview.html	Lynx is a text-only browser. The Lynx Viewer generates an HTML page that indicates how much of the content of the Web page would be available to Lynx	Free	Delorie Software
A-Prompt	http://aprompt.snow.utoronto.ca	A free accessibility evaluation and repair tool that checks against WCAG 1.0, Section 508 and BITV guidelines	Free	ATRC University of Toronto
Deque Ramp	http://www.deque.com	Tests for accessibility against WCAG 1.0 and Section 508 guidelines and has plug-ins for FrontPage, Dreamweaver and HomeSite	$79-1,499 depending on the product	Deque Systems, Inc.
HTML-Kit	http://www.chami.com/html-kit	Web-authoring tool with many functions, including HTML validation and conversion to XHTML	Free	
The WAVE	http://www.wave.webaim.org/index.jsp	Helps sighted viewers see ALT text and the order in which items will be read by screen readers	Free	Temple University

Web authoring tools assist the author of a website to include accessibility measures during the design of Web pages. While evaluation tools can also be used during the design phase, and some often are, authoring tools are specifically designed for this purpose. One such tool is Accessibility Designer (Asakawa & Takagi, 2001; Maeda et al., 2004; Hironobu Takagi & Asakawa, 2000; Hironobu Takagi et al., 2004), created by IBM. This tool allows the designer to

experience their site as a person with a disability would experience it. Accessibility Designer can simulate low vision and blindness and automatically detect usability problems.

2.3.1.2 Accessibility Measurements

Currently, most methods of evaluating accessibility provide absolute ratings: either the website complies with all guidelines or it is considered inaccessible. Most do not take into consideration the size or complexity of the website. Characteristics of quality accessibility metrics include (Bambang Parmanto & Zeng, 2005):

- Quantitative score providing a continuous range of values from perfectly accessible to completely inaccessible. This allows for assessment of changes in Web accessibility over time as well as comparison between websites or between groups of websites.
- Large discriminating power of the metric and range of values beyond simply accessible and inaccessible. This allows assessment of the rate of change of Web accessibility.
- Fair, by taking into account and adjusting to the size and complexity of the websites.
- Scalable, to conduct large-scale Web accessibility studies.
- Normative, meaning that it should be derived from standard guidelines of Web accessibility, such as WCAG 1.0 or Section 508.

While many comprehensive methods for determining the accessibility of a website can be very manual, the author's research colleagues have devised a method that automatically evaluates websites. The tool, Kelvin, is a Java-based crawler that evaluates pages of a website and provides data regarding accessibility, readability, and complexity. The accessibility metric, detailed in (Bambang Parmanto & Zeng, 2005), is summarized in the next section.

Web Accessibility Barrier (WAB) Metric

Without a metric that produces a score along a continuum, it is impossible to trend accessibility. A measurement is also useful because it allows for comparisons, such as between websites or groups of websites.

The Web Accessibility Barrier (WAB) score was developed with the intentions of overcoming the deficiencies of the current measurements used in Web accessibility studies. The current rating system and the "Bobby Approved" measurement reflect an absolute measure of accessibility: either the website conforms to all checkpoints or it is considered inaccessible. The new metric provides a quantitative score that provides a continuous range of values from perfectly accessible to completely inaccessible.

The metric (Figure 7) is a proxy indicator of Web accessibility and examines 25 checkpoints that can be automatically evaluated, based on WCAG 1.0 and Section 508 guidelines (see APPENDIX B for the checkpoint specifics). The metric measures accessibility for persons with disabilities because it is based on accepted Web accessibility standards. The number of violations of the checkpoints is the basis for the score.

$$WABScore = \frac{\sum_{p}\sum_{v}(\frac{n_v}{N_v})(w_v)}{Np}$$

p : Total pages of a website
v : Total violations of a Web page
n_v : Number of violations
N_v : Number of potential violations
Wv : Weight of violations in inverse proportion to WCAG priority level.
Np : Total number of pages checked

Figure 7. The WAB Formula

The WAB formula takes into consideration the actual violations of the page and normalizes them against the potential violations. For example, if the checkpoint looks at the number of images without alternative text, the number of violations would be the actual number of images without alternative text while the number of potential violations would be the number of images within the page. The measure utilizes the checkpoint priorities in reverse. Priority 1 violations weigh three times more than a Priority 3 violation, since Priority 1 violations pose more difficulties in accessibility than Priority 3 violations. The WAB score for each website is the summed WAB score of the Web pages normalized against the total number of pages. A higher WAB score means more accessibility barriers exist. A lower score means better conformance with Web Content Accessibility Guidelines (WCAG) 1.0 guidelines. A score of zero denotes that the website does not violate any Web accessibility guidelines and should not present any accessibility barriers to persons with disabilities.

A previous work (Bambang Parmanto & Zeng, 2005) proposes the WAB as a novel metric for measuring content accessibility of the Web for persons with disabilities. This study, which includes reliability and validity testing of the metric, found that the metric provides a good representation of the website's accessibility. The study calculated the scores of approximately 1,141 rated (accessible) websites with 'AAA', 'AA', and 'A' conformance levels; and 500 random non-rated (non-accessible) websites. Scores of the WAB metrics provide continuous 'degrees' of accessibility. The average scores of 'AAA', 'AA', 'A', and non-rated websites are 2.02, 2.74, 4.47, and 10.5, respectively. Further analysis revealed that a threshold exists between accessible and non-accessible websites. A threshold of 5.5 separates accessible websites from non-accessible ones with a high degree of accuracy (with area under the curve of 0.962 as measured using Receiver Operating Characteristics [ROC] Curve (Egan, 1975)). A WAB score

of 5.5 or less means a website has better conformance to the WCAG and contains few barriers to accessibility, whereas scores above 5.5 indicate increasingly more barriers to accessibility.

2.3.2 Measurement for Evaluating Complexity

Complexity of the websites is also examined for the purposes of explaining accessibility. The complexity score (Figure 8) was designed to follow the complexity sequence derived when one looks at a dot, a square, or an enclosed object such as a cube: a dot is simpler than a square and a two-dimensional square is simpler than a cube. The complexity score is derived by parsing the entire HTML document and assigning a value to each HTML tag (code used in HTML documents to indicate elements). By weighing certain HTML tags differently, the complexity score captures the fact that components of the Web page pose differing levels of barriers to accessibility. Object tags (e.g. <OBJECT> and </OBJECT>), represented by the cube in the metaphor, are coded with a value of 100 units because they are the most complex elements. Script tags (e.g. <SCRIPT> and </SCRIPT>), represented by the square in the metaphor, are coded with a value of 10 units because they are less complex than objects, yet more so than many other HTML tags. All other tags (e.g. <P>, </P>, <TR>, </TR>), represented by the dot in the metaphor, are coded with a value of one unit. A tag value starts at the opening angle, '<', and ends at the ending angle, '>', and only standard tag names are recognized. All other non-identifying modifiers (e.g. ID, VALIGN, etc.) are ignored. The tags' unit values are summed and this summation represents the complexity score for the single page. The total of the scores of the pages evaluated for the website normalized by the number of pages analyzed provides the assessment of website complexity for each website.

$$Complexity = \sum(Tag * 1) + \sum(Script * 10) + \sum(Object * 100)$$

Figure 8. Complexity Score

For illustration, the homepage and 13 first-level pages were evaluated for www.multimap.com (Figure 9). The site contained a total of 495 single tags and 44 scripts and 0 objects. By applying the complexity algorithm and normalizing for the number of pages analyzed, the complexity score for Multimap.com is 66.79. Similarly, www.iVillage.com was analyzed. The homepage and sixteen first-level pages were evaluated. There were a total of 4,066 single tags, 292 scripts, and 7 objects. The complexity score for this site is 452.12.

Complexity(Multimap) = 495 single tags*1 + 44 scripts*10 + 0 objects*100 = 935/14 pages = 66.79

Complexity(iVillage) = 4,066 single tags*1 + 292 scripts*10 + 7 objects*100 = 7,686/17 pages = 452.12

Figure 9. Complexity Example

2.3.3 Transcoding Intermediaries

Transcoding systems have the ability to transform websites from their original state into one that is accessible. Transcoding holds much promise in making the Web accessible, relieving designers from time consuming and costly retrofitting and redesign solutions. This section details other transcoding systems in the literature.

The IBM Tokyo Research group (Asakawa & Takagi, 2001; Maeda et al., 2004; Hironobu Takagi & Asakawa, 2000; Hironobu Takagi et al., 2004) developed a transcoding intermediary (proxy) to transcode existing Web pages. Their proxy uses WebSphere

Transcoding Publisher (WTP) and two databases and consists of five modules using three kinds of annotations. The modules include portal (authenticates users and controls portal pages), simplification (simplifies based on the differential method), full-text (transcodes pages based on annotations input by volunteers), user (transcodes based on user-specified annotations) and experienced-based rules (transcodes based on the authors' experience). They communicate using three kinds of annotations: volunteer-specified, user-specified and automatically-created. Their user interface has simplification, full-text, and original page transcoding modes. Maeda et. al. (Maeda et al., 2004) describes the following functions of the system included for blind users: 1) skip to main content link, 2) simplification of the Web page, 3) reordering of the page content, and 4) adding ALT attributes to image links. For low vision users, the system can: 1) change text size, 2) change line height, 3) enlarge images, 4) change foreground and background colors, and 5) create a digest of the page (reduces and simplifies page content while preserving overall layout).

Another example of a Web intermediary is described in Liu et. al. (Liu et al., 2004). Their server-based approach provides text-magnification, color contrast, and text narration. The services featured on the U.S. National Library of Medicine's Senior Health Website (http://nihseniorhealth.gov) demonstrate the approach described in the paper. Users can invoke the services on the Web page via keyboard or mouse. The application servers used by the service consist of audio-processing, visual-processing, and extended page-formatting components that add the associated audio and visual features before sending the re-formatted pages back to the user. The audio is played on the user's computer via a Java-based audio player.

Betsie (BBC Education Text to Speech Internet Enhancer) is the filter program used by the BBC to create text-only versions of its website (BBC, N.D.). Betsie utilizes a Perl script to reformat any page within the BBC Online site into a form that is suitable for the user's computer. This includes removing images and unnecessary formatting, with all BBC Navigation Bar links moved to the bottom, and delivering a text-only version.

The Essentiality and Proficiency Tool (Dhiensa, Machin, Smith, & Stone, 2005) is another proxy service that allows users to customize their Web interaction according to their needs. By rating Web content as to its essentiality to the meaning of the site, the authors restrict the volume of content displayed to the user. While the tool is generic for all users, it requires the Web author to include essentiality tags for the site content.

Another system that performs semantic annotation and transcoding is described in Nagao et. al. (Nagao, Shirai, & Squire, 2001). Their system allows for easy annotation utilizing user-friendly tools, even when the annotator is not the author of the site. The concept is that annotating documents externally allows for machines (i.e.: computers) to transcode the documents to various formats more easily and efficiently. This system requires human intervention for the annotation. The transcoding proxy then uses the external annotations to semantically transcode the documents according to user preferences.

2.4 WEB INDUSTRY

This section provides information as to what the Web industry has done to make strides toward an accessible Web.

2.4.1 World Wide Web Consortium

The World Wide Web Consortium (W3C) is an international organization dedicated to the standardization of the World Wide Web. In 1996, W3C established the Web Accessibility Initiative (WAI), launching a campaign that called for a more accessible Web for persons with disabilities. The WAI approach to Web accessibility revolves around three interrelated initiatives (USAccessBoard, 2004). First is the content accessibility of websites for persons with disabilities to perceive, understand, and use. Second is making Web browsers and media players usable for persons with disabilities by making them operable through assistive technologies. The third component requires Web authoring tools and technologies to support production of accessible Web content and sites, so that persons with disabilities can use them effectively. The three different sets of guidelines issued by W3C to address these initiative are the Web Content Accessibility Guidelines (WCAG), User Agent Accessibility Guidelines (UAAG), and Authoring Tool Accessibility Guidelines (ATAG) (W3C, N.D.).

WCAG 1.0 (Chisolm, Vanderheiden, & Jacobs, 2001) documents a voluntary set of guidelines to be followed when designing accessible Web pages. WCAG 1.0 is composed of 14 guidelines, each with several checkpoints (65 checkpoints in all), addressing various aspects of

accessibility to persons with physical, visual, hearing and cognitive/neurological disabilities. Version 1.0 of the guidelines was published in May 1999 and primarily addresses the needs of visually impaired users. Version 2.0, which is still in working draft form, takes a broader view and includes greater accessibility for other groups, especially taking note of those with cognitive or reading disabilities (W3C, 2005). The checkpoints (Chisolm et al., 2001) are organized into three levels of priority. Priority 1 ensures that the page itself is accessible and these checkpoints must be met to prevent lack of access for some groups of users. Priority 2 checkpoints should be met to prevent difficulties in access for some users. Meeting Priority 3 makes access easier for some users. Web designers can use WCAG 1.0 Conformance Logos to indicate a claim of conformance to the specific level of the WCAG 1.0. The conformance levels (Chisolm et al., 2001) are in line with the priority levels. Conformance Level "A" implies that all Priority 1 checkpoints have been satisfied. Conformance Level "AA" implies that all Priority 1 and 2 checkpoints have been satisfied and Conformance Level "AAA" means that all Priority 1, 2, and 3 checkpoints have been satisfied.

WCAG 2.0 Working Draft (W3C, 2005) builds on WCAG 1.0 and has the same aim, which is to explain how to make Web content accessible to persons with disabilities and to define target levels of accessibility. WCAG 2.0 attempts to apply guidelines to a wider range of technologies and to use wording that may be understood by a varied audience. Differences between WCAG 1.0 and WCAG 2.0 include the organization and structure of the guidelines. WCAG 2.0 Working Draft uses guidelines to group success criteria, where WCAG 1.0 uses guidelines to group checkpoints. Working Draft of 2.0 categorizes a success criterion into 1 of 3 levels, whereas WCAG 1.0 assigns a priority to a checkpoint.

W3C also publishes recommendations for cascading style sheets (CSS). CSS, especially the level 2 recommendation (CSS2), are known to directly affect the accessibility of Web documents (W3C, 1999). This is because CSS separate document structure from presentation. CSS also allow for control over font size, color, and style and allow users to override author styles.

2.4.2 Universal Design

Universal design is a term coined in the early 1970s by Ronald Mace, the founder of the Center for Universal Design at North Carolina State University (NCSU). It is defined as "the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design (TheCenterForUniversalDesign, 1997b)". The "gold standard" in accessible Web design is to follow universal design principles because, as sometimes called "usability for all", universal design aims to benefit all users. There are seven principles of universal design put forth by the NCSU (TheCenterForUniversalDesign, 1997a)[*]. Each principle is accompanied by a set of guidelines on how to implement each principle. The principles are described below and the complete criteria and guidelines are presented in APPENDIX C:

1. **Equitable Use** – the design is useful and marketable to people with diverse abilities
2. **Flexibility in Use** – the design accommodates a wide range of individual preferences and abilities

[*] Copyright © 1997 NC State University, The Center for Universal Design.

3. **Simple and Intuitive** – use of the design is easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration level
4. **Perceptible Information** – the design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities
5. **Tolerance for Error** – the design minimizes hazards and the adverse consequences of accidental or unintended actions
6. **Low Physical Effort** – the design can be used efficiently and comfortably and with a minimum of fatigue
7. **Size and Space for Approach and Use –** appropriate size and space is provided for approach, reach, manipulation, and use regardless of user's body size, posture, or mobility.

Examples of universal Web design include (Thompson, 2004) text alternatives to visual content benefiting not only the visually impaired, but also those using text-based browsers, slow Internet connections, and those using handheld devices such as PDAs. Text alternatives to audio content not only benefit those with aural disabilities, but also those in noisy environments or with inadequate or no sound hardware. Avoiding color aids those with difficulty in color differentiation and those using monochrome monitors and handheld devices with grayscale screens. These and more examples of how universal Web design benefits all users are summarized in Table 2 (Thompson, 2004).

Table 2. Benefits of Universal Web Design

Design Element	Beneficiary is one who:

Text alternative to visual content	• Has no immediate access to graphics:
	  • Text-based browser
	  • Slow Internet connection
	  • Handheld devices like PDA
	  • Voice Web and Web portal systems

Text alternative to audio content	• Has limited access or no access to sound output • Deaf or hard of hearing • Accessing Internet in noisy environment • Has inadequate sound hardware **Captioned multimedia can also be indexed and searched upon
Avoiding color to convey information	• Color-blind individuals • Uses monochrome monitor • Uses handheld devices with grayscale screens
High contract foreground/background colors	• Visual impairments **Lessens squinting and eye fatigue
Avoiding flashing images of 2Hz – 55Hz	• Has seizure disorders • Distracted by animation
Using relative units instead of absolute	**Ensures content will fit the screen regardless of resolution
Clarifying natural language usage	• Using screen readers so it can automatically detect appropriate language **Allows search engines to index by language
Clear, simple design	**Everyone can easily and efficiently use the site because it is consistent and intuitive

Web page authors can place statements on the website describing exactly how the website is universally designed. Called "universal usability statements" (Hochheiser & Shneiderman, 2001), these statements describe the content of the site, browser requirements, network requirements, and other characteristics that may influence the usability of the website. For persons who are blind, this statement may tell them that the page has been tested with their screen reader and they will be reassured that they can explore the site without frustration.

Universal design and accessibility can also be a part of e-business plans, so that goods, services, and information are posted and promoted to the widest possible customer base. By creating one platform, and not giving the illusion of "separate but equal" by using text-only

designs, e-businesses can cultivate brand and consumer loyalty and reduce the costs of retrofitting sites (P. D. Blanck & Sandler, 2000).

In general, achieving universal design for the Web involves separating structure from style and using structural markup (Santovec, 2005). Cascading style sheets can be used to separate structure from style because they are used to dictate the graphical styling of the content. The structural markup in HTML includes (Santovec, 2005):

- Headers
- MAP (collections of links)
- List elements
- Form control labels
- Tabular data headers
- Abbreviations

By creating Web content that is display-independent, content can be transformed and displayed in different forms and for different media, including ones that haven't been invented yet (B. Shneiderman & Hochheiser, 2001).

2.5 CONSUMERS

Blind Internet consumers and their advocates have filed several lawsuits against companies for allegedly having inaccessible websites, stating discrimination under the ADA. The applicability of Title II and Title III of the ADA have been in question.

Title III of the ADA (42U.S.C.§§12101etseq., 1990) protects against discrimination with disabilities in “public accommodations”. A “public accommodation” is any private (non-governmental) entity, regardless of size, that offers goods and services to the general public. It only applies to those businesses that operate a place of public accommodation only to the extent that it is operating a place of public accommodation. Not all businesses are public accommodations. For example, a wholesaler selling only to other businesses, and not to the public, is not a place of public accommodation under Title III of the ADA (King, 2003).

Title II of the ADA (42U.S.C.§§12101etseq., 1990) includes the term effective communication. The U.S. Department of Education, Office of Civil Rights (OCR) has defined the term as the transfer of information with the following three components: 1) timeliness of delivery; 2) accuracy of the translation; and 3) provision in a manner and medium appropriate to the significance of the message and the abilities of the individual with the disability. Although this is not yet applied to Title III, it does provide a framework for evaluating Internet activities (P. D. Blanck & Sandler, 2000).

Prior to the Internet was the case of Carparts Distribution Center, Inc. v. Automotive Wholesaler’s Association of New England, Inc. in 1994 ("Carparts Distrib. Cntr., Inc. v. Automotive Wholesalers Ass'n of New England," 1994). The First Circuit Court of Appeals held that “public accommodations” are not limited to physical structures and that the services of a health provider were covered under Title III (Kretchmer & Carveth, 2003). It was decided that persons purchasing goods and services over the telephone or by mail are offered the same protection by the ADA as those that purchase the same goods and services within the walls of the brick and mortar business structure (Kretchmer & Carveth, 2003; M. Sloan, 2001). The Seventh

Circuit also takes this position: in Doe v. Mutual of Omaha Ins. Co. ("Doe v. Mutual of Omaha Ins. Co.," 1999), Judge Posner explicitly stated websites in his opinion.

A Justice Department Opinion Letter (Patrick, 1996) states that the ADA does apply to the Internet. The letter, written by Deval L. Patrick, Assistant Attorney General of the Civil Rights Division on September 9, 1996, in response to an inquiry from U.S. Senator Tom Harkin, includes the quote:

> "Covered entities under the ADA are required to provide effective communication, regardless of whether they generally communicate through print media, audio media, or computerized media such as the Internet. Covered entities that use the Internet for communications regarding their programs, goods, or services must be prepared to offer those communications through accessible means as well."

Court rulings concerning the application of the ADA to the Internet have gone both ways (see Table 3). Suits against America Online ("National Federation of the Blind v. America Online, Inc.," 1999), Barnes and Noble, Inc., and Claire's stores (Haggman, 2002) were either settled out of court or dropped when the company agreed to make their websites accessible (Kretchmer & Carveth, 2003). In 2002, one judge ruled that Southwest Airlines ("Access Now v. Southwest Airlines Co.," 2002) did not have to modify its website. Access Now, Inc. appealed the ruling, but the ruling was upheld two years later by the Court of Appeals ("The National Law Journal", 2007). Another judge ruled that the Atlanta, Georgia mass transit system, MARTA, did have to reconstruct its website or violate the ADA ("Vincent Martin et al. v. Metro Atlanta Rapid Transit Authority," 2002). A more recent ruling made by New York Attorney General Eliot Spitzer opined that the ADA requires private websites to be accessible to

the blind and visually impaired (NYStateAttorneyGeneral, 2004). The companies that operate the website involved in the investigation, Ramada.com and Priceline.com, agreed to make their sites accessible to assistive technologies that access the Internet. The most recent case is against Target Corporation ("National Federation of the Blind v. Target Corporation," 2006). The lawsuit claims that Target's website lacks alternative text, contains inaccessible image maps, and requires the use of a mouse to complete transactions. Target Corporation attempted to have the case dismissed, but in September 2006 a federal district court judge ruled that the case against Target Corporation may continue.

Table 3. Lawsuits Concerning Allegedly Inaccessible Websites

Website	Complaint	Year Filed	Result
America Online (AOL)	Inaccessible to screen readers	1999	Settled, AOL to make accessible site
Barnes and Noble, Inc.	Inaccessible to screen readers	2002	Settled, company agreed to modify site
Claire's stores	Inaccessible to screen readers	2002	Company agreed to modify site
Southwest Airlines	Inaccessible to screen readers, and in particular -no ALT text -text in form fields -no headers in data tables -no skip navigation link	2002	Dismissed in 2002, Appealed by Access Now Inc, and dismissed again in 2004
MARTA	Telephone access to schedule and route info not equivalent	2002	MARTA had to make accessible site
Ramada.com	Inaccessible to screen readers	2004	Agreed to make site accessible
Priceline.com	Inaccessible to screen readers	2004	Agreed to make site accessible
Target Corporation	Inaccessible to screen readers, in particular: -no ALT text -inaccessible image maps -transactions require mouse	2006	Case can proceed, but so far Target does not have to modify site

2.6 USABILITY

Usability is a concept closely related to accessibility. While accessibility should be taken into consideration, simply following standards for accessibility does not make a website usable nor make a positive impression on the user. Usability must also be taken into account.

Usability as a field is often referred to as CHI (computer-human interaction), HCI (human-computer interaction), UCD (user-centered design), and HMI (human-machine interface), among others (Nielsen, 1993). Factors taken into consideration when evaluating the user's experience of usability include (Nielsen, 1993; USDeptHHS, N.D.):

- Ease of learning – how fast can a user who has never seen the user interface before learn it sufficiently to accomplish tasks?
- Efficiency of use – once an experienced user has learned to use the system, how fast can he or she accomplish tasks?
- Memorability – how effectively can the user use the system upon subsequent usages?
- Error frequency and severity – how often do users make errors, how serious are the errors, and how do users recover from the errors?
- Subjective satisfaction – how much does the user like using the system?

Thatcher's work (Thatcher, n.d.) demonstrates that accessible sites are not necessarily usable sites. Thatcher describes a website that technically meets accessibility standards but doesn't adequately provide a positive experience to users with severe visual impairments. Long descriptions (similar to alternative text for images, but longer in length) are provided, however they are very wordy. While users of screen readers can often choose whether or not they want to

listen to long descriptions, in this website the designers placed an invisible 1-pixel image next to each main image link and placed the same long description text as ALT text in the invisible image. This ensures that the blind visitor must listen to every long description whether or not they want to. This page also uses “spacer images” to facilitate the layout of the page. To deal with this type of image in an accessible manner, the designer must use empty ALT text, alt=””, so that assistive technology can ignore the spacer images. This particular agency website includes as ALT text of their spacer images: alt=”A clear one pixel image for spacing.” This means that each time the screen reader approaches one of the 17 spacer images on this site, it reads what is included in the ALT text instead of ignoring a useless image, resulting in an experience that is most likely unsatisfactory.

3.0 HOMEPAGE STUDY

3.1 INTRODUCTION

Jakob Nielsen (Nielsen, 2000) argues that the homepage is the gateway to the website and therefore sets the tone of the entire website for the user. There are many studies of Web accessibility that evaluate only the homepages (Davis, 2002; Flowers, Bray, & Algozzine, 1999; Klein et al., 2003; J. Lazar et al., 2003; Jonathan Lazar & Greenidge, 2006; Loiacono & McCoy, 2006; Paris, 2006; Spindler, 2002; Yu, 2002), a selected handful of pages (Diaper & Worman, 2003; D. Sloan, Gregor, Booth, & Gibson, 2002; Thompson, 2003), or limit the levels of pages evaluated for the website (S. Hackett, Parmanto, & Zeng, 2004; Jackson-Sanborn et al., 2002). One can look at the homepage of a site as being the "doorway" into the site as was done in Yu (Yu, 2002). Yu (Yu, 2002) looked at four sets of homepages for each of the 108 California Community Colleges, where available, including the homepages of the college, library, distance education, and disabled student programs and services. The rationale behind looking at only homepages is that the initial Web pages are gateways to major resources; if these pages are free from accessibility errors, they provide successful pathways to the information (Yu, 2002). Or, as stated in Klein et al. (Klein et al., 2003), if the home page is not accessible, the rest of the site probably isn't accessible. Similarly, Loiacono and McCoy (Loiacono & McCoy, 2006) felt that homepage evaluation was appropriate because visitors are most likely to enter through a

homepage and, if the homepage is not accessible the accessibility of the remainder of the site becomes irrelevant. Because manual checks or large-scale studies can be very cumbersome, one can accept these few pages as being representative of the website.

Performing large-scale studies of entire websites can be burdensome with manual inspection; however, with the use of automated tools, such as the Kelvin Web crawler developed for use with the WAB metric, it is much more feasible. If the homepage is a true representation of the entire site, these studies looking at only the homepage are valid; however, if not, these studies have no consequence. This study aims to address this issue.

The findings from this study will guide future evaluations of Web accessibility, specifically the lawsuits study described in the next chapter. If only homepages are necessary for evaluation, gathering data on earlier versions of websites from the Wayback Machine will be possible even on dynamically-generated websites.

3.2 METHODS

3.2.1 Materials

This study hypothesizes that homepage accessibility is indicative of the accessibility of the entire website. The hypothesis was explored using the first 50 websites from Alexa.com's Top 500 English websites on April 10, 2007. Alexa® Internet's traffic rankings rate how popular a site is with other users (AlexaInternet, N.D.). Since rankings of websites can change from day to day, depending on the traffic to that site, the most popular websites can change from day to day. These websites were chosen to be representative of present day popular websites.

3.2.2 Measurement

The WAB score was utilized to determine the accessibility measurement of each page of the website. The complexity of each level of the website was also calculated. Pages from levels zero through three of the website were evaluated (see Figure 10). Each page was counted once: for example, if the homepage and a page at level 2 have links to a search page, the search page was only counted once.

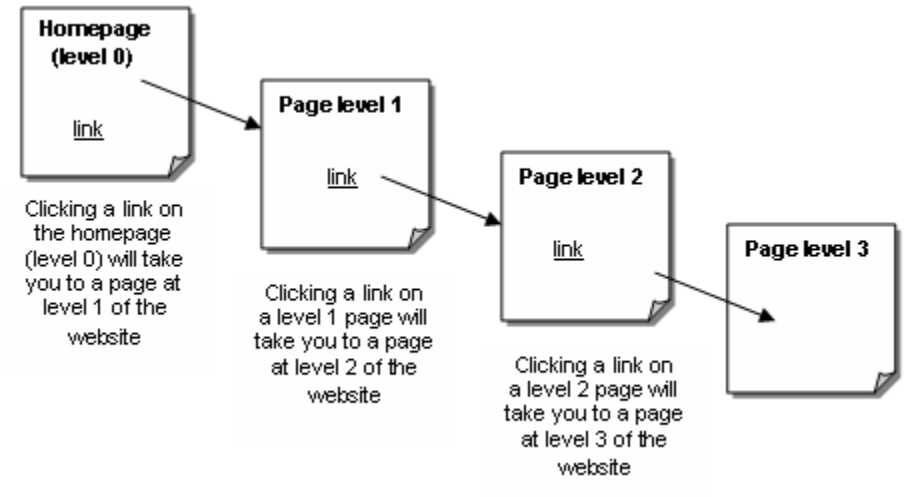


Figure 10. First 4 levels of a Website

3.2.3 Data Analysis

Descriptive statistics were used to describe the websites as a whole. Because the real interest is whether the homepage WAB score is correlated to the WAB score of the entire website, an intra-class correlation (ICC) (Shrout & Fleiss, 1979) statistic was computed comparing the WAB score of the homepage (level 0) to the WAB scores of the other levels of the website (average of

WAB scores of levels 1, 2, and 3). ICC was also computed to determine correlation between the scores of the levels of the website other than the homepage. The ICC statistic evaluates absolute agreement (within-subjects effects) and consistency (between-subjects effects) depending on how the denominator is designated. The denominator is one of consistency when the variance in the level scores is excluded from the denominator mean square, and it is one of absolute agreement when the variance of the level scores is not excluded from the denominator. Two-way mixed effects model single measure reliability, ICC(3,1), with absolute agreement was used was used in this analysis (McGraw & Wong, 1996). The formula to compute intra-class correlation coefficient for this analysis is provided in Figure 11.

$$ICC(A,1) = \frac{MS_{rows} - MS_{errors}}{MS_{rows} + (k-1)MS_{errors} + \frac{k}{n}(MS_{columns} - MS_{errors})}$$

Figure 11. Intra-class Correlation Algorithm

3.3 RESULTS

Thirty-three of the top 50 websites were evaluated because (1) six were unavailable for Kelvin evaluation due to lack of a designated "content type" within the HTML, a Kelvin requirement; (2) ten were excluded from the study because Kelvin was not able to evaluate pages of all four levels of the website; and (3) one website was predominantly in a language other than English. Descriptive details of the 33 sites are shown in APPENDIX D. The means of each level and the averages included in the analysis are included in Table 4.

Table 4. Mean WAB for Different Levels of the Websites

Level of website	Total Number of Pages	Avg. Number of Pages	Mean WAB score	St. Dev.
Level 0	33	1	8.17	3.25
Level 1	2,217	67	6.47	2.54
Level 2	29,928	907	7.06	2.28
Level 3	264,377	8,011	7.25	2.36
Average of levels 1,2, & 3	-	-	6.93	2.24
Average of levels 2 & 3	-	-	7.16	2.29

The ICC of level 0 and the average of levels 1, 2, and 3 is 0.250 ($p=0.062$) and indicates a low correlation between the homepage WAB score and that of the rest of the website. An ICC was computed for levels 1, 2, and 3, to see how these levels correlate to each other: 0.784 ($p<0.0001$) indicating a high-level of correlation between these levels. ICCs for the homepage and each level were computed. These statistics are shown in Table 5. The homepage accessibility correlates most highly with level 1; however, this correlation is still weak. Level 1 is also highly correlated with the average WAB scores of levels 2 and 3.

Table 5. Intraclass correlation statistics

LEVELS	ICC(3,1)	95% CI	P-value
Level 1, Level 2, and Level 3	0.784	0.65 - 0.88	<0.0001
Level 0 and avg of levels 1,2,3	0.25	-0.07 - 0.53	0.062
Level 0 and Level 1	0.372	0.05 - 0.63	0.006
Level 0 and Level 2	0.183	-0.14 - 0.48	0.138
Level 0 and Level 3	0.134	-0.20-0.45	0.218
Level 1 and avg of levels 2 & 3	0.747	0.55 - 0.87	<0.0001

A paired-sample t-test was computed to compare level 0 to the average WAB of levels 1, 2, and 3 and there is a statistically significant difference (df=32, p=0.043). The average WAB of all homepages is 8.17 and the average WAB of levels 1, 2, and 3 is 6.93.

Finally, a scatterplot of the homepage WABs and the WABs of the average of levels 1, 2, and 3 depicts only a small pattern of correlation (Figure 12).

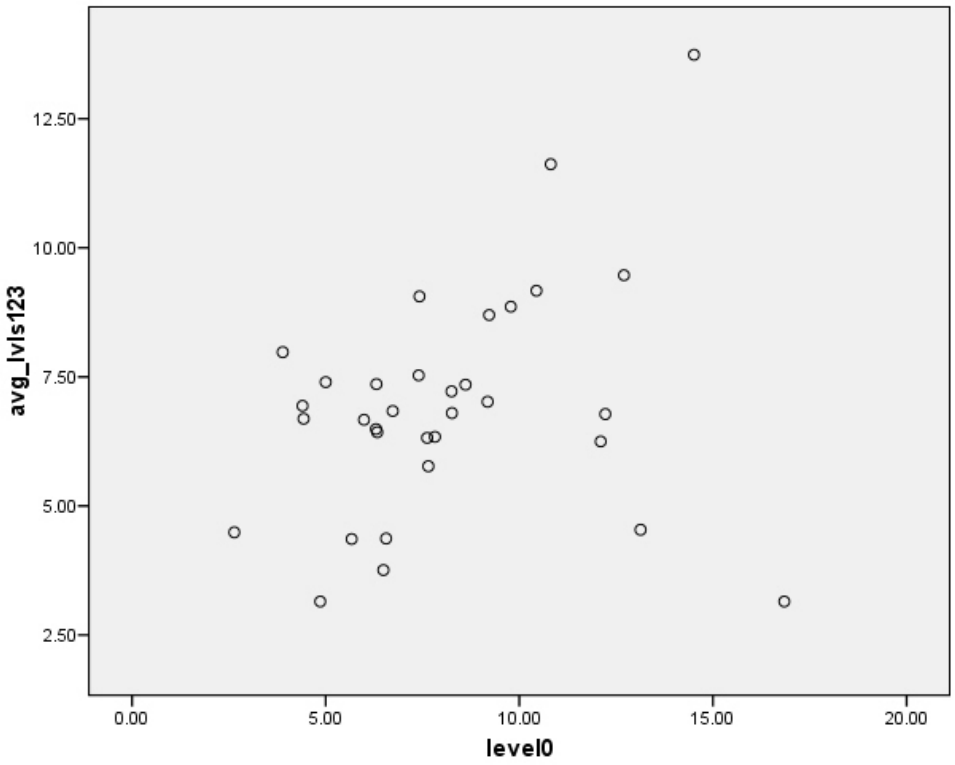


Figure 12. Scatterplot of WAB Score of Level 0 vs. Average WAB Score of Levels 1,2,&3

3.4 DISCUSSION

The WAB score of the homepages of the popular websites evaluated are not strongly correlated to the WAB scores of the rest of the website leading to a rejection of the hypothesis that

homepage accessibility is indicative of the accessibility of the entire website. These results demonstrate that evaluating the homepage alone is not sufficient when evaluating Web pages for accessibility. Previous studies using only the homepage in the analysis (Davis, 2002; Flowers et al., 1999; Klein et al., 2003; J. Lazar et al., 2003; Jonathan Lazar & Greenidge, 2006; Loiacono & McCoy, 2006; Paris, 2006; Spindler, 2002; Yu, 2002) may not have show the whole picture of accessibility. However, the WAB scores for levels 1, 2, and 3 of these websites are highly correlated and previous studies that included more pages than just the homepage (Diaper & Worman, 2003; D. Sloan et al., 2002; Thompson, 2003), if even a limited number of deeper pages (S. Hackett et al., 2004; Jackson-Sanborn et al., 2002), may have provided better estimates of the accessibility of the websites under evaluation. Because the WAB scores of the deeper levels are highly correlated, one can assume that using the homepage and level 1 of a website will give more accurate results as to the accessibility of the entire website.

A limitation of the study can be attributed to the variation in sample sizes collected from the popular websites and the varying number of pages evaluated for each level of the website. Some of the websites had thousands of pages included in the analysis, while others had relatively few. This could bias the averages to be more consistent with the scores of the sites that had a larger number of pages evaluated.

3.5 CONCLUSIONS AND IMPLICATIONS

The results of the evaluation of the accessibility evaluation of websites involved in lawsuits in the next chapter will include the evaluation of the homepage and level 1 of the websites. Because the WAB scores of levels 1, 2, and 3 are highly correlated, it makes sense to limit the

evaluations to the homepage and level 1 of the website for purposes of accuracy and resource management, as it is administratively simpler to obtain data for level 0 and level 1 than it is to collect data for level 0 and level 2 or level 0 and level 3. Future studies in Web accessibility should also include the homepage and at least one other level of the website to ensure accurate measurement of accessibility.

4.0 A CASE STUDY OF THE IMPACT OF LAWSUITS ON ACCESSIBILITY

4.1 INTRODUCTION

Persons with disabilities have filed several lawsuits against companies for maintaining inaccessible websites. This chapter examines the websites of companies that have been sued to determine whether the lawsuits have had an impact on website accessibility. Evaluation of the success or impact of lawsuits on accessibility is presently lacking in the literature.

The ADA was signed before the Internet became a part of mainstream society and, therefore, makes no mention of the accessibility of the Internet. Despite this, it is the belief of many with and without disabilities that the Internet should be accessible. In its short history the Web has continually seen the introduction of complex technologies. A previous study (S. Hackett et al., 2004) concludes that it is these complex Web design technologies that often present obstacles for persons with disabilities.

The first study presented in this chapter is a preliminary study of two company websites, America Online (AOL) and the Metropolitan Atlanta Rapid Transit Authority (MARTA). A more comprehensive study is then carried out that includes AOL and MARTA plus other websites of companies that have been sued. The websites included in this study are sites that have had lawsuits brought against them by persons with disabilities and their advocates. None of these companies have claimed that making their website accessible would cause undue burden.

The results of each company website were compared to a random control group of websites. The random control group is part of the author's previous research examining accessibility and complexity from 1997-2002, now extended to include the years 1997-2007. The findings of each company website are also compared to its own control website: a website of a similarly-sized company that has not been sued, and within the same industry as the sued company.

Many studies discuss the lack of accessibility of the Web (S. Hackett et al., 2004; Klein et al., 2003; Stowers, 2002; West, 2001). Some have found (Stowers, 2002; West, 2001) that the introduction of Section 508 (29U.S.C.§794d, 1986) standards hasn't helped to defray accessibility problems in websites of federally-funded programs and services. Section 508 (29U.S.C.§794d, 1986), as amended by the Workforce Investment Act of 1998 (P.L.105-220, 1998) requires that electronic and information technology developed or purchased by the U.S. federal government be accessible by persons with disabilities. If federally-mandated standards aren't solving the problem, voluntary guidelines, such as the Web Content Accessibility Guidelines (WCAG) (Chisolm et al., 2001) developed by W3C, may be even less effective. This study aims to determine if lawsuits are a viable solution to a more accessible Web.

4.2 PRELIMINARY WORK

The author conducted a preliminary study on websites of two companies, AOL and MARTA, that have been sued for having allegedly inaccessible websites under the Americans with Disabilities Act (ADA) (42U.S.C.§§12101etseq., 1990). The goal is to see how the accessibility of the websites has changed in relation to the lawsuits.

The National Federation of the Blind (NFB) filed an ADA lawsuit against America Online (AOL) on November 4, 1999 (SEDBTAC, 2002). The lawsuit sought injunctive and declaratory relief to bring AOL into compliance with Title III of the ADA after AOL failed to alter its software to be compatible with screen readers. An agreement was reached on July 26, 2000, when NFB agreed to drop the suit in return for specific accommodations, which included AOL agreeing to continue existing efforts to ensure that future software is compatible with screen readers and publishing their policy on accessibility (SEDBTAC, 2002; Slatin & Rush, 2002). The agreement provided one year to review progress and included the stipulation that NFB could file suit again if problems remained (Slatin & Rush, 2002).

In October 2002, a class action lawsuit of Atlanta-based persons with disabilities was filed against MARTA and became one of the first federal court cases to rule that the ADA does apply to the Internet (SEDBTAC, 2002). Under Title II of the ADA, the court found that until MARTA reformats its website to be readable by screen readers, its website was "violating the ADA mandate of making adequate communications capacity available, through accessible formats and technology (Waddell, 2002)."

Using the WAB metric (Bambang Parmanto & Zeng, 2005) to determine the website's WAB score, versions of AOL (www.aol.com) and MARTA (www.itsmarta.com) websites were evaluated for changes surrounding the lawsuits. Convenience samples of the AOL and MARTA websites were collected from the Wayback Machine and evaluated for the years surrounding the respective lawsuits. When possible, one archived instance of each website was selected per year. All pages within the website having an archive date within the same year as the selected date were evaluated. The WAB scores were normalized to provide a single WAB score per year. The years 1997, 1998, 2001, and 2005 were studied for the AOL website. The years 2000-2005

were studied for the MARTA website. Table 6 presents the raw data regarding the number of pages evaluated, mean WAB scores, and standard deviations for all of the years evaluated for each website.

Table 6. Descriptive Statistics for years evaluated for MARTA and AOL websites

	MARTA			AOL		
	# pages	Mean WAB	SD	# pages	Mean WAB	SD
1997	-	-	-	42	7.09	2.47
1998	-	-	-	261	5.96	1.68
1999	-	-	-	-	-	-
2000	1,092	8.65	0.65	-	-	-
2001	464	8.68	0.76	25	7.04	1.51
2002	245	13.09	0.77	-	-	-
2003	82	9.62	0.95	-	-	-
2004	1,001	3.73	3.03	-	-	-
2005	1,604	4.43	1.82	173	8.16	2.69

Mean WAB scores for AOL decreased from 1997 to 1998, increased in 2001 and again in 2005 (Figure 13). ANOVA was computed comparing the mean WAB scores for each year and a significant difference was found ($F(3,497)=36.69$, $p<0.0001$). Tukey's HSD procedure was used to do pair-wise comparisons among means of the years and revealed that 1997 was significantly different from 1998 and 2005; 1998 was also significantly different from 2005. 2001 showed no significant differences from 2005. This may be due to the small number of pages evaluated. The data show that the AOL website has become less accessible since the lawsuit was settled in 2000.

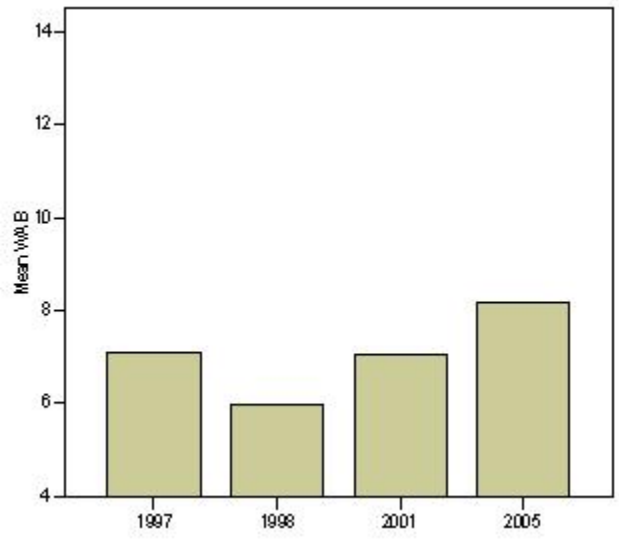


Figure 13. AOL - Mean WAB Scores

For the MARTA website, mean WAB scores increased from 2000 to 2002 and then decreased from 2003-2005 (Figure 14). ANOVA was computed and a significant difference was found among the years ($F(5,4482)=1926.13$, $p<0.0001$). Tukey's HSD procedure was used to do pair-wise comparisons among means of the years, revealing that websites selected for all years were significantly different from one another with the exception of the years 2000 and 2001. Because a score of 5.5 or less indicates that a website is accessible (Bambang Parmanto & Zeng, 2005), it appears that efforts have been made to make the MARTA website accessible since the lawsuit in 2002.

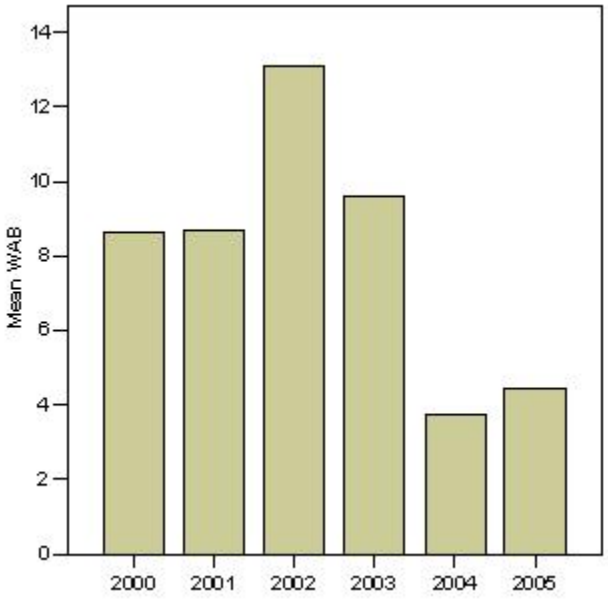


Figure 14. MARTA - Mean WAB Scores

4.3 METHODS

4.3.1 Materials

Convenience samples for websites of the following companies were evaluated for as many years as possible surrounding the respective lawsuits: America Online (AOL), Barnes and Noble, Inc. (Barnes and Noble), Southwest Airlines (Southwest), Metropolitan Atlanta Rapid Transit Authority (MARTA), Ramada.com (Ramada), Priceline.com (Priceline), Claire's stores (Claire's), and Target Corporation (Target). A convenience sample of the websites comprising the control group of non-sued websites was also collected. Table 7 shows the sued vs. non-sued pairings. When possible, two archived instances of each website were selected per year, one

from the first quarter (January – April) and one from the last quarter (September – December). Although website designs change frequently, studies suggest that a yearly time-frame of analysis is appropriate for examining the evolution of website design and this approach was used by Ivory et. al. (Ivory & Megraw, 2005) in their large study of design pattern evolution. For this reason, it is assumed that two samples per year for each website evaluated are adequate for this study.

Table 7. Sued and "Not Sued" Control Websites

Sued Company/Website	Control Group Company/Website	Rationale for choosing Control Website
America Online (AOL) www.aol.com	**Yahoo** www.yahoo.com	Forbes.com list of Digital Media Companies[14]
Barnes and Noble www.barnesandnoble.com	**Alibris** www.alibris.com	Forbes.com Directory of Favorites, Books[15]
Southwest Airlines (Southwest) www.southwest.com	**U.S. Airways** www.usairways.com	Forbes.com list of "The World's 2000 Largest Public Companies[16]"
Metro Atlanta Rapid Transit Authority (MARTA) www.itsmarta.com	**Tri-County Metropolitan Transportation District of Oregon (TriMet)** www.trimet.org	American Public Transportation Association, city with similar passenger miles[17]
Ramada.com (Ramada) www.ramada.com	**Marriott** www.marriott.com	Forbes.com list of "The World's 2000 Largest Public Companies"
Priceline.com (Priceline) www.priceline.com	**Fodors** www.fodors.com	Forbes.com Directory of Favorites, Travel[18]
Claire's stores (Claire's) www.claires.com	**Bluenile** www.bluenile.com	Forbes.com Directory of Favorites, Jewelry[19]
Target Corporation (Target) www.target.com	**Walmart** www.walmart.com	Forbes.com list of "The World's 2000 Largest Public Companies"

[14] http://www.forbes.com/2005/05/31/digital_companies.html
[15] http://www.forbes.com/bow/b2c/category.jhtml?id=76
[16] http://www.forbes.com/2006/03/29/06f2k_worlds-largest-public-companies_land.html
[17] http://www.ntdprogram.com/ntdprogram/pubs/dt/2004/PDF_files/2004_Table_19.pdf
[18] http://www.forbes.com/bow/b2c/category.jhtml?id=31
[19] http://www.forbes.com/bow/b2c/category.jhtml?id=124

4.3.2 Measurement

The WAB score was used to evaluate the accessibility of each website. The findings from the homepage study in chapter 3 determined that the homepage and level 1 should be evaluated. For purposes of explaining accessibility, the complexity score of each website was also calculated.

4.3.3 Data Analysis

The WAB scores were normalized to provide a single WAB score twice per year for each website. Because the results of the study in chapter 3 indicate that the homepage alone is not enough to gauge the accessibility of the website, data from the homepage and 1-level from the homepage were collected. Analysis of variance (ANOVA) was computed on the common periods between each pairing of sued and control websites. The common periods were analyzed because this provides for a fair comparison and there was little statistical loss when removing the non-common periods.

4.4 RESULTS

Due to limitations posed by the Wayback Machine, only five of the proposed eight sued websites were evaluated. The Wayback Machine has technical limitations in archiving dynamically-generated Web pages. Dynamically generated websites usually are generated by software applications and database management systems “on-the-fly”, and therefore are very difficult to archive. While websites’ homepages are often archived, dynamically-generated pages built from

templates and a database management system (and are quite common) are not archived. Because the archive is incomplete, the Wayback Machine grabs the closest index if the requested document is not there, resulting in links being redirected to another date or, more often, to the current website for dynamically-generated Web pages.

Figure 15 depicts the samples collected from the Wayback Machine for the sued websites. The stars indicate when the lawsuits were filed. Barnes and Noble was not included in the graphic due to lack of data available in the Wayback Machine for any pages other than a few homepages. For lack of adequate data to be evaluated, www.barnesandnoble.com, www.target.com, and www.ramada.com were eliminated from the study and not included in the analyses. Target was excluded from the analysis due to lack of available data following the lawsuit. Ramada was excluded because data for only one period following the lawsuit was available. Samples were also collected from the Wayback Machine for the control websites (Figure 16).

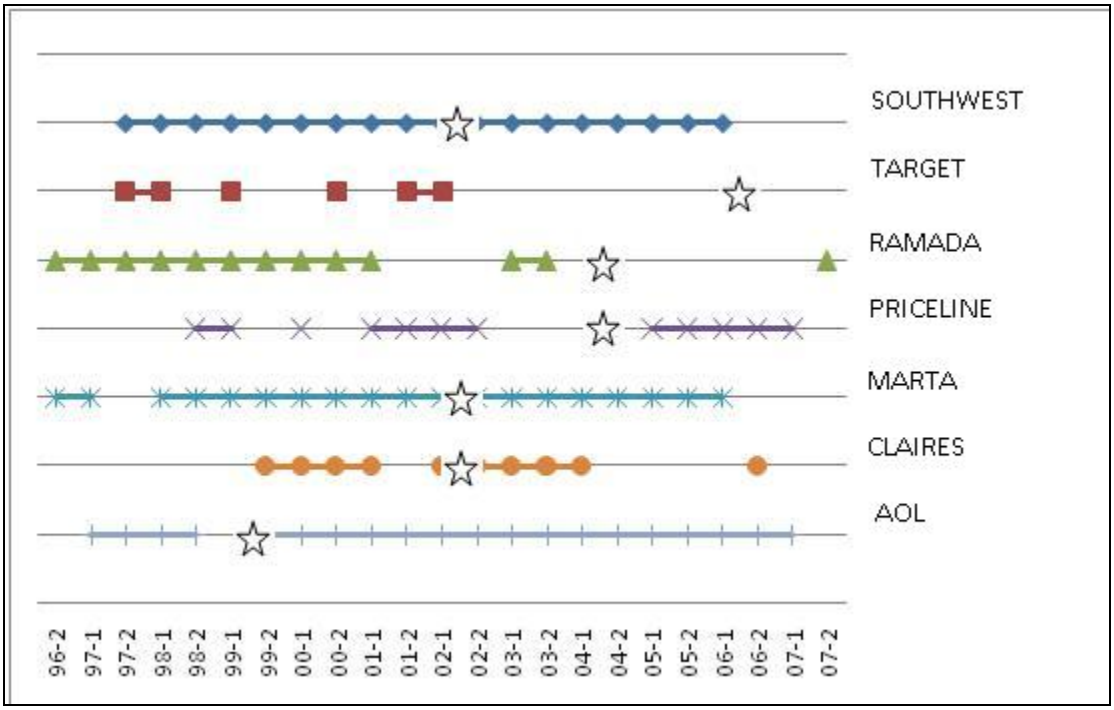


Figure 15. Samples Collected from the Wayback Machine for Sued Websites, stars indicate year of lawsuit

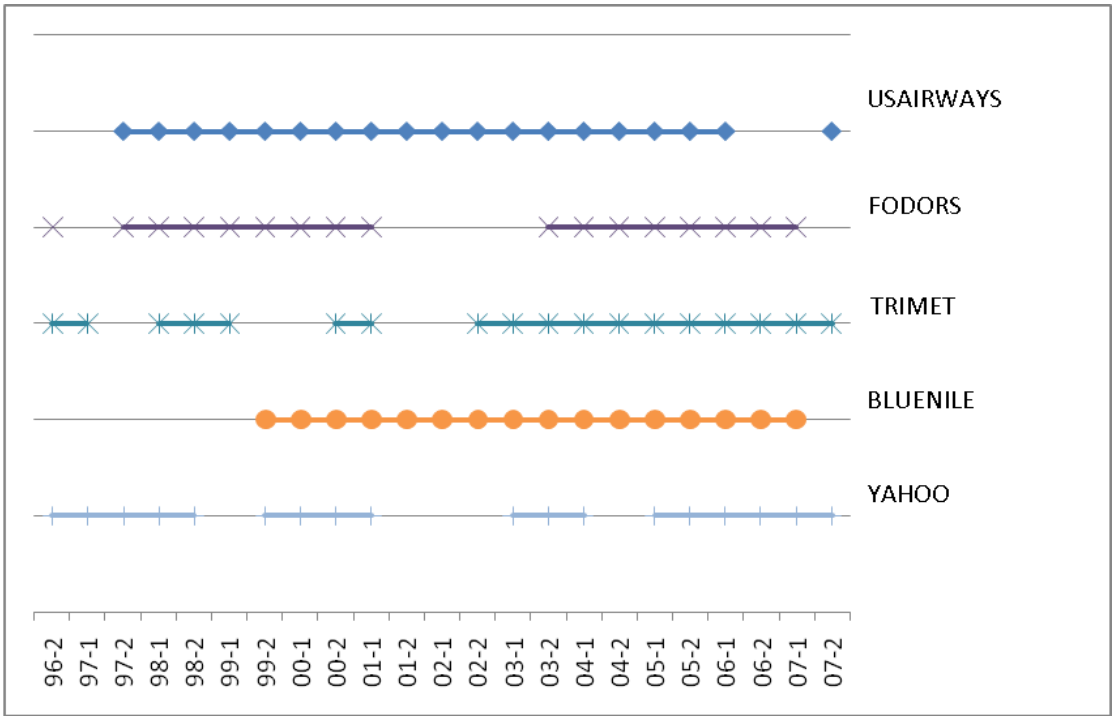


Figure 16. Samples Collected from the Wayback Machine for Control Websites

APPENDIX E includes the various checkpoint information from the Kelvin evaluation and the percent of errors for the selected checkpoints. Not all checkpoints are included in the Appendix. The checkpoints not included are:

- Provide alternative text for each APPLET
- Each FRAME must reference an HTML file
- Provide a NOFRAMES section when using FRAMES
- Avoid blinking text created with the BLINK element
- Avoid scrolling text created with the MARQUEE element
- Do not cause a page to refresh automatically
- Do not cause a page to redirect to a new URL
- Give each FRAME a title

- Create link phrases that make sense when read out of context
- Do not use the same link phrase more than once when the links point to different URLs
- Include a document TITLE
- Provide alternative content for each OBJECT.

The reasons for not including these checkpoints are (1) none (or almost none) of the sites used the elements in question and/or (2) there were so few violations of the checkpoint that it had minimal impact on the WAB score.

4.4.1 American Online

ANOVA was computed on the common periods between AOL and Yahoo and there was a main effect for site ($F(1,14) = 8.997$, $p<0.0001$), with Yahoo having a higher WAB score during all but one period. There was a statistically significant decrease in WAB score for the AOL website from 1999_2 to 2000_1 ($p<0.0001$) (Figure 17). The AOL website underwent a redesign at this time. The decrease in WAB scores results from AOL having less checkpoint violations for many checkpoints (Table 8). This is followed by a significant increase in WAB score in 2000_2 ($p<0.0001$). This increase results from AOL increasing the checkpoint violations for most checkpoints. Since the end of 2006, both website are becoming slightly less accessible, with increasing WAB scores; however, none of these increases is statistically significant. The WAB scores for the Yahoo website drops in 2005_1 and again in 2006_2. Both of these coincide with a website redesign in the Yahoo website.

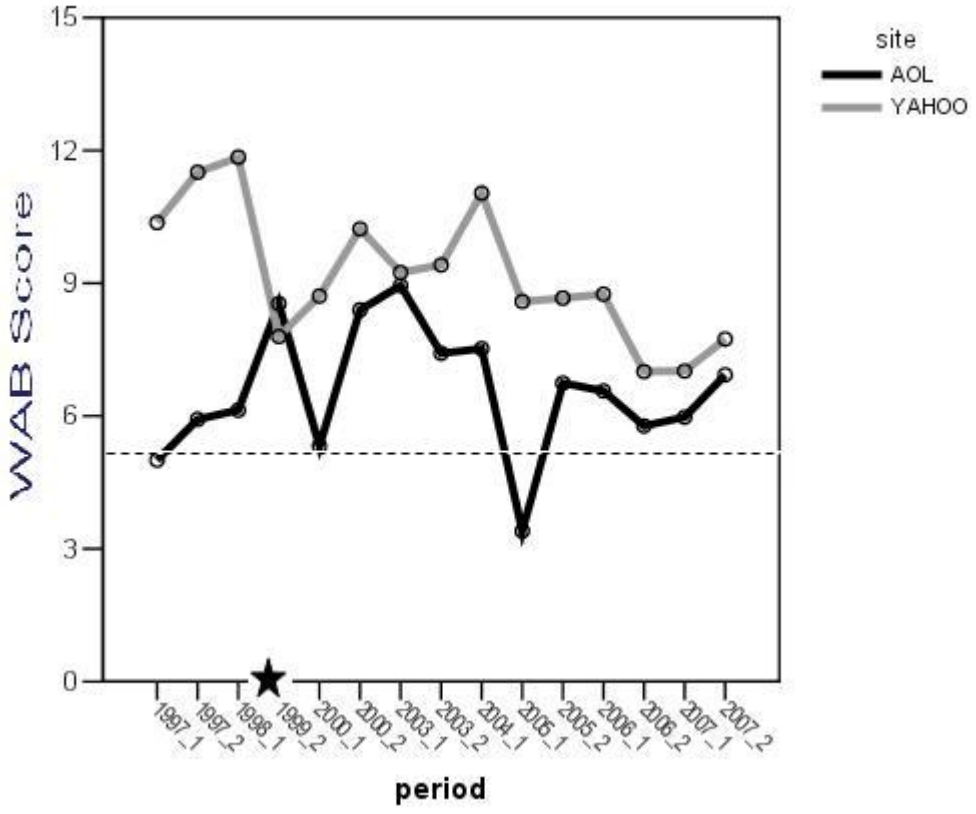


Figure 17. Common periods for AOL and Yahoo

Table 8. AOL percentage of checkpoint violations for select periods and checkpoints

AOL	1999_2	2000_1	2000_2
Provide alternative text for all images	63%	32%	54%
Provide alternative text for all image-type buttons in forms	67%	47%	38%
Provide alternative text for all image-map hot spots	45%	35%	75%
Client-side image map contains a link not presented elsewhere on the page	76%	55%	88%
Use a public text identifier in a DOCTYPE statement	51%	26%	25%
Use relative sizing and positioning rather than absolute	21%	15%	25%
Identify the language of the text	96%	83%	91%
Include default, place holding characters in edit boxes and text areas	65%	56%	64%
Explicitly associate form controls and their labels with the LABEL element	87%	71%	84%

Looking at all of the periods where the websites were evaluated, WAB scores of the AOL website can be seen increasing prior to the lawsuit, indicating that the website was becoming less

accessible (Figure 18). While the period immediately following the lawsuit saw one of the lower WAB scores for the AOL website, in the years following the lawsuit the WAB scores for AOL did not improve; the accessibility of the site didn't start improving until the later part of 2003 and, following a low score in 2004_2, increased again. Considering that the accessibility threshold is 5.5 and the recent WAB scores of AOL are around 6-7, the AOL website is relatively accessible and better than it was at the time the lawsuit was filed. The WAB scores of AOL and Yahoo aren't much different in recent years (2006-2007) and, as mentioned, both have increasing WAB scores. These increases are below the trend occurring in the popular websites studied.

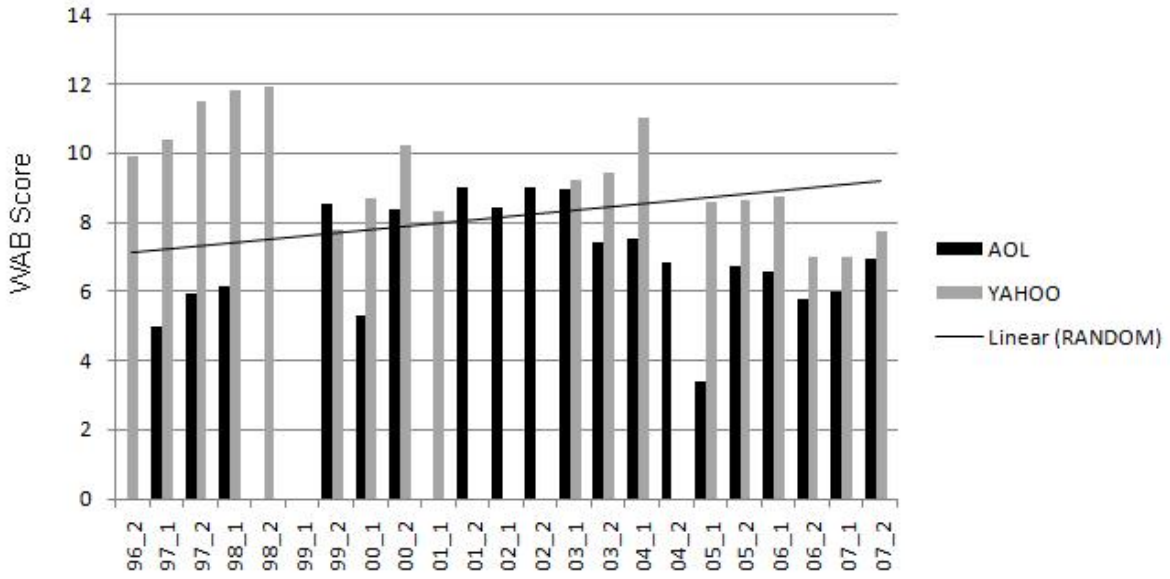


Figure 18. WAB scores of AOL and Yahoo, with trend line for random websites and star indicating year of AOL lawsuit

The trend line of random websites in Figure 18 shows that, in general, websites on the Internet are becoming less accessible. The trend lines for AOL and Yahoo in Figure 19 indicate

that the trend for AOL is a slight decrease in WAB scores over the years, while the trend of the WAB scores of Yahoo is a more rapid decrease. These trends are both in contrast to what is happening in the popular Web, in general.

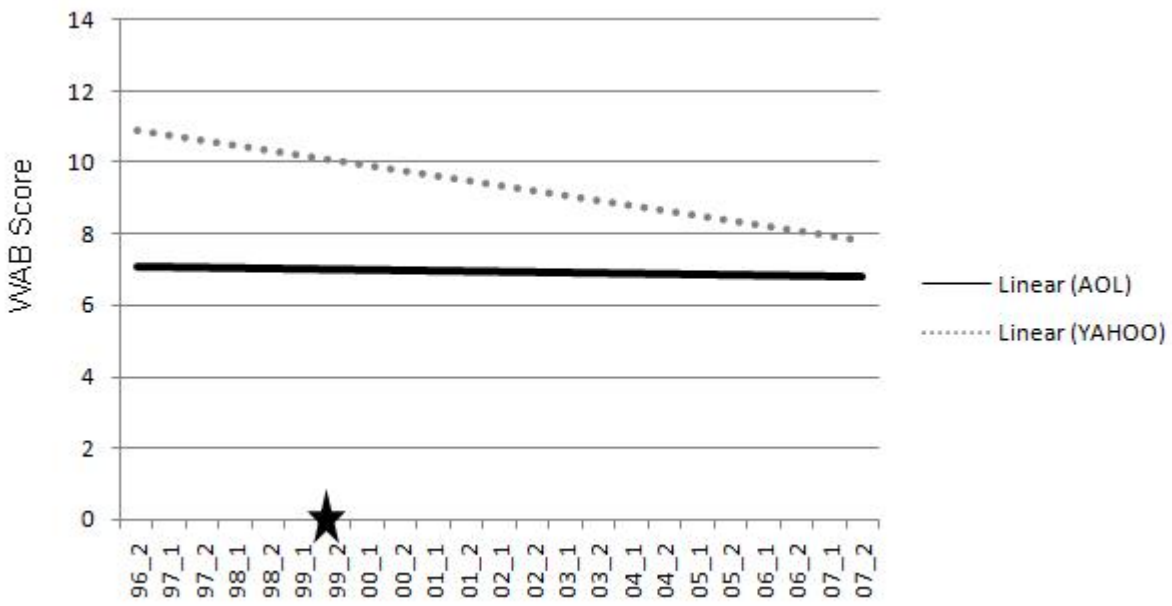


Figure 19. Trend lines of WAB scores for AOL and Yahoo, star indicates year of AOL lawsuit

The AOL and Yahoo websites, like the random websites studies, are increasing in complexity (Figure 20). The AOL website has been very complex in recent years, with more complexity than websites in general. Because the AOL website has been maintaining WAB scores between 5.5 and 7 in recent periods, this indicates that AOL is maintaining some balance between increasing complexity in the design of the website and WAB scores of the website.

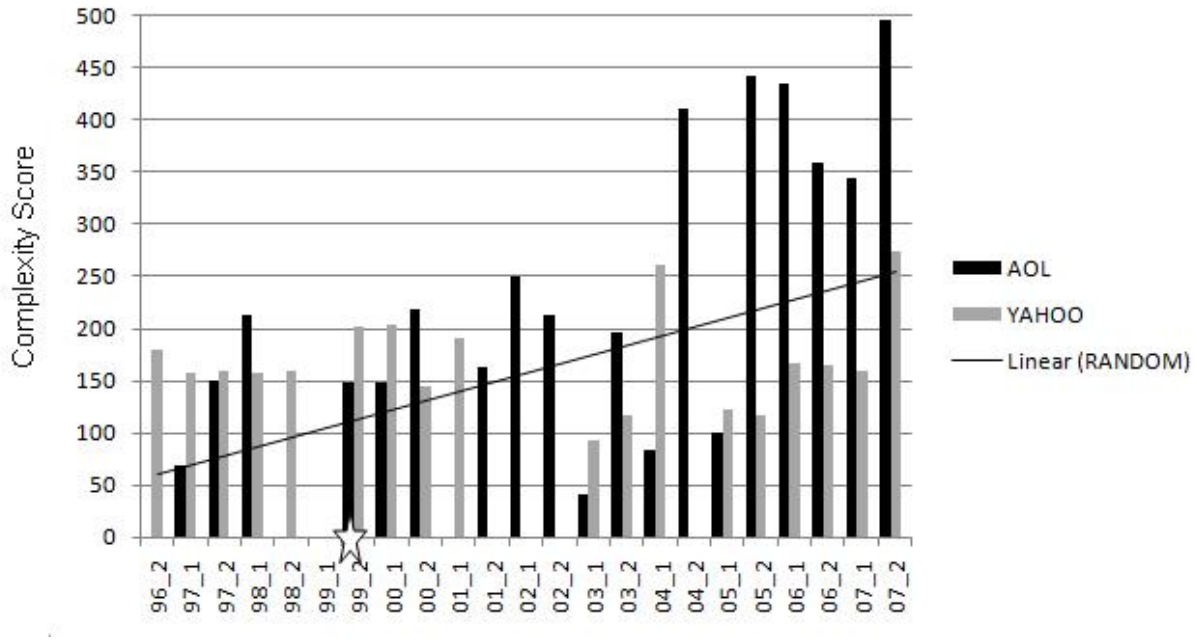


Figure 20. Complexity scores of AOL and Yahoo, with trend line for random websites and star indicating year of AOL lawsuit

4.4.2 Metropolitan Atlanta Rapid Transit Authority

ANOVA was computed on the common periods between MARTA and TriMet and there was a main effect for site ($F(1,13) = 76.353$, $p<0.0001$), with MARTA having higher WAB scores than TriMet for all common periods before the lawsuit and lower scores than TriMet after the lawsuit. There has been a dramatic drop in WAB scores for MARTA since the lawsuit (Figure 21), with a significant decrease from 2002_1 to 2003_2 ($p<0.0001$) and another significant decrease from 2003_2 to 2004_1 ($p<0.0001$). These decreases are a result of fewer violations for most checkpoints. These changes also coincide with a redesign of the MARTA website that occurred in the first quarter of 2004. Notable differences in the design from 2002_1 to 2004_1 (Table 9) include only a handful of images without alternative text, removing image maps, identifying the language of the text, and not requiring the use of the mouse for event handlers. Following the

2004 website redesign, the WAB score has remained below 5.5, indicating that they are maintaining an accessible website. In recent periods, the TriMet website also has decreasing WAB scores, indicating that they are also attempting to maintain an accessible website. Following the MARTA lawsuit, there was a redesign of the TriMet website in the first quarter of 2006 that coincides with the drop seen in the WAB scores from 2005_1 to 2006_1. As a result of the redesign, the TriMet website contains fewer images, tables, and image maps and fewer violations of many of the checkpoints.

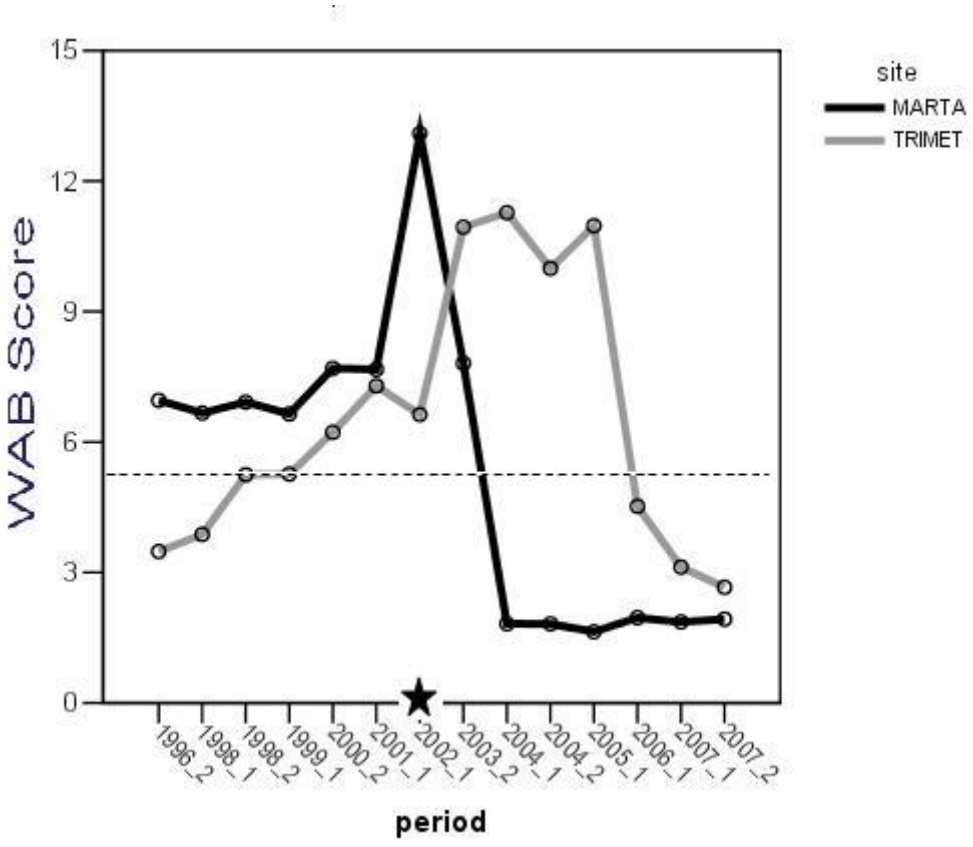


Figure 21. Common periods for MARTA and TriMet

Table 9. MARTA percentage of checkpoint violations for select periods and checkpoints

MARTA	2002_1	2003_2	2004_1
Provide alternative text for all images	96%	6%	1%
Provide alternative text for all image-map hot spots	77%	0%	Na
Client-side image map contains a link not presented elsewhere on the page	81%	91%	Na
Use a public text identifier in a DOCTYPE statement	100%	100%	13%
Use relative sizing and positioning rather than absolute	57%	60%	21%
Identify the language of the text	100%	100%	0%
Make sure event handlers do not require the use of a mouse	100%	100%	Na

Looking at all of the periods for the MARTA evaluation (Figure 22), the period prior to the lawsuit had the highest WAB score of all versions of the MARTA website evaluated. Prior to the lawsuit, the MARTA website mirrored the trend of decreasing accessibility that is seen in the random websites representing the general Web. The TriMet WAB scores were still very high following the MARTA lawsuit, but are dramatically lower since the redesign in 2006.

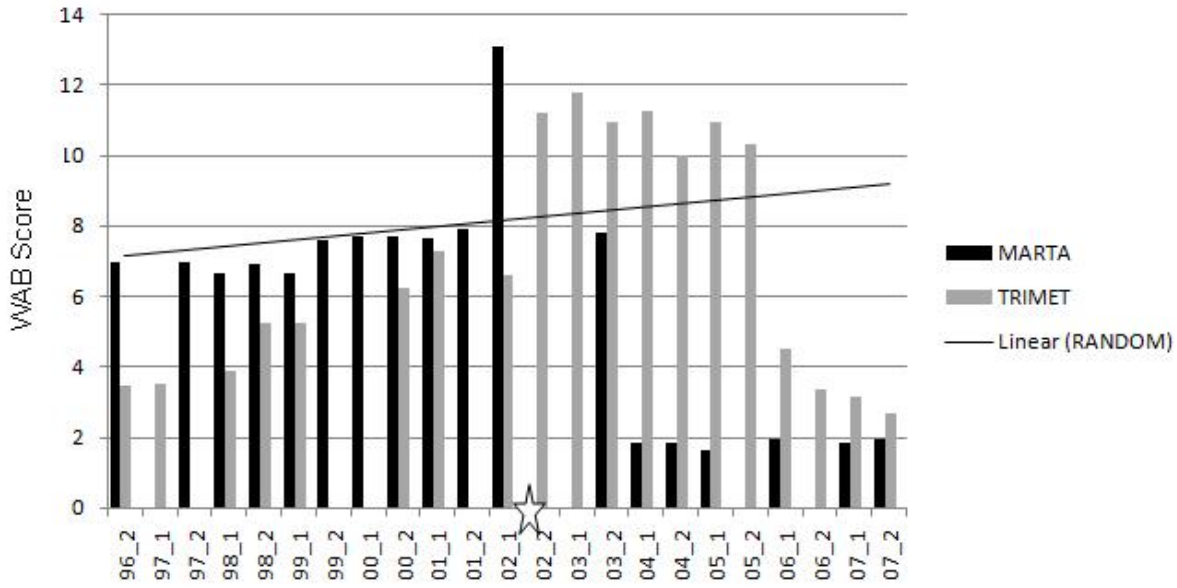


Figure 22. WAB scores of MARTA and TriMet, with trend line for random websites and star indicating year of MARTA lawsuit

The trend line of the MARTA website (Figure 23) follows the decreasing WAB scores that are seen in Figure 22. The trend line of WAB scores of the TriMet website indicates that the TriMet website is becoming less accessible; however the WAB scores seen in Figure 22 show that the TriMet website is becoming more accessible in recent periods. The trend of MARTA is in contrast to what is happening in the popular Web, in general.

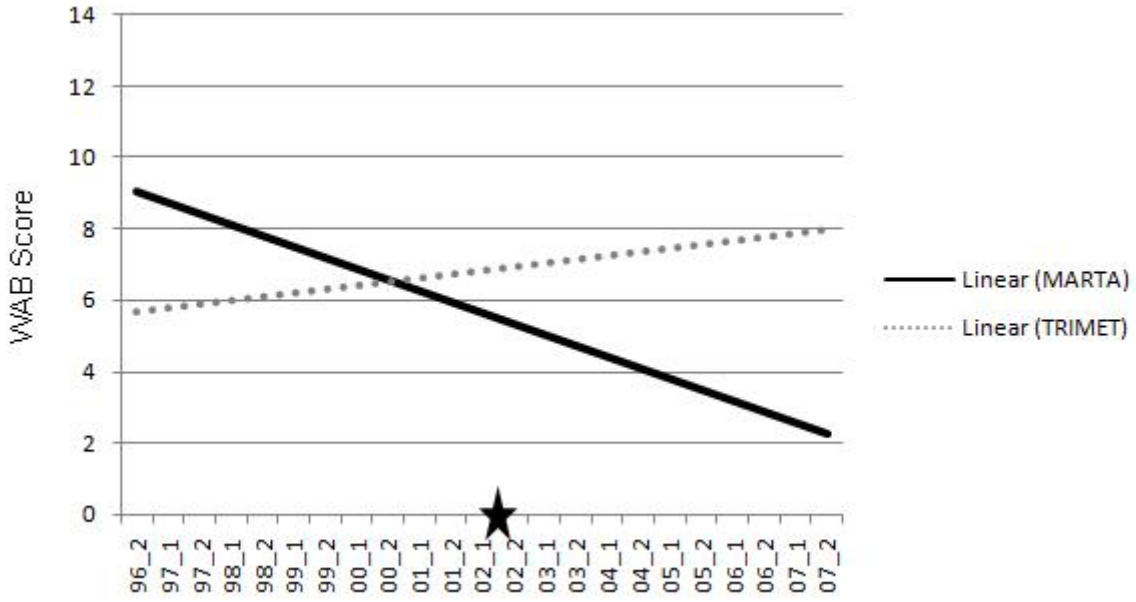


Figure 23. Trend lines of WAB scores for MARTA and TriMet, star indicates year of MARTA lawsuit

The complexity of the MARTA website has increased slightly over the years, while remaining lower than the Web in general (Figure 24). The TriMet website has maintained very low complexity throughout the years.

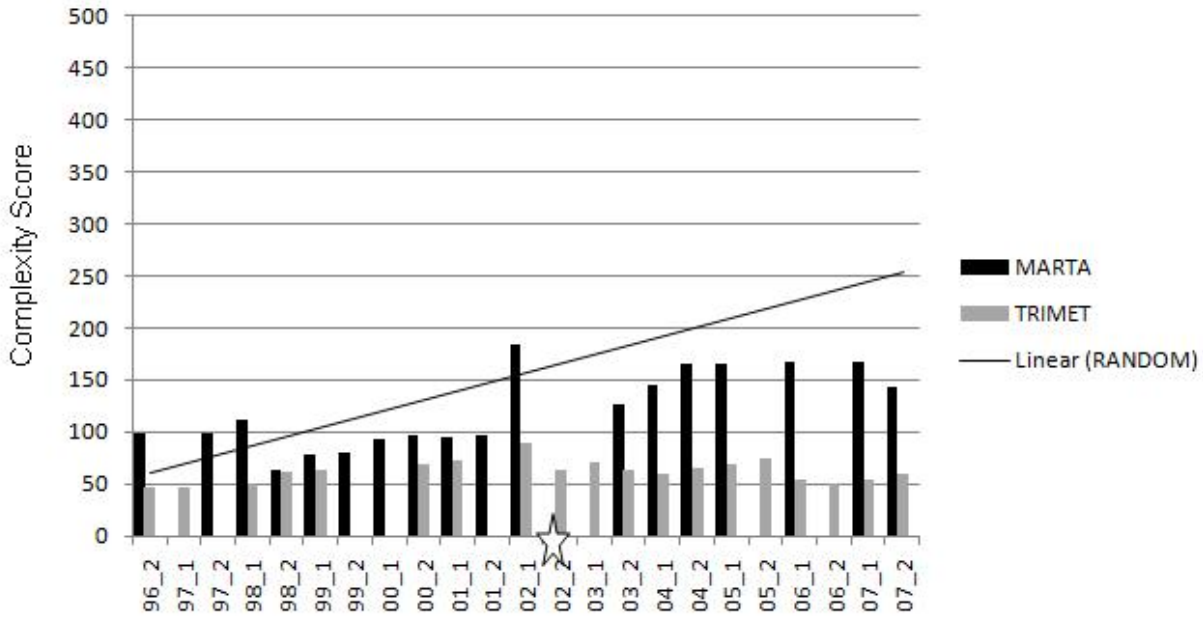


Figure 24. Complexity scores of MARTA and TriMet, with trend line for random websites and star indicating year of MARTA lawsuit

4.4.3 Claire's

ANOVA was computed on the common periods between Claire's and Bluenile and there was a main effect for site ($F(1,8) = 7.428$, $p<0.0001$), with the WAB scores for Bluenile being higher in all but one period. There was a decrease in WAB score for the Claire's website from the period 2002_1 to 2002_2 that coincides with the lawsuit but is not the result of a website redesign. This is followed by a mild increase in WAB score until another decrease in 2006_2. These decreases are not statistically significant. Following a sharp increase in WAB score in 2000_2, the Bluenile website also exhibits decreases in WAB scores over the years. Even though there are decreases in WAB scores in both of these websites over the years, the WAB scores are still high and indicate some degree of inaccessibility. The 2006_2 version of the

Claire's website contains less images and tables, but more image map hot spots. There are no notable differences in the Bluenile website throughout the years.

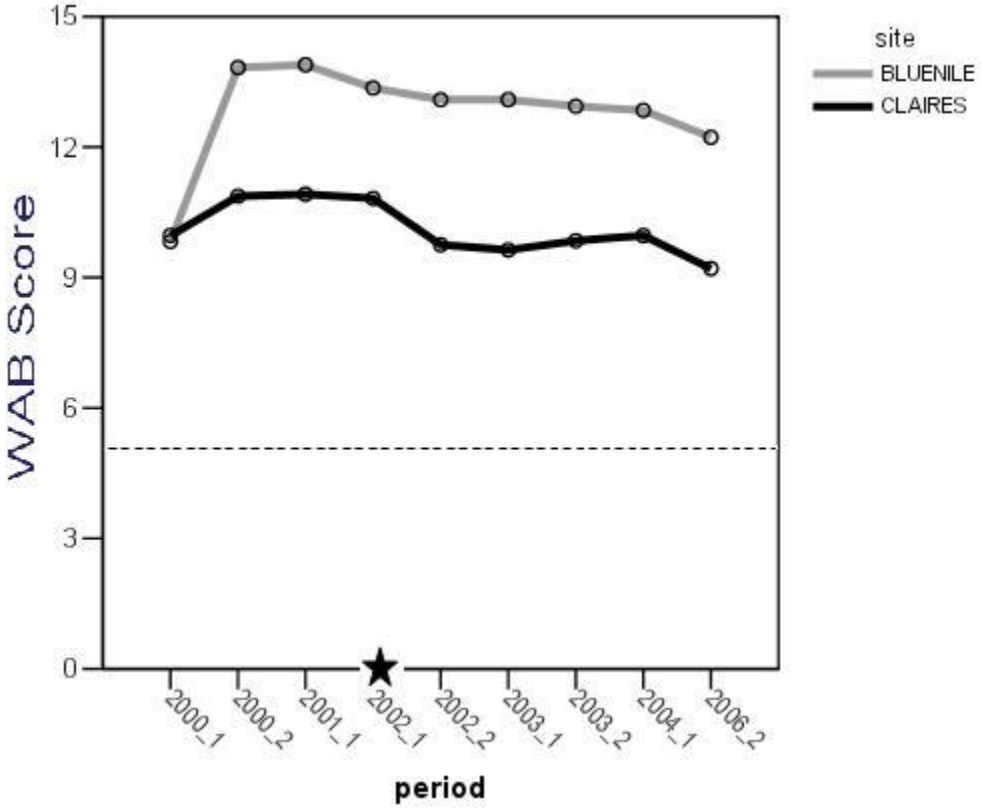


Figure 25. Common periods for Claire's and Bluenile

Looking at all of the periods where the websites were evaluated, both the Claire's and Bluenile websites have consistently inaccessible websites. The Claire's website actually exhibits small increases in WAB score in the periods following the lawsuit, but has a slightly decreased WAB score for the 2006_2 period, the latest data available. Both websites have higher WAB scores than the popular websites studied. While the random trend line in this example is flatter

due to the fewer periods examined, a slight increase can still be seen over time. Claire's and Bluenile have consistently higher WAB scores than the random trend line.

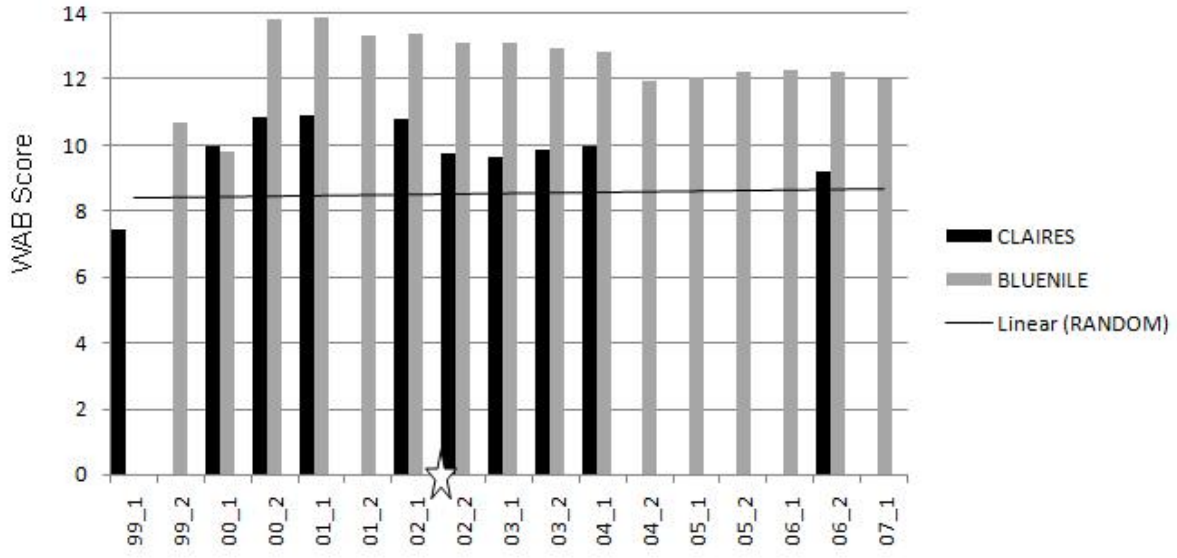


Figure 26. WAB scores of Claire's and Bluenile, with trend line for random websites and star indicating year of Claire's lawsuit

The Claire's and Bluenile trend lines (Figure 27) indicate inaccessible websites over time. The WAB score trend for Claire's is to increase over time, while recent data shows a slight decrease in WAB score. The trend line for Bluenile indicates that the website is neither increasing nor decreasing in accessibility. Both lines are higher than the random trend line presented in Figure 26.

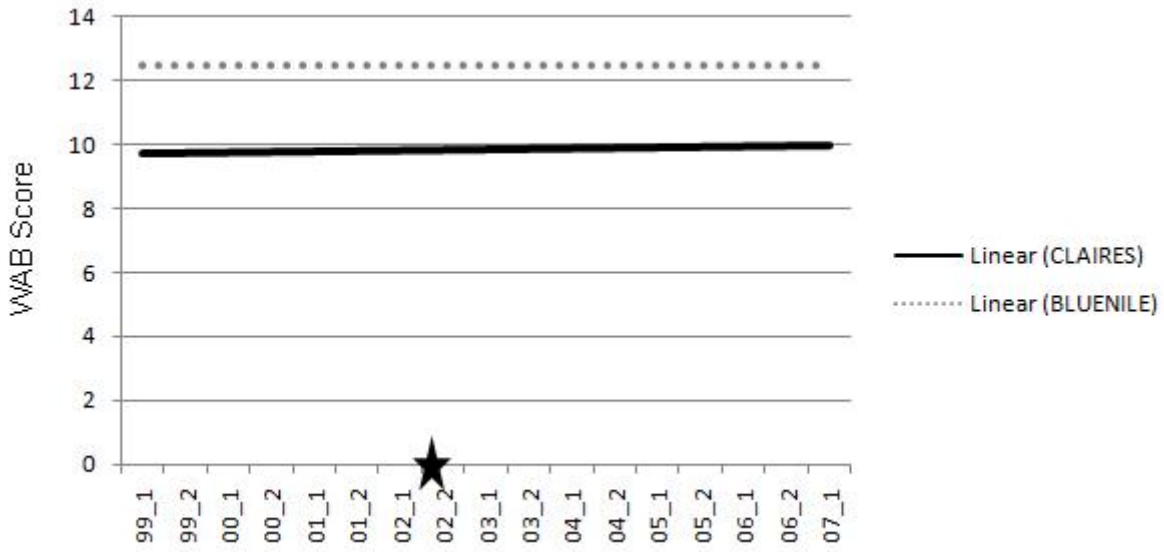


Figure 27. Trend lines of WAB scores for Claire's and Bluenile, star indicates year of Claire's lawsuit

The complexity of the Bluenile website is high and appears to be increasing again in recent periods. It is inconclusive with the data presented to tell if the complexity of Claire's is increasing over time, but the data examined in 2006_2 appears to be similar to the complexity scores for 2002_1 through 2004_1.

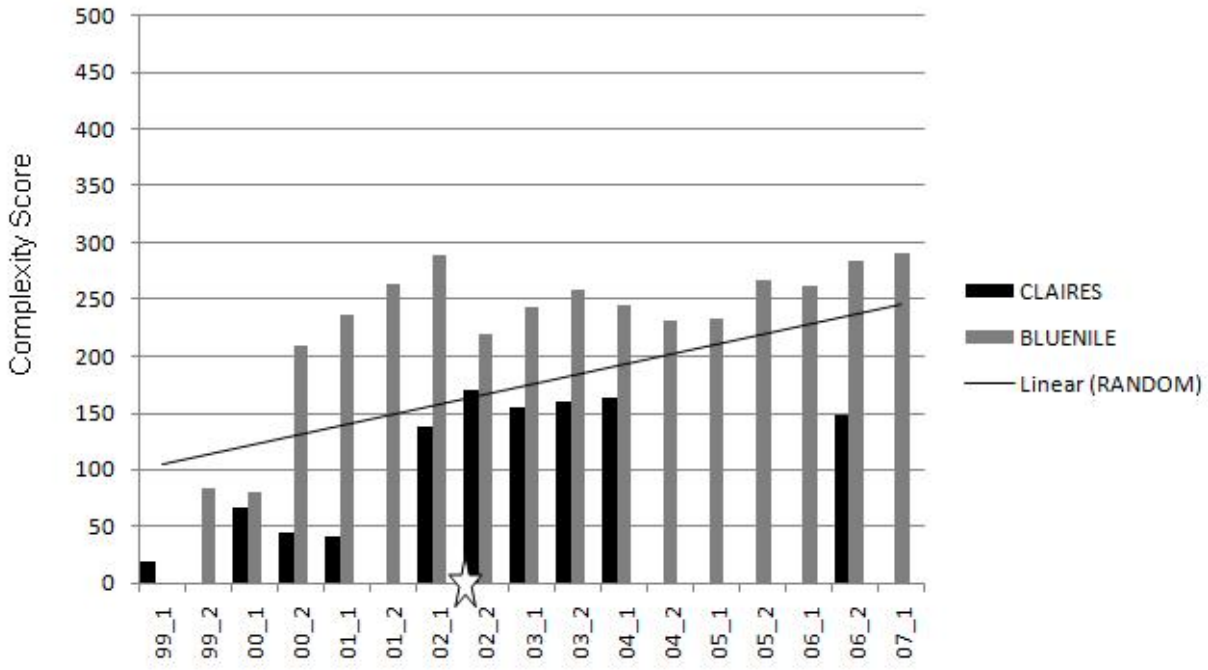


Figure 28. Complexity scores of Claire's and Bluenile, with trend line for random websites and star indicating year of Claire's lawsuit

4.4.4 Priceline

ANOVA was computed on the common periods between Priceline and Fodors and there was a main effect for site ($F(1,9) = 14.43$, $p<0.0001$), with lower WAB scores for Priceline in all common periods. The WAB for Priceline decreases between the periods 2001_1 to 2004_2 (Figure 29) and this decrease is statistically significant ($p=0.003$). This decrease coincides with a website redesign and results from decreases in checkpoint violations, including fewer violations of the following checkpoints: use a public text identifier in a DOCTYPE statement, nest headings properly, identify the language of the text, and provide a summary for tables (Table 10). The WAB scores of the Priceline website remain low following the lawsuit and are below

5.5, meaning that the website is accessible. The Fodors website has high WAB scores in the periods surrounding the Priceline lawsuit, but does start to decrease toward the end of 2005, coinciding with a website redesign. The WAB scores of Fodors, while remaining lower, are still far from indicating an accessible website; however, since the lawsuit against Priceline, the Fodors website includes fewer potential for violations (less image-type buttons in forms, image map hot spots) and fewer violations of some checkpoints (providing alt text for images, using relative sizing rather than absolute, associating form controls and labels).

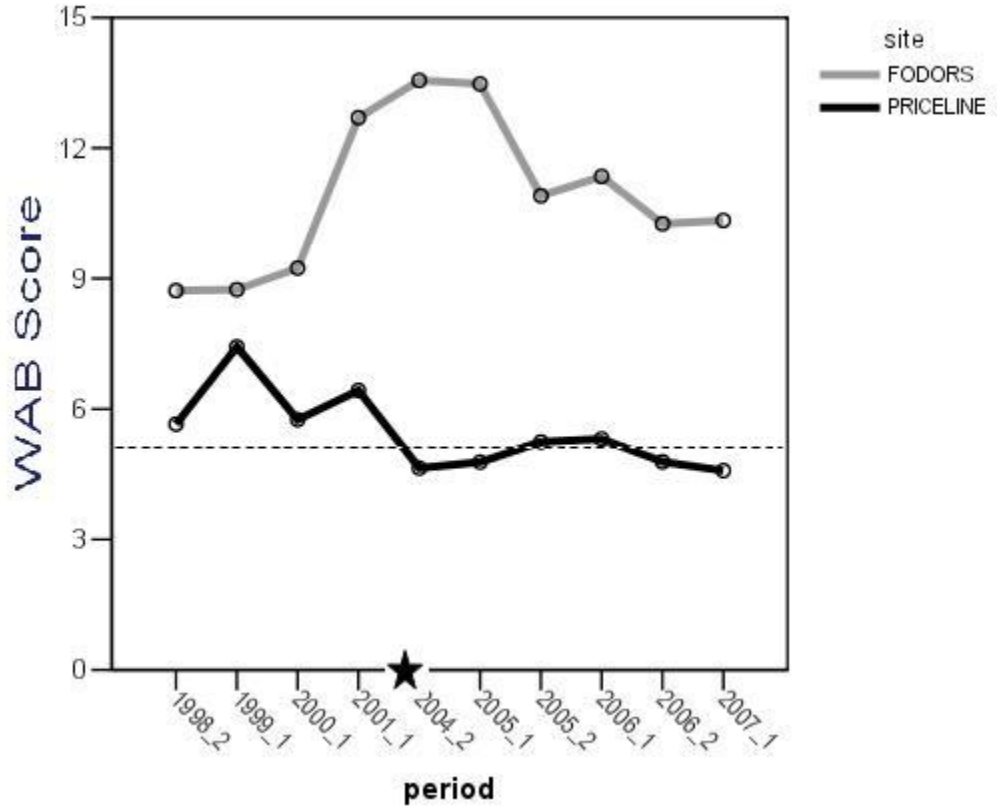


Figure 29. Common periods of Priceline and Fodors

Table 10. Priceline percentage of checkpoint violations for select periods and checkpoints

PRICELINE	2001_1	2004_2
Use a public text identifier in a DOCTYPE statement	36%	0%
Use relative sizing and positioning rather than absolute	11%	9%
Next headings properly	50%	12%
Identify the language of the text	43%	3%
Provide a summary for tables	94%	55%

Looking at all of the periods in which the websites were evaluated (Figure 30), the Priceline WAB scores are lower following the lawsuit, while the Fodors website remains to have high WAB scores.

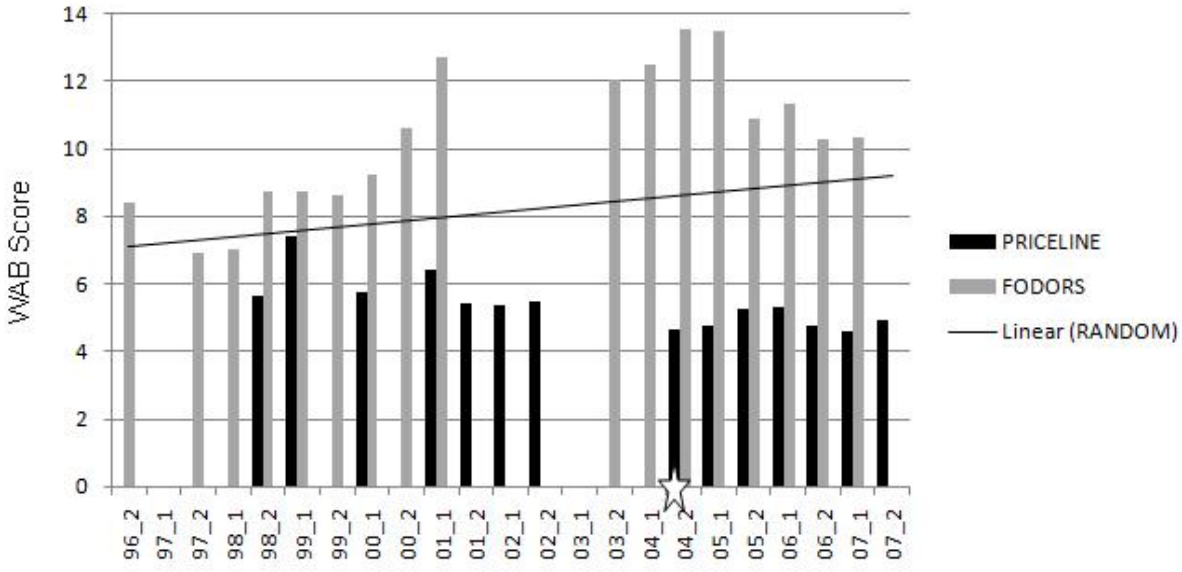


Figure 30. WAB scores of Priceline and Fodors, with trend line for random websites and star indicating year of Priceline lawsuit

The trend lines presented in Figure 31 show that the trend for the WAB scores of the Priceline are on a downward trend. This trend started prior to the lawsuit against Priceline. The trend for WAB scores of the Fodors website, in contrast, is that the WAB scores are rising.

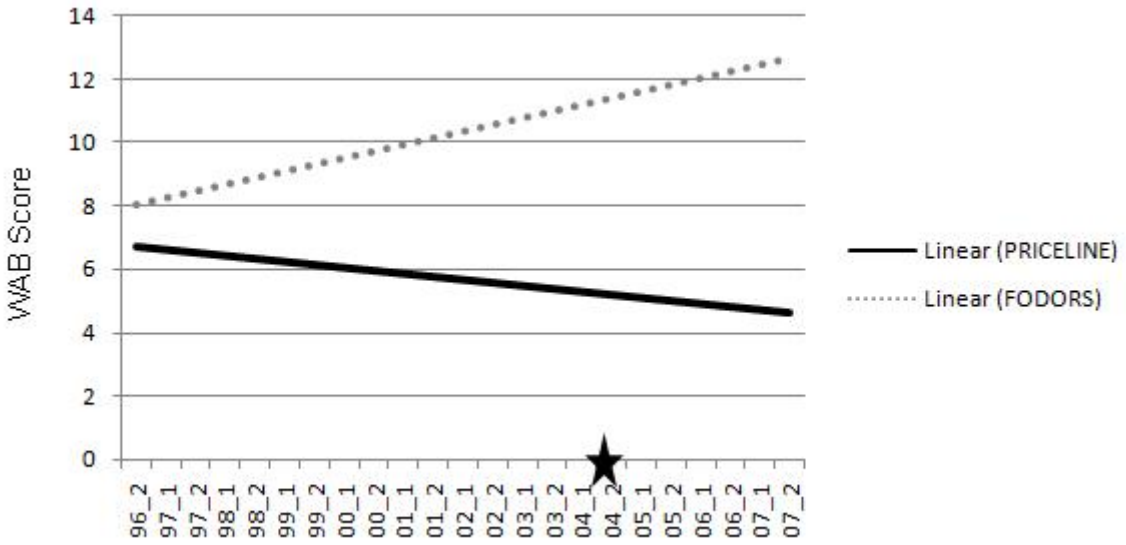


Figure 31. Trend lines of WAB scores for Priceline and Fodors, star indicates year of Priceline lawsuit

The Fodors website is not as complex as Priceline's, as indicated by the complexity scores (Figure 32). The level of complexity seen in the Priceline website, in conjunction with the low WAB scores, indicates that Priceline is maintaining an accessible website despite the complexity. The Fodors website is not exhibiting this behavior, as the complexity scores aren't too high, but the WAB scores are.

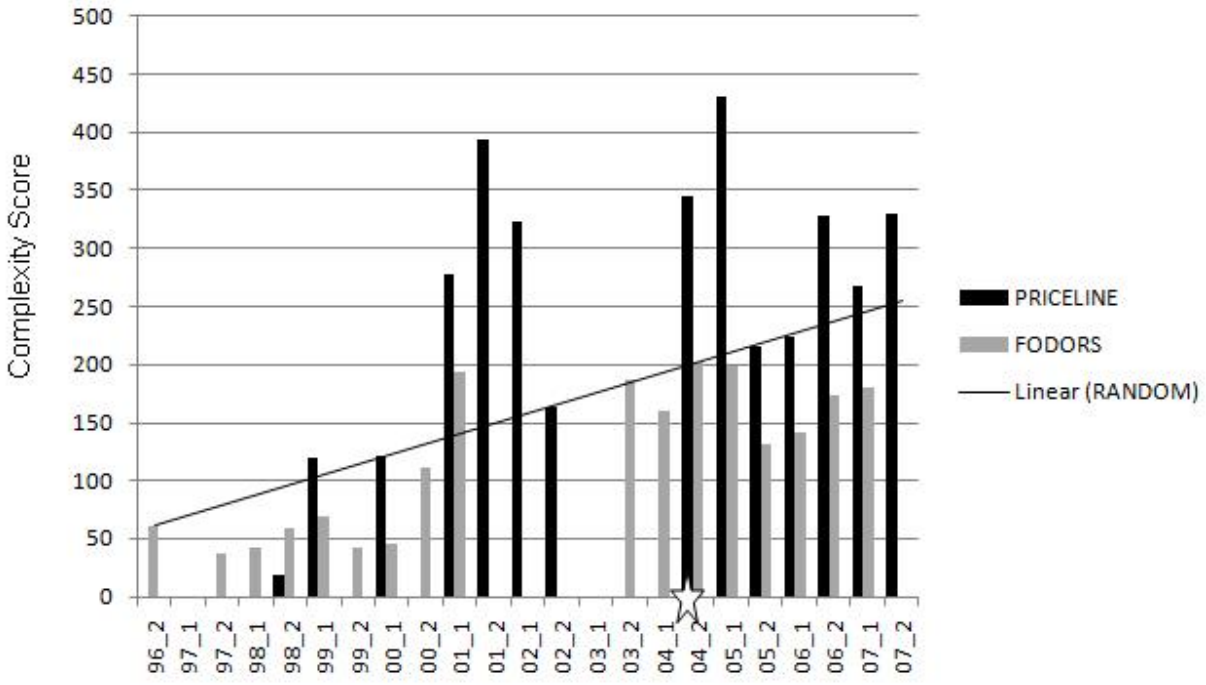


Figure 32. Complexity scores of Priceline and Fodors, with trend line for random websites and star indicating year of Priceline lawsuit

4.4.5 Southwest Airlines

ANOVA was computed on the common periods between Southwest and U.S. Airways and there was a main effect for site ($F(1,18) = 17.836$, $p<0.0001$), with Southwest WAB scores showing a drastic increase and decrease over the periods while the U.S. Airways WAB scores exhibit a steady increase. Following the 2002 lawsuit, the Southwest website experienced decreases in WAB scores (Figure 33), with large decreases seen in 2003_1 ($p=0.228$, not significant), 2005_2 ($p=0.009$), and 2007_2 ($p<0.0001$). There was a major website redesign in 2003_1 and 2007_2, while the 2005_2 decrease results from a minor redesign. These decreases are largely due to new website designs with alternative text for most images image-type buttons in forms, and image map hot spots; as well as the use of public text identifiers in DOCTYPE statements and

including place holding characters in edit boxes (Table 11). The Southwest website has a low WAB score for 2007_2, while the U.S. Airways website has increasing WAB scores over the years. The 2007_2 U.S. Airways website does not contain image-map hot spots and has public text identifiers for all but one DOCTYPE statement, but it also contains more event handlers requiring the use of a mouse and more form controls (of which none are associated with their labels via the LABEL element). The U.S. Airways underwent a redesign in 2007 and there was a slight decrease in WAB coinciding with the redesign.

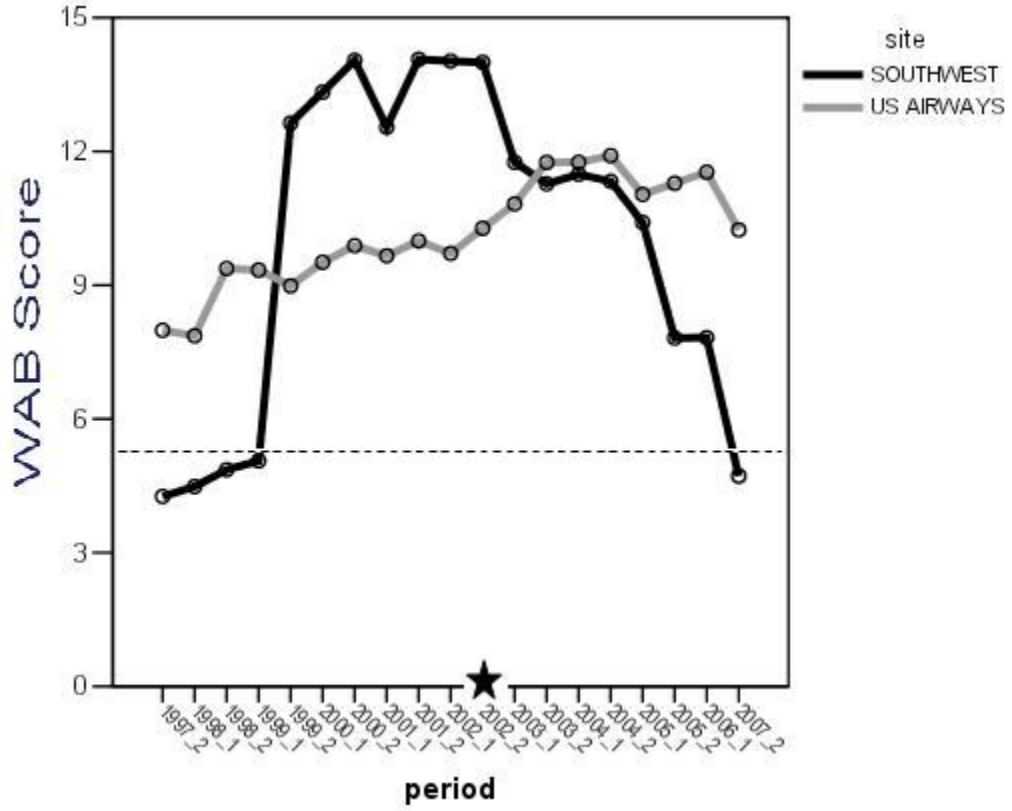


Figure 33. Common periods of Southwest and U.S. Airways

Table 11. Southwest percentage of checkpoint violations for select periods and checkpoints

SOUTHWEST	2002_2	2003_1	2005_1	2005_2	2006_1	2007_2
Provide alternative text for all images	92%	45%	10%	4%	5%	4%
Provide alternative text for all image-type buttons in forms	100%	94%	95%	5%	6%	0%
Provide alternative text for all image-map hot spots	100%	Na	100%	100%	0%	Na
Use a public text identifier in a DOCTYPE statement	100%	94%	83%	81%	83%	69%
Provide a summary for tables	100%	100%	97%	83%	86%	86%
Include default, place holding characters in edit boxes and text areas	100%	97%	98%	96%	94%	51%

Looking at all of the periods where the websites were evaluated, the Southwest website had a large increase in WAB score in 1999_1 that was maintained until the lawsuit. The WAB scores decreased following the lawsuit, but there was also a decrease in 2005_2 and another in 2007_2. Together this shows that Southwest is attempting to redesign its website to be accessible. The WAB scores of the U.S. Airways website are higher than the trend line of the random websites studied and indicates that U.S. Airways has an inaccessible website.

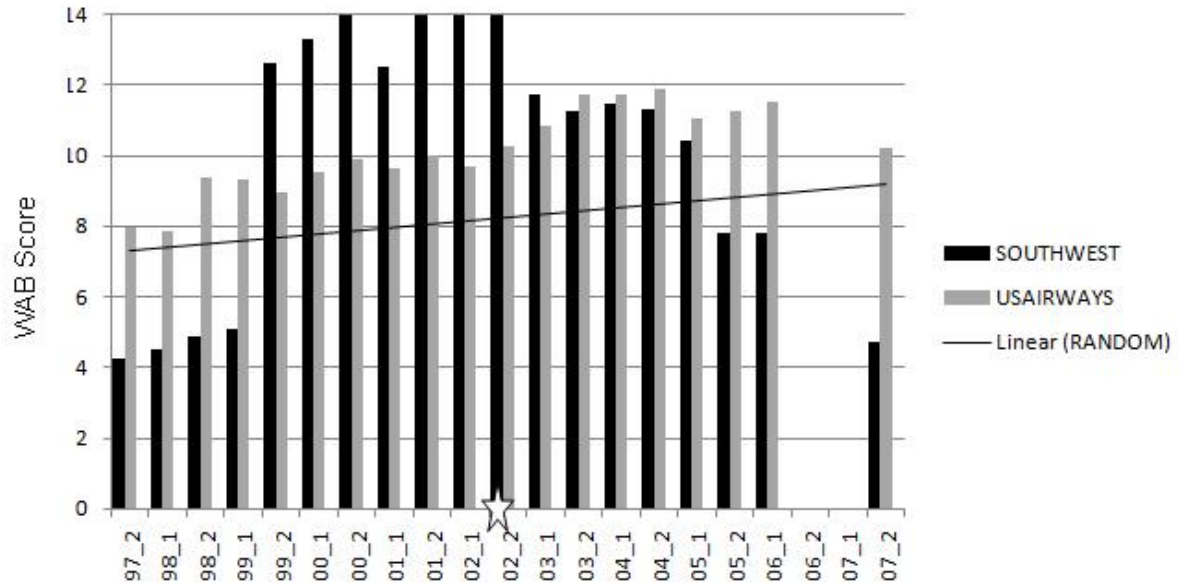


Figure 34. WAB scores of Southwest and U.S. Airways, with trend line for random websites and star indicating year of Southwest lawsuit

The trend lines presented in Figure 35 indicate increasing WAB scores for both the Southwest and U.S. Airways websites; however, the trend is a lesser increase in WAB for Southwest than U.S. Airways. The fact that one can see that the actual WAB scores are decreasing in Figure 34 is promising.

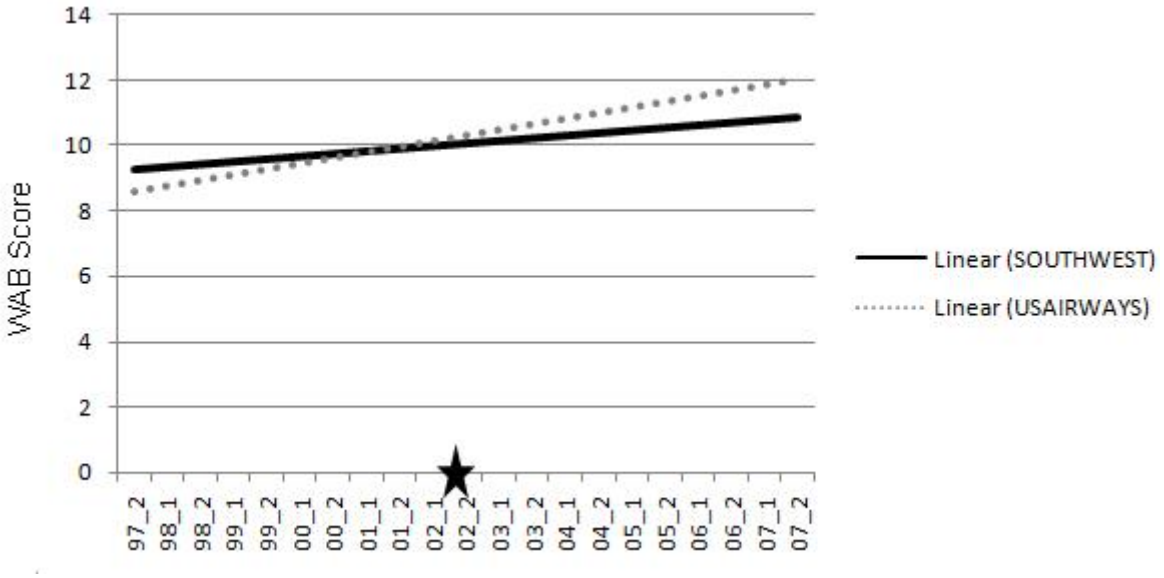


Figure 35. Trend lines of WAB scores for Southwest and U.S. Airways, star indicates year of Southwest lawsuit

The complexity of the U.S. Airways website can be seen increasing along the trend of the random websites examined, while the Southwest website has only had increased complexity scores in recent periods. Considering that the WAB scores of the Southwest website are decreasing while the complexity is increasing indicates that the company is attempting to maintain an accessible website.

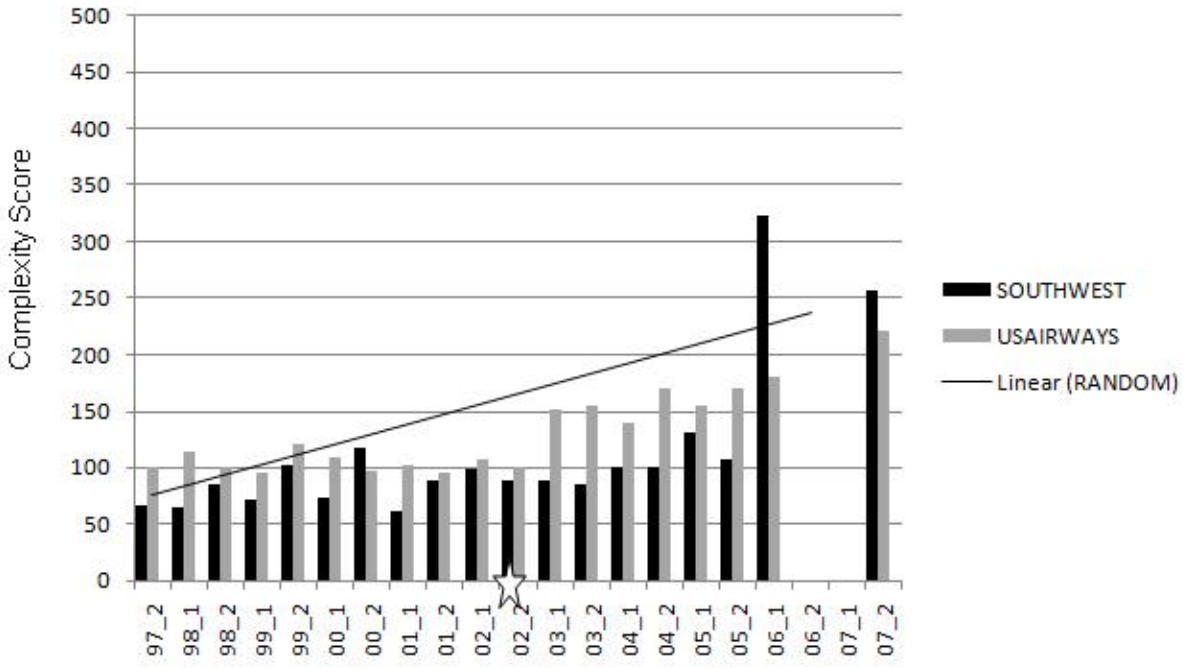


Figure 36. Complexity scores of Southwest and U.S. Airways, with trend line for random websites and star indicating year of Southwest lawsuit

4.5 DISCUSSION

The lawsuit against AOL did not result in a drastic overall drop in the WAB score of the AOL website. However, the accessibility score dropped in the period immediately following the lawsuit and this is due to a website redesign in 2000. While the WAB scores increased again for the next couple of years, the trend of the WAB score for the AOL website depicts a very slight decline in accessibility barriers and not the increase in barriers that is occurring in the random Web. The AOL website also has fewer violations of WCAG 1.0 guideline checkpoints after the lawsuit and no longer includes image-type buttons in forms or image maps in the site design.

Yahoo may have taken notice of the lawsuit against AOL, as the WAB scores for the Yahoo website are on a downward trend and there are two drops in WAB scores that coincide with Yahoo website redesigns in 2004 and 2006. The Yahoo website now includes more alternative text for images, fewer image maps hot spots, and fewer violations of not associating form controls and their labels.

The lawsuit against the MARTA website was successful. The WAB scores for the website dropped significantly following the lawsuit and have remained below the accessibility threshold of 5.5 since the lawsuit, indicating that MARTA is maintaining an accessible website. In addition to simply becoming accessible by adding alternative text to the existing design, MARTA also redesigned the website (i.e.: to not include image maps and event handlers that require the use of a mouse). TriMet also appears to be making attempts at a more accessible website in recent periods. The decrease in WAB scores (from 2005_1 to 2006_1) resulted from a redesign of the website at the beginning of 2006. The redesigned website contained fewer images without alternative text, as well as a decreased presence of image maps, tables, event handlers requiring the use of a mouse, edit boxes, and form controls. It may be that TriMet was influenced by the MARTA lawsuit and realize that, as a website providing a public service, they need to provide accessible information.

The lawsuit against Claire's was less effective in leading to a more accessible website. The WAB scores in the periods following the lawsuit were slightly decreased and do not represent major modifications that attempt to increase accessibility. The more recent data obtained also support these findings. The important point is that the Claire's website is gradually becoming more accessible. The Claire's website exhibits some changes since the lawsuit; while there are less images and tables, there are more image map hot spots but few violations of not

including alternative text for these hot spots. Bluenile also has an inaccessible website and doesn't appear to have been influenced by the Claire's lawsuit. There are no notable differences in the Bluenile website throughout the years studied.

In 2004, Priceline agreed to make their website accessible and they have been true to that agreement. There is not strong evidence to support a claim that the Priceline lawsuit was a success; because there is missing data, the accessibility of the Priceline website immediately prior to the lawsuit cannot be commented on. The data available from before the lawsuit show WAB scores that aren't too far from the accessibility threshold of 5.5, indicating that it is possible that Priceline did not have to make drastic modifications to the website to make it accessible. The increase in accessibility seen in 2004, however, coincides with a redesign of the Priceline website. The accessibility of the Priceline website is different than that of the trend occurring in the random Web and also in comparison to the Fodors website. The Fodors website may have been influenced by the Priceline lawsuit, as following the lawsuit it exhibits fewer violations of many of the WCAG 1.0 checkpoints. While a substantial number of violations remain, the accessibility has been improving since the Priceline lawsuit and with the Fodors website redesign that occurred in 2005.

Because the lawsuit against Southwest was dropped, Southwest did not have to modify its website; however the lawsuit must have made an impact on the Southwest company as the accessibility of their website has been improving gradually ever since, with improvements in accessibility coinciding with website redesigns in 2003, 2005, and 2007. The most recent period shows an accessibility score for the Southwest website that indicates that it is accessible, contradicting the trend over time that the website is becoming less accessible. This is promising. Also promising is the low WAB score despite recent increases in website complexity for

Southwest, indicating a conscious effort to keep the website accessible while incorporating more complex technologies into the website. Following the lawsuit, the Southwest website contains very few images without alternative text and no longer contains image map hot spots or image map buttons in forms. The U.S. Airways website, in contrast, continues to be inaccessible, with trends in accessibility and complexity scores that mirror what is occurring in the general Web. While the U.S. Airways website has improved with respect to some WCAG 1.0 checkpoints in the 2007 redesign, it has become worse with respect to others.

The case studies presented here demonstrate mixed evidence that lawsuits work. In the cases of MARTA and Southwest, there is strong supporting evidence that lawsuits have been successful. Drastic decreases in accessibility scores following the respective lawsuits indicate efforts by the companies to maintain an accessible website. In the cases of AOL, Claire's, and Priceline, the evidence is not as strong to support a claim that the lawsuits were successful. The AOL website hasn't changed much over the years; there wasn't a drastic drop in WAB scores following the lawsuit and the website does not have WAB scores below the accessibility threshold of 5.5. The Claire's website still has a lot of improvements to make. While it has become slightly more accessible, the WAB scores are still rather high. The Priceline website could be argued as successful, as the WAB scores are below the accessibility threshold. A big drop in WAB score coinciding with the lawsuit was not seen in the data; however, the scores were not much above the accessibility threshold prior to the lawsuit and there was a website redesign in 2004. The important point regarding the AOL, Claire's, and Priceline websites is that, while not considered to drastically affect the accessibility of the websites, the lawsuits appear to keep the sites from following the trend of inaccessibility that is seen in the general Web.

In three of the five cases presented here, the lawsuit of one website in the industry may have affected at least one other website in that industry. The websites of Yahoo, TriMet, and Fodors may have been influenced by the lawsuits against AOL, MARTA, and Priceline, respectively. For Yahoo and Fodors, this could be due to the fear of a lawsuit against them and, it should be noted, the Fodors website is not yet reasonably accessible. In the case of TriMet, this is probably due to the fact that MARTA and TriMet are websites that provide information regarding public transportation, information that many with disabilities rely on in their daily lives. Also, being vessels of public transportation, MARTA and TriMet may receive federal funding and therefore be required to maintain accessible websites through the application of the Section 504 of the Rehabilitation Act (29U.S.C.§794, 1973) that prohibits disability discrimination by state and private entities receiving federal funding.

4.6 CONCLUSIONS

This is one of the first empirical studies examining the effectiveness of lawsuits on Web accessibility. Because there is no regulatory body governing the ADA (it is set by case law), it is necessary to see if the consumer-driven lawsuits method is effective for addressing Web accessibility. The results presented here show mixed evidence that lawsuits work by forcing companies to modify their websites to contain fewer barriers to people with disabilities: two cases show strong evidence for the success of lawsuits, but three do not. Lawsuits, however necessary from a disability policy perspective, are inefficient due to the resources required (time and money) to see limited results. Because this is a case study look, it is inconclusive to say that lawsuits are effective in stimulating widespread non-governmental-entity Web accessibility;

however, the lawsuits examined in this study may have influenced at least three other websites. Until there is sufficient case law established to support the applicability of the ADA to private entities, many websites may not voluntarily modify their websites. A larger study is needed to examine the extent of the impact of lawsuits on different industries.

5.0 COMPARATIVE USABILITY STUDY

5.1 INTRODUCTION

One way in which websites can be made more accessible is by implementing a Web transcoding intermediary, a service that transforms a website from its original state into one that is accessible. Transcoding holds much promise in making the Web accessible, relieving designers from time consuming and costly retrofitting and redesign solutions. The study in this chapter examines two different websites (one built without consideration of Web accessibility or universal design and one built to universal design standards), and compares the usability of the original websites to the usability of these websites after they have been transcoded via the AcceSS 2.1 transcoding intermediary.

As mentioned in chapter 2, one could see universal design, the "gold standard", as the mitigation technique to support because universal design takes into consideration elements of Web accessibility along with elements of usability and addresses the largest population. However, for optimal usability, an interface for blind users would be designed in accordance with the one-dimensional auditory presentation that is most favorable for screen readers (Nielsen, 2003) and a website presented through AcceSS 2.1 has the potential to meet the needs of blind users better than universal design. It is hypothesized that the AcceSS 2.1 transformations will allow users to complete tasks faster, with fewer errors, and with greater

satisfaction on both universally designed and non-universally designed websites, but the impact on user satisfaction will be greater when used to access non-universally designed websites.

The accessibility transformation provided by AcceSS 1.0 was tested in a colleague's dissertation (Zeng, 2004). A general theme among the findings was that users place a greater emphasis on usability than accessibility. AcceSS 1.0 was modified and the resulting version, AcceSS 2.0, includes summarization and simplification within the transformation to address the usability needs of users. The novelty of the AcceSS 2.0 application provides the potential for significant usability issues.

Preliminary studies of the usability of AcceSS 2.0 were conducted to detect the major usability issues while this version of the software was still in development. Iterative design was used to address the identified issues, resulting in AcceSS 2.1. The results of the preliminary study on AcceSS 2.0 are promising and encourage greater investigating into the usability of AcceSS 2.1. AcceSS 2.1 was the version of the software used in this study to determine the benefits of transformation when accessing universally designed and non-universally designed websites.

5.2 BACKGROUND

Standard Web display is inadequate for users with visual impairments since they must approach the page in a linear fashion via a screen reader to obtain an overall comprehension of the page. Visual users can immediately obtain a "bird's eye view" by quickly scanning the page. AcceSS 2.0 and 2.1 (AcceSS 2.X) combine simplification and summarization techniques to allow visually-impaired users to more quickly obtain a gestalt understanding of the Web page.

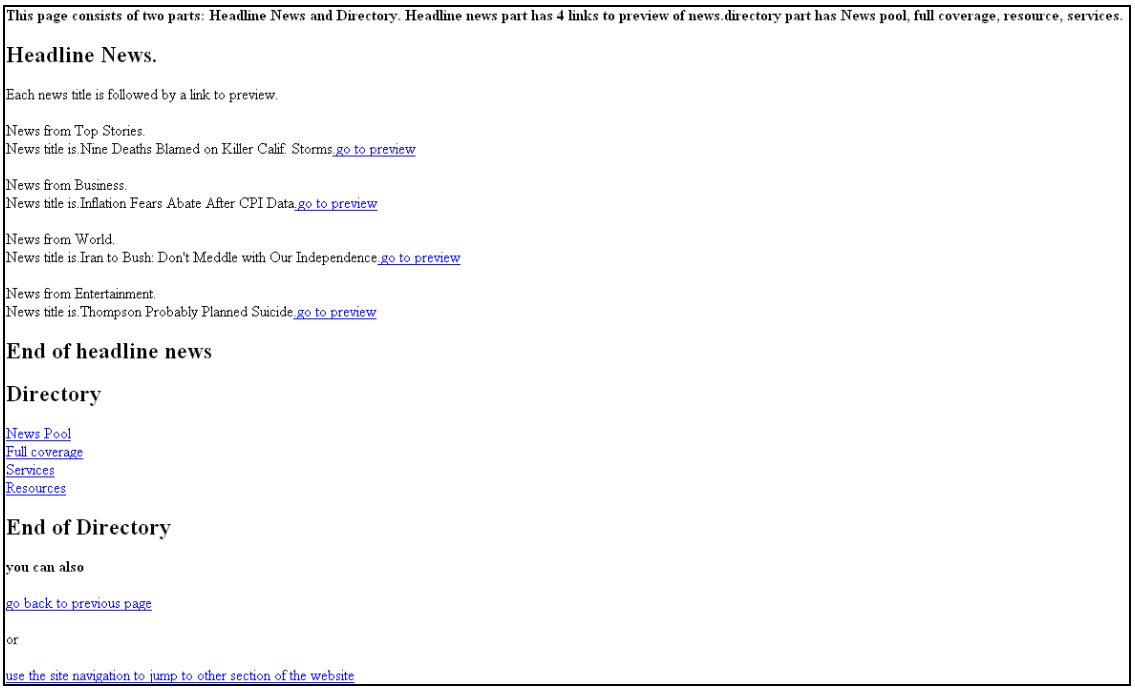
Building upon work by others (Goble, Harper, & Stevens, 2000; Harper, Goble, & Stevens, 2001; Hori, Ono, Joyanago, & Abe, 2002; Hironubi Takagi et al., 2002; Zajicek & Powell, 1997), AcceSS 2.X incorporates the concepts of simplification, summarization, and navigation. Simplification is achieved by utilizing template and pattern matching algorithms to determine which parts of the Web page are most important (B. Parmanto, Ferrydiansyah et al., 2005) and discarding those that are not. The result is an absence of clutter, such as headers and footers, images, and advertisements, on the Web page. Summarization is then carried out on the remaining content.

Summarization extends the concept of context probing suggested by Harper et al. (Harper, Goble, Stevens, & Yesilada, 2004) by creating a preview of the entire page. Summarization relies heavily on structure and important landmarks (title, subtitles, etc.) (B. Parmanto, Ferrydiansyah et al., 2005). Parts of the summary page are often available in a news website, such as Yahoo! News, in the form of an abstract of the full story (see A in Figure 37). The AcceSS 2.X summarization algorithm first checks if a news story abstract is available, and if so, uses it on the transformed page. If unavailable, the first few sentences of the story are used. The summarization process produces an outline of the Web page that gives the visually-impaired user a sufficient understanding of the page without further navigation, similar to what a visual user would do in the first few seconds of scanning a Web page.

Figure 37. Original Yahoo! News Page showing an abstract (A) and list of category links (B)

Together, simplification and summarization form a "virtual guide dog" for the Web. Figure 38 shows an example of a virtual guide dog page, which is seen at the page level. This provides an overview of that page without the user having to listen with a screen reader to the entire original page, which is replete with graphics, advertisements, and other clutter. Each separate news story is on its own line. From the virtual guide dog the user can select to preview the story if they would like to see more about the story, or choose links to other elements of the

website such as News Pool, Services, or Resources, as well as go back to the previous page or to the website navigation tool (available in AcceSS 2.0).



This page consists of two parts: Headline News and Directory. Headline news part has 4 links to preview of news.directory part has News pool, full coverage, resource, services.

Headline News.

Each news title is followed by a link to preview.

News from Top Stories.
News title is.Nine Deaths Blamed on Killer Calif. Storms.go to preview

News from Business.
News title is.Inflation Fears Abate After CPI Data.go to preview

News from World.
News title is.Iran to Bush: Don't Meddle with Our Independence.go to preview

News from Entertainment.
News title is.Thompson Probably Planned Suicide.go to preview

End of headline news

Directory

News Pool
Full coverage
Services
Resources

End of Directory

you can also

go back to previous page

or

use the site navigation to jump to other section of the website

Figure 38. Guide Dog page for Headline News

The website navigation tool is another feature that AcceSS 2.0 provides the user. This tool gives a website-level outline, allowing the user to quickly and easily navigate from one area of the website to another (Figure 39). The website navigation tool is a stable landmark to which the user can return from any page within the website from a link present at the bottom of every page.

Figure 39. Site Navigation for Yahoo! News Website

5.3 PRELIMINARY STUDIES

The author conducted a series of preliminary studies on AcceSS 2.0 and AcceSS 2.1 (Stephanie Hackett & Parmanto, 2006) during the iterative design process. Because the summarization and navigation features of AcceSS 2.X render pages to be very different from the originals, it was important to evaluate human-computer interaction when designing AcceSS 2.X.

In the first preliminary study on AcceSS 2.0, two participants were asked to complete 3 tasks on the original Yahoo! News (Yahoo!News, 2005) website and the transformed website. Each participant was able to complete all three tasks using the transformed website, while only one was able to complete any of the tasks using the original site (Figure 40).

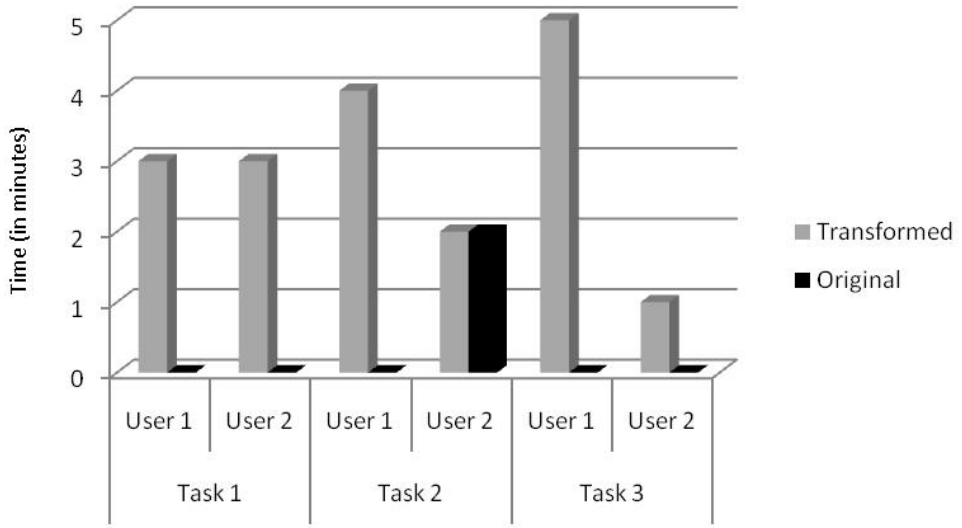


Figure 40. Time to task completion. If no time noted, the task was not completed within the 5 minute threshold

Both users preferred accessing the websites via AcceSS 2.0, with one user commenting that she especially liked the lack of graphics. She also felt that it would be better to go to the full story instead of going to the abstract/preview page first and when completing the task that explicitly asks the user to utilize the abstract page to obtain the answer she went directly to the full story for the answer. The second user did utilize the abstract page when searching for the answer to each of the three tasks using AcceSS 2.0. Both participants appeared to have an understanding of the virtual guide dog and the site navigation tools by the end of the session. Both users were more satisfied with their experience using the transformed website than the

original. Other findings included: 1) making the "go to preview" link on the virtual guide dog page more descriptive to enable users to use the JAWS for Windows "links list" more effectively, and 2) to place the link to the site navigation page at the top of the page instead of the bottom.

The findings from the first preliminary study were addressed and a second preliminary study of AcceSS 2.0 involved six visually-impaired computer users recruited from the local Pittsburgh, Pennsylvania area. After completing each task set, participants were asked to complete a usability questionnaire as well as a questionnaire of their computer background.

Each website had a set of scenario-based tasks that required the user to gather information from a story or an abstract within the websites. The tasks were made as identical as the differences between presentations allowed. One of the tasks asked users to find the abstract of an article regarding a new type of synthetic paste used to repair early tooth decay and to tell the experimenter the country from which the innovation comes.

Overall, all participants were more satisfied with the transformed Yahoo! News website than the original. The IBM Computer System Usability Questionnaire (CSUQ) (Lewis, 1995) (APPENDIX F) usability questionnaire captured user satisfaction of system usefulness, information quality, and interface quality. Users' collective satisfaction in all three of these areas was greater when using the transformed website over the original website (Figure 41).

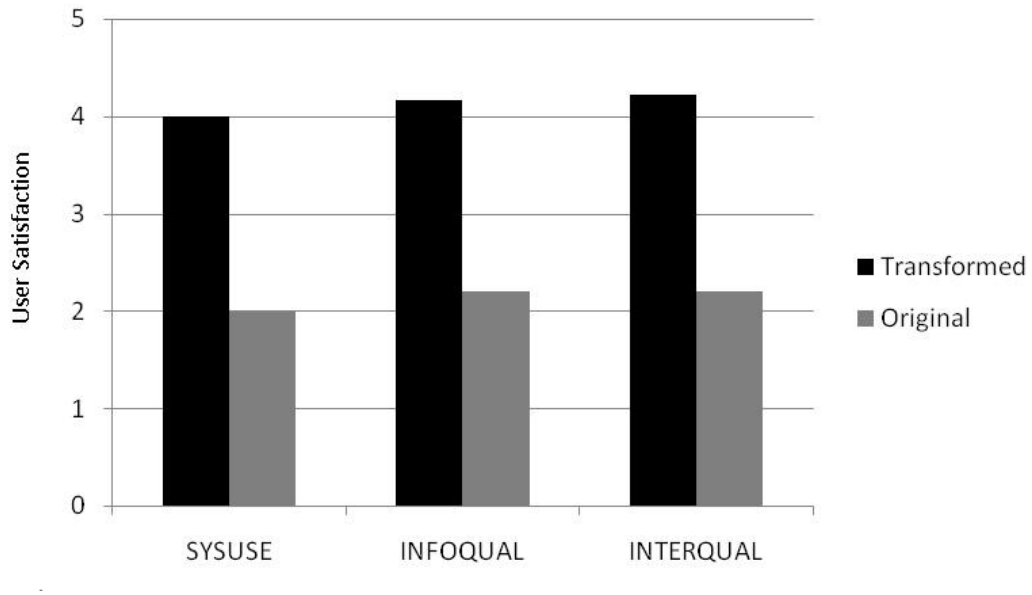


Figure 41. Collective Averages User Satisfaction for Original and Transformed Yahoo! News website (higher score indicates higher satisfaction)

The transformed website with the virtual guide dog scored much better on the questionnaire than did the un-transformed original website, with even the lowest scores for the transformed website being higher than the highest scores on the original website. This highlights the improved satisfaction level with the guide dog as compared with the original Yahoo! News Web page.

The transformed format was more efficient than the original format. Participants were able to go directly to the story by clicking on the link from the virtual guide dog page instead of having to listen to all of the category links that are listed in the left-hand column of every page of the Yahoo! News website (see B in Figure 37). One user felt that "the organization of the [transcoded] page allowed you to always know where to find the links you need" and that this led to a feeling of "increased control."

The majority of the participants were comfortable using the virtual guide dog and the site navigation tool by the end of the task session with the transformed Yahoo! News website. Often, when starting their search for the answer to task two and three, the user would say, "the first thing I want to do is go to the site navigation." One user commented that "making the navigation page separate was a good strategy." Another user questioned "without seeing the page, how can I make a mental model of the page?" and concluded at the end of the session that the transcoded Web page allowed for easier digestion of information, "Audibly, the [transcoded page] is set up well and easily navigable."

The user observations above suggest that the simplification and summarization provided by AcceSS 2.0 in the form of the virtual guide dog help in building gestalt understanding of the page for visually-impaired Internet users. Users were able to more quickly and efficiently answer tasks using the AcceSS-transcoded website and lower frustration levels were seen when users were completing tasks on this website. All participants preferred the transformed website over the original, with the exception of the most Web-experienced user, who was undecided. This user felt, however, that if the service was available he would try it.

There is a balance between simplification and loss of information. The goal is to provide the user with only those elements of the Web page that are meaningful to them, while eliminating the clutter, or insignificant information, on the screen. AcceSS 2.1 integrates the guide dog and site navigation tools into one tool in an attempt to find the balance between simplification and loss of information. This new feature required testing.

A preliminary study of AcceSS 2.1 was conducted with four blind computer users from the Pittsburgh, PA area to test the integration of the site navigation and guide dog features. Observations by the researcher along with anecdotal findings from the study participants

revealed several navigation issues: 1) links were not sufficiently descriptive and 2) links leading to important information were buried under a link that wasn't descriptive. These issues were addressed and the system was re-tested with two of the four participants. The hard data from the re-tests are promising (Figure 42); however, they are biased due to the fact that both participants had previous exposure to the system and the task scenarios. The results from the preliminary studies of AcceSS 2.1 provide encouragement for the usability study of AcceSS 2.1 on two different designs: universally and non-universally designed websites.

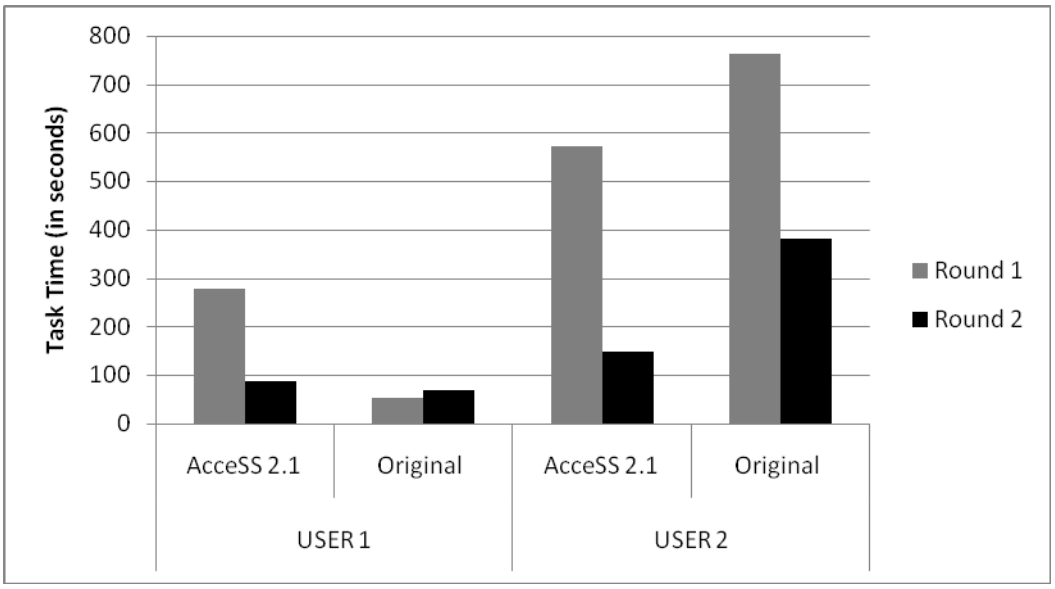


Figure 42. Preliminary AcceSS 2.1 Average Task Times

5.4 METHODS

5.4.1 Participants

A study notice was posted to several email distribution lists for blind computer users in the Pittsburgh, PA region (APPENDIX G). Visually-impaired computer users from the surrounding Pittsburgh, PA area were prescreened via telephone using the questionnaire in APPENDIX H. This was done in the hopes for obtaining a representative sample of users with respect to sex, age, and user experience.

5.4.2 Experimental Design

This study used a cross-over technique (see Figure 43), meaning that users interacted with and performed tasks on both the original and the transcoded presentation of two different approaches to website design: universally-designed and non-universally-designed, as well as a reference website. The test was conducted as a within-subject design, which controls for individual variability (Nielsen, 1993). The cross-over study design also decreases the sample size needed. Each participant interacted with two presentations of three different websites (A-F): the original and transcoded versions of the universally-designed, non-universally-designed, and reference websites.

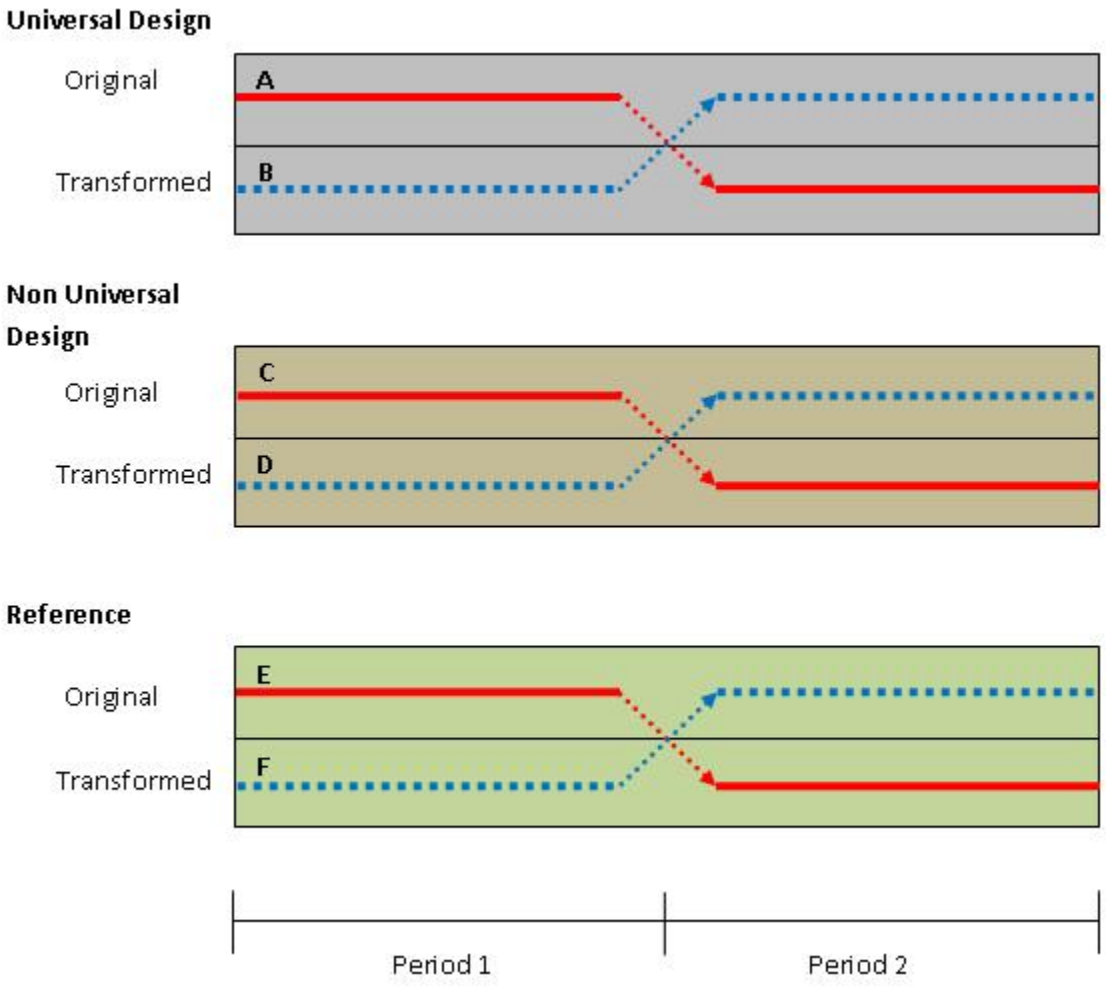


Figure 43. Cross-Over Study Design

A coin toss determined: 1) the system that the first participant interacted with (half starting with the non-universally designed website [C or D] and the other half starting with the universally-designed website [A or B]) and 2) the presentation style that the first participant interacted with (half starting with the original [A or C] and half start with the transcoded [B or D]). The order alternated for subsequent participants. This helps to control for learning effects (Nielsen, 1993). To balance the administration of the reference website, half of the participants started the entire study session on the reference website, while the other half ended on the

reference website. The system interface is the independent variable. The statistical analysis used for comparing performance on the original website and the transformed website is a paired-samples t-test because the same participants have results measured for both styles of presentation. Statistical analysis for determining main effects and interactions is a mixed-model analysis of variance (ANOVA). Mixed-model analysis allows one to put both fixed and random variables in the model to analyze the effects of these variables. ANOVA was also used to test for differences in user satisfaction among the three sites in the study, with Tukey's HSD post-hoc test to determine pair-wise differences.

Based on the test plan presented in Nielsen (Nielsen, 1993), the test plan for this study is presented in APPENDIX I.

5.4.3 Materials

Non-universally designed and universally-designed websites were identified. Each of the potential websites was evaluated using the checklist (APPENDIX J) to determine whether the website meets the guidelines of the Principles of Universal Design (TheCenterForUniversalDesign, 1997a). As noted in the Principles of Universal Design, all guidelines may not be relevant to all designs and, thus, some of the guidelines are not applicable (N/A) to the Web. The website meets all the guidelines if all of the answers to the questions fall within the shaded areas.

In addition to following a universal design, the universally-designed site chosen is expected to be a typical website of an institution and used by the institution to support its business and presence on the Internet. The website is also expected to be typical in terms of complexity, in regards to what users will experience in their travels on the Web. A few websites

that had won awards for universal design were ruled out due to simplicity and/or the presence of universal design statements on the site (which could introduce bias).

The universally-designed website used in the study is the University of Pittsburgh School of Health and Rehabilitation Science's (SHRS) website: www.shrs.pitt.edu. This website was chosen because it is an academic website focusing on rehabilitation science, is universally-designed, and is the website of the school in which the researcher is a student. The non-universally designed website was identified through a Google search for "health rehabilitation sciences" to search for schools similar to SHRS at other universities. Several potential websites were identified and two independent raters, the author and a research assistant, completed the checklist presented in APPENDIX J for each of six non-universally designed websites. Inter-rater reliability was established and the kappa was 0.54, indicating moderate inter-rater reliability (Landis & Koch, 1977). Based on the results of the checklists, the non-universally designed website chosen for the study was the School of Allied Medical Professions (AMP) at Ohio State University: www.amp.osu.edu.

Cnn.com is the reference website for the study. A reference website was included because our previous research on AcceSS has proven to be beneficial to users when interacting with complex, corporate-like websites. This study focuses on educational websites that are simpler in nature and this type of website has not been tested previously with AcceSS. Cnn.com was chosen because it is one of the first four corporate, non-universally-designed websites from Alexa.com's Top 500 listing of most popular English-language websites. Because the number and distribution of websites are undeterminable due to the size and dynamics of the Web, many probabilistic sampling methods, such as random or stratified sampling, are not applicable. An alternative sampling method widely adopted by researchers conducting studies on websites is to

utilize the directory services provided by many Web search engines. Also, by using a popular website, one can assume it is typical and representative of the type of website commonly encountered on the Web. Of the 4 potential websites identified, www.cnn.com was one of the most popular and it failed to meet the most criteria from the Principles of Universal Design checklist.

Each website was archived onto a server and all participants accessed the websites from this server during the test sessions. This ensured that all participants interacted with the same version of each website. The same participants performed tasks on all three websites.

For illustration of the websites that the users interacted with in this study, Figure 44 shows a screen shot of the homepage of the original www.cnn.com, while Figure 45 is a screen shot of the same homepage after it has been transcoded by AcceSS 2.1.

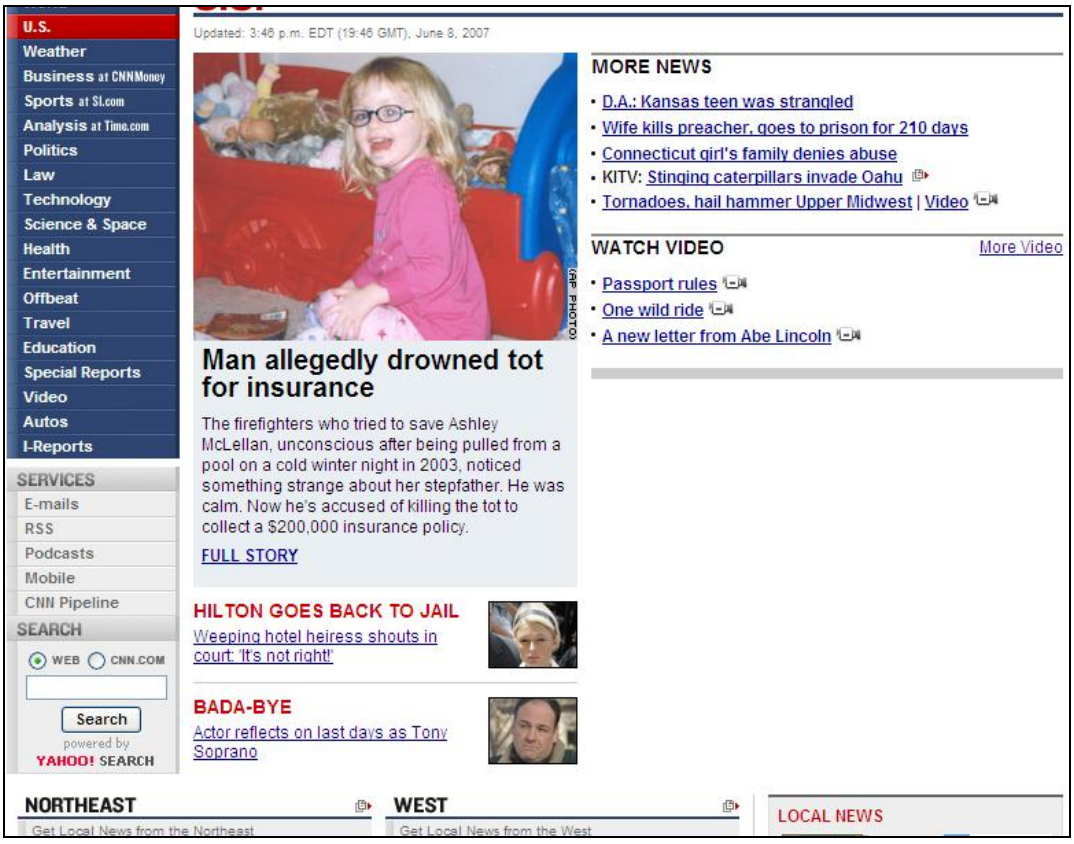


Figure 44. Original Homepage of CNN.com

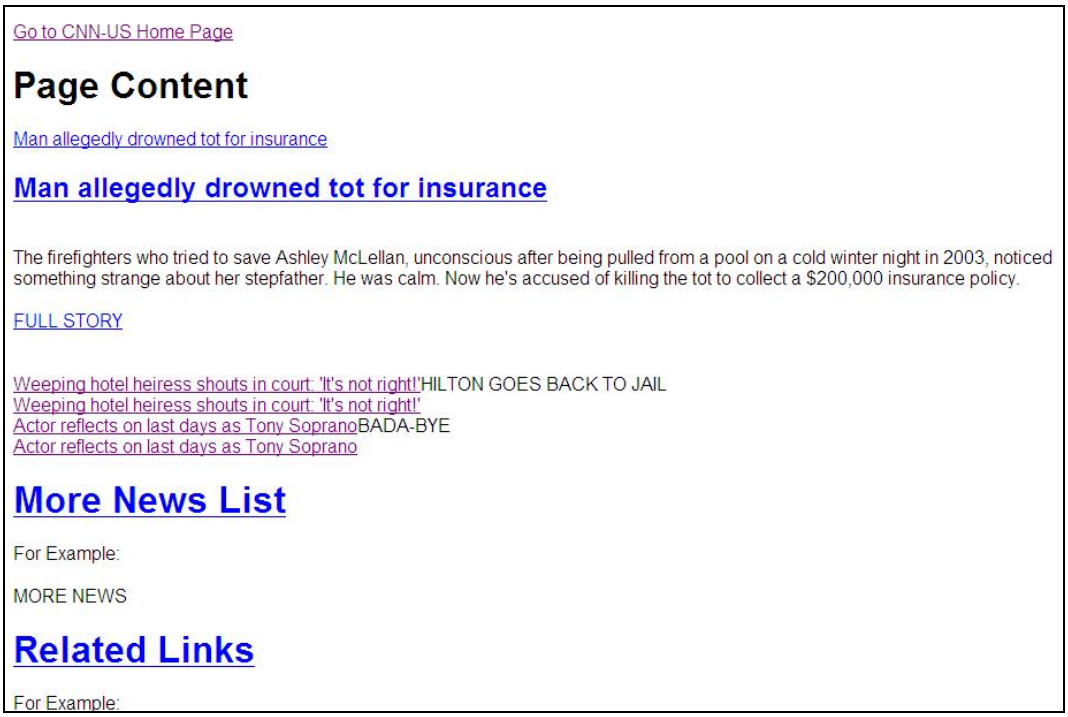


Figure 45. Transcoded Homepage of CNN.com

5.4.4 Measurement

The usability measurements (dependent variables) of interest in this study included:

1. The time to complete a specific task (efficiency was measured by the average of both tasks completed by the user on each system),
2. The number of user errors (an error is an action taken by the user that takes the user away from the desired destination),
3. Subjective satisfaction, and
4. Which presentation style (transcoded or original) the user preferred.

Subjective satisfaction was measured using the IBM Computer System Usability Questionnaire (CSUQ) (Lewis, 1995). The CSUQ (APPENDIX F) is a publicly available questionnaire containing 19 questions with a seven-point Likert scale for each answer. The CSUQ has

excellent internal consistency with an overall coefficient alpha of 0.97. This questionnaire was used in the preliminary study and proved to be effective. The modifications to the CSUQ included replacing the term "system" or "computer system" with "website" and changing the orientation of the Likert scale so that 1 indicates the least agreement and 7 indicates the greatest agreement to the statement. This change was made because the survey is read to users and during preliminary studies multiple users made the statement that "it would make more sense to me if the higher scores indicated higher satisfaction."

5.4.5 Tasks

Participants were asked to complete two tasks on each of the transcoded and original SHRS, AMP, and CNN websites, resulting in twelve total tasks. This number of tasks was chosen because: 1) previous similar research used this number of tasks (Brajnik et al., 2005) and 2) previous experience has shown that lay users, such as those participating in this study, become tired if testing times become too long.

Tasks were scenario based and designed to be as similar as differences in presentation allowed. This included developing tasks that:

- Required the same number of links be followed to complete,
- Required the user to follow links in the same section of the site (i.e. body, header), and
- Had the answer in similar sections of the websites (beginning, middle, end).

The tasks for each website (Table 12) were presented in scenario format. One task is information gathering in nature, while the other is more action-oriented by requesting the user to email, print, or download information once it is located. Tasks are fairly equal with respect to complexity.

Table 12. Task Scenarios

Website	Presentation	SCENARIO 1 (information task)	SCENARIO 2 (action task)
SHRS www.shrs.pitt.edu (universally designed)	Original	You've heard in the news that the Neuromuscular Research Laboratory and UPMC have partnered with a government agency for injury prevention research. Navigate the SHRS website to find out the name of that agency.	You are currently a new student at SHRS and need to get some information regarding information services at the school. Navigate the SHRS website to download the information services orientation handout.
	AcceSS 2.1	You are considering going back to school and want to learn more about the opportunities that SHRS offers. Navigate the SHRS website and tell me the levels of education offered by SHRS.	You are an undergraduate student at SHRS and would like to download the student handbook. Navigate the SHRS website to download the SHRS Undergraduate Student Handbook for 2006-2007.
AMP www.amp.osu.edu (non-universally designed)	Original	You've heard about the 2007 Hite Family Symposium going on at OSU. Navigate the AMP website to find the date of the symposium.	You are a current student of Radiologic Sciences and Therapy. Navigate the AMP website to download the Radiologic Sciences and Therapy Student Handbook.
	AcceSS 2.1	You are interested in learning more about the School of Allied Medical Professions at Ohio State University. Navigate the AMP website to find out what the school's	You are a future student considering taking courses toward a degree in Athletic Training. Navigate the AMP website to download a brochure for

		director says about the growth of jobs in the allied health professions in the next 10 years.	prospective students of Athletic Training.
CNN www.cnn.com (reference)	Original	You have been a fan of Toni Soprano since the start of the HBO series The Soprano's and know the series finale is coming soon. Navigate the CNN website and tell me, according to the site, when the series finale will be.	You see an article on CNN US subdirectory about tornadoes hammering the Upper Midwest. Navigate the CNN website to find that article and email it to your friend who lives in the Wisconsin.
	AcceSS 2.1	You've been following the Paris Hilton case with interest. Navigate the CNN site to read the latest. According to the website, how many days did Hilton serve in jail before her release?	While searching for more news than what is present on the US subdirectory homepage, you came across a story about a preacher's wife who kills and goes to jail for 210 days. Find that article and print it for a friend.

5.5 RESULTS

5.5.1 Study Participants

Fifteen visually-impaired computers users from the Pittsburgh, PA area participated in the study. Each user signed the consent form (APPENDIX K), which was read to the user, before beginning the study. All participants owned their own computer, had an Internet connection in the home or office, used a screen reader, and used the computer and the Internet on a daily basis.

Figure 46 depicts the type of screen readers used by the study participants; only one participant used a screen reader other than JAWS for Windows. Figure 47 depicts the daily Internet and computer usage of the participants. The majority of users (75%) interact with the Internet between one and five hours per day. Sixty percent of the participants were female and 87% were over age 40. Only 2 participants were in the 21-30 age range. Over half of the participants (53%) had completed college, 27% indicated high school as the highest level of education completed and 20% had completed graduate school.

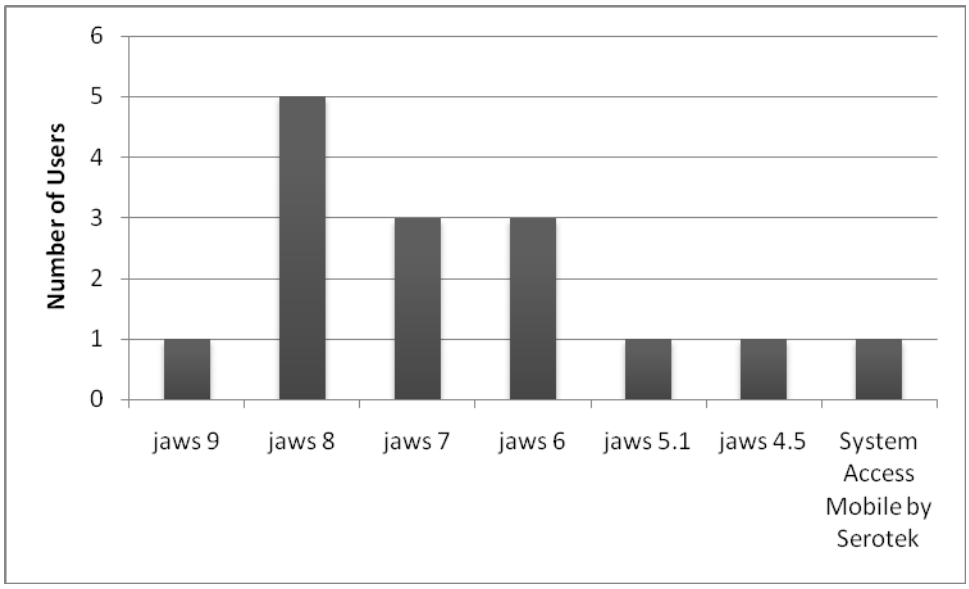


Figure 46. Screen Readers Used by Participants

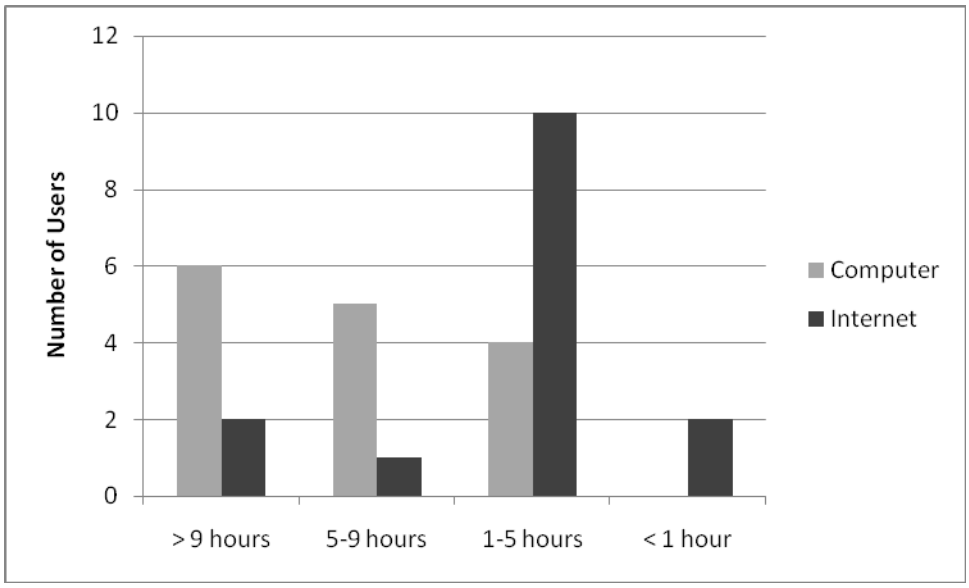


Figure 47. Daily Computer and Internet Use of Participants

Users perform a variety of daily tasks on the computer and Internet. Figure 48 and Figure 49 graphically depict the various computer and Internet tasks participants perform on a regular basis.

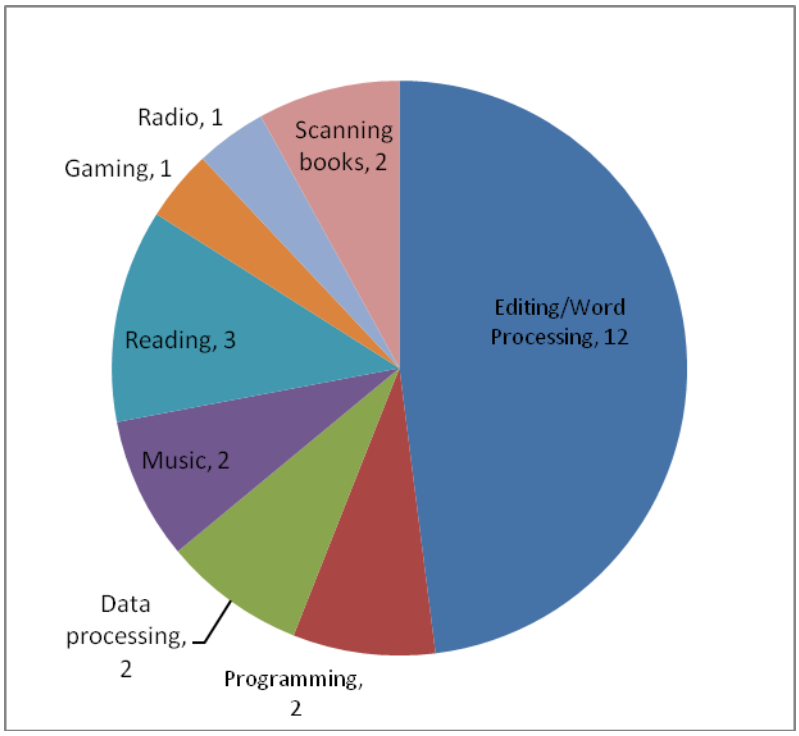


Figure 48. Tasks Participants Perform on the Computer

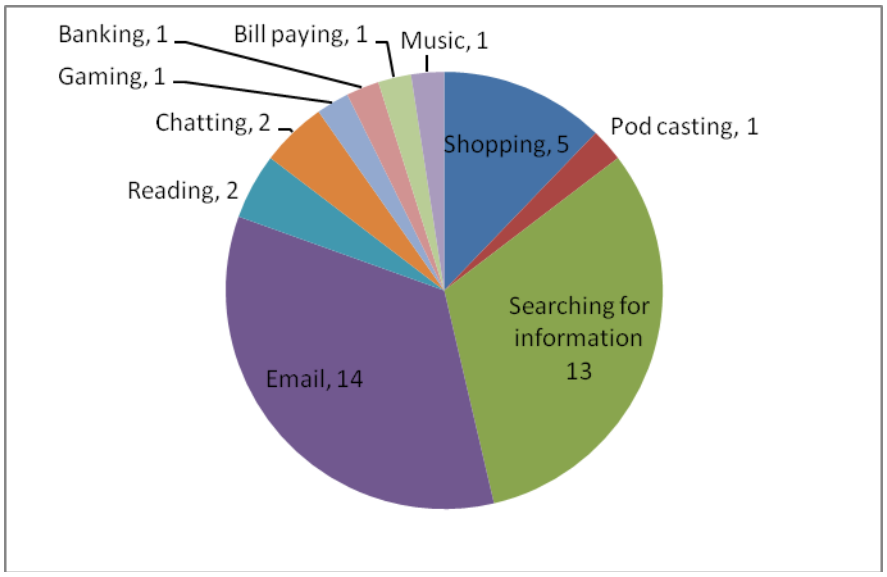


Figure 49. Tasks Participants Perform on the Internet

5.5.2 Data Analysis

5.5.2.1 Task Completion Time

Descriptive statistics of the results for SHRS, AMP, and CNN are presented in Table 13 and Figure 50 shows a box-plot of the results for each of the websites. The times for both tasks on each website were averaged together to get a total efficiency score (time) for each website. Because tasks were very similar in complexity, task times per task were not examined. Paired t-tests comparing the mean times of task completion for the original and transcoded websites show statistical significance for all three websites included in the study (Table 14), with p-values of 0.046 for SHRS, 0.049 for AMP, and 0.007 for CNN.

Table 13. Descriptive Statistics for Average Task Completion Time (in seconds)

	Mean Time (in seconds)	Minimum	Maximum	St. Dev.
SHRS original	291.87	46	651	185.61
SHRS transformed	187.13	48	417	114.84
AMP original	189.93	49	517	131.04
AMP transformed	123.2	21	247	79.83
CNN original	234.73	68	596	164.77
CNN transformed	99.73	37	223	52.54

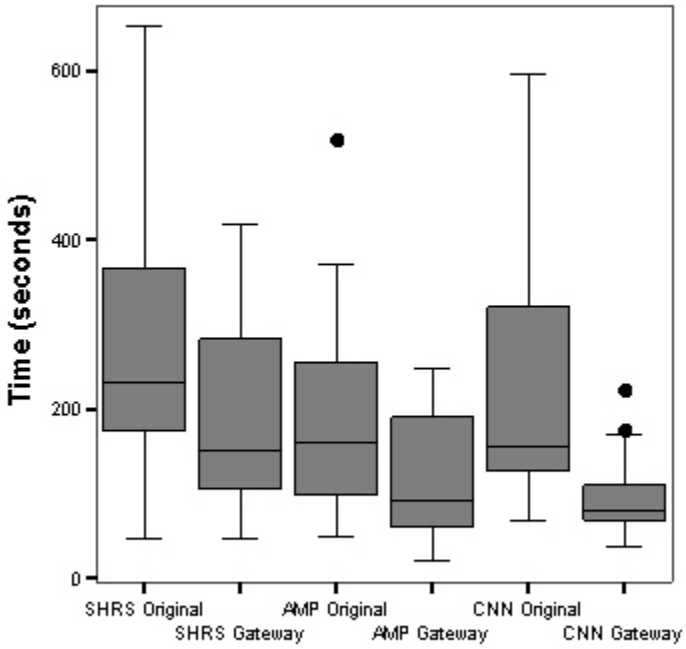


Figure 50. Box-plot of Average Task Times for Original and AcceSS 2.1 (gateway)

Table 14. Paired Samples T-Test (Paired Differences) for Average Time to Complete Tasks

	Correlation	Mean Diff.	Std. Dev. Diff.	Std. Error Mean	P-value (2-tailed)
SHRS orig/transformed	0.315	104.73	184.94	47.75	0.046
AMP orig/transformed	0.437	66.73	119.99	30.98	0.049
CNN orig/transformed	0.156	135	164.95	42.59	0.007

5.5.2.2 Errors

Errors that users made while completing tasks were also measured. Overall, there were more errors made on the SHRS original and SHRS transformed websites than the other websites

(Table 15). There were no statistically significant findings when comparing the number of errors made when using the transcoded websites versus the original websites (Table 16); however, overall users made less errors on the transformed websites than on the original. Figure 51 shows the box-plots of the errors made by system and website.

Table 15. Descriptive Statisticss for Number of Errors Made by Participants on Each Website

	Mean	Min	Max	St. Dev.	Std. Error Mean
SHRS original	2.8	0	9	2.73	0.71
SHRS transformed	1.8	0	5	1.93	0.50
AMP original	1.1	0	5	1.43	0.37
AMP transformed	0.6	0	2	0.83	0.21
CNN original	0.8	0	5	1.47	0.38
CNN transformed	0.2	0	2	0.56	0.14

Table 16. Paired Samples Test – paired differences for Errors

	Correlation	Mean Diff.	Std. Dev. Diff.	Std. Error Mean	P-value (2-tailed)
SHRS orig/transformed	0.06	1.0	3.25	0.84	0.25
AMP orig/transformed	-0.04	0.47	1.68	0.43	0.3
CNN orig/transformed	0.14	0.6	1.5	0.39	0.14

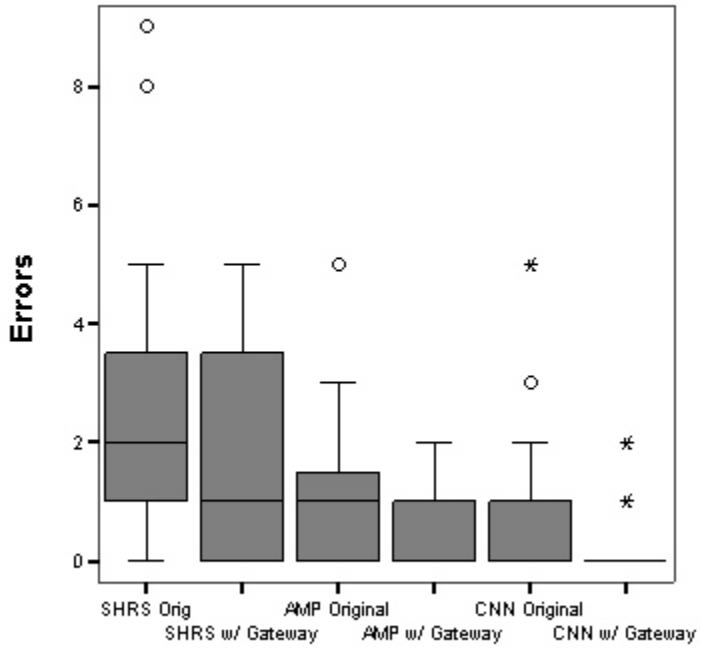


Figure 51. Boxplot of Errors Made by Website

5.5.2.3 Task Completion Rate

Because very few incorrect answers were given by participants, there was not enough statistical power to perform statistical analyses on answer correctness data. Two users gave incorrect responses for 1 of 2 tasks on both the SHRS and AMP websites and 1 user gave an incorrect response for 1 task on the CNN website. Of 180 total responses (from 15 participants over 12 tasks), only 5 responses were incorrect (2.8%). The correct response rate for the transcoded websites is 100% while the correct response rate for the original websites is 94.5%.

5.5.2.4 User Satisfaction

User satisfaction was collected via the CSUQ usability questionnaire. There are 19 questions on the questionnaire and the questions capture user satisfaction pertaining to system usefulness (SYSUSE), information quality (INFOQUAL) and interface quality (INTERQUAL). Questions 1-8 capture SYSUSE, questions 9-15 capture INFOQUAL, questions 16-18 capture INTERQUAL, and questions 1-19 capture OVERALL system satisfaction. The researcher read the statements on the CSUQ aloud to the participant and the participant responded with a number from 1-7, as to his/her agreement with the statement, with 1 being "strongly disagree" and 7 being "strongly agree". Higher scores indicate higher satisfaction with the system.

Paired samples t-tests were performed on each of the satisfaction components captured by the CSUQ and all but one website had statistically significant results for each component (Table 17). The only component that was not statistically significant is the user satisfaction of the interface quality of www.amp.osu.edu. These results indicate the users were more satisfied overall and with the system usefulness, information quality, and interface quality of the transformed websites over the original websites they interacted with.

Table 17. P-value Results for Paired t-tests for User Satisfaction of Original vs. Transcoded Websites

	AMP	SHRS	CNN
OVERALLL	0.001	0.007	0.005
SYSUSE	0.001	0.012	0.007
INFOQUAL	0.001	0.011	0.009
INTERQUAL	0.061	0.002	0.004

The following figures (Figure 52, Figure 53, Figure 54, and Figure 55) graphically represent the average user satisfaction for the three website used in the study.

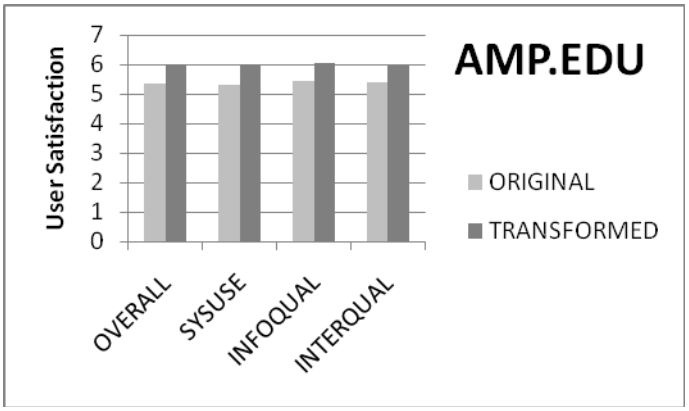


Figure 52. Average User Satisfaction Results for www.amp.osu.edu

Figure 53. Average User Satisfaction Results for www.shrs.pitt.edu

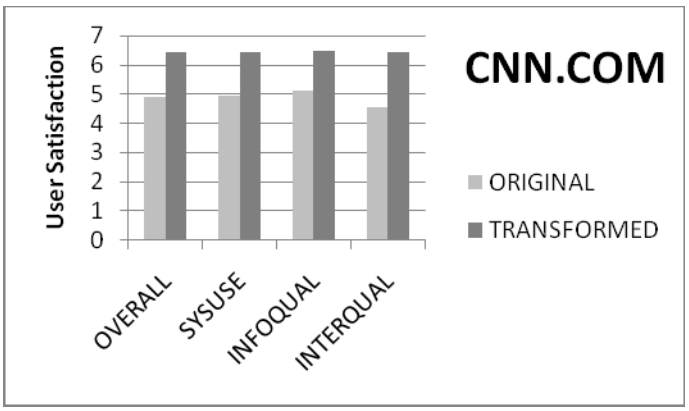


Figure 54. Average User Satisfaction Results for www.cnn.com

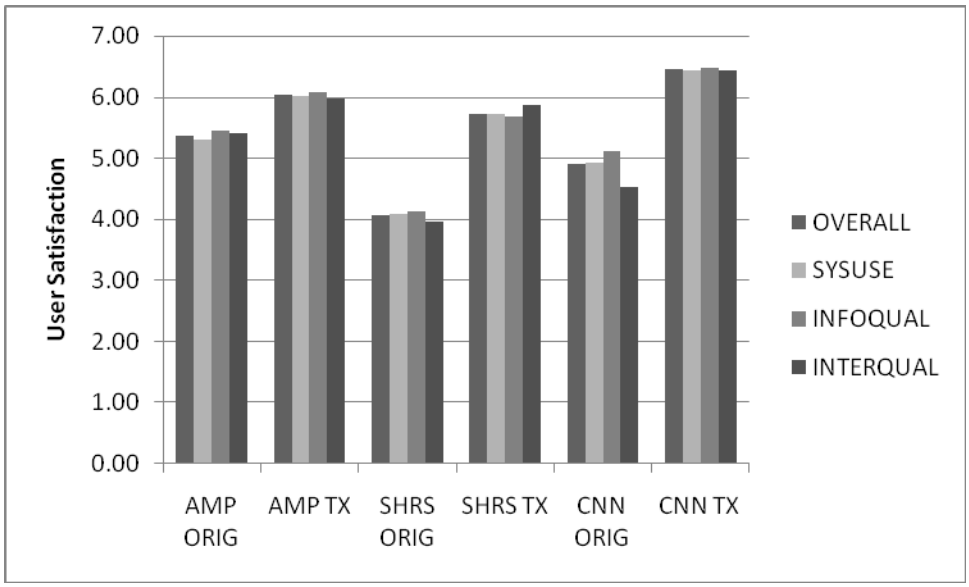


Figure 55. Comparison of User Satisfaction for All Websites

ANOVA was computed to determine differences in user satisfaction over the three websites included in the study. There are statistically significant differences between the websites for all components of user satisfaction (OVERALL, SYSUSE, INFOQUAL, and INTERQUAL), with $p<0.0001$. Tukey's HSD post-hoc test was computed to see where the pair-wise differences are statistically significant (see Table 18). The user satisfaction for the SHRS original presentation is statistically different than the user satisfaction for the SHRS transcoded

presentation for all areas of user satisfaction captured by the CSUQ. Statistically significant differences were also seen between the transcoded and original satisfaction scores for the CNN website. There were no statistically significant findings for the AMP website.

Table 18. Tukey's HSD P-values for Differences in User Satisfaction

Tukey's HSD p-values	OVERALL	SYSQUAL	INFOQUAL	INTERQUAL
AMP transcoded and original	0.753	0.74	0.778	0.869
SHRS transcoded and original	0.01	0.022	0.017	0.004
CNN transcoded and original	0.022	0.048	0.061	0.004

Contrary to the hypothesis, the difference in user satisfaction was greater in the SHRS website (the universally designed website) than the AMP website (the non-UD website); the differences between the original and transcoded SHRS scores were statistically significant for all areas of user satisfaction and the differences for the AMP website were not significantly different for any of the user satisfaction areas. The differences in satisfaction scores for the CNN original and transcoded websites were also statistically significant for OVERALL, SYSQUAL, and INTERQUAL and show a trend for INFOQUAL. Other significant differences include the SHRS original scores as compared to the scores for the transformed AMP and CNN websites for all areas of user satisfaction: OVERALL (p=0.001 and p<0.0001, respectively for AMP and CNN), SYSQUAL (p=0.004 and p<0.0001), INFOQUAL (p=0.001 and p<0.0001), and INTERQUAL (p=0.002 and p<0.0001).

At the end of the testing session, users were asked which presentation (original or transcoded) they preferred overall. These results are shown in Figure 56. The majority of users preferred the transformed websites (80%). Only three participants had mixed opinions and these

users all mentioned that they felt this way due to a lack of familiarity with the transcoded websites. All three felt confident that once they became familiar with the transcoded websites, they would prefer them.

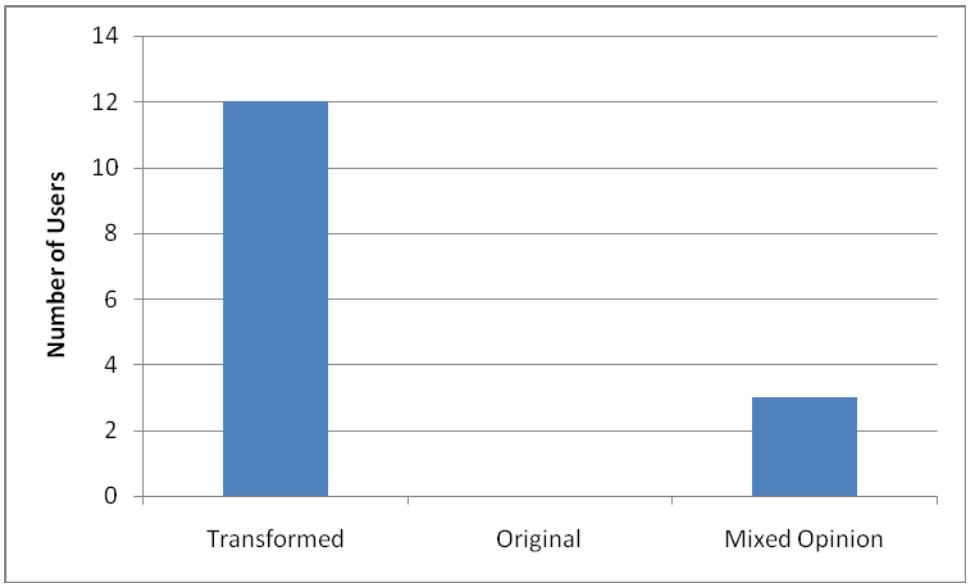


Figure 56. User System Preference

5.5.2.5 Mixed-Model Analysis of Variance

Mixed-model ANOVA was performed to answer several questions pertaining to the study design and to determine if these variables have an effect on the study outcomes. These questions are:

1. Is there an effect for which system (original or transcoded) the user started on? This answers the question of whether the treatment effect varies based on which system the user started, called here Design Effect.
2. Is there an effect for which task the user starts with (task 1 or task 2) for the website? This answers the question of whether the treatment effect varies based on which task the user started with, called here Task Effect.

3. Is there an effect for the period of the study in which the user completed the tasks (period 1 vs period 2)? This answers the question of whether there is a performance difference based on the period in which the tasks are completed, called here Period Effect.
4. Does the website in which the user starts the study matter? Because the study comprised users interacting with three different websites, this answers the question of whether the treatment effect varies based on which website the user started, called here the Path Effect.

1. Design Effect

The design effect was examined at the website level to determine if the treatment effect varies depending on whether the participant started on the transcoded or original website. The results (Table 19) indicate that for all three websites the treatment effect (for time or errors) was not affected by the system on which the participant started. Also, the main effect of the design variable shows that the total time (transcoded + original) is not affected by which system the user started with (p=0.365 for SHRS, p=0.084 for AMP, and p=0.178 for CNN). Finally, the main effect of the design variable shows that the total errors (original + transcoded) is not affected by which task the user started with (p=0.37 for SHRS, p=0.145 for AMP, and p=0.365 for CNN).

Table 19. Mixed Model Analysis for Design Effect (p-values)

	SHRS	AMP	CNN
TIME	0.882	0.093	0.064
ERRORS	0.88	0.507	0.948

2. Task Effect

The task effect was examined at the website level to determine if the treatment effect varies depending on whether started with task 1 or task 2 for the websites. The results (Table 20) indicate that for all three websites the treatment effect (for time or errors) was not affected by the task on which the user started. Also, the main effect of the task variable shows that the total time (original + transcoded) is not affected by which task the user started with (p=0.81 for SHRS, p=0.632 for AMP, and p=0.33 for CNN). Finally, the main effect of the task variable shows that the total errors (original + transcoded) is not affected by which task the user started with (p=0.454 for SHRS, p=0.842 for AMP, and p=0.766 for CNN).

Table 20. Mixed Model Analysis for Task Effect (p-values)

	SHRS	AMP	CNN
TIME	0.306	0.276	0.323
ERRORS	0.359	0.201	0.469

3. Period Effect

The period effect was examined at the study level (across all three sites) to determine if the treatment effect varies depending on whether the user interacts with AcceSS 2.1 first or second. This was a between-subjects analysis, since half of the participants interacted with the original websites for period one and half interacted with AcceSS 2.1 for period one and vice versa for period two. Figure 57 shows that regardless of which system (original or AcceSS 2.1) the user interacts with first, users still have faster completion times when using the AcceSS 2.1. However, it seems that users perform faster with AcceSS 2.1 when they are using it first and perform better on the original websites when they are accessing them second. There is no main

effect for period (p=0.623) but there is a "period X system" interaction, with p=0.013. This is an anticipated interaction and it supports the hypothesis of the study.

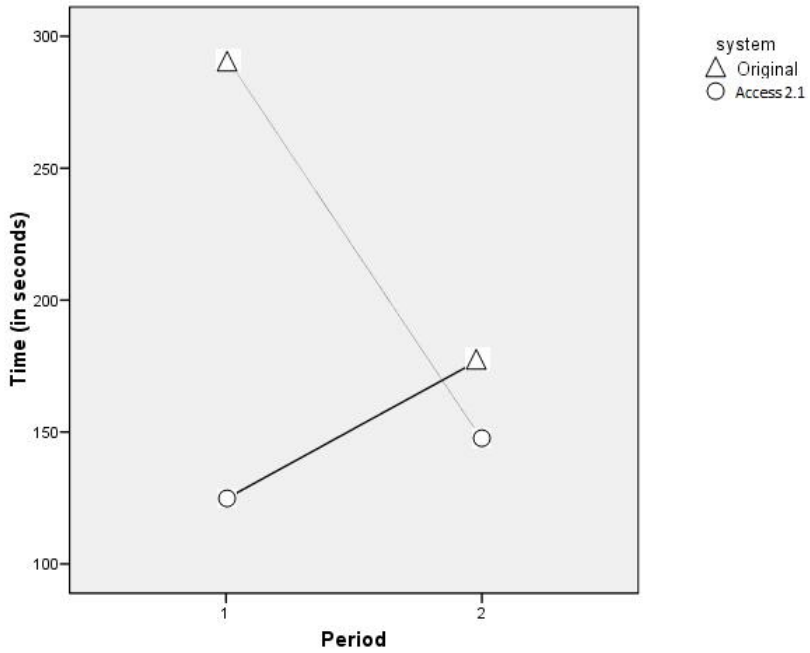


Figure 57. Period Effect on Efficiency

With respect to the number of errors per period, Figure 58 shows that regardless of which system (original or AcceSS 2.1) the user interacts with first, users have fewer errors when using AcceSS 2.1. There is no main effect for period (p=0.844) and there is no "period X system" interaction (p=0.106).

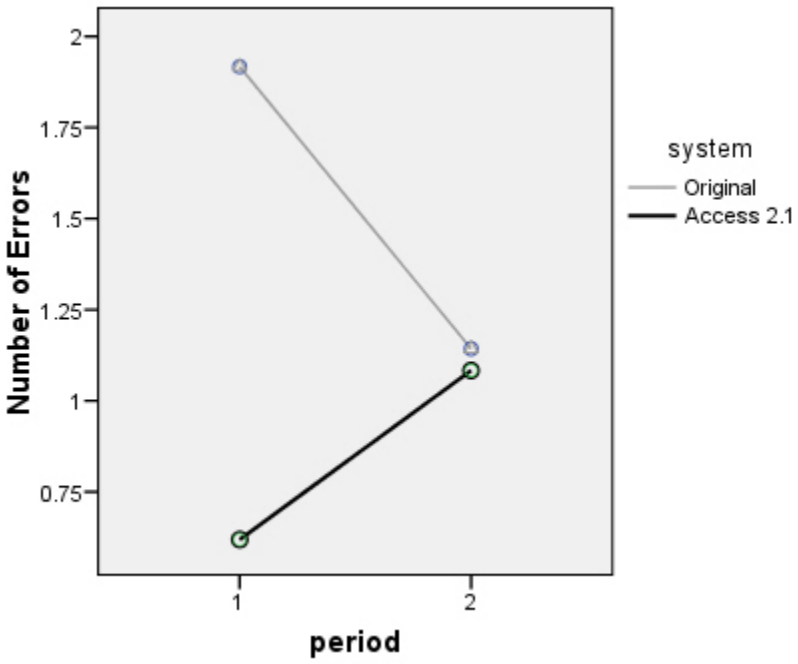


Figure 58. Period Effect on Errors

4. Path Effect

The last question answered by mixed-model analysis is whether the treatment varies based on which website (SHRS, AMP, or CNN) the user started with and, again, is looked at across the websites. Looking only at the efficiency (time) of the user on each of the systems, the results indicate that there is no main effect for the website the user starts the study with (p=0.06). There is also no "system X website" interaction (p=0.192). Looking at errors made for the user on each the systems, the results indicate that there is not a main effect for the website the user starts with (p=0.88) and there is also no "system X website" interaction (p=0.848).

5.6 DISCUSSION

Results show that users perform tasks faster, with fewer errors, and with greater satisfaction when accessing Web pages via AcceSS 2.1, regardless of whether or not the site was designed to universal design standards. While the results from all websites examined are positive, the results for the CNN website show the most improved difference in time. Given that the complexity of the CNN website is greater than that of SHRS or AMP, this is not surprising and was also the rationale behind including CNN in the study as a reference website. Users were polled as to their familiarity with the CNN website prior to the study. This was done to eliminate the possibility that users were more familiar with the CNN website than the SHRS and AMP websites. Only 3 of 15 users had ever been on the CNN website and these users were not regular users of the CNN website.

An unexpected outcome of the study was that users were least satisfied by the SHRS original website and that the differences in user satisfaction seen between original and transcoded websites were significantly different for the SHRS website and not the AMP website. Because SHRS is universally designed, it was hypothesized that users would be more satisfied with this website than the AMP or CNN websites and satisfaction ratings between the original and transcoded versions of the SHRS website would see the smallest differences. These differences were not seen. The reason for this is that, overall, when users spent a long time on one or both tasks for the website they were very likely to rate that website lower, or at least equal, in satisfaction to the other version of that website. With respect to the SHRS website, the following contributed to lower satisfaction:

- There was a greater incidence of slow task completion times (greater than 5 minutes) on the SHRS website than on the other websites. While none of the users had slow task

completion times for both SHRS tasks on the original SHRS website, the poor experience on one of the tasks affects the user's satisfaction rating for the website.

- There were more users with slow tasks times on both the SHRS original and transcoded websites, resulting in lower satisfaction ratings for both presentations of the website and, ultimately, less of a difference in satisfaction scores between the presentation styles.
- There were also more occurrences of slow task completion times on the SHRS transformed website than the other transformed websites. This can be seen in the descriptive data: the mean transformed SHRS time is just slightly faster than the mean AMP original time.
- The SHRS original and transformed websites saw the highest occurrences of errors. The number of user errors seems to frustrate users and result in lower satisfaction ratings.

These results stress the importance of usability over simple accessibility, of which navigation is a large part. While sighted users have the ability to quickly scan the Web page to obtain an understanding of the structure and content, blind users do not. Blind users must rely on headings and links to "scan" and conceptualize the Web page and even the entire website. This conceptual model of the page or site then guides the user in navigation. Obtaining and maintaining this "scan" can be burdensome on the short- and long- term memory of the user, causing frustration. Consistent page layout and consistent labeling of links throughout the site can assist the user.

The SHRS website has a low WAB score, indicating good accessibility, and is also universally designed; however, the website presented some navigation issues that caused frustration among the users. One notable navigation issue with the SHRS website is that the

main menu on the left side of the webpage is present on all pages throughout the website, but the submenus on the pages vary. For example (refer to Figure 59 and Figure 60), the "Student Resources" submenu is present on the homepage but not on other pages of the website. On other pages, a "Resources" submenu is displayed above links for: "Faculty and Staff", "Students", and "Alumni." This difference is of particular interest to the task scenario 2 for the SHRS original presentation (refer back to table Table 12).

Figure 59. SHRS Homepage

Figure 60. SHRS 1st level page

If a user missed the "Student Resources" submenu on the homepage, they often had a difficult time navigating through the website to find the information requested by the task. This was especially true when the user utilized JAWS links list to navigate, because on pages other than the homepage the user would only hear "link Student" and not be able to associate this with the heading "Resources". Another navigation issue presented with these different submenus is that the "Student Resources" submenu on the homepage contains a link to "Information Services", while the "Students" link from the "Resources" submenu contains a link to "Computing Resources at SHRS". User comments indicating frustration included:

- "I don't think I'm going to find the information,"
- "I don't think the information is on this website," and
- "None of these links will lead me to that information."

One user finally gave as his answer, "I would call them and request the information over the phone. It's easier than trying to find the information on the website."

This frustration stresses the importance of navigation and being able to reach the same information in different ways via consistently labeled links and headings. Take for instance the CNN website: some users listened to the entire page and found the link to the appropriate story, while others used the main navigation menu to choose "Entertainment" or "Weather" depending on the task. In either case, users reached the same information even though they took different paths. The same was true for the AMP website: the user could reach the Radiologic Sciences and Therapy Student Handbook by first following the link to "Current Students" and then "Radiologic Sciences and Therapy" or by following the link to "Radiologic Sciences and Therapy" and then "Current Students." Presenting multiple paths to the same information increases the opportunities for the blind user to hear the appropriate link without have to retrace their steps through the website. It is important to ensure that the information and links are consistently labeled to avoid user frustration.

Another reason for the unexpected satisfaction results may be mismatched task scenarios. While the tasks were made as similar as possible between the original and transformed websites, the scenario statements have wording differences that may have contributed to user frustration. Users often approach unfamiliar pages by first listening to the links and headings. If they are unable to detect a link or heading that contained information to complete the task, many of the users would only then allow JAWS to read through the page. Three of 4 tasks for the SHRS and AMP websites could be completed by listening to the links and headings; only 1 task for each required the user to listen to JAWS read through the page to find the answer because the answer could not be located by listening to links or headings. However, the scenario statements for the AMP website may be more explicit in regards to "how" the users were to reach the information. For example, the transformed AMP action task scenario stated, "You are a future student

considering taking courses toward a degree in Athletic Training. Navigate the AMP website to download a brochure for prospective students of Athletic Training." Once users began the task they heard the link to "future students" and followed it and then the link to "Athletic Training" and followed it to reach the "Prospective Student Brochure". In contrast, the transformed SHRS action task scenario stated, "You are an undergraduate student at SHRS and would like to download the student handbook. Navigate the SHRS website to download the SHRS Undergraduate Student Handbook for 2006-2007." To complete this task the user had to follow the link for "Sub Menu" then "Student Handbooks" before finding the link to download the "SHRS Undergraduate Student Handbook 2006-2007". The AMP task includes in the scenario all of the required links that the user must follow to complete the task, while the SHRS task does not. The SHRS task requires the user to follow a link that is a built-in feature of AcceSS 2.1, the sub menu, while the AMP task doesn't. This may have contributed to increased time and increased frustration to the user when completing the tasks on the SHRS website, resulting in longer task completion time and lower satisfaction ratings for the SHRS website. Similarly, the action task for the AMP original presentation stated, "You are a current student of Radiologic Sciences and Therapy. Navigate the AMP website to download the Radiologic Sciences and Therapy Student Handbook." Upon starting this task, users heard the link to either "Radiologic Sciences and Therapy" or "Current Students" and followed one of these links, then heard the link for "Current Students" or "Radiologic Sciences and Therapy" (either path or navigation would take the user to the same destination) and then find the link to download the handbook. The action task for the SHRS original presentation stated, "You are currently a new student at SHRS and need to get some information regarding information services at the school. Navigate the SHRS website to download the orientation handout." Some users experienced difficulty with

this task because they tried to use the links list to search for “orientation” or “handout” or would follow the link to “student handbooks” (which they hear first when listening through the page) and end up on the wrong page of the website before navigating back to the homepage and finding the link to “information services”. While this task requires the user to follow the link to “information services” and then find the link for “orientation handout”, this task presented some confusion and difficulty for some of the users. This leads the researcher to believe that scenario wording is a very important component of usability testing for blind users.

5.7 CONCLUSIONS

The study results show that the faster the user is able to complete the scenarios, the more satisfied they are with the system. It was anticipated that AcceSS 2.1 would have less of an impact on the time and satisfaction results for the universally designed website than the non-universally designed site. The differences in time between the original and transcoded presentations of the SHRS website were greater than those observed in the AMP website. The differences in user satisfaction for the SHRS website were also greater than the AMP website. Higher satisfaction ratings for the original presentation of the universally designed website were expected. The SHRS website, however, had lower satisfaction ratings for the original presentation than the other websites in the study, even lower than the complex CNN website. An explanation for the unexpected results is that the wording of the task scenarios for the SHRS website tasks had more ambiguity than the task scenarios for the other websites and led to increased time and lower user satisfaction.

The more important finding from the unanticipated results is that users prioritize navigation over simple accessibility when completing tasks on a website. Even though the original SHRS website was universally designed, there were still navigational obstacles for the blind user. The results show that transcoding technology can result in improved user satisfaction even when users are interacting with a website that has been designed to universal design standards and that the transformation provided by AcceSS 2.1 meets the needs of the blind user better than universal design.

6.0 SUMMARY, CONCLUSIONS, & FUTURE DIRECTIONS

6.1 SUMMARY

There are various driving forces promoting an accessible Web. Within each of these forces are potential solutions to mitigating Web accessibility barriers for the blind computer user. Presented herein are two of these potential solutions: consumer-driven lawsuits and transcoding intermediaries. Two major research questions raised by the study are:

1. Do consumer-driven lawsuits cause changes in the websites of the companies being sued? This question posed another, methodologically-driven question:

   1a. Because the archiving of dynamic pages is not optimal, can the homepage be used to determine website accessibility?

2. Can transcoding technology be used to mitigate the problem of increasing accessibility barriers?

These research questions have been answered by:

1. An evaluation of the homepage and first-level Web pages of websites of companies that have been sued, after a determination that the homepage alone cannot be used to gauge the accessibility of the entire website. Also investigated was the relationship between the level of website accessibility of the sued company's website and a control website, as

well as a comparison of the sued websites to the trend occurring in the popular websites on the Web, in general.

2. An evaluation of the usability of the AcceSS 2.1 transcoding intermediary by comparing user performance on tasks completed on websites before and after transformation by AcceSS 2.1. AcceSS 2.1 was examined with three websites: a website that was designed to universal design standards, a website that was designed without adherence to universal design standards, and a reference website that is more complex.

The studies in this project only address some of the potential solutions to Web accessibility and barrier mitigation. There are still many other solutions that still need to be explored.

6.2 CONCLUSIONS

Both solutions to mitigating barriers presented in this project are viable for attaining Web accessibility: chapter 4 demonstrated mixed results that lawsuits do stimulate companies to modify their websites to be more accessible, or at least keep worsening accessibility at bay, while chapter 5 showed that the AcceSS 2.1 transcoding intermediary presents a website that is more usable and on which users are able to finish tasks faster and with fewer errors and, in this case, made a greater impact on user satisfaction with the universally designed website over the non-universally designed website. Results show that the transformation provided by AcceSS 2.1 can meet the satisfaction needs of the blind user better than universal design.

The solutions presented here are very different in scope and reach. The lawsuits solution is an effort to bring the issue of Web accessibility into the social conscience. While sometimes effective on the websites brought into question by the lawsuits (MARTA and Southwest), they

don't always result in a drastic drop in barriers nor do they affect other private sector websites. Lawsuits are necessary if the goal is to establish case law for the extension of the ADA to the Internet, but each lawsuit affects one website at a time, at best, and it takes great amounts of time and effort to see results. Technology, in the form of transcoding intermediaries, allows for a seamless solution that can affect millions of websites and users with a minimal amount of time and money. Both solutions are necessary and should be taken in tandem to have the greatest force on Web accessibility, an issue that continues to get worse. The interplay of all of the forces (government, Web industry, technology, and consumers) is needed if the issue of Web accessibility is going to tip the force field diagram into a more positive position for Web accessibility.

6.3 FUTURE DIRECTIONS

Future studies originating from this thesis that the researcher is interested in pursuing include:

1. A prospective study of changes occurring in websites following a lawsuit to circumvent the Wayback Machine limitations. This type of study would be particularly useful for the most recent Target Corporation lawsuit, but also for any of the websites where data collection was limited by what was available in the Wayback Machine. User studies that include usability issues in addition to accessibility evaluation would also capture navigation issues within the websites and provide insight into navigational design solutions for users with disabilities.
2. An examination of different task complexities and completion times in correlation with user satisfaction to develop acceptable standards for the blind user. The results could

lead to improved transformations for the blind computer user to ensure that all information presented on a website can be reached within these acceptable standards.

3. Research into task scenario structure for blind user usability testing. How users react to different scenario statements could lead to task development guidelines for usability studies with blind computer users. While there is much research on developing systems that will better the experience of the blind Web user, blind Web users approach tasks differently than sighted users and different factors need to be taken into consideration to ensure accurate testing results with this user population. For this reason, research into usability testing specific to blind computer users would be beneficial.
4. Incorporation and testing of WCAG 2.0 checkpoints in Kelvin. Once the latest proposed guidelines become a W3C recommendation, new accessibility assessments of websites will need to be performed to evaluate compliance with WCAG 2.0. Prior to evaluation, the new guidelines will need to be incorporated into the automatic crawler program, Kelvin.
5. Investigating optimal transformations for users with varying disabilities. The current project focuses on accessibility for the blind. Future research to determine the optimal presentation to users with cognitive and mobility disabilities should be performed to broaden the reach of AcceSS and to allow for transformations based upon disability. For example, users with cognitive disabilities would benefit from information portrayed pictorially, while users with mobility disabilities would benefit from a presentation style that eliminates clicking and scrolling.

APPENDIX A: SCREEN READERS

IBM Home Page Reader

The final version of IBM Home Page Reader (HPR) is 3.04. Some of the new features introduced in this version of HPR include (IBM, N.D.-a, N.D.-b):

- Ability to read accessible, tagged Adobe Reader 6.0 PDF documents (if they were created using Microsoft Active Accessibility)
- Ability to read accessible Macromedia Flash Player 7 content (if they were created using the ActiveX Internet Explorer plug-in version of Flash MX 2004 for MS Windows)
- Highlighting of controls and images in the Graphics view as they are spoken
- Simple page magnification using either the Zoom setting within HPR or the Magnifier tool in Windows
- Capability to read Web pages that contain multiple frames as though they consisted of a single frame
- Improved rendering of empty and nonexistent alternative information, provided by the ALT attribute for images and links

Specific system requirements to successfully run HPR on a computer are included below (IBM, N.D.-a).

IBM Home Page Reader System Requirements

Processor	Equivalent to an Intel Pentiu, 233 MHz processor, 300 MHz recommended
Memory	64-128 MB
Hard disk drive	130 MB of available space
Graphics	SVGA 800x600, 256 colors
CD-ROM	Quad speed, MS Windows compatible
Modem	28.8KBPS, MS Windows compatible
OS	Windows 2000 or XP
Internet	ISP connection
For PDF support	Adobe Reader version 6.0
For Flash support	Macromedia Flash Player 7
Mulitlanguage support	US and UK English, Brazilian Portuguese, French, Finnish, German, Italian and Spanish
Price	From IBM website: $142 or by downloadable file: $117

Windows-Eyes

GW Micro released its latest version of Window-Eyes, Window-Eyes 6.1, in April 2007. New features included in this version are (GWMicro, 2007):

- Microsoft Word, Excel, and PowerPoint 2000/XP/2003/2007 support
- Access to Microsoft Outlook Calendar and Email
- Remote access with Microsoft Windows XP Remote Desktop, Citrix Metaframe XP, and Microsoft Terminal Services
- Menu level system that allows beginners to access the most commonly used features, while keeping more advanced options available for Intermediate and Advanced users
- Multiple keyboard layouts
- Support for all video systems
- Supports Adobe PDF and Macromedia Flash

Window-Eyes is compatible with Windows 2000, XP, Server 2003, and Vista. It also provides support for more than 50 speech synthesizers and 40 Braille displays. It provides greater PDF support and support for Macromedia Flash and full support for Microsoft Active Accessibility (MSAA) (GWMicro, 2005). Specific system requirements to successfully use Window-Eyes are included in the table below (EnableMart, N.D.).

Window-Eyes System Requirements

Processor	IBM compatible with a minimum of 300 MHz recommended
Memory	128 MB or greater
Hard disk drive	20 MB of available space
CD-ROM	Need one available
OS	Windows Me, 2000, XP, 2003, and Vista
Software speech	Mulit-channel sound card, such as Sound Blaster Audigy or Sound Blaster Live
Internet	Internet Explorer 6 or greater
Price	From GW Micro website: $895 or a 60 evaluation for $39

JAWS for Windows

Freedom Scientific's JAWS for Windows is the most popular screen reader software and according to Eric Damery, Vice President of Business Development at Freedom Scientific, JAWS now holds 80 percent of market share for screen readers worldwide (Rath, 2006). The version of JAWS examined here is 8.0, released June 2007, because this is the version that the majority of participants in the usability study used. Some of the features available in JAWS 8.0 are listed below (FreedomScientific, 2007):

- Keystrokes for Windows Vista Gadgets
- Support for Internet Explorer 7 and tabbed navigation

- Skim reading by text color or text attribute
- Enhanced reading of Web pages with dynamic content
- AOL Instant Messenger 6.0 support
- Table description in Microsoft Word, not available in Word 2007
- Viewing cell comments in a Microsoft Excel spreadsheet.

JAWS for Windows System Requirements

Memory	32 MB is required, 64 MB is required for Windows 2000 or XP, and 128 MB is recommended
Graphics	VGA or higher-resolution video adapter, Super VGA 256-color is recommended
OS	Windows 2003 Server, 2000, XP, and Vista
Internet	TCP/IP network connectivity to jaws.ncsu.edu
Mulitlanguage support	Multi-lingual software speech synthesizer, "Eloquence for JAWS" includes: American English, British English, Castilian Spanish, Latin American Spanish, French, French Canadian, German, Italian, Brazilian Portuguese, and Finnish
Price	Standard edition for Windows XP $895

APPENDIX B: 25 CHECKPOINTS OF WAB SCORE

WCAG 1.0 Check-point	Description	HTML checking for potential violation
1.1	Provide alternative text for all images.	<img>
1.1	Provide alternative text for each APPLET.	<applet>
1.1	Provide alternative content for each OBJECT.	<object>
1.1	Provide alternative text for all image-type buttons in forms.	<input type="image" … >
1.1	Provide alternative text for all image map hot-spots (AREAs).	<area>
1.5	Client-side image map contains a link not presented elsewhere on the page.	<area>
3.2	Use a public text identifier in a DOCTYPE statement.	Whole document. Simply yes or no
3.4	Use relative sizing and positioning (% values) rather than absolute (pixels).	<font>, <table>, <td>, <tr>, <th>
3.5	Nest headings properly.	Any headline tag <h1> … <h6>
4.3	Identify the language of the text.	Whole document. Simply yes or no
5.5	Provide a summary for tables.	<table>
6.2	Each FRAME must reference an HTML file.	<frame>
6.5	Provide a NOFRAMES section when using FRAMEs.	Whole document, simply yes or no
7.2	Avoid blinking text created with the BLINK element.	Simply count as one. Not able to decide denominator.
7.3	Avoid scrolling text created with the MARQUEE element.	Simply count as one. Not able to decide denominator
7.4	Do not cause a page to refresh automatically.	Simply count as one. Not able to decide denominator
7.5	Do not cause a page to redirect to a new URL.	Simply count as one. Not able to decide denominator
9.3	Make sure event handlers do not require use of a mouse.	onmousedown, onkeydown, onmouseup, onkeyup, onclick, onkeypress, onmouseover, onfocus, onmouseout, onblur

10.4	Include default, place-holding characters in edit boxes and text areas.	<textarea><input><select>
10.5	Separate adjacent links with more than white space.	<a>
12.1	Give each frame a title.	<frame>
12.4	Explicitly associate form controls and their labels with the LABEL element.	<textarea><input><select>
13.1	Create link phrases that make sense when read out of context.	<a>
13.1	Do not use the same link phrase more than once when the links point to different URLs.	<a>
13.2	Include a document TITLE.	Whole document, simply yes or no

APPENDIX C: CRITERIA FOR UNIVERSAL USABILITY

The seven criteria and guidelines are listed below[**]

PRINCIPLE ONE: Equitable Use
The design is useful and marketable to people with diverse abilities.

Guidelines:

1a. Provide the same means of use for all users: identical whenever possible; equivalent when not.
1b. Avoid segregating or stigmatizing any users.
1c. Provisions for privacy, security, and safety should be equally available to all users.
1d. Make the design appealing to all users.

PRINCIPLE TWO: Flexibility in Use
The design accommodates a wide range of individual preferences and abilities.

Guidelines:

2a. Provide choice in methods of use.
2b. Accommodate right- or left-handed access and use.
2c. Facilitate the user's accuracy and precision.
2d. Provide adaptability to the user's pace.

PRINCIPLE THREE: Simple and Intuitive Use
Use of the design is easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration level.

Guidelines:

3a. Eliminate unnecessary complexity.
3b. Be consistent with user expectations and intuition.
3c. Accommodate a wide range of literacy and language skills.

[**] The Principles of Universal Design were conceived and developed by The Center for Universal Design at North Carolina State University. Use or application of the Principles in any form by an individual or organization is separate and distinct from the Principles and does not constitute or imply acceptance or endorsement by The Center for Universal Design of the use or application.

3d. Arrange information consistent with its importance.
3e. Provide effective prompting and feedback during and after task completion.

PRINCIPLE FOUR: Perceptible Information
The design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities.

Guidelines:

4a. Use different modes (pictorial, verbal, tactile) for redundant presentation of essential information.
4b. Provide adequate contrast between essential information and its surroundings.
4c. Maximize "legibility" of essential information.
4d. Differentiate elements in ways that can be described (i.e., make it easy to give instructions or directions).
4e. Provide compatibility with a variety of techniques or devices used by people with sensory limitations.

PRINCIPLE FIVE: Tolerance for Error
The design minimizes hazards and the adverse consequences of accidental or unintended actions.

Guidelines:

5a. Arrange elements to minimize hazards and errors: most used elements, most accessible; hazardous elements eliminated, isolated, or shielded.
5b. Provide warnings of hazards and errors.
5c. Provide fail safe features.
5d. Discourage unconscious action in tasks that require vigilance.

PRINCIPLE SIX: Low Physical Effort
The design can be used efficiently and comfortably and with a minimum of fatigue.

Guidelines:

6a. Allow user to maintain a neutral body position.
6b. Use reasonable operating forces.
6c. Minimize repetitive actions.
6d. Minimize sustained physical effort.

PRINCIPLE SEVEN: Size and Space for Approach and Use
Appropriate size and space is provided for approach, reach, manipulation, and use regardless of user's body size, posture, or mobility.

Guidelines:
7a. Provide a clear line of sight to important elements for any seated or standing user.
7b. Make reach to all components comfortable for any seated or standing user.
7c. Accommodate variations in hand and grip size.
7d. Provide adequate space for the use of assistive devices or personal assistance.

APPENDIX D: DESCRIPTIVE STATISTICS OF WEBSITES IN HOMEPAGE EVALUATION

Website Date evaluated	Level	# pages	WAB avg	WAB median	WAB min	WAB max	WAB s.d.	COMPLEXITY avg	COMPLEXITY median	COMPLEXITY min	COMPLEXITY max	COMPLEXITY s.d.
www.adobe.com	**level 0**	1	5.67	-	-	-	-	272.00	-	-	-	-
5/3/2007	**level 1**	160	4.34	4.00	2.00	11.00	1.28	106.13	0.00	0.00	957.00	155.47
	level 2	1,405	4.38	4.19	0.00	11.00	1.32	231.88	254.00	0.00	1343.00	140.15
	level 3	6,825	4.35	4.17	0.00	12.00	1.21	233.16	246.00	0.00	4531.00	175.23
www.bbc.co.uk	**level 0**	1	7.82	-	-	-	-	183.00	-	-	-	-
4/13/2007	**level 1**	71	5.34	5.07	3.00	11.00	2.52	107.08	73.00	5.00	527.00	120.91
	level 2	1,160	6.78	6.96	1.00	13.00	2.58	183.10	167.50	0.00	740.00	125.14
	level 3	14,692	6.90	7.22	0.00	20.00	2.34	165.51	145.00	0.00	14427.00	177.22
www.adultfriendfinder.com	**level 0**	1	16.84	-	-	-	-	379.00	-	-	-	-
5/3/2007	**level 1**	2	2.90	2.90	1.80	4.00	1.56	17.00	17.00	0.00	34.00	24.04
	level 2	78	2.67	2.80	1.80	12.20	1.18	54.36	60.00	34.00	177.00	18.01
	level 3	5,301	3.89	4.82	1.80	4.90	1.02	54.05	50.00	0.00	61.00	5.26

Website Date evaluated	Level	# pages	WAB					COMPLEXITY				
			avg	median	min	max	s.d.	avg	median	min	max	s.d.
www.alibaba.com	**level 0**	1	8.26	-	-	-	-	252.00	-	-	-	-
5/25/2007	**level 1**	123	6.77	8.12	3.23	9.69	2.41	311.86	271.00	50.00	568.00	170.10
	level 2	4,666	6.85	6.84	1.53	13.70	1.46	353.09	291.00	0.00	628.00	171.19
	level 3	34,220	6.77	6.48	2.84	9.39	0.92	275.17	237.00	0.00	579.00	107.31
www.aol.com	**level 0**	1	7.62	-	-	-	-	578.00	-	-	-	-
4/30/2007	**level 1**	8	4.45	4.81	1.00	8.00	3.44	302.13	327.00	6.00	589.00	294.12
	level 2	10	6.90	7.66	0.00	8.00	2.43	512.00	558.00	74.00	578.00	154.22
	level 3	56	7.60	7.66	6.00	8.00	0.30	561.14	558.00	492.00	589.00	15.12
www.apple.com	**level 0**	1	7.65	-	-	-	-	142.00	-	-	-	-
5/3/2007	**level 1**	28	5.79	6.47	1.00	9.00	2.48	116.71	128.00	5.00	291.00	72.97
	level 2	421	5.69	6.04	1.00	12.00	2.20	130.34	121.00	0.00	1266.00	100.35
	level 3	2,503	5.84	5.98	0.00	13.00	1.62	127.91	108.00	3.00	1226.00	99.20
www.badongo.com	**level 0**	1	12.70	-	-	-	-	173.00	-	-	-	-
5/14/2007	**level 1**	23	9.87	10.09	8.00	13.00	1.86	97.57	77.00	52.00	180.00	44.69
	level 2	105	9.88	10.61	4.00	13.00	1.56	99.54	102.00	0.00	428.00	49.58
	level 3	751	8.65	8.55	7.00	13.00	0.69	92.35	82.00	46.00	428.00	32.72

Website Date evaluated	Level	# pages	WAB					COMPLEXITY				
			avg	median	min	max	s.d.	avg	median	min	max	s.d.
www.hi5.com	**level 0**	1	9.78	-	-	-	-	185.00	-	-	-	-
4/13/2007	**level 1**	47	8.86	8.38	6.00	12.00	1.42	176.15	153.00	96.00	836.00	105.72
	level 2	677	8.84	8.89	6.00	12.00	1.19	249.79	263.00	0.00	836.00	100.39
	level 3	8,393	8.87	8.83	4.00	16.00	1.13	217.09	216.00	0.00	3870.00	112.56
www.google.co.uk	**level 0**	1	6.31	-	-	-	-	41.00	-	-	-	-
4/13/2007	**level 1**	5	7.82	8.87	5.00	9.00	2.03	94.80	93.00	44.00	173.00	49.37
	level 2	42	6.72	6.34	4.00	10.00	1.69	114.57	65.50	3.00	912.00	162.76
	level 3	224	7.53	7.12	2.00	11.00	2.24	202.22	108.50	0.00	5335.00	376.69
www.cnn.com	**level 0**	1	5.99	-	-	-	-	596.00	-	-	-	-
5/26/2007	**level 1**	109	6.24	6.46	3.00	13.00	2.10	267.79	323.00	4.00	596.00	150.98
	level 2	916	6.68	6.57	3.00	13.00	2.17	311.98	291.00	0.00	2954.00	238.79
	level 3	11,515	7.08	7.50	1.00	19.00	1.82	283.89	290.00	0.00	5603.00	130.85
www.facebook.com	**level 0**	1	2.64	-	-	-	-	73.00	-	-	-	-
4/13/2007	**level 1**	13	3.99	3.63	3.00	7.00	1.10	177.15	110.00	0.00	813.00	208.12
	level 2	39	4.68	4.63	3.00	9.00	1.14	91.03	90.00	59.00	190.00	27.59
	level 3	24	4.80	4.68	2.00	9.00	1.39	83.58	78.00	59.00	190.00	26.40

Website Date evaluated	Level	# pages	WAB					COMPLEXITY				
			avg	median	min	max	s.d.	avg	median	min	max	s.d.
www.flickr.com	**level 0**	1	7.42	-	-	-	-	15.00	-	-	-	-
5/22/2007	**level 1**	13	8.80	9.35	1.00	13.00	2.57	295.62	171.00	8.00	2002.00	514.85
	level 2	678	8.71	8.66	1.00	13.00	2.28	216.35	170.00	0.00	2011.00	184.84
	level 3	22,338	9.66	9.85	1.00	13.00	1.87	360.40	212.00	7.00	10491.00	418.28
www.fotolog.net	**level 0**	1	13.13	-	-	-	-	212.00	-	-	-	-
6/26/2007	**level 1**	21	3.56	3.00	3.00	8.20	1.18	25.81	5.00	0.00	288.00	71.82
	level 2	65	5.79	4.72	2.50	8.20	1.86	146.65	184.00	0.00	661.00	119.26
	level 3	695	4.28	4.43	2.20	8.20	0.84	161.13	181.00	0.00	904.00	149.84
www.friendster.com	**level 0**	1	9.22	-	-	-	-	275.00	-	-	-	-
6/23/2007	**level 1**	26	8.39	8.23	6.00	12.00	1.47	336.65	296.50	104.00	657.00	118.13
	level 2	212	8.85	8.56	4.00	14.00	1.56	393.67	316.00	0.00	1375.00	162.69
	level 3	68	8.87	8.54	7.00	13.00	1.47	385.81	314.50	189.00	1082.00	164.48
www.go.com	**level 0**	1	10.44	-	-	-	-	246.00	-	-	-	-
7/15/2007	**level 1**	56	9.35	10.00	1.00	16.00	3.05	280.61	247.00	3.00	857.00	183.39
	level 2	1,057	8.77	9.46	1.00	18.00	2.95	322.07	274.00	0.00	3216.00	230.32
	level 3	939	9.38	10.08	2.00	11.00	1.51	431.17	451.00	0.00	636.00	66.42

Website Date evaluated	Level	# pages	WAB					COMPLEXITY				
			avg	median	min	max	s.d.	avg	median	min	max	s.d.
www.google.com	**level 0**	1	8.25	-	-	-	-	44.00	-	-	-	-
4/11/2007	**level 1**	4	7.99	8.87	5.00	9.23	2.00	98.75	88.50	4.00	214.00	90.06
	level 2	33	7.15	7.63	2.20	10.97	2.07	125.27	68.00	3.00	599.00	154.82
	level 3	346	6.51	6.40	2.18	12.28	1.62	88.69	57.50	3.00	912.00	90.78
www.google.com.au	**level 0**	1	6.30	-	-	-	-	38.00	-	-	-	-
5/14/2007	**level 1**	4	6.97	7.01	5.00	9.00	2.51	77.50	82.00	42.00	104.00	27.36
	level 2	34	6.26	6.22	1.00	10.00	1.87	120.74	66.50	3.00	912.00	175.31
	level 3	109	6.23	6.29	1.00	11.00	2.03	106.49	90.00	0.00	1553.00	173.98
www.google.ca	**level 0**	1	6.33	-	-	-	-	40.00	-	-	-	-
4/30/2007	**level 1**	5	5.98	5.00	5.00	9.00	1.92	65.60	63.00	4.00	110.00	44.24
	level 2	34	6.38	6.30	3.00	9.00	1.62	107.30	49.00	3.00	912.00	190.14
	level 3	116	6.94	6.91	1.00	12.00	2.07	129.23	95.50	2.00	912.00	141.12
www.youtube.com	**level 0**	1	12.10	-	-	-	-	291.00	-	-	-	-
4/11/2007	**level 1**	53	6.87	6.04	3.00	12.00	2.92	210.32	89.00	0.00	5018.00	682.61
	level 2	99	6.07	6.00	3.00	15.00	2.00	106.05	90.00	0.00	467.00	107.15
	level 3	137	5.82	6.04	3.00	16.00	2.04	100.75	110.00	0.00	493.00	97.74

Website Date evaluated	Level	# pages	WAB					COMPLEXITY				
			avg	median	min	max	s.d.	avg	median	min	max	s.d.
www.imageshack.us	**level 0**	1	6.49	-	-	-	-	116.00	-	-	-	-
7/11/2007	**level 1**	20	3.40	3.20	3.00	6.00	0.84	100.05	111.00	0.00	162.00	34.05
	level 2	49	3.82	4.00	1.00	6.00	1.55	93.51	72.00	0.00	985.00	143.95
	level 3	62	4.06	4.00	2.00	6.00	1.00	132.18	113.00	0.00	653.00	144.94
www.live.com	**level 0**	1	7.40	-	-	-	-	46.00	-	-	-	-
7/11/2007	**level 1**	9	6.83	7.40	3.00	11.00	2.49	111.00	88.00	4.00	376.00	108.76
	level 2	135	8.37	9.01	1.00	10.00	1.99	323.28	437.00	0.00	528.00	194.82
	level 3	1,703	7.39	7.79	2.00	12.00	1.66	341.75	352.00	2.00	734.00	128.38
www.megaupload.com	**level 0**	1	8.61	-	-	-	-	358.00	-	-	-	-
4/11/2007	**level 1**	9	7.08	6.07	5.54	8.71	1.48	159.11	173.00	16.00	340.00	86.40
	level 2	15	6.67	8.32	2.00	9.50	2.60	63.80	57.00	0.00	112.00	37.07
	level 3	6	8.31	8.31	8.31	8.31	0.00	113.00	113.00	113.00	113.00	0.00
www.microsoft.com	**level 0**	1	5.00	-	-	-	-	4.00	-	-	-	-
4/11/2007	**level 1**	1	4.08	-	-	-	-	313.00	-	-	-	-
	level 2	28	9.12	9.48	4.00	17.00	2.77	175.71	159.00	0.00	487.00	121.32
	level 3	521	8.99	9.38	1.00	14.00	1.96	196.31	164.00	0.00	2735.00	161.82

Website Date evaluated	Level	# pages	WAB					COMPLEXITY				
			avg	median	min	max	s.d.	avg	median	min	max	s.d.
www.msn.com	**level 0**	1	4.43	-	-	-	-	289.00	-	-	-	-
7/11/2007	**level 1**	95	6.06	5.10	1.00	16.00	3.37	296.12	289.00	0.00	808.00	215.81
	level 2	1,938	6.09	5.29	0.00	16.00	2.83	325.88	336.50	0.00	1399.00	199.19
	level 3	547	7.91	7.90	3.00	12.00	0.89	329.58	332.00	0.00	1361.00	85.81
www.myspace.com	**level 0**	1	9.18	-	-	-	-	248.00	-	-	-	-
4/11/2007	**level 1**	8	6.30	7.00	2.25	8.57	1.89	136.38	102.00	8.00	287.00	106.01
	level 2	93	7.01	7.04	5.00	13.06	0.90	254.99	286.00	4.00	314.00	73.07
	level 3	19	7.76	5.00	5.00	13.06	3.23	99.63	4.00	4.00	314.00	120.45
www.orkut.com	**level 0**	1	4.40	-	-	-	-	72.00	-	-	-	-
7/11/2007	**level 1**	7	5.09	4.59	4.36	8.22	1.40	83.43	65.00	3.00	262.00	82.16
	level 2	25	7.70	8.17	4.36	8.35	1.21	210.40	233.00	3.00	287.00	73.62
	level 3	110	8.02	8.15	4.29	8.42	0.64	225.43	223.00	118.00	288.00	26.46
www.photobucket.com	**level 0**	1	6.37	-	-	-	-	165.00	-	-	-	-
6/29/2007	**level 1**	34	6.48	6.49	3.00	8.00	1.62	185.09	201.00	0.00	297.00	74.74
	level 2	334	7.13	6.50	3.00	10.00	1.33	218.16	225.00	0.00	265.00	54.89
	level 3	355	6.92	6.46	3.00	8.00	1.22	220.85	250.00	0.00	265.00	54.20

Website Date evaluated	Level	# pages	WAB					COMPLEXITY				
			avg	median	min	max	s.d.	avg	median	min	max	s.d.
www.rediff.com	**level 0**	1	14.51	-	-	-	-	1007.00	-	-	-	-
5/3/2007	**level 1**	36	13.90	15.85	7.00	18.00	3.18	439.46	418.50	147.00	1079.00	174.02
	level 2	396	13.46	15.65	4.00	17.00	3.54	524.19	402.00	0.00	3121.00	552.97
	level 3	491	13.85	15.63	3.00	18.00	3.43	410.60	420.00	0.00	3103.00	412.45
www.soso.com	**level 0**	1	10.81	-	-	-	-	33.00	-	-	-	-
6/24/2007	**level 1**	2	11.49	11.49	10.75	12.23	1.05	60.50	60.50	43.00	78.00	24.75
	level 2	6	11.09	11.01	9.33	12.59	1.10	60.33	38.50	20.00	174.00	57.52
	level 3	57	12.28	12.20	10.16	13.45	0.45	63.58	60.00	38.00	128.00	16.65
www.sourceforge.net	**level 0**	1	4.86	-	-	-	-	468.00	-	-	-	-
7/11/2007	**level 1**	91	3.18	3.09	2.00	9.00	1.08	450.81	442.00	0.00	927.00	244.93
	level 2	3,192	3.20	3.24	1.00	11.00	0.95	429.75	401.00	0.00	2086.00	244.40
	level 3	8,433	3.06	2.99	0.00	10.00	1.10	330.09	318.00	0.00	1358.00	180.41
www.wordpress.com	**level 0**	1	6.56	-	-	-	-	153.00	-	-	-	-
7/11/2007	**level 1**	54	3.87	4.64	0.00	15.00	2.35	233.22	210.00	17.00	953.00	133.68
	level 2	3,467	4.29	4.70	0.00	13.00	2.00	274.62	221.00	0.00	4691.00	264.58
	level 3	10,336	4.96	4.75	0.00	14.00	2.25	379.22	249.50	0.00	6918.00	401.40

Website Date evaluated	Level	# pages	WAB					COMPLEXITY				
			avg	median	min	max	s.d.	avg	median	min	max	s.d.
www.xanga.com	**level 0**	1	3.89	-	-	-	-	179.00	-	-	-	-
5/3/2007	**level 1**	917	3.20	3.00	0.00	12.44	1.23	6.86	0.00	0.00	498.00	43.34
	level 2	2,488	10.36	10.41	0.00	20.45	2.01	277.43	238.00	2.00	3280.00	193.10
	level 3	60,685	10.40	10.27	0.00	22.60	2.00	239.54	219.00	5.00	99352.00	560.73
www.amazon.com	**level 0**	1	12.22	-	-	-	-	195.00	-	-	-	-
4/13/2007	**level 1**	163	8.15	7.38	4.00	18.13	4.54	120.54	68.00	0.00	797.00	152.79
	level 2	6,031	6.72	4.00	3.00	18.17	3.39	143.97	0.00	0.00	1074.00	198.11
	level 3	71,800	5.46	4.00	3.00	18.74	2.65	73.90	0.00	0.00	998.00	148.75

APPENDIX E: SELECT KELVIN CHECKPOINT RESULTS FOR WEBSITES IN LAWSUIT STUDY

P=potential errors	Provide alternative text for all images						Provide alternative text for all image-type buttons in forms						Provide alternative text for all image-map hot spots					
A = actual	Period 1			Period 2			Period 1			Period 2			Period 1			Period 2		
%err=A/P	P	A	%err	P	A	%err	P	A	%err	P	A	%err	P	A	%err	P	A	%err
CLAIRE'S																		
1999	13	13	100%				0	0					0	0				
2000	652	519	80%	285	99	35%	1	1	100%	1	1	100%	0	0		36	36	100%
2001	282	109	39%				0	0					33	33	100%			
2002	1158	414	36%	1585	462	29%	23	7	30%	28	2	7%	27	6	22%	34	11	32%
2003	1683	496	29%	1550	579	37%	32	3	9%	27	2	7%	83	2	2%	37	1	3%
2004	1804	706	39%				31	2	6%				35	1	3%			
2006				614	210	34%				16	2	13%				102	12	12%
BLUENILE																		
1999				815	165	20%				6	5	83%				11	6	55%
2000	1250	266	21%	5987	4978	83%	3	3	100%	58	58	100%	0	0		10	0	0%
2001	5788	4726	82%	6638	5444	82%	57	57	100%	94	68	72%	28	0	0%	14	4	29%
2002	6652	5426	82%	5074	3842	76%	89	68	76%	124	63	51%	18	8	44%	261	31	12%
2003	6171	4775	77%	13783	10772	78%	137	68	50%	266	118	44%	294	34	12%	594	22	4%
2004	6748	5230	78%	6048	4565	75%	131	59	45%	120	53	44%	294	5	2%	45	5	11%
2005	7082	5431	77%	7475	5743	77%	137	65	47%	135	66	49%	49	6	12%	16	4	25%
2006	6723	5183	77%	6288	4854	77%	126	61	48%	114	55	48%	12	4	33%	10	2	20%
2007	7293	5434	75%				133	60	45%				8	2	25%			

P=potential errors A = actual %err=A/P	Client-side image map contains a link not presented elsewhere on the page						Use a public text identifier in a DOCTYPE statement						Use relative sizing and positioning rather than absolute					
	Period 1			Period 2			Period 1			Period 2			Period 1			Period 2		
	P	A	%err	P	A	%err	P	A	%err	P	A	%err	P	A	%err	P	A	%err
CLAIRE'S																		
1999	0	0					3	3	100%				21	9	43%			
2000	0	0		36	35	97%	21	21	100%	13	13	100%	1046	532	51%	568	312	55%
2001	33	32	97%				13	13	100%				542	289	53%			
2002	27	14	52%	34	28	82%	22	22	100%	32	32	100%	1553	1003	65%	2104	1289	61%
2003	83	70	84%	37	29	78%	35	35	100%	30	30	100%	2276	1381	61%	2058	1206	59%
2004	35	30	86%				34	34	100%				2387	1429	60%			
2006				102	94	92%				14	14	100%				958	552	58%
BLUENILE																		
1999				11	11	100%				18	18	100%				1069	305	29%
2000	0	0		10	10	100%	28	28	100%	50	50	100%	1444	420	29%	11289	3948	35%
2001	28	28	100%	14	13	93%	47	47	100%	54	54	100%	10855	3723	34%	13400	4239	32%
2002	18	16	89%	261	254	97%	52	52	100%	46	46	100%	12911	4044	31%	9122	2142	23%
2003	294	282	96%	594	590	99%	53	53	100%	112	112	100%	12018	2580	21%	23323	5687	24%
2004	294	282	96%	45	23	51%	56	56	100%	51	51	100%	11110	2740	25%	9517	2360	25%
2005	49	43	88%	16	16	100%	59	59	100%	60	60	100%	11096	2722	25%	12813	3093	24%
2006	12	12	100%	10	10	100%	56	56	100%	53	53	100%	11322	2819	25%	10494	2657	25%
2007	8	8	100%				60	60	100%				12276	3013	25%			

P=potential errors A = actual %err=A/P	Nest headings properly						Identify the language of the text						Provide a summary for tables					
	Period 1			Period 2			Period 1			Period 2			Period 1			Period 2		
	P	A	%err	P	A	%err	P	A	%err	P	A	%err	P	A	%err	P	A	%err
CLAIRE'S																		
1999	0	0					3	3	100%				3	3	100%			
2000	0	0		0	0		21	21	100%	13	13	100%	162	162	100%	88	88	100%
2001	0	0					13	13	100%				84	84	100%			
2002	0	0		1	0	0%	22	8	36%	31	5	16%	309	262	85%	426	345	81%
2003	1	0	0%	0	0		35	8	23%	30	7	23%	455	368	81%	418	340	81%
2004	0	0					34	8	24%				479	392	82%			
2006				0	0					14	0	0%				192	160	83%
BLUENILE																		
1999				0	0					18	18	100%				202	202	100%
2000	0	0		0	0		28	28	100%	50	50	100%	292	292	100%	1734	1734	100%
2001	0	0		0	0		47	47	100%	54	54	100%	1653	1653	100%	1886	1886	100%
2002	0	0		0	0		52	52	100%	46	46	100%	1892	1892	100%	1596	1596	100%
2003	0	0		0	0		53	53	100%	112	112	100%	1927	1927	100%	4413	4413	100%
2004	0	0		0	0		56	56	100%	51	51	100%	2156	2156	100%	1924	1924	100%
2005	0	0		0	0		59	59	100%	60	60	100%	2212	2212	100%	2430	2430	100%
2006	0	0		0	0		56	56	100%	53	53	100%	2200	2200	100%	2077	2077	100%
2007	0	0					60	60	100%				2373	2373	100%			

P=potential errors	Make sure event handlers do not require use of a mouse						Include default, place holding characters in edit boxes and text areas						Separate adjacent links with more than white space					
A = actual	Period 1			Period 2			Period 1			Period 2			Period 1			Period 2		
%err=A/P	P	A	%err	P	A	%err	P	A	%err	P	A	%err	P	A	%err	P	A	%err
CLAIRE'S																		
1999	0	0					0	0					2	0	0%			
2000	229	229	100%	6	6	100%	8	6	75%	2	2	100%	393	11	3%	31	11	35%
2001	12	12	100%				0	0					35	14	40%			
2002	132	132	100%	260	260	100%	58	33	57%	66	30	45%	388	156	40%	632	233	37%
2003	295	295	100%	257	257	100%	74	33	45%	63	29	46%	694	233	34%	681	235	35%
2004	278	278	100%				75	34	45%				779	260	33%			
2006				102	102	100%				40	18	45%				421	80	19%
BLUENILE																		
1999				279	279	100%				15	6	40%				139	119	86%
2000	470	470	100%	1336	1336	100%	9	3	33%	117	58	50%	201	160	80%	852	10	1%
2001	506	506	100%	737	737	100%	129	58	45%	183	96	52%	928	61	7%	1046	32	3%
2002	1004	1004	100%	315	315	100%	176	90	51%	243	126	52%	1059	38	4%	1068	46	4%
2003	471	471	100%	1136	1136	100%	275	140	51%	591	274	46%	1506	88	6%	3302	178	5%
2004	527	527	100%	385	385	100%	278	135	49%	255	122	48%	1657	112	7%	1498	104	7%
2005	475	475	100%	590	590	100%	291	139	48%	302	138	46%	1832	145	8%	1800	256	14%
2006	562	562	100%	525	525	100%	280	128	46%	284	117	41%	1450	244	17%	1384	188	14%
2007	465	465	100%				318	136	43%				1627	203	12%			

P=potential errors A = actual %err=A/P	Explicitly associate form controls and their labels with the LABEL element					
	Period 1			Period 2		
	P	**A**	**%err**	**P**	**A**	**%err**
CLAIRE'S						
1999	0	0				
2000	8	8	100%	2	2	100%
2001	0	0				
2002	58	29	50%	66	34	52%
2003	74	39	53%	63	33	52%
2004	75	38	51%			
2006				40	24	60%
BLUENILE						
1999				15	9	60%
2000	9	6	67%	117	59	50%
2001	129	72	56%	183	89	49%
2002	176	87	49%	243	119	49%
2003	275	138	50%	591	325	55%
2004	278	147	53%	255	135	53%
2005	291	154	53%	302	167	55%
2006	280	154	55%	284	170	60%
2007	318	189	59%			

P=potential errors A = actual %err=A/P	Provide alternative text for all images						Provide alternative text for all image-type buttons in forms						Provide alternative text for all image-map hot spots					
	Period 1			Period 2			Period 1			Period 2			Period 1			Period 2		
	P	A	%err	P	A	%err	P	A	%err	P	A	%err	P	A	%err	P	A	%err
PRICELINE																		
1998				12	2	17%				0	0					13	0	0%
1999	165	12	7%				6	0	0%				7	6	86%			
2000	267	52	19%				10	0	0%				0	0				
2001	326	34	10%	758	32	4%	38	0	0%	115	0	0%	0	0		0	0	
2002	870	123	14%	1408	67	5%	65	0	0%	86	1	1%	0	0		0	0	
2004				4680	534	11%				377	1	0%				0	0	
2005	1165	47	4%	1767	143	8%	177	0	0%	65	1	2%	0	0		0	0	
2006	1936	166	9%	1421	126	9%	68	1	1%	68	2	3%	0	0		0	0	
2007	1372	125	9%	2057	394	19%	66	2	3%	75	2	3%	0	0		0	0	
FODORS																		
1996				53	24	45%				0	0					22	14	64%
1997				98	9	9%				0	0					25	18	72%
1998	111	10	9%	135	75	56%	1	1	100%	2	1	50%	41	34	83%	62	62	100%
1999	84	28	33%	103	42	41%	2	1	50%	2	1	50%	35	35	100%	60	60	100%
2000	143	99	69%	1074	894	83%	1	1	100%	0	0		74	74	100%	637	637	100%
2001	1165	947	81%				6	6	100%				686	529	77%			
2003				2189	2016	92%				14	13	93%				589	556	94%
2004	1939	1795	93%	1824	1535	84%	34	33	97%	41	41	100%	539	97	18%	671	81	12%
2005	1813	1511	83%	430	271	63%	40	40	100%	1	1	100%	652	81	12%	365	74	20%
2006	536	320	60%	680	378	56%	1	1	100%	7	7	100%	379	22	6%	169	14	8%
2007	704	387	55%				7	7	100%				169	14	8%			

P=potential errors A = actual %err=A/P	Client-side image map contains a link not presented elsewhere on the page						Use a public text identifier in a DOCTYPE statement						Use relative sizing and positioning rather than absolute					
	Period 1			Period 2			Period 1			Period 2			Period 1			Period 2		
	P	A	%err	P	A	%err	P	A	%err	P	A	%err	P	A	%err	P	A	%err
PRICELINE																		
1998				13	13	100%				5	5	100%				26	1	4%
1999	7	6	86%				13	13	100%				839	160	19%			
2000	0	0					15	10	67%				1170	154	13%			
2001	0	0		0	0		14	5	36%	24	5	21%	790	86	11%	814	151	19%
2002	0	0		0	0		23	5	22%	34	5	15%	3898	346	9%	5094	751	15%
2004				0	0					102	0	0%				19746	1759	9%
2005	0	0		0	0		35	0	0%	45	0	0%	1516	223	15%	7926	1092	14%
2006	0	0		0	0		54	0	0%	47	0	0%	8625	1253	15%	9875	995	10%
2007	0	0		0	0		46	0	0%	39	0	0%	8693	934	11%	6953	802	12%
FODORS																		
1996				22	21	95%				13	13	100%				296	26	9%
1997				25	25	100%				12	12	100%				182	0	0%
1998	41	40	98%	62	50	81%	13	13	100%	13	12	92%	224	0	0%	292	53	18%
1999	35	30	86%	60	49	82%	9	9	100%	16	16	100%	200	23	12%	224	3	1%
2000	74	61	82%	637	533	84%	19	19	100%	35	23	66%	283	24	8%	2406	1067	44%
2001	686	546	80%				33	24	73%				3082	1363	44%			
2003				589	385	65%				63	44	70%				6161	3160	51%
2004	539	342	63%	671	397	59%	66	48	73%	78	65	83%	5263	2819	54%	5402	2742	51%
2005	652	399	61%	365	356	98%	80	67	84%	48	27	56%	5393	2759	51%	2189	902	41%
2006	379	375	99%	169	166	98%	45	24	53%	51	22	43%	2428	997	41%	3360	1142	34%
2007	169	167	99%				52	25	48%				3484	1155	33%			

P=potential errors A = actual %err=A/P	Nest headings properly						Identify the language of the text						Provide a summary for tables					
	Period 1			Period 2			Period 1			Period 2			Period 1			Period 2		
	P	A	%err	P	A	%err	P	A	%err	P	A	%err	P	A	%err	P	A	%err
PRICELINE																		
1998				0	0					4	4	100%				6	6	100%
1999	0	0					13	13	100%				133	133	100%			
2000	0	0					15	12	80%				150	144	96%			
2001	48	24	50%	199	104	52%	14	6	43%	24	5	21%	140	131	94%	145	132	91%
2002	45	0	0%	44	0	0%	23	5	22%	34	6	18%	477	310	65%	533	256	48%
2004				276	32	12%				102	3	3%				2240	1229	55%
2005	297	152	51%	121	65	54%	35	1	3%	45	2	4%	272	200	74%	745	549	74%
2006	125	74	59%	177	116	66%	54	2	4%	47	3	6%	885	727	82%	827	597	72%
2007	60	4	7%	253	123	49%	46	3	7%	39	3	8%	815	553	68%	837	697	83%
FODORS																		
1996				0	0					13	13	100%				67	67	100%
1997				1	0	0%				11	11	100%				31	31	100%
1998	1	0	0%	0	0		12	12	100%	13	13	100%	26	26	100%	40	40	100%
1999	0	0		0	0		9	9	100%	16	16	100%	29	29	100%	36	36	100%
2000	0	0		2	0	0%	19	19	100%	35	35	100%	58	58	100%	205	205	100%
2001	2	0	0%				33	33	100%				459	459	100%			
2003				0	0					63	63	100%				763	763	100%
2004	0	0		0	0		66	66	100%	78	78	100%	764	764	100%	959	958	100%
2005	0	0		0	0		80	80	100%	48	48	100%	961	960	100%	452	452	100%
2006	0	0		0	0		45	45	100%	51	51	100%	509	509	100%	661	661	100%
2007	0	0					52	52	100%				679	679	100%			

P=potential errors	Make sure event handlers do not require use of a mouse						Include default, place holding characters in edit boxes and text areas						Separate adjacent links with more than white space					
A = actual	Period 1			Period 2			Period 1			Period 2			Period 1			Period 2		
%err=A/P	P	A	%err	P	A	%err	P	A	%err	P	A	%err	P	A	%err	P	A	%err
PRICELINE																		
1998				0	0					1	0	0%				11	0	0%
1999	26	26	100%				33	33	100%				78	4	5%			
2000	62	62	100%				51	37	73%				253	3	1%			
2001	254	254	100%	804	804	100%	180	68	38%	567	147	26%	553	19	3%	1442	69	5%
2002	598	598	100%	1116	1116	100%	344	132	38%	295	136	46%	1418	25	2%	1451	50	3%
2004				3854	3854	100%				1771	683	39%				7518	156	2%
2005	1228	1228	100%	471	471	100%	861	237	28%	249	134	54%	2334	104	4%	2407	83	3%
2006	459	459	100%	544	544	100%	292	179	61%	256	120	47%	2726	97	4%	4431	56	1%
2007	521	521	100%	830	830	100%	239	109	46%	268	105	39%	2322	52	2%	3891	13	0%
FODORS																		
1996				1	1	100%				9	2	22%				151	1	1%
1997				7	7	100%				2	0	0%				64	22	34%
1998	7	7	100%	33	33	100%	1	1	100%	7	7	100%	53	22	42%	119	2	2%
1999	15	15	100%	4	4	100%	7	7	100%	5	2	40%	77	2	3%	84	0	0%
2000	14	14	100%	208	208	100%	7	1	14%	6	0	0%	128	1	1%	1569	20	1%
2001	347	347	100%				35	34	97%				1550	52	3%			
2003				356	356	100%				44	25	57%				2805	40	1%
2004	303	303	100%	345	345	100%	94	69	73%	127	125	98%	2794	37	1%	3928	26	1%
2005	340	340	100%	88	88	100%	128	126	98%	64	58	91%	3970	31	1%	2300	9	0%
2006	132	132	100%	394	394	100%	65	60	92%	86	71	83%	2335	11	0%	3040	81	3%
2007	405	405	100%				91	76	84%				3136	85	3%			

P=potential errors A = actual %err=A/P	Explicitly associate form controls and their labels with the LABEL element					
	Period 1			Period 2		
	P	A	%err	P	A	%err
PRICELINE						
1998				1	1	100%
1999	33	19	58%			
2000	51	35	69%			
2001	180	58	32%	567	87	15%
2002	344	168	49%	295	176	60%
2004				1771	802	45%
2005	861	148	17%	249	182	73%
2006	292	227	78%	256	158	62%
2007	239	136	57%	268	195	73%
FODORS						
1996				9	7	78%
1997				2	2	100%
1998	1	0	0%	7	5	71%
1999	7	5	71%	5	3	60%
2000	7	6	86%	6	6	100%
2001	35	35	100%			
2003				44	36	82%
2004	94	89	95%	127	113	89%
2005	128	114	89%	64	60	94%
2006	65	61	94%	86	74	86%
2007	91	79	87%			

P=potential errors A = actual %err=A/P	Provide alternative text for all images						Provide alternative text for all image-type buttons in forms						Provide alternative text for all image-map hot spots					
	Period 1			Period 2			Period 1			Period 2			Period 1			Period 2		
	P	A	%err	P	A	%err	P	A	%err	P	A	%err	P	A	%err	P	A	%err
AOL																		
1997	150	62	41%	547	281	51%	0	0		0	0		6	6	100%	0	0	
1998	388	217	56%				0	0					0	0				
1999				3900	2472	63%				12	8	67%				500	225	45%
2000	690	220	32%	4031	2168	54%	15	7	47%	26	10	38%	20	7	35%	459	345	75%
2001				157	122	78%				0	0					42	0	0%
2002	84	58	69%	100	70	70%	0	0		0	0		18	0	0%	18	0	0%
2003	242	152	63%	1483	492	33%	0	0		18	2	11%	0	0		0	0	
2004	58	21	36%	1333	94	7%	5	0	0%	6	0	0%	21	0	0%	0	0	
2005	68	1	1%	1358	92	7%	4	0	0%	5	0	0%	0	0		0	0	
2006	1053	47	4%	432	36	8%	5	0	0%	0	0		0	0		0	0	
2007	397	43	11%	939	158	17%	0	0		0	0		0	0		0	0	
YAHOO																		
1996				1433	186	13%				0	0					360	340	94%
1997	1052	41	4%	1138	855	75%	0	0		0	0		367	367	100%	389	385	99%
1998	952	651	68%	1129	678	60%	0	0		1	0	0%	362	362	100%	363	363	100%
1999				345	126	37%				1	0	0%				14	4	29%
2000	237	69	29%	131	95	73%	1	0	0%	2	1	50%	14	4	29%	23	13	57%
2001	339	133	39%				2	1	50%				26	16	62%			
2003	28	18	64%	28	18	64%	0	0		0	0		7	6	86%	7	6	86%
2004	40	22	55%				0	0					14	12	86%			
2005	23	8	35%	28	11	39%	0	0		0	0		0	0		0	0	
2006	45	14	31%	687	255	37%	0	0		8	6	75%	12	8	67%	8	7	88%
2007	625	211	34%	1117	289	26%	10	7	70%	16	12	75%	46	7	15%	54	13	24%

P=potential errors A = actual %err=A/P	Client-side image map contains a link not presented elsewhere on the page						Use a public text identifier in a DOCTYPE statement						Use relative sizing and positioning rather than absolute					
	Period 1			Period 2			Period 1			Period 2			Period 1			Period 2		
	P	A	%err	P	A	%err	P	A	%err	P	A	%err	P	A	%err	P	A	%err
AOL																		
1997	6	5	83%	0	0		11	1	9%	32	1	3%	357	38	11%	3094	288	9%
1998	0	0					17	0	0%				2767	189	7%			
1999				500	381	76%				134	68	51%				19710	4158	21%
2000	20	11	55%	459	405	88%	46	12	26%	149	37	25%	1197	185	15%	17420	4428	25%
2001				42	35	83%				5	5	100%				1070	401	37%
2002	18	14	78%	18	14	78%	3	3	100%	3	3	100%	671	69	10%	828	321	39%
2003	0	0		0	0		68	68	100%	93	48	52%	856	0	0%	2479	326	13%
2004	21	21	100%	0	0		14	10	71%	35	1	3%	100	0	0%	759	21	3%
2005	0	0		0	0		11	0	0%	34	0	0%	17	2	12%	816	21	3%
2006	0	0		0	0		30	2	7%	23	4	17%	704	19	3%	1002	4	0%
2007	0	0		0	0		23	6	26%	28	0	0%	975	0	0%	211	0	0%
YAHOO																		
1996				360	282	78%				94	92	98%				4270	123	3%
1997	367	302	82%	389	322	83%	88	88	100%	95	94	99%	2133	18	1%	2900	19	1%
1998	362	300	83%	363	301	83%	85	85	100%	80	79	99%	1072	18	2%	1438	22	2%
1999				14	10	71%				21	19	90%				3218	57	2%
2000	14	10	71%	23	17	74%	17	16	94%	17	15	88%	3023	136	4%	1523	177	12%
2001	26	18	69%				30	20	67%				3842	396	10%			
2003	7	0	0%	7	0	0%	7	7	100%	5	5	100%	441	0	0%	426	0	0%
2004	14	0	0%				4	4	100%				768	0	0%			
2005	0	0		0	0		4	4	100%	5	5	100%	386	0	0%	443	11	2%
2006	12	0	0%	8	8	100%	6	6	100%	41	27	66%	828	11	1%	3363	326	10%
2007	46	46	100%	54	51	94%	46	29	63%	46	12	26%	3597	279	8%	2211	265	12%

P=potential errors A = actual %err=A/P	Nest headings properly						Identify the language of the text						Provide a summary for tables					
	Period 1			Period 2			Period 1			Period 2			Period 1			Period 2		
	P	**A**	**%err**	**P**	**A**	**%err**	**P**	**A**	**%err**	**P**	**A**	**%err**	**P**	**A**	**%err**	**P**	**A**	**%err**
AOL																		
1997	2	0	0%	0	0		11	11	100%	32	32	100%	23	23	100%	222	222	100%
1998	0	0					17	17	100%				159	159	100%			
1999				21	2	10%				134	129	96%				2044	2044	100%
2000	169	45	27%	400	84	21%	46	38	83%	149	135	91%	158	157	99%	1963	1963	100%
2001				6	0	0%				5	5	100%				104	104	100%
2002	0	0		0	0		3	3	100%	3	3	100%	52	52	100%	76	76	100%
2003	0	0		229	68	30%	68	68	100%	91	82	90%	290	290	100%	438	438	100%
2004	6	0	0%	358	229	64%	14	13	93%	35	18	51%	36	36	100%	147	147	100%
2005	119	19	16%	332	186	56%	11	1	9%	34	17	50%	2	2	100%	167	167	100%
2006	293	179	61%	259	146	56%	30	13	43%	22	7	32%	121	121	100%	23	23	100%
2007	259	135	52%	425	179	42%	22	7	32%	28	6	21%	23	23	100%	58	55	95%
YAHOO																		
1996				72	11	15%				93	93	100%				876	876	100%
1997	29	0	0%	30	0	0%	88	88	100%	95	95	100%	453	453	100%	587	586	100%
1998	39	0	0%	48	12	25%	85	85	100%	80	80	100%	232	232	100%	268	268	100%
1999				25	1	4%				20	20	100%				585	585	100%
2000	2	0	0%	14	1	7%	16	16	100%	17	17	100%	604	604	100%	352	346	98%
2001	95	36	38%				29	29	100%				656	647	99%			
2003	0	0		0	0		7	7	100%	5	5	100%	91	91	100%	85	85	100%
2004	0	0					4	4	100%				144	144	100%			
2005	0	0		0	0		4	4	100%	5	5	100%	101	101	100%	112	112	100%
2006	0	0		184	105	57%	6	6	100%	41	39	95%	209	209	100%	702	699	100%
2007	213	115	54%	564	312	55%	46	43	93%	46	40	87%	713	710	100%	451	423	94%

P=potential errors A = actual %err=A/P	Make sure event handlers do not require use of a mouse						Include default, place holding characters in edit boxes and text areas						Separate adjacent links with more than white space					
	Period 1			Period 2			Period 1			Period 2			Period 1			Period 2		
	P	A	%err	P	A	%err	P	A	%err	P	A	%err	P	A	%err	P	A	%err
AOL																		
1997	8	8	100%	8	8	100%	5	5	100%	49	40	82%	180	7	4%	1367	37	3%
1998	0	0					34	24	71%				1114	4	0%			
1999				76	76	100%				190	124	65%				6365	234	4%
2000	301	301	100%	1307	1299	99%	79	44	56%	277	176	64%	1690	64	4%	8524	181	2%
2001				0	0					6	3	50%				379	4	1%
2002	0	0		0	0		5	3	60%	4	3	75%	224	4	2%	202	4	2%
2003	0	0		2008	2000	100%	76	6	8%	208	77	37%	644	0	0%	4199	270	6%
2004	4	4	100%	1881	1875	100%	20	11	55%	97	68	70%	134	0	0%	3622	223	6%
2005	4	4	100%	2027	2022	100%	19	12	63%	103	71	69%	396	18	5%	3627	227	6%
2006	1093	1087	99%	611	607	99%	158	65	41%	52	32	62%	2649	129	5%	2067	170	8%
2007	572	570	100%	1898	1898	100%	56	31	55%	79	33	42%	1911	142	7%	4107	374	9%
YAHOO																		
1996				6	6	100%				119	98	82%				2690	31	1%
1997	9	9	100%	12	12	100%	104	83	80%	126	91	72%	1776	18	1%	2063	33	2%
1998	2	2	100%	15	15	100%	92	85	92%	95	85	89%	1459	20	1%	1659	32	2%
1999				18	18	100%				48	25	52%				1230	43	3%
2000	11	11	100%	8	8	100%	27	16	59%	29	15	52%	860	44	5%	453	7	2%
2001	26	26	100%				45	29	64%				1732	18	1%			
2003	0	0		0	0		8	2	25%	6	2	33%	60	0	0%	40	0	0%
2004	2	2	100%				6	4	67%				30	0	0%			
2005	0	0		1	1	100%	5	2	40%	5	2	40%	30	0	0%	36	0	0%
2006	0	0		119	119	100%	7	4	57%	74	32	43%	40	0	0%	2103	84	4%
2007	105	105	100%	125	125	100%	86	40	47%	214	165	77%	2451	85	3%	3799	132	3%

P=potential errors A = actual %err=A/P	Explicitly associate form controls and their labels with the LABEL element					
	Period 1			Period 2		
	P	A	%err	P	A	%err
AOL						
1997	5	5	100%	49	47	96%
1998	34	34	100%			
1999				190	166	87%
2000	79	56	71%	277	234	84%
2001				6	6	100%
2002	5	5	100%	4	4	100%
2003	76	76	100%	208	183	88%
2004	20	13	65%	97	82	85%
2005	19	16	84%	103	90	87%
2006	158	146	92%	52	48	92%
2007	56	51	91%	79	75	95%
YAHOO						
1996				119	116	97%
1997	104	102	98%	126	123	98%
1998	92	92	100%	95	94	99%
1999				48	48	100%
2000	27	27	100%	29	28	97%
2001	45	43	96%			
2003	8	8	100%	6	6	100%
2004	6	6	100%			
2005	5	5	100%	5	5	100%
2006	7	7	100%	74	50	68%
2007	86	60	70%	214	168	79%

P=potential errors A = actual %err=A/P	Provide alternative text for all images						Provide alternative text for all image-type buttons in forms						Provide alternative text for all image-map hot spots					
	Period 1			Period 2			Period 1			Period 2			Period 1			Period 2		
	P	A	%err	P	A	%err	P	A	%err	P	A	%err	P	A	%err	P	A	%err
SOUTHWEST																		
1997				85	74	87%				0	0					0	0	
1998	81	76	94%	189	116	61%	0	0		0	0		0	0		0	0	
1999	168	96	57%	378	357	94%	0	0		9	9	100%	0	0		0	0	
2000	498	479	96%	513	480	94%	12	12	100%	14	14	100%	0	0		56	56	100%
2001	232	212	91%	801	769	96%	6	6	100%	18	18	100%	0	0		0	0	
2002	680	640	94%	825	760	92%	16	16	100%	18	18	100%	0	0		58	58	100%
2003	877	395	45%	919	319	35%	16	15	94%	17	16	94%	0	0		58	58	100%
2004	899	314	35%	1198	423	35%	16	15	94%	21	20	95%	118	118	100%	60	60	100%
2005	1258	123	10%	1203	49	4%	21	20	95%	19	1	5%	60	60	100%	60	60	100%
2006	1093	58	5%				16	1	6%				62	0	0%			
2007				1456	60	4%				12	0	0%				0	0	
USAIRWAYS																		
1997				204	93	46%				0	0					5	5	100%
1998	222	100	45%	254	120	47%	0	0		1	1	100%	5	5	100%	11	5	45%
1999	256	121	47%	376	209	56%	1	1	100%	1	1	100%	11	5	45%	11	5	45%
2000	386	239	62%	537	445	83%	1	1	100%	9	8	89%	11	5	45%	12	0	0%
2001	720	615	85%	768	647	84%	10	9	90%	13	12	92%	12	0	0%	32	20	63%
2002	704	602	86%	742	622	84%	10	9	90%	16	12	75%	9	3	33%	8	2	25%
2003	519	450	87%	633	577	91%	13	13	100%	12	12	100%	32	32	100%	19	19	100%
2004	822	746	91%	776	708	91%	19	19	100%	15	15	100%	13	13	100%	11	11	100%
2005	854	748	88%	748	669	89%	19	19	100%	13	13	100%	10	8	80%	40	0	0%
2006	974	867	89%				16	16	100%				61	0	0%			
2007				230	103	45%				88	47	53%				0	0	

P=potential errors A = actual %err=A/P	Client-side image map contains a link not presented elsewhere on the page						Use a public text identifier in a DOCTYPE statement						Use relative sizing and positioning rather than absolute					
	Period 1			Period 2			Period 1			Period 2			Period 1			Period 2		
	P	A	%err	P	A	%err	P	A	%err	P	A	%err	P	A	%err	P	A	%err
SOUTHWEST																		
1997				0	0					13	2	15%				277	0	0%
1998	0	0		0	0		13	1	8%	14	1	7%	257	0	0%	429	0	0%
1999	0	0		0	0		14	3	21%	14	14	100%	348	2	1%	2237	167	7%
2000	0	0		56	56	100%	15	15	100%	16	16	100%	919	133	14%	3274	167	5%
2001	0	0		0	0		9	9	100%	20	20	100%	528	69	13%	2346	196	8%
2002	0	0		58	58	100%	17	17	100%	20	20	100%	1909	205	11%	2142	196	9%
2003	0	0		58	58	100%	17	16	94%	19	17	89%	1457	61	4%	1353	40	3%
2004	118	118	100%	60	60	100%	18	16	89%	23	20	87%	1792	50	3%	1943	80	4%
2005	60	60	100%	60	60	100%	24	20	83%	26	21	81%	2798	94	3%	1615	68	4%
2006	62	62	100%				23	19	83%				3559	73	2%			
2007				0	0					42	29	69%				4366	140	3%
USAIRWAYS																		
1997				5	3	60%				12	12	100%				451	32	7%
1998	5	3	60%	11	8	73%	13	13	100%	12	12	100%	2838	1135	40%	273	83	30%
1999	11	8	73%	11	7	64%	13	13	100%	14	13	93%	290	85	29%	484	92	19%
2000	11	7	64%	12	10	83%	16	16	100%	23	23	100%	474	112	24%	1647	1078	65%
2001	12	10	83%	32	29	91%	29	29	100%	29	28	97%	1993	1203	60%	2318	1382	60%
2002	9	8	89%	8	7	88%	27	26	96%	29	28	97%	2651	1638	62%	2527	1541	61%
2003	32	32	100%	19	7	37%	19	18	95%	22	22	100%	2340	1727	74%	2701	1785	66%
2004	13	10	77%	11	9	82%	25	25	100%	19	19	100%	3259	2059	63%	3012	1672	56%
2005	10	9	90%	40	30	75%	29	29	100%	25	22	88%	4083	2412	59%	2232	1373	62%
2006	61	44	72%				32	27	84%				3140	2003	64%			
2007				0	0					37	1	3%				975	45	5%

P=potential errors A = actual %err=A/P	Nest headings properly						Identify the language of the text						Provide a summary for tables					
	Period 1			Period 2			Period 1			Period 2			Period 1			Period 2		
	P	A	%err	P	A	%err	P	A	%err	P	A	%err	P	A	%err	P	A	%err
SOUTHWEST																		
1997				2	0	0%				12	12	100%				1	1	100%
1998	2	0	0%	34	1	3%	12	12	100%	14	14	100%	1	1	100%	9	9	100%
1999	7	1	14%	59	0	0%	13	13	100%	14	14	100%	6	6	100%	51	51	100%
2000	41	0	0%	79	0	0%	15	15	100%	16	16	100%	53	53	100%	73	73	100%
2001	16	0	0%	69	7	10%	9	9	100%	20	20	100%	40	40	100%	96	96	100%
2002	59	5	8%	58	3	5%	17	17	100%	20	20	100%	92	92	100%	100	100	100%
2003	43	0	0%	44	0	0%	17	17	100%	19	19	100%	101	101	100%	128	128	100%
2004	35	0	0%	41	0	0%	18	18	100%	23	23	100%	127	127	100%	182	182	100%
2005	26	0	0%	54	1	2%	24	24	100%	26	26	100%	192	186	97%	210	175	83%
2006	52	1	2%				23	23	100%				200	172	86%			
2007				59	2	3%				42	42	100%				235	202	86%
USAIRWAYS																		
1997				0	0					12	12	100%				29	29	100%
1998	0	0		1	0	0%	13	13	100%	12	12	100%	30	30	100%	46	46	100%
1999	0	0		4	0	0%	13	13	100%	14	14	100%	49	49	100%	59	59	100%
2000	0	0		0	0		16	16	100%	23	23	100%	72	72	100%	253	253	100%
2001	0	0		0	0		29	29	100%	29	29	100%	310	310	100%	342	342	100%
2002	0	0		0	0		27	27	100%	29	29	100%	311	311	100%	351	351	100%
2003	0	0		0	0		19	19	100%	22	22	100%	259	259	100%	267	267	100%
2004	0	0		0	0		25	25	100%	19	19	100%	332	332	100%	298	298	100%
2005	0	0		48	6	13%	29	29	100%	25	25	100%	418	418	100%	274	274	100%
2006	55	9	16%				32	32	100%				361	361	100%			
2007				117	50	43%				37	37	100%				142	142	100%

P=potential errors	Make sure event handlers do not require use of a mouse						Include default, place holding characters in edit boxes and text areas						Separate adjacent links with more than white space					
A = actual	Period 1			Period 2			Period 1			Period 2			Period 1			Period 2		
%err=A/P	P	A	%err	P	A	%err	P	A	%err	P	A	%err	P	A	%err	P	A	%err
SOUTHWEST																		
1997				0	0					0	0					44	44	100%
1998	0	0		0	0		0	0		3	0	0%	45	45	100%	204	53	26%
1999	0	0		71	71	100%	3	0	0%	24	19	79%	187	48	26%	266	3	1%
2000	92	92	100%	106	106	100%	47	47	100%	36	36	100%	263	0	0%	417	2	0%
2001	48	48	100%	129	129	100%	19	17	89%	46	46	100%	168	1	1%	439	2	0%
2002	111	111	100%	130	130	100%	37	37	100%	42	42	100%	397	3	1%	439	3	1%
2003	105	105	100%	120	111	93%	37	36	97%	47	46	98%	397	0	0%	423	2	0%
2004	111	102	92%	139	127	91%	39	38	97%	50	49	98%	435	2	0%	537	0	0%
2005	136	124	91%	146	137	94%	50	49	98%	45	43	96%	586	0	0%	593	1	0%
2006	125	116	93%				51	48	94%				673	1	0%			
2007				30	27	90%				120	61	51%				1217	0	0%
USAIRWAYS																		
1997				55	55	100%				7	4	57%				104	3	3%
1998	55	55	100%	76	76	100%	7	4	57%	10	6	60%	106	3	3%	130	5	4%
1999	76	76	100%	78	78	100%	11	6	55%	10	6	60%	132	5	4%	157	8	5%
2000	68	68	100%	6	6	100%	25	18	72%	35	28	80%	165	7	4%	351	92	26%
2001	6	6	100%	6	6	100%	41	30	73%	48	41	85%	502	124	25%	386	73	19%
2002	21	21	100%	27	27	100%	67	25	37%	114	45	39%	556	67	12%	358	70	20%
2003	6	6	100%	12	12	100%	101	32	32%	68	32	47%	520	47	9%	665	75	11%
2004	13	13	100%	23	23	100%	178	44	25%	72	33	46%	348	58	17%	278	41	15%
2005	41	41	100%	40	40	100%	97	47	48%	38	27	71%	562	65	12%	565	99	18%
2006	59	59	100%				61	46	75%				697	114	16%			
2007				129	129	100%				245	208	85%				637	2	0%

P=potential errors A = actual %err=A/P	Explicitly associate form controls and their labels with the LABEL element					
	Period 1			Period 2		
	P	A	%err	P	A	%err
SOUTHWEST						
1997				0	0	
1998	0	0		3	3	100%
1999	3	3	100%	24	15	63%
2000	47	34	72%	36	22	61%
2001	19	13	68%	46	28	61%
2002	37	21	57%	42	24	57%
2003	37	21	57%	47	29	62%
2004	39	23	59%	50	29	58%
2005	50	29	58%	45	24	53%
2006	51	32	63%			
2007				120	107	89%
USAIRWAYS						
1997				7	5	71%
1998	7	5	71%	10	7	70%
1999	11	8	73%	10	7	70%
2000	25	21	84%	35	30	86%
2001	41	35	85%	48	45	94%
2002	67	31	46%	114	52	46%
2003	101	47	47%	68	36	53%
2004	178	46	26%	72	33	46%
2005	97	47	48%	38	31	82%
2006	61	52	85%			
2007				245	245	100%

P=potential errors A = actual %err=A/P	Provide alternative text for all images						Provide alternative text for all image-type buttons in forms						Provide alternative text for all image-map hot spots					
	Period 1			Period 2			Period 1			Period 2			Period 1			Period 2		
	P	A	%err	P	A	%err	P	A	%err	P	A	%err	P	A	%err	P	A	%err
MARTA																		
1996				64	64	100%				0	0					39	39	100%
1997				82	82	100%				0	0					56	56	100%
1998	77	77	100%	68	68	100%	0	0		0	0		16	16	100%	39	39	100%
1999	91	81	89%	257	113	44%	0	0		0	0		39	39	100%	1	0	0%
2000	304	128	42%	376	162	43%	0	0		0	0		1	0	0%	1	0	0%
2001	409	174	43%	377	150	40%	0	0		0	0		1	0	0%	8	7	88%
2002	508	486	96%				0	0					134	103	77%			
2003				367	23	6%				0	0					11	0	0%
2004	354	5	1%	582	18	3%	1	0	0%	0	0		0	0		3	0	0%
2005	550	6	1%				0	0					8	0	0%			
2006	496	15	3%				0	0					0	0				
2007	586	9	2%	596	13	2%	0	0		0	0		0	0		5	0	0%
TRIMET																		
1996				37	16	43%				0	0					0	0	
1997	36	16	44%				0	0					0	0				
1998	60	30	50%	293	9	3%	0	0		0	0		20	0	0%	20	0	0%
1999	287	9	3%				0	0					20	0	0%			
2000				147	11	7%				0	0					0	0	
2001	185	39	21%				2	0	0%				55	1	2%			
2002	37	4	11%	260	96	37%	0	0		13	0	0%	4	0	0%	289	19	7%
2003	368	120	33%	588	165	28%	6	0	0%	7	0	0%	269	21	8%	391	26	7%
2004	556	139	25%	734	207	28%	11	0	0%	21	0	0%	372	29	8%	455	28	6%
2005	733	195	27%	766	216	28%	18	0	0%	18	0	0%	450	30	7%	465	24	5%
2006	206	41	20%	174	24	14%	9	0	0%	6	0	0%	87	3	3%	47	4	9%
2007	180	23	13%	242	16	7%	5	0	0%	9	0	0%	30	4	13%	7	4	57%

P=potential errors A = actual %err=A/P	Client-side image map contains a link not presented elsewhere on the page						Use a public text identifier in a DOCTYPE statement						Use relative sizing and positioning rather than absolute					
	Period 1			Period 2			Period 1			Period 2			Period 1			Period 2		
	P	A	%err	P	A	%err	P	A	%err	P	A	%err	P	A	%err	P	A	%err
MARTA																		
1996				39	39	100%				16	16	100%				748	2	0%
1997				56	45	80%				22	20	91%				1056	9	1%
1998	16	6	38%	39	39	100%	20	18	90%	26	26	100%	1083	11	1%	947	14	1%
1999	39	39	100%	1	0	0%	30	28	93%	11	11	100%	1144	20	2%	648	95	15%
2000	1	0	0%	1	0	0%	12	12	100%	15	15	100%	794	110	14%	1010	136	13%
2001	1	0	0%	8	6	75%	16	16	100%	16	16	100%	1090	144	13%	1075	137	13%
2002	134	109	81%				26	26	100%				603	345	57%			
2003				11	10	91%				15	15	100%				281	170	60%
2004	0	0		3	2	67%	23	3	13%	32	2	6%	1231	263	21%	2306	386	17%
2005	8	7	88%				30	1	3%				1980	364	18%			
2006	0	0					27	1	4%				1694	324	19%			
2007	0	0		5	0	0%	33	2	6%	36	2	6%	2160	386	18%	2319	438	19%
TRIMET																		
1996				0	0					20	20	100%				27	0	0%
1997	0	0					19	19	100%				27	0	0%			
1998	20	20	100%	20	20	100%	18	18	100%	18	18	100%	41	4	10%	279	29	10%
1999	20	20	100%				17	17	100%				259	24	9%			
2000				0	0					16	14	88%				293	129	44%
2001	55	55	100%				17	15	88%				345	119	34%			
2002	4	4	100%	289	240	83%	3	3	100%	22	20	91%	119	11	9%	361	100	28%
2003	269	207	77%	391	322	82%	23	22	96%	34	31	91%	616	179	29%	873	175	20%
2004	372	302	81%	455	388	85%	32	29	91%	40	28	70%	830	168	20%	1271	245	19%
2005	450	380	84%	465	403	87%	36	29	81%	37	27	73%	1278	271	21%	1445	247	17%
2006	87	82	94%	47	41	87%	28	6	21%	27	2	7%	219	18	8%	116	15	13%
2007	30	24	80%	7	1	14%	31	1	3%	36	0	0%	112	10	9%	140	7	5%

P=potential errors A = actual %err=A/P	Nest headings properly						Identify the language of the text						Provide a summary for tables					
	Period 1			Period 2			Period 1			Period 2			Period 1			Period 2		
	P	A	%err	P	A	%err	P	A	%err	P	A	%err	P	A	%err	P	A	%err
MARTA																		
1996				7	0	0%				16	16	100%				18	18	100%
1997				50	0	0%				22	22	100%				28	28	100%
1998	50	0	0%	14	0	0%	20	20	100%	26	26	100%	22	22	100%	25	25	100%
1999	3	0	0%	0	0		30	30	100%	11	11	100%	37	37	100%	58	58	100%
2000	0	0		0	0		12	12	100%	15	15	100%	75	75	100%	92	92	100%
2001	0	0		0	0		16	16	100%	16	16	100%	101	101	100%	95	95	100%
2002	0	0					26	26	100%				104	104	100%			
2003				21	0	0%				15	15	100%				55	55	100%
2004	38	0	0%	49	1	2%	21	0	0%	32	1	3%	223	223	100%	348	344	99%
2005	46	0	0%				30	0	0%				336	332	99%			
2006	33	0	0%				27	0	0%				284	282	99%			
2007	47	1	2%	57	0	0%	33	0	0%	35	1	3%	344	342	99%	349	349	100%
TRIMET																		
1996				33	0	0%				20	20	100%				2	2	100%
1997	31	0	0%				19	19	100%				2	2	100%			
1998	28	0	0%	5	0	0%	18	18	100%	18	18	100%	6	6	100%	50	50	100%
1999	3	0	0%				17	17	100%				47	47	100%			
2000				15	4	27%				16	16	100%				40	40	100%
2001	23	4	17%				17	17	100%				44	44	100%			
2002	2	0	0%	114	10	9%	3	3	100%	22	22	100%	14	14	100%	76	76	100%
2003	162	32	20%	177	34	19%	23	23	100%	34	34	100%	127	127	100%	176	175	99%
2004	148	28	19%	184	50	27%	32	32	100%	40	40	100%	174	173	99%	207	205	99%
2005	173	22	13%	193	23	12%	36	36	100%	37	37	100%	206	204	99%	213	211	99%
2006	163	17	10%	138	11	8%	28	26	93%	27	25	93%	33	32	97%	13	13	100%
2007	194	31	16%	285	66	23%	31	30	97%	36	34	94%	10	10	100%	8	7	88%

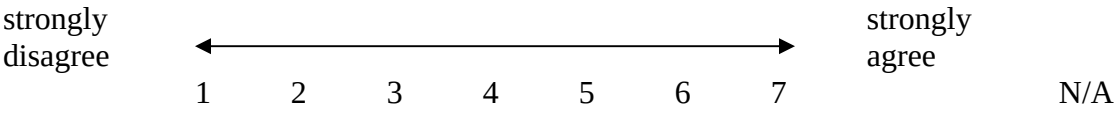
P=potential errors A = actual %err=A/P	Make sure event handlers do not require use of a mouse						Include default, place holding characters in edit boxes and text areas						Separate adjacent links with more than white space					
	Period 1			Period 2			Period 1			Period 2			Period 1			Period 2		
	P	A	%err	P	A	%err	P	A	%err	P	A	%err	P	A	%err	P	A	%err
MARTA																		
1996				0	0					1	0	0%				241	30	12%
1997				0	0					2	0	0%				276	33	12%
1998	0	0		0	0		0	0		1	0	0%	246	32	13%	292	30	10%
1999	0	0		70	70	100%	2	0	0%	0	0		321	28	9%	164	11	7%
2000	84	84	100%	105	105	100%	0	0		0	0		175	12	7%	213	16	8%
2001	112	112	100%	105	105	100%	0	0		1	0	0%	237	17	7%	218	15	7%
2002	182	182	100%				0	0					379	0	0%			
2003				105	105	100%				0	0					260	28	11%
2004	0	0		0	0		3	1	33%	3	2	67%	339	3	1%	552	33	6%
2005	0	0					1	0	0%				538	31	6%			
2006	5	5	100%				1	0	0%				511	38	7%			
2007	0	0		0	0		1	0	0%	1	0	0%	657	38	6%	593	46	8%
TRIMET																		
1996				0	0					0	0					248	0	0%
1997	0	0					0	0					228	0	0%			
1998	7	7	100%	7	7	100%	2	2	100%	2	2	100%	248	4	2%	315	136	43%
1999	7	7	100%				2	2	100%				307	132	43%			
2000				0	0					0	0					301	45	15%
2001	11	11	100%				6	4	67%				308	66	21%			
2002	1	1	100%	93	93	100%	1	1	100%	76	44	58%	135	12	9%	359	118	33%
2003	151	151	100%	214	214	100%	81	56	69%	76	73	96%	395	121	31%	611	112	18%
2004	202	202	100%	281	281	100%	90	78	87%	115	86	75%	566	110	19%	837	123	15%
2005	286	286	100%	264	264	100%	111	85	77%	103	78	76%	759	141	19%	765	123	16%
2006	43	43	100%	23	23	100%	31	23	74%	14	11	79%	648	45	7%	615	16	3%
2007	15	15	100%	3	3	100%	12	7	58%	17	10	59%	748	18	2%	899	23	3%

P=potential errors A = actual %err=A/P	Explicitly associate form controls and their labels with the LABEL element					
	Period 1			Period 2		
	P	A	%err	P	A	%err
MARTA						
1996				1	1	100%
1997				2	2	100%
1998	0	0		1	1	100%
1999	2	2	100%	0	0	
2000	0	0		0	0	
2001	0	0		1	1	100%
2002	0	0				
2003				0	0	
2004	3	1	33%	3	1	33%
2005	1	1	100%			
2006	1	1	100%			
2007	1	1	100%	1	1	100%
TRIMET						
1996				0	0	
1997	0	0				
1998	2	2	100%	2	2	100%
1999	2	2	100%			
2000				0	0	
2001	6	6	100%			
2002	1	1	100%	76	76	100%
2003	81	81	100%	76	75	99%
2004	90	90	100%	115	114	99%
2005	111	110	99%	103	102	99%
2006	31	28	90%	14	11	79%
2007	12	12	100%	17	14	82%

APPENDIX F: CSUQ

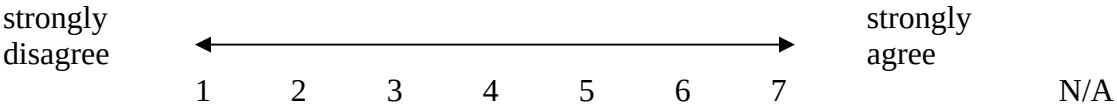
IBM COMPUTER SYSTEM USABILITY QUESTIONNAIRE (CSUQ)

1. Overall, I am satisfied with how easy it is to use this website.



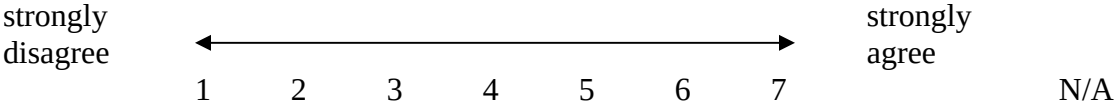
Comments:

2. It was simple to use this website.



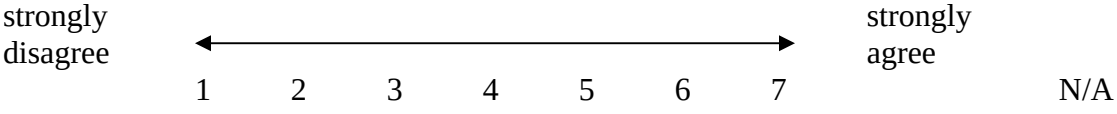
Comments:

3. I could effectively complete the tasks and scenarios using this website.



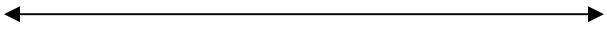
Comments:

4. I was able to complete the tasks and scenarios quickly using this website.



Comments:

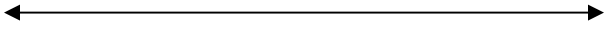
5. I was able to efficiently complete the tasks and scenarios using this website.

strongly disagree  strongly agree

1 2 3 4 5 6 7 N/A

Comments:

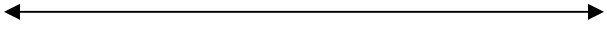
6. I felt comfortable using this website.

strongly disagree  strongly agree

1 2 3 4 5 6 7 N/A

Comments:

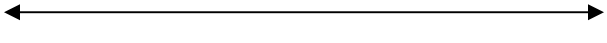
7. It was easy to learn to use this website.

strongly disagree  strongly agree

1 2 3 4 5 6 7 N/A

Comments:

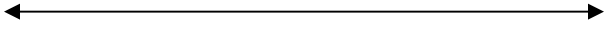
8. I believe I could become productive quickly using this website.

strongly disagree  strongly agree

1 2 3 4 5 6 7 N/A

Comments:

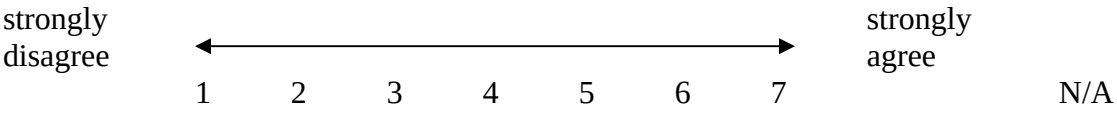
9. The website gave error messages that clearly told me how to fix problems.

strongly disagree  strongly agree

1 2 3 4 5 6 7 N/A

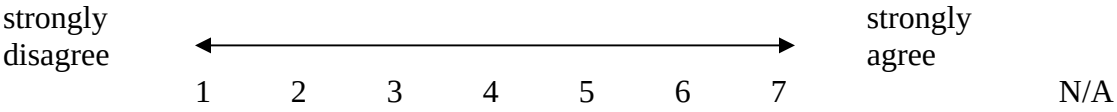
Comments:

10. Whenever I made a mistake using the website, I could recover easily and quickly.



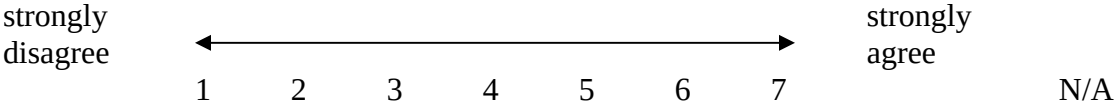
Comments:

11. The information (such as on-line help, on-screen messages, and other documentation) provided with this website was clear.



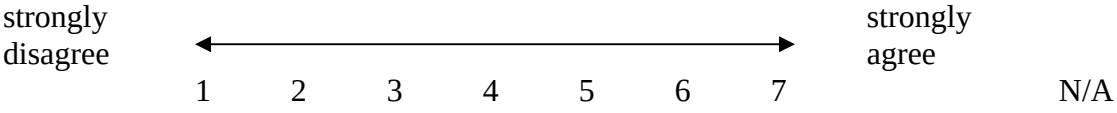
Comments:

12. It was easy to find the information I needed.



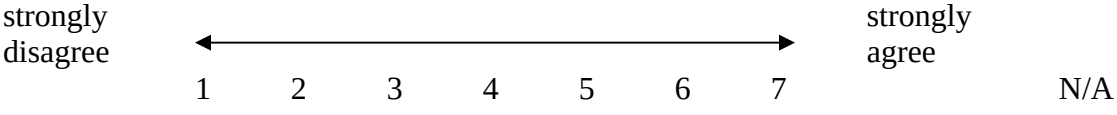
Comments:

13. The information provided by the website was easy to understand.



Comments:

14. The information was effective in helping me complete the tasks and scenarios.



Comments:

15. The organization of information on the website pages was clear.

strongly disagree — strongly agree

1 2 3 4 5 6 7 N/A

Comments:

16. The interface of this website was pleasant.

strongly disagree — strongly agree

1 2 3 4 5 6 7 N/A

Comments:

17. I liked using the interface of this website.

strongly disagree — strongly agree

1 2 3 4 5 6 7 N/A

Comments:

18. This website has all the functions and capabilities I expect it to have.

strongly disagree — strongly agree

1 2 3 4 5 6 7 N/A

Comments:

19. Overall, I am satisfied with this website.

strongly disagree — strongly agree

1 2 3 4 5 6 7 N/A

Comments:

APPENDIX G: RECRUITMENT

SUBJECT RECRUITMENT FLYER

Research Subjects Needed

Experiment of Web Page Usability

You will be asked to browse Web pages, finish several tasks, and fill two questionnaires. All will be finished in about one hour and a half and you will get $30 as compensation.

The whole experiment will be conducted on campus at 6051 Forbes Tower.

Contact Stephanie Hackett at (412) 383-6648 or Dr. Bambang Parmanto at (412) 383-6649 for more details. Please leave your name and a phone number at which you can be contacted for an appointment.

APPENDIX H: BACKGROUND QUESTIONNAIRE

QUESTIONNAIRE FOR GATHERING THE SUBJECT'S BACKGROUND IN COMPUTER, INTERNET AND SCREEN READER

Questionnaire for evaluation of the subjects' familiarity to computer, the Internet and the Web:

1. What is your age?
   ☐ 10 – 20
   ☐ 21-30
   ☐ 31-40
   ☐ > 40

2. What is the highest level of education you have completed?
   ☐ High school
   ☐ College
   ☐ Graduate school

3. What is your gender?
   ☐ Male
   ☐ Female

4. Do you own a computer yourself?
   ☐ Yes
   ☐ No
   ☐ Unknown
   ☐ N/A

5. How many hours a day do you use computers?
   ☐ < 1
   ☐ 1- 5
   ☐ 5- 9
   ☐ > 9

6. What do you do when you use computers?
   ☐ Editing
   ☐ Gaming
   ☐ Internet Surfing
   ☐ Programming
   ☐ Data processing
   ☐ Others
   Specify _____
   ☐ N/A

7. How many hours a day do you use the Internet?
   ☐ < 1
   ☐ 1- 5
   ☐ 5- 9
   ☐ > 9

8. What do you do when you use the Internet?
   ☐ Searching information
   ☐ Gaming
   ☐ Online chatting
   ☐ Email
   ☐ Others
   Specify _____
   ☐ N/A

9. Do you use any screen reader when you browse Web pages?
   ☐ Yes
   ☐ No
   ☐ Unknown
   ☐ N/A

10. Which screen reader do you use most often?

    _____

APPENDIX I: USABILITY TEST PLAN

Goal of the test:	Compare the usability of a universally-designed website before and after transcoding and the usability of a non-universally designed website before and after transcoding
Where and when will the test take place?	In user homes and places of work
How long is each session expected to take?	1 hour 30 minutes
What computer support/equipment will be needed?	User's computer and screen reader software, experimenter laptop, video and audio tape
What software needs to be ready for the test?	AcceSS/Web Transcoding Gateway
Who are the test users and how will they be contacted?	Visually-impaired computer users from the surrounding Pittsburgh PA area and users who have been involved in the focus groups and previous experiments; the study will also be listed on ViPACE
How many test users are needed?	Preliminary power analysis computation for a large effect shows that 21 users are required
What criteria will be used to determine when the users have finished each of the test tasks correctly?	When they have given me an answer they are satisfied with.
To what extent will the experimenter be allowed to help the users during the test?	Experimenter intervention will be kept to a minimum, with the exception of assisting the users if they appear to become frustrated

APPENDIX J: UNIVERSAL DESIGN CHECKLIST

	Question to be Answered?	Yes	No	Justification
Principle 1a	Does the site have an accessible website: WAB score of 5.5 or less?			This score has been determined to indicate an accessible website as compared to WCAG 1.0.
1b	Same as above			Same as above.
1c	N/A			N/A
1d	Is the site design unappealing or offending?			Would be unsatisfactory to certain users.
Principle 2a	Does the site allow for different size fonts and color contrasts?			Allows users to set their own presentation preferences.
2b	N/A			N/A
2c	Does the site use image maps or interactive menus?			Both require a user to use a mouse which may not be possible for some users with mobility issues.
2d	Does the site refresh automatically every couple of minutes?			This may require user to reenter information that was entered since the last refresh.
Principle 3a	Would the site be difficult for novice users and be too complicated to remember from use to use?			Users wouldn't be able to effectively accomplish browsing on the site.
3b	Are links descriptive as to where they lead? Is layout from page to page consistent?			Users may get frustrated or lost in the website. Consistent page design eases the learning curve.
3c	Is simple and straight-forward language used?			Same as above.
3d	Do links take the user to information relevant to the link description (as opposed to having to scroll and search the new page)?			Screen readers and persons with cognitive disabilities would have to read through lots of text to get to the desired text.
3e	Does website confirm user actions appropriately, if applicable (ie: when placing something into cart or submitting information)?			Some users may need this type of visual or audio feedback.
Principle 4a	Is there alt text for images and closed captioning for audio and video clips?			Assists users with disabilities or in compromised environments.
4b	Is there a good contrast			Assists users who are visually-impaired

	between foreground and background?			or in low-light conditions.
4c	Do image-type buttons without alt text contain essential information?			Without alt text this information would be unavailable to users of screen readers.
4d	N/A			N/A
4e	Can the site be effectively browsed with a screen reader? Is closed captioning provided for multimedia?			Allows for access to persons with sensory limitations.
Principle 5a	N/A			N/A
5b	N/A			N/A
5c	N/A			N/A
5d	Is the website error tolerant?			It is easy for users to correct unintentional actions.
Principle 6a	N/A			N/A
6b	N/A			N/A
6c	Does the cursor go directly to new content of the website?			The user using a screen reader doesn't have to listen to all menus every time they visit a new page if content is the same
6d	N/A			N/A
Principle 7a	N/A			N/A
7b	N/A			N/A
7c	Can the mouse and keyboard be used to interact with website?			Benefits users with mobility issues
7d	N/A			N/A

APPENDIX K: CONSENT FORM

WEB ACCESSIBILITY GATEWAY SERVER USABILITY STUDY INFORMED CONSENT DOCUMENT

Department of Health Information Management
School of Health and Rehabilitation Sciences

CONSENT TO ACT AS A PARTICIPANT IN A USABILITY STUDY

TITLE: Web Accessibility Gateway Server Usability Study

PRINCIPAL INVESTIGATOR: Bambang Parmanto, Ph.D.
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SOURCE OF SUPPORT: National Institute on Disability and Rehabilitation Research

What is the purpose of this usability study?

It is increasingly known that the Internet, as an important information resource, present many accessibility barriers to people with disabilities. Many of these barriers can be detected,

monitored and removed by computer program. Our research group has been developing a Web accessibility gateway server that improves the web accessibility for people with disabilities by automatically mitigating these barriers. We are interested to know whether the server also increase the usability of the web for people with disabilities by removing the web content accessibility barriers. Usability is generally considered as the efficiency, effectiveness and satisfaction when performing certain tasks.

You are being asked to participate in a research study in which we will test whether a Web accessibility gateway server can improve the usability of web pages for blind users.

It is anticipated that the Web Accessibility Gateway Server will assist people with disabilities and even general public accessing the Internet in two important ways.

First, it will automatically remove all detectable web accessibility barriers presented in the web page. Therefore, the people with disabilities will have a more positive interaction with the Web when they use the Internet as the information resources.

Second, it will benefit the general public by providing Web content efficiently and effectively when their sensory ability is limited by environment. Some examples are low bandwidth connection, noisy surrounding and mobile device.

In this research study, we will compare the performance of interacting with web pages directly or via the gateway server. You will also fill out a questionnaire about your satisfaction to the web pages.

Who is being asked to take part in this research study?

You are being invited to participate in this research study because you are at least 18 years old, have visual impairment and/or potential users of PDA (Personal Digital Assistant), and have experience with computer and Internet. Between 18 and 30 individuals will participate in this study at the University of Pittsburgh.

What will my participation in this research study involve?

If you agree to participate in the usability study of the Web accessibility gateway server, you will be asked to follow several steps to complete the test. First, you will be asked to browse selected Web pages using Web browser and assistive technology you prefer. Second, you will be asked to accomplish several tasks when you browse each Web page. Last, you will be asked to finish a questionnaire about whether you are satisfied with the Web page browsing experiment.

What are the possible risks, side effects, and discomforts of this research study?

There is no risk of physical injury associated with your participation in the usability test. Since we don't collect your personal identifiable information, participation in the study is not expected to involve the possible risk that your information is known to other individuals, although there always exists a risk for breach of confidentiality. This risk is minimized by keeping your research information confidential.

What are possible benefits from taking part in this study?

It is unlikely that you will receive any direct benefit as a result of your participation in the usability study. However, your feedback and suggestion to us about the Web accessibility gateway server might help us gain knowledge to improve the service to the people with disabilities as a group.

Will my insurance provider or I be charged for the costs of any procedures performed as part of this research study?

Since this is not a clinical study, neither your insurance provider nor you will be charged for the cost of any procedure performed as part of the research study.

Will I be paid if I take part in this research study?

You will be paid a total of $30 if you complete all parts of this study. If, for whatever reason, you complete part but not all of the study, the terms of this payment will be as follows: 1) $20 for completing the performance test including accessing web pages and finishing required tasks. 2) An additional $10 for completing the post test questionnaire. In addition, any parking fees related to your participation in this study will be paid for by the study.

Who will know about my participation in this research study?

All records related to your involvement in this research study will be stored in a locked file cabinet. Your identity on these records will be indicated by a case number rather than by your name, and the information linking these case numbers with your identity will be kept separate from the research records. Only the researchers listed on the first page of this form and their staff will have access to your research records. Your research records will be maintained for at least 5 years following study completion as per University policy.

Any information about you obtained from this research will be kept as confidential (private) as possible. You will not be identified by name in any publication of research results unless you sign a separate form giving your permission (release). In unusual cases, your research records may be released in response to an order from a court of law. It is also possible that authorized representatives of the study sponsor (National Institute on Disability and Rehabilitation Research and National Telecommunication and Information Administration), and/or the University Research Conduct and Compliance Office may inspect your research records. There may be representatives from the sponsoring agency present during the conduct of the study. If the researchers learn that you or someone with whom you are involved is in serious danger or harm, they will need to inform the appropriate agencies as required by Pennsylvania law.

Is my participation in this research study voluntary?

Your participation in this research study is completely voluntary. You do not have to take part in this research study and, should you change your mind, you can withdraw from the study at any time. Your current and future care at the University of Pittsburgh and any other benefits for which you qualify will be the same whether you participate in this study or not.

May I withdraw, at a future date, my consent for participation in this research study?

You may withdraw, at any time, your consent for participation in the research study. However, any research use of the data collected from you prior to the date you formally withdraw your permission will not be destroyed

****

VOLUNTARY CONSENT

All of the above has been explained to me and all of my current questions have been answered. I understand that I am encouraged to ask questions about any aspect of this research study during the course of this study, and that such future questions will be answered by the researchers listed on the first page of this form. Any questions which I have about my rights as a research participant will be answered by the Human Subject Protection Advocate of the IRB Office, University of Pittsburgh (412-578-8570).

By signing this form, I agree to participate in this research study. A copy of this consent form will be given to me.

_____ _____

Participant's Signature Date

CERTIFICATION of INFORMED CONSENT

I certify that I have explained the nature and purpose of this research study to the above-named individual(s), and I have discussed the potential benefits and possible risks of study participation. Any questions the individual(s) have about this study have been answered, and we will always be available to address future questions as they arise.

_____ _____

Printed Name of Person Obtaining Consent Role in Research Study

_____ _____

Signature of Person Obtaining Consent Date

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