# **APPLIED RESEARCH**

SUMMARY

- Reports on a study of 10 low-vision users
- Explores how to provide "experience equity" and universal usable access to all low-vision users and other special needs users—with their wide diversity of needs
- Suggests a "vision of the future" solution

# Helping Low-vision and Other Users with Web Sites That Meet Their Needs: Is One Site for All Feasible?

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### INTRODUCTION

his is the second article on research that the Communication Technologies Branch of the United States National Cancer Institute (part of the National Institutes of Health and the Department of Health and Human Services) conducted with vision-impaired users. In this research, we observed users as they worked with Web sites and the assistive devices they typically use (screen readers or screen magnifiers).

#### A brief reprise of the first article

Our earlier article (Theofanos and Redish 2003) was based on observations of 16 blind users listening to the screen with screen-reading software, either JAWS (http://www. freedomscientific.com) or Window-Eyes (http://www. gwmicro.com).

For that first study, we recruited users who need screen-reading software—users who listen to Web sites rather than see them. The users in our first study were all legally blind; they varied in when they had become blind (from birth, from childhood illness or injury, from gradual deterioration of their eyesight as they grew older). We did not systematically recruit people with different causes for their blindness; we were interested in their current needs.

In our study of blind users, we found many ways in which sites that were technically acceptable to an automatic checking program like Bobby (http://bobby. watchfire.com/bobby/html/en/index.jsp) or LIFT (http:// www.usablenet.com) failed those users. As a result of that study, we were able to propose 29 guidelines that Web designers and developers can immediately use to achieve *usability and accessibility* for people who listen to screen readers.

#### A brief introduction to this second article

For the study we are reporting about here, we also recruited users who need a specific type of software. In this case, our criterion was that users needed to magnify the text with the assistive software ZoomText (http://www. aisquared.com). Our participants worked with ZoomText 7. Just after we finished this study, AI Squared released ZoomText 8, which includes some enhancements that our test showed users needed.

Thus, all of our users had vision problems that were more severe than needing glasses or contact lenses. They needed to go beyond the browser's options for text size—at least some of the time. Although some of our users also listened to the screen (through ZoomText's voice feature), they were not dependent on listening as the blind users in our first study had been.

Our low-vision users had a variety of vision problems—some congenital, some more typical of the aging process. Although we did not systematically recruit for specific vision problems, the fact that our users had different needs gave us one of the most critical insights in this study: **The needs of low-vision users are too diverse for simple solutions to Web accessibility and usability.** 

Yes, we can show a few ways in which sites are missing the needs of all low-vision users and provide guidelines for fixing those problems. (See the section on "Findings that Web developers can implement immediately.") However, the diversity of vision needs and the resulting adaptations that low-vision users require mean that there are no simple solutions to making Web sites work for everyone.

In this article, therefore, you will not find many simple guidelines. Instead, we raise a critical issue and suggest a "vision of the future" solution. We introduce this issue briefly in the next section and discuss it in detail at the end of the article.

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# THE CRITICAL ISSUE FOR LOW-VISION USERS

The 10 low-vision users in our study were much more diverse in their needs with respect to using Web sites than were the 16 blind users.

We found very little difference in how our blind users listened to Web sites. They did little to customize the screen-reading software.

Low-vision users, on the other hand, customize many aspects of their screen, using the operating system, the browser, and the screen-magnifying software. And they each customize differently based on their individual vision abilities and weaknesses. No one solution, in terms of what colors to use, what type size to use, what screen layout to use, would meet the needs of all the low-vision users we worked with.

These users, however, do not want a "different" site: They don't want a "screen-magnifier version" or a "text version" if that means a site that has to be separately maintained from the main version. They believe the sites would not be equivalent. They believe the "special" site would not be kept up-to-date.

The issue is how to provide "experience equity" and universal usable access to all low-vision usersand other special needs users-with their wide diversity of needs. (The term "experience equity" comes from a spokesperson for the U.S. National Federation of the Blind.) Today, most products (Web sites and other programs) are developed for "average" users with tweaking for other users who have "special needs." We suggest that we should instead focus on deeper solutions in which all users can create flexible and portable personal profiles that customize Web sites (and other programs) to their needs. Web sites (and other programs) would be served up dynamically from the same source code in ways that gracefully transform screens to accommodate these different needs. We explore this issue further in the last section of the article.

Before that, we consider

- Reasons why we should worry about low-vision users
- ◆ A little more about the study
- Ways that low-vision users work with Web sites
- Findings that developers can implement immediately

### WHY WORRY ABOUT LOW-VISION USERS?

Vision impairment is one of the most feared disabilities, and studies show that the number of people who suffer vision loss is already large and will continue to increase (National Eye Institute 2002).

**Vision impairments are more prevalent than you think.** Worldwide, 180 million people are blind or visually impaired (World Health Organization 2001). That includes 2

million people in the U. K. (Royal National Institute for the Blind n.d.) and 7.7 million people in the U. S. (U.S. Department of the Census 1997). Of those 7.7 million, about half (3.4 million) are aged 40 and over—one million blind people and 2.4 million visually impaired people (National Eye Institute 2002).

**That number is growing.** The National Eye Institute expects the 3.4 million number to double within the next three decades as the baby boomer generation ages.

All of us are facing the threat of vision loss and even blindness from age-related disease. The leading causes of vision impairment in the U. S. are

- Diabetic retinopathy, affecting more than 5.3 million Americans 18 and older
- Age-related macular degeneration, affecting more than 1.6 million Americans over age 60
- Cataracts, affecting 20.5 million Americans age 65 and older
- Glaucoma, affecting 2.2 million Americans and approximately another 2 million who are unaware they have it

Thus, improving accessibility improves usability for all of us. By thinking about how to make Web sites work for those who have vision problems now, we are also making a better future for everyone.

# A LITTLE MORE ABOUT THE STUDY

Between March and May 2003, we observed and listened to 10 low-vision users as they worked with Web sites. All used a software product called ZoomText to enlarge the text. (See Figure 1.) Some also used the browser's option to change text size. (See Figure 2.)

### Who participated?

Our 10 participants included six men and four women. Eight had congenital vision weaknesses; two had lost vision later in life. Our participants included unemployed people, older students, a teacher, a lawyer, an office manager, and consultants. All were literate and experienced computer users. One participant also had serious cognitive impairments from a congenital problem; however, he was also very articulate and well educated with an advanced degree. We did not specifically ask their age, but the participants seemed to range from 20's to 50's. We realize that this study focused on only one of many types of disabilities. Nonetheless, as with our earlier study of blind users, we learned a great deal that is worth sharing. Furthermore, the last section of this article raises issues that relate to all types of disabilities.

#### What did they do?

Each participant worked individually with us for two hours. At the beginning of each session, we invited the



Figure 1. The ZoomText 7 menu with options for customizing how the screen is viewed.

participant to customize the software. Many did extensive customizing. They changed the level of magnification, the background and/or text colors, the pointer color, the pointer size, the voice on/off setting, the way the screen was magnified, and so on.

We began each session with a few questions about expectations and about the ways that the participant typically works with Web sites. At the end of each session, we asked questions about reactions to the experience and to the specific sites that the participant visited.

For most of the session, participants used the Internet to complete up to nine scenarios that we suggested (in typical usability testing fashion) and one of their own. All of the sites in our scenarios were U.S. government sites.

# HOW LOW-VISION USERS WORK WITH WEB SITES

Note: We refer to the participants by number. P1 is the first person we worked with in the study; P10 is the last.

# Low-vision users are just as impatient as other users.

In some ways, our low-vision participants were exactly like all other users we have worked with. They skimmed; they scanned; they looked for bold headings to help them both orient themselves on the page and get a quick view of what the main points were. Our participants made comments like these:

- P1: "If I don't find it quickly, I'm out of here"
- P5: "I read the bullets. I tend to skim."
- P9: "Headings and bold are very important."



Figure 2. Changing the text size in Internet Explorer 6.0.

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<ul> <li>Vaccines</li> </ul>	Initiative, Broad Effort to Improve
	Agendes Across the County
<ul> <li>Aging</li> </ul>	(Full Story)
Medicare	
Health Issues	October 39, 2003 - HHS to Avaid
<ul> <li>Coping and Caring</li> </ul>	Individuals During Celebration of
	National Disability Employment
<ul> <li>Specific Populations</li> </ul>	Ful Story
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Figure 3. What a sighted user sees of the www.hhs.gov page at  $1024 \times 768$  on a 17'' monitor.

## Some develop strategies for getting an overview of a Web page, but others do not—and are easily lost on Web pages.

Obviously, the larger the text, the less users see on the screen at one time, and it is much harder to get a "mental model" of a Web page when you can see only a small part of it. Several of our participants had specific strategies for looking over a page at a size they could not read and then magnifying a portion to read.

Five of the 10 participants changed magnification size frequently as they were working. Two used the ZoomText menu, moving back and forth between a low and high magnification. For example, P7 set text size to Largest in the browser, then used ZoomText at 1x (no further magnification) to see as much of the page as possible and then upped the magnification to 2x to read. P8 moved between 2x and 5x. Figures 3, 4, and 5 show the same Web page at no magnification, at 2x, and at 5x.

Three participants knew that if you have a mouse with a wheel, CTRL-mouse wheel changes text size increasing the size as you move the wheel up, decreasing the size as you move the wheel down. In the browser, it runs through the text sizes from smallest to largest. In a program like Word, it increases or decreases the size by 10% with each turn of the wheel. In Zoom-Text, it increases or decreases the magnification one step (1x, 2x, 3x, and so forth) with each turn. These three participants used CTRL-mouse wheel to move quickly between getting an overview of a new Web page and reading part of the page.

Some of these participants also had other strategies. P5 changed the window size to eliminate horizontal scrolling at large font size. Of course, that strategy only works with text that floats to fill the window and wraps at the window's edge. P7 and P9 told us that they often copied and pasted



**Figure 4.** What participants saw of the www.hhs.gov page at 2x.



**Figure 5.** What participants saw of the www.hhs.gov page at 5x.

material into Word where they could enlarge the font even more and make it bold, thus rendering it easier for them to see.

Two other participants made conscious decisions about viewing strategies to accommodate the problems caused by wanting to maximize both how much of the page they see and how easily they can read it. P10 kept the magnification at 2x, which he said was lower than he needed; he said he was sacrificing ease of reading for seeing more on the screen. P3 used the lens option in ZoomText, which keeps a 1x view of the screen and enlarges just a portion as the mouse sweeps over it—just like a magnifying glass (see Figure 6).

However, all of these strategies only work if you know about them. Three of our 10 participants had no special strategies. What they did not see on the page at the magnification they used was lost to them.



Figure 6. One participant used the lens feature.

# Unlike blind users, low-vision users working with a screen magnifier are very mouse-oriented.

Blind users who work with screen readers use the keyboard to direct the screen reader; they almost never use the mouse (see Theofanos and Redish 2003). Nine of our 10 low-vision users, however, used the mouse even more than a typical sighted user. Most of our participants did not use cursor control keys even when doing so might have helped them. Instead, they moused around the screen very rapidly, and, in doing so, often lost any sense of where they were on the Web page.

We might speculate that their impatience (typical of computer users) together with the fact that at high magnification so little of the screen is visible at one time leads to rapid mousing. Cursor control keys would be slower to use and would require moving hands between the keyboard and the mouse.

#### Moving around the screen rapidly at large magnification produces vertigo. Observers were affected, and new users cannot work online for long periods.

As you can imagine, when magnified, most sites require a great deal of both vertical and horizontal scrolling. Participants did this scrolling very rapidly with the mouse. With the level of magnification they used, small mouse movements seemed greatly exaggerated. Many of the observers in our study experienced motion sickness while watching users move rapidly around the screen. So this is a caution for usability testers who are planning to conduct studies with low-vision users.

A ZoomText instructor told us that it takes a while to become accustomed to the movement. In the beginning, she could work with the tool for only about 20 minutes at a time. Over time, apparently, users become accustomed to the rapid movement, and none of our participants complained or asked to stop the session. However, it is still a good idea for developers to think about how long a task in their product is likely to take. If tasks must take a long time, set them up so that users can stop and return to work later without having to redo earlier work. (This is an important guideline for all users; many users are frequently interrupted and must suspend tasks throughout the day.)

# On a magnified screen, users cannot see the scroll bar and the text at the same time.

Scrolling becomes a problem when the screen is magnified. Our participants realized this, making comments like these:

P7: "With my eyes, it's more like hit or miss."

P9: "It's easy to lose your spot."

Some participants never used the scroll bar. They moused vertically down the page, a strategy that can be time consuming. Using the scroll bar, however, means constantly going back and forth between scroll bar and content area. That can also be time consuming and frustrating—because it is so hard to tell how much to scroll.

# Users who do not work with the scroll bar may never go to the right side of the screen.

For one of our scenarios, the easiest path was to find an item in the Features list, part of a third column on the right of the page. Only three participants found the right column by mousing around the screen. One other used CTRL-F to find a keyword, which revealed the right column to her. The others did not notice that there was a right column. P10, one of the users who found the item in the right column, complained about how long it takes to get down to the lower right of the screen when you have to mouse through several columns of magnified text.

Delivering multi-column pages to these users as a single column with anchor links might be a better choice *for them*, but it also might not be the best choice for the typical fully-sighted user. This is the type of problem that leads us to the vision of the future that we raise in the last section of this article.

# Users can miss items—even those adjacent to each other—when the screen is magnified.

Spacing on the screen is another issue where what is acceptable for the average user may cause problems for users who work at large magnification. For example, the field for selecting the state on the Nursing Home Compare screen is so wide that the drop-down list and the down arrow are not on the screen at the same time in 5x magnification. If users can get past that problem, they then have to click the Next Step button to the right of the state selection



Figure 7. The relevant part of the page with no magnification.

field. At 5x, it's off the screen. In Figures 7 and 8, you can see how this part of this page looks to a user with no vision problems and to a user who has to magnify the screen to 5x.

Again, the best solution for the user at 5x might not be the best solution for other users. One participant, who teaches children with special needs, commented on a different page on the importance of *having space* on the page. For many of her students, a very dense page is too difficult to use. We need a way to have the same content adjust to the varied needs of different users.

# Some users do not know how to customize all the aspects that they want to change.

One last point about how our low-vision participants work with Web sites: Although we saw a lot of customization, we also had to help some users who told us how their screens and software were set up but who did not know how to make the changes. For example, our technical expert had to help P1 adjust the colors to what she typically uses. She did not remember how she had gotten the combination she has on her own system. P2 told the facilitator that on his own computer the pointer is a big yellow arrow, but he had no idea how to make it look that way. The facilitator had to show him how to do it. The facilitator also had to help P10 turn off the voice.

We shouldn't be surprised at this. Most computer users, low-vision or not, do not do any special configuration when they get new hardware or software. If they do not have special needs, most users just live with the defaults. If they do have special needs, someone may do the set up for them. They never change that initial setup and do not understand how to do it. Even if they did it themselves, they may not remember how to do it again.

It is best, then, to provide the most-needed features as defaults.

# FINDINGS THAT WEB DEVELOPERS CAN IMPLEMENT IMMEDIATELY

In this section, we describe insights from our observations and we give guidelines (numbered G1, G2, and so forth) that can help designers and developers both meet the letter of the law and actually make Web sites more usable for low-vision users.

#### Combining magnification with color changes made users mistake information in a left navigation column for main content.

When you are looking at only a small portion of a screen, the contextual clues that tell you where you are on the Web

Home.asp

# State / Territory: Selec

A, FL, NY, OH, TX have split these states in ha ilifornia). If you are not s <u>unties</u> belonging to each



page are often lost. This problem is compounded when users customize the colors and so lose some of the distinctions that had been built into the Web page.

In changing the colors, some of our participants eliminated the distinction between the left navigation and the main content area. Then they did not realize that what they were seeing when they first got to the page were links to other pages and not the main content of the page they were on. The left-hand column became the primary focus because they saw it as content, not as navigation.

For example, consider the page in Figures 9 and 10.

Our participants were trying to find a list of nursing homes near where they live. At the time of our testing, this page included a ZIP code locator in the left navigation bar. None of our fully-sighted users selected that feature. Because it was in the left navigation bar, they assumed it was not pertinent to the main content area.

However, three ZoomText users picked it, thinking it was the place to ask for nursing homes in a given ZIP code. (In fact, it is a link to the Postal Service site where you can enter an address to find out what ZIP code that address is in.)

The World Wide Web Consortium (W3C) accessibility guidelines (1999) clearly state: "Do not rely on color alone." This is generally taken to refer to text and image color. However, it should also refer to background color.

**G1.** Never rely on color alone to convey functional meaning—that includes not relying on background color alone to define different sections of a Web page.

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LIPS	
Zip Code Locator	
Medicare Eligibility, Enrollment, and Premiums	Nursi
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Figure 9. Grayscale reproduction of the Nursing Home Compare screen with no color change.

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Figure 10. The same screen with colors changed. Even in the grayscale version printed here, the difference is obvious.

### Removing color can make tabs disappear.

Many Web sites today rely on tabs to indicate different sections of the site, and the tabs are distinguished only by their colored backgrounds. When users eliminate these colors, the tab outlines disappear. The words of one tab blend into the words of the next. This phenomenon caused total confusion for users who had changed the colors, as you can see by contrasting Figures 11 and 12.

#### Questions & Answers

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Subject	~

Figure 11. Grayscale reproduction of a tabbed screen (http://answers.hhs.gov/cgi-bin/hhs.cfg/php/enduser/std\_alp.php) in its default colors.



**Figure 12.** Even in the grayscale version reproduced here, the same screen with colors changed clearly loses any indication that there were tabs.

**G2.** Outline tabs with a black border so that they look like tabs even when their special colors are taken away.

# Changing text size in the browser does not affect graphic images.

Internet Explorer has an option to change text size. Some of our participants used that. However, that setting changes size only for text; it does not affect graphic images. Using this feature leads to anomalies such as the page in Figure 13. The links are smaller than the non-linked bullets under them.

This is an important problem for two reasons:

1. Our participants were all ZoomText users, but a far greater number of low-vision users around the world do not have special screen-magnifying software. They rely on changing text size in the browser.

2. Some of our participants used both the Largest text setting in the browser and magnification in ZoomText. Although both images and text expand as magnification increases in ZoomText,



**Figure 13.** The links that are graphic images do not get larger when the text is set to "Largest" in Internet Explorer 6.0.

when you increase the text using the browser feature, you change the proportion between text size and image size. Zoom-Text does not compensate for that difference.

**G3.** Do not use graphic images for textual elements like links.

#### Text size changes only if the Web page uses relative text size.

One user commented that he doesn't always need ZoomText if changing the text size in the browser works, but he said that strategy works only on some pages. He didn't know why it sometimes works and sometimes doesn't. A technical person knows that some browsers cannot override absolute font sizes.

**G4.** Use relative sizes for text, not absolute sizes.

# Sometimes different styles are designated differently, so some text changes size and other text does not.

We found that on many pages some text enlarged and other text did not. For example, on the page in Figure 14, the paragraph text enlarges but the bulleted text does not.

#### Back to Smallpox Home Page

#### Reactions after Smallpox Vaccination [Esta página en españo]

The smallpox vaccine prevents smallpox. For most people, it is safe and effective. Most people experience normal, typically mild reactions to the vaccine, which indicate that it is beginning to work. Some people may experience reactions that may require medical attention.

#### Normal, Typically Mild Reactions

These reactions usually go away without treatment:

The arm receiving the vaccination may be sore and red where the vaccine was given.
 The Iglands in the armpts may become large and sore.
 The vaccinated person may run a low fever.
 One out of 3 people may feel bad enough to miss work, school, or recreational activity or have trouble sleeping.

Figure 14. Note how the bullets are still small while the rest of the text is enlarged.

This page is controlled by a stylesheet; it is likely that the text specifications in the stylesheet for different style types are not consistently set to relative type sizes.

**G5.** Check style sheets and fonts on actual pages to be sure that all the text enlarges properly.

#### Sans serif type is easier for low-vision people to read than serif type.

Most of the Web sites that our participants worked with were in sans serif type. This is good. The American Printing House for the Blind (Kichel 2001) recommends sans serif for low-vision users even in print materials. A recent research study found that reduced-vision users as well as normally-sighted users all preferred sans serif to serif type in computer displays. They also all preferred roman (nonitalic) type to italic type. This study included reducedvision users with different types of vision problems and different levels of severity of their problems. All groups preferred sans serif type (Reece 2002).

#### **G6.** Use sans serif type for Web sites.

# ACHIEVING EXPERIENCE EQUITY AND UNIVERSAL USABLE ACCESS FOR ALL USERS

We return to the issue that we raised at the beginning of the article: How to achieve experience equity and universal usable access for all users. Most Web sites today are designed and built first for users without any special needs. Web users with special needs must use an assistive technology or a few possible adjustments to work with that Web site. With increased awareness of the diversity of users, with the Section 508 mandate in the U.S. and the Disability Discrimination Act in the U.K., and with the work of the W3C Web Accessibility Initiative, some Web designers now add elements or features to make their sites work well with some assistive technologies.

Even that adaptation is not being done often enough.

A recent study of 1,000 Web sites in the United Kingdom found that "81% of Websites (808) failed to meet minimum standards for disabled Web access. The survey also found that the average home page contains 108 barriers that make it impossible or very difficult for disabled people to use" (Disability Rights Commission 2004).

A study of the home pages of 500 health information Web sites found exactly the same statistic: 81% were not accessible (Davis 2002). An even more recent study of 108 Web sites with health information for consumers found that none complied fully with even the aspects of accessibility that could be checked by the automated program Bobby (Zeng and Parmanto 2004).

The current paradigm that expects developers to add extra coding and make specific design changes apparently requires more than most developers are doing. Whether the problem is awareness, knowledge, skill, motivation, time, or other resources, adapting sites for accessibility is simply not happening often enough or well enough.

Furthermore, even following the current guidelines would not be enough for many users. Even if Web designers and the developers of assistive technologies followed all the advice in this and our earlier article, they would not solve all problems for all users with special needs. There are too many variables to allow one version of a Web site to provide a graceful transformation of the information to address all of the various users' diverse needs-even with the very latest in assistive technologies. And building separate Web sites that have to be separately maintained is not the answer. Users are suspicious of the currency and completeness of separate sites.

A few others have recognized the problem of accommodating the wide diversity of users' needs. Aries Arditi, a senior research fellow with the Arlene R. Gordon Research Institute at Lighthouse International, has written

Accessible Web designs for low vision, then, must take into account a wide range of access methods, and provide many more features, corresponding to the wide range of visual capabilities of the low vision population. Paradoxically, providing access to users who do not see at all may be easier than doing so for those who see but with low vision. Because providing access to those with low vision is so much more complicated, specifying exactly what constitutes good accessibility and compliance with laws or standards makes Web accessibility for low vision a particularly thorny issue, one which will have to be addressed in the very near future. (Arditi 2002)

#### Needed: A new paradigm

We need a paradigm shift in the way we think about accessibility. We may be approaching accessibility from the wrong direction. Today, we are putting assistive technol-



**Figure 15.** How we handle accessibility today and a future vision where all users can specify personal profiles that work on any system and change the parameters of screens, Web sites, and other programs to meet their needs.

ogy on top of existing Web sites. We are changing Web sites after we build them. Accessibility is an afterthought. Instead of our current approach, we should think about accessibility from the bottom up, not as something put on top afterwards.

In our proposed new paradigm, information about the user's specific needs would be collected and identified independent of any access mechanisms (see Figure 15). Intervening technology would then translate those needs to dynamically change and present Web sites (and other programs) to meet the individual needs of each user. In our picture of the future, everyone using any device or technology could have the information offered to meet their individualized specifications. Everyone, whether disabled or not, could specify how they want information served to them.

This approach would enable much more than changing the colors or the type size. We are talking about technology that can take an individual's specifications for color; type size; graphics or text; number of columns; sound or not; animation or not; control by speech, eye-gaze, special device, and so forth—and probably many other variables and present a usable and useful Web site.

#### An example: How many columns are best for you?

As P9 told us, "columns can be challenging" for users who magnify the screen. We saw several instances of this problem. For example, when participants removed the contrast in color, they mistook the left navigation bar of a site for the main content. Some participants never moved the mouse far enough to the right to discover the column of news and features on one home page.

For these users, a one-column rendition of Web pages with anchor links at the top to differentiate between navigation, content, news, and so forth would have been much easier to use. One of the guidelines from the American Printing House for the Blind is, "Where possible, columns and divided words should be avoided" (Kichel 2001).

However, we would not recommend a one-column format for all users and all page types. Navigation on the side, news on the side, and other multi-column formats work very well for most users on many Web pages. What we need is more flexibility in delivering individualized formats-much more flexibility than currently exists.

We realize that this issue of columns can be solved fairly easily today with two versions of a cascading stylesheet (CSS) and a button that allows users to switch between them. Our point is that this is only one of many renditions that would be needed to serve all users with different specific needs. Would we need to have a hundred or more different CSSs for each Web site? Is that the most effective and efficient solution? And how will we ensure that the Web site will be usable and useful in all of these renditions?

#### Our requirements: Wide range of flexibility, portability, and graceful transformation of the information

Shneiderman (2002, p. 42) talks about flexibility when he says,

Automobile designers have long understood the benefits of accommodating a wide range of users. They feature adjustable seats, steering wheels, mirrors, and lighting level as standard equipment and offer optional equipment for those who need additional flexibility.

We want to go further. Part of what we are suggesting is similar to the way that some high-end cars work today where different drivers of the same car can each set their needs for all of these adjustable features one time. The adjusted settings are saved so that with the push of a button in the car or just by opening the door or putting the key in the ignition, the car resets itself for all of these adjustments for the particular needs of each driver. To carry this analogy to the computer: in our vision, a whole set of adjustments would be linked to a user's profile so that when the user logged in to the computer—no matter what computer the user was at—instructions for the adjustments would be given to any program the user opens and to each Web site the user goes to. There are three elements to our vision here:

- ◆ A wide range of flexibility
- Portability
- ◆ Graceful transformation without loss of information

**Wide range of flexibility** As an analogy for the level of flexibility that would be needed to achieve universal *usable* access, consider not the car but the way that you order a computer today or the way that wheelchairs are customized. You can buy a "computer in a box" and even add on peripherals to make it do what you need; but many of us don't do that. We order a computer by selecting components one by one to meet our specific needs. We think that building the right computer from the bottom up is better than trying to tweak a pre-constructed computer after the fact.

You can find a "one size fits all [or none]" wheelchair in a medical supply store, but such a chair is not suitable for a person who is going to spend all day every day in one. Personal wheelchairs are put together individually from components that preexist in a warehouse of pieces. From the width of the seat, to the height of the back, to the level of the arms, to the angle of the foot rests, to the type of wheels, every component of a personal wheelchair is carefully selected to meet that person's needs. These are not adjustments made to a preexisting chair; they are choices that, when assembled, constitute a chair that is right for the individual user.

**Portability** In our study, users came to us and so had to show us how they adjusted their computers—and some could not do it. You could argue that we should have gone to their homes or workplaces, and there would have been advantages to doing that. But, if we had, we would have missed the important lesson about how difficult it is for a low-vision person to use someone else's computer. That situation regularly occurs. So universal usable access means letting users carry their configurations with them. To continue the automobile metaphor, that means having a key that adjusts not only the car they normally drive but any car they may need to drive anywhere at any time.

#### Graceful transformation without loss of information

The blind and low-vision users in our two studies wanted to have the same information that everyone else gets. This desire makes the issues related to screen magnifiers different from the issues related to personal digital assistants (PDAs) despite the fact that, in both cases, we are concerned with how to display information when the user can only see a little at a time. Expectations are different. Most users see the PDA as a supplementary tool (Ghosh 2003). They think that only certain types of applications work well on the PDA. They are willing to sacrifice features to get the basic information that fits well onto the small screen of the PDA. They have their full-screen computers for other uses. For low-vision users, however, the magnified screen is all they have; they need all the information delivered in that medium. Our research has shown that all three of these factors—a wide range of flexibility, portability, and graceful transformation without loss of information—are necessary to satisfy the range of diversity among low-vision users. And the range of special needs goes well beyond vision-impairment. We suspect that the need for all three will be even greater when we consider the diversity of people with cognitive and motor impairments.

#### How to achieve this vision

We aren't sure what it would take to reach this future. Is it an expanded version of XML? XML plus Java plus new versions of the browsers? Personal CSSs? Something new entirely?

Obviously, separating content from structure and presentation is critical (see the statement by the W3C at http:// www.w3.org/TR/WCAG10/#Introduction). But today's approaches and technologies for separating content from structure and presentation do not go nearly far enough. Single-sourcing content-management systems that dynamically compose the page you need can be set today for a variety of output forms. However, those output forms must each be specified; the systems don't—at least now—respond to the level of diversity that we are discussing. Even the varieties of renditions of Web sites that you can see at http://www.csszengarden.com/ are not nearly enough for the level of flexibility we are talking about here.

This is the real challenge of universal usable access—not providing assistance on top of a regular Web site, but rather serving up Web sites in individualized versions from the same source through technology that understands each user's specific needs and adjusts the Web site to meet those needs. Information architects, information designers, visual designers, content writers, and technology specialists will need to work together using this technology to develop and use guidelines for assuring that the design and information will work in the myriad of combinations of parameters that individual users need. **TC** 

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### NOTE

Any commercial product identified in this document is for the purpose of describing a software research environment. This identification does not imply any recommendation or endorsement by the National Institute of Standards and Technology.

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## **APPLIED RESEARCH**

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