Designing Web Sites for Older Adults: A Review of Recent Research

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Prepared for AARP
By Janice (Ginny) Redish and Dana Chisnell

AARP
601 E ST, NW
Washington, DC 20049
www.aarp.org

Dana Chisnell
UsabilityWorks
San Francisco, California
www.usabilityworks.net

Janice (Ginny) Redish
Redish & Associates, Inc.
Bethesda, Maryland
www.redish.net

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About This Project

In this document, we review recent, relevant research about Web site design and older adult users. This literature review is the first step in a larger project sponsored by AARP. From the research reviewed here, we developed a set of heuristics to use in persona-based, task-based reviews of 50 Web sites that older adult users are likely to go to. The results of the rest of the project will be published in early 2005.

Why do this review of the literature?

We conducted this literature review to:

- better understand the "older adult" audience
- identify common usability and design issues specific to older Web users
- provide guidance to designers and developers of any Web site or Web-based application – within AARP and elsewhere – who have older adults in their audiences
- add information about e-commerce Web sites and Web transactions to AARP's information and to AARP's Older Wiser Wired (OWW) Web site (www.aarp.org/olderwiserwired)

Who should read this review of the literature?

While the primary audience for the review is people inside AARP who are responsible for providing content, designing Web sites or pages, and for supporting membership, we also hope that AARP partners and affiliates will find value in the findings.

And, because AARP supports the larger community of Web site designers, user experience professionals, and usability practitioners, AARP has made this literature review available in print and online form.

How does this literature review differ from others?

Focus

This review focuses on Web site design for older adults. But it is not limited to information about Web sites directed toward seniors. Our findings and heuristics are applicable to all types of Web sites that have older adults in their audiences, from search engines to e-commerce sites, to reference Web sites, and beyond.

Our review concentrates on research from the disciplines of interaction and navigation, information architecture, presentation or visual design, and. information design, thus it is narrower than some other reviews. We have used these other reviews for their insights into older users and the Web and our annotations of them focus on what they have to say that can inform Web design.

For example,

- Czaja and Lee [15][1] look more broadly at computer systems and older adults, including the use of technology other than the Web in work and home environments.
- Lippincott's [32] review concentrates on research about older adults and technical communication products.
- Morrell, et al. [40] use research about cognition, aging, and gerontology theory in their review on how older adults use health information on the Web. Their review resulted in Web site design guidelines for sites specifically geared toward seniors.
- Craik and Salthouse [14] – actually a handbook rather than a review – cover all things related to aging and cognition, including the human factors of technology.

Time frame

This review covers material published or presented between January 2000 and September 2004. It includes many items that have come out in the past few months. Thus it is more up-to-date than previous reviews.

Scope

This review includes books, book chapters, articles, presentations, even pre-prints.
We set a wide net, as we explain in the next section.

Where did we find literature to review?

To limit the scope of this literature review so as to make it manageable, we defined "recent" as published from January 2000 to September 2004.

To find relevant research, we included studies and experiments done both inside AARP and by others in universities, corporations, non-profits, and government agencies.

We reviewed articles, books, presentations, Web sites, papers – whatever we could find about designing Web sites for older adults. We were most interested in primary research published since 2000, but we also included a few reviews of research published within our time frame. These often covered not only interesting and relevant recent articles, they also reviewed older research that gave us further insight about our topic.

We knew of some sources from the fields of user interface design, human-computer interaction, user experience design, and technical communication.

We started by gathering sources through AARP's AgeLine database, where we found hundreds of resources about older adults and issues of aging. We narrowed our selections to the many reports of studies specific to Web site design. We also searched from Google, GuruNet, and AskJeeves.com. We consulted several online libraries and research tools, such as RedLightGreen.com, Questia.com, ACM's Digital Library, and the archives of the Society for Technical Communication (STC) and the Usability

[1] Reference numbers in brackets such as this one indicate that the item is included in the Annotated Bibliography starting on page 40.

Professionals' Association (UPA). We gathered papers from many international conferences and their proceedings.

As we found sources, we also reviewed *their* relevant references. We queried other practitioners who work in fields related to Web site design for older adults. In a few cases, we contacted the authors directly with questions or to get copies of articles that were otherwise unavailable.

We also contacted usability and human factors professionals at Microsoft, IBM, and Sun Microsystems.

How is this document organized?

After this brief introduction, you will find

- our discussion of critical issues related to "Who is an 'older adult?'"
  - What age makes someone an "older adult"?
  - What factors besides age must we consider in segmenting older adults into meaningful user groups?
  - What must we keep in mind about older adults when designing Web sites?
- synopses of findings, divided into categories describing what we have learned about
  - interaction design and multi-modal access
  - information architecture
  - visual design
  - information design
  - conducting research with older adults
- an annotated bibliography that lists all of the sources for this review alphabetically by primary author

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- Caroline Jarrett
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- Mary Zajicek, who led us to an otherwise unavailable but important article

About Older Adults and Web Site Design

Much of what we found in the literature about older adults is good design for everyone. Everyone benefits from Web sites where the interaction matches users' tasks; where navigation and information are grouped well; where navigation elements like buttons and links are used consistently and follow conventions; where the writing is clear, straightforward, in the active voice, etc. And much of what makes up good design for younger adults helps older adults as well – and often is even more important for older adults.

To cite just a few examples:

- Zaphiris, Kurniawan and Ellis [56] found that users – both young and old – are more successful finding information in broad, shallow hierarchies than they are with narrow, deep information architectures.
- Chadwick-Dias, McNulty and Tullis [10] found that when they fixed their site to make it easier for older adults, both older and younger adults did better.
- From research about blind and low-vision users, Theofanos and Redish [46] advocate implementing highly skimmable text by, for example, presenting content in lists, with the most important keywords at the beginning of each item in the list.

We are very much interested in these results, and we are particularly interested in what, if anything, is different about older adults and what is especially needed to make Web sites work for "older adults."

Older adults are different

Age is more — and less — than a number

Older adults are different from younger adults. Boomers (born 1946-1964) are different from Generation Xers (born 1965 or later), but Boomers are also different from the GI generation (born in 1934 or before) and the Silent Generation (born 1935-1946).[2] Some researchers would argue that older adults are more diverse than younger people are. Within this group, older adults have different experiences and different needs, habits, thoughts, and beliefs. Because of this diversity, it is extremely difficult to generalize performance, behaviors, and preferences to the 8 million (22%) Americans 65 and older and 58% of people aged 50-64 older who are online. [Fox [19]]

Older adults have a wide variety of physical and cognitive abilities

Typically, eyesight degrades, hearing may get worse, and short-term memory becomes less reliable. But not for everyone. And not at the same age. Eyesight may be worse for some older adults who also have other health conditions. Motor skills and fine coordination may degrade earlier or further for people with arthritis or other age-related issues. Short-term memory can be affected by medications taken for other conditions associated with aging, such as high cholesterol or high blood pressure.

[2] AARP The Magazine, "Wake-up Call" by Peter Keating, September and October 2004. Available online at www.aarpmagazine.org/people/Articles/a2004-07-20-mag-wakeup.html

Life experience contributes different lessons

Because older adults have been through many important life and world events and changes, they come to the Web (and everything else) with their own preconceptions and motivations, attitudes, and approaches – even myths.

Some older adults take technology for granted, but for others using the Web is new territory. People in their 50s and 60s are more likely to have used computers at work. But many older adults – even those who are middle aged – are learning to use computers and the Web on their own.

Those of us who have been using computers for a long time or who have perhaps even grown up with computers as a part of everyday life have much experience to draw on to make inferences about new computing experiences. Many older adults do not have these experiences. Younger designers developing Web sites for older adults need to learn more about older adults' life experiences. Younger designers need to not use their own experiences and expectations when building sites for older adults who have not shared those experiences or expectations.

How – and whether – people are trained to use computers and the Web is important

Studies show that many older adults learn new technology best in situations that are task and goal oriented – and collaborative in nature. [Fisk, et al. [17]; Morrell, et al. [39]; Chadwick-Dias, McNulty and Tullis [10]; Coyne and Nielsen [13]] Perhaps we all learn best in collaborative settings, but older adults did not have the benefit of that type of interaction with computers and the Web because those technologies were not part of their work environments. Some researchers insist that providing training is the only way to make Web sites truly accessible and useful to older adults who have low Web expertise [Czaja and Lee [15]; Morrell et al [39]]. Wright [50] suggests that if you set up learning situations in which opportunities for errors are reduced, distractions from task goals are also reduced. In such situations, attention, memory, and recognition abilities are also better supported.

Implementing design changes to increase the usability of Web sites for older adults also increased usability for younger adults – but the design changes did not close the gap in ease of use between older and younger adults. [Chadwick-Dias, McNulty and Tullis [10]; Hawthorn [26]]

What are the critical issues?

Some issues uncovered in the research are shared across the diverse audience of older adult Web users; some are not. And here we run into a few critical issues that bear discussing before we get into specific synopses on what the literature contributes to designing Web sites for users over 50. In the next sections we explore these four issues:

- **Who is an "older adult?"** Researchers do not agree on the minimum age for an "older adult" or how to segment older adults into age groups.
- **What factors besides age must we consider?** Age is not the only criterion that we should be using to segment the older adult population. Another criterion is ability. Much of the research on older adults focuses on dealing with disabilities that come with aging – on changes in cognition (memory), mobility, fine motor control, vision, and hearing. And yet, it is also clear from the research that there is great diversity of all of these cognitive and physical changes within the "older" population, even within each age cohort. Furthermore, even age and ability

are not sufficient to understand individual needs within an "older adult" population. Attitude and aptitude (particularly expertise) are turning out to be as relevant as age and ability.

- **What else must we keep in mind?** All web design should involve users. Involving users is especially critical when designing for older adults because the designers are usually younger people with very different expertise and experience than the people they are designing for. For this issue, we discuss a new approach to user-centered design and a broad view of what user experience means.
- **What research questions remain?** Although in many ways, different sources that we review support each other, in some areas, the studies in this annotated bibliography found different results. More research is needed to understand these differences. Furthermore, our analysis – as well as that of the researchers we cite – leads to more questions. We list some in our discussion of this issue.

Who is an "older adult"?

At AARP, people who are 50 years old and older are considered "older adults"; and in many studies included in this review, people in their 50s were considered "older adults."

However, this is not universally the definition used in research on "older adults." Some studies did not define "older" but used participants who were 65 and older and called them "seniors" [For example, Coyne and Nielsen [13]; Morrell et al in the *Compendium* [40]]. Table 1 (next page) shows the age ranges of older adults in many of the studies included in this review.

It is important to note the age ranges that different researchers include in their studies and to be aware of the audiences they are trying to help when they develop Web sites or guidelines for Web sites. What works best for older adults from one age group might not be best for older adults in other age groups. Where possible, in the annotations, we note the ages of the participants in the research we review.

In "Segmenting Adult Web Users into Meaningful Age Categories," [2] Bailey reviews a number of studies and articles to determine "how old is old?" Bailey suggests these segments:

- young - 18-39
- middle-aged - 40-59
- older - 60-74
- old-old - 75+

Table 1. **Age ranges in studies of older adults**

Study	Age of "older adults"	Included younger participants
Bailey, Ahmadi and Koyani	70-80	yes
Bernard, Liao and Mills	62-83	
Chadwick-Dias, McNulty and Tullis	55-82	yes
Chadwick-Dias, Tedesco and Tullis	65+	yes
Chisnell, Lee and Redish	50+	
Coyne and Nielsen	65-80+	yes
Gregor, Newell and Zajicek	not specified	
Hawthorn	60+	yes
Jacko, et al.	54-91	
Josephson and Holmes	mean 58; range 55-65	yes
Kantner and Rosenbaum	65+	
Lin	57-67	
Maguire and Pearce	50-70	yes
Moore and Matthews	50+	
Wagner and Turns	51 - 80+	yes
White, Jerrams-Smith and Heathcote	not specified	
Wright and Belt	50 - 83	yes
Wright, Belt and John	61 - 75	yes
Zajicek and Hall	not specified[3]	
Zaphiris, Kurniawan and Ellis	mean age 67.5; range 57+	yes

[3] Although Zajicek and Hall do not specify in their paper what they mean by "elderly," in other publications not included in this review Zajicek defines "older adult" as age 70 and older.

What factors besides age must we consider?

Age is much more than a chronological indicator. As the birthday card says, "70 (or 40 or 50 or 60) isn't old if you're a tree."

There is huge diversity in an audience that ranges in age from 50s to 80s, 90s, and beyond. Part of this diversity is ability, and yet even within abilities, there is great diversity. We know that there are many ways in which vision, cognition, and motor skills diminish with age. Part of this diversity is in attitude and aptitude. There are more older adults going online for the first time every year, but many other older adults have been using computers for a long time for a wide variety of purposes.

In AARP's 2003 studies, many participants told us that when their parents were their age, their parents were old, but the participants themselves were not. For one thing, they expected to live longer than their parents expected to. But we also heard different attitudes – more about an overriding positive outlook that accounted for something other than expectations of longevity [Mazur and Lee [34]; Chisnell, Lee and Redish [11]].

Why is it important not to view older adults as one group?

Several of the studies we reviewed assert that by viewing older adults as one large group we are missing important elements of diversity that probably would influence design quite heavily. Oversimplifying or stereotyping older adults to design to the least able does not always benefit all users [Battle and Hoffman [5]; Hawthorn [26]; Lippincott [32]; Theofanos and Redish in press [46]; White, Jerrams-Smith and Heathcote [49]] and could alienate some [Hawthorn [26]; Morrell, et al.[38]]. As Hawthorn finds:

> Firstly, it is almost impossible to gain properly representative samples. In fact, given the variability inherent in the older population, techniques that produce average results misrepresent rather than inform.

Wright [50] concurs, concluding, "When conducting user tests it is not necessarily the case that age is the most important characteristic on which people should be matched."

The next three sections discuss the different factors, besides chronological age, that figure into this diversity.

Ability

As Gregor, Newell, and Zajicek [21] suggest, older users might be better thought of in terms of ability rather than age. They divide older adults into three groups:

- fit older people: These people don't appear to be disabled and don't consider themselves disabled, but they definitely are not as able as they were when they were younger.
- frail older people: These people usually have at least one obvious disability, but often have other limitations.
- disabled people who grow older: These people have long-term disabilities that are also affected by aging.

Many researchers in this review studied older adults who were novice users and/or had disabilities:

Fisk, et al. [17]
Gregor, Newell and Zajicek [21]
Hawthorn [26]
Jacko, et al [27]
Kantner and Rosenbaum [29]
Moore and Matthews [37]
Morrell, et al. [40]
Theofanos and Redish [45][46]
White, Jerrams-Smith and Heathcote [49]
Zajicek and Hall [55]
Zajicek and Morrissey [54]

These are important users within the older adult population, but they do not represent the entire spectrum of older adults.

Others of the researchers focused on "fit older users" who have some Web experience:

Bailey, et al. [3]
Bernard, et al.[6]
Chadwick-Dias, et al. (all studies)
Chisnell, Lee and Redish [11]
Coyne and Nielsen [13]
Josephson and Holmes [28]
Lin [31]
Zaphiris, et al. [56]

The needs and differences among the types of older adults are important for Web designers. (In this literature review, we include only a few references to the literature about accessibility independent of age; we focus on accessibility research related to older adult users.)

Aptitude (experience and expertise)

In research with users of all ages, experience and expertise with the technology may be important factors in how well users work with Web sites. As with ability and attitude, it is not entirely clear how these correlate with chronological age. The current population of older adults generally has less experience and expertise than younger users; however, that is obviously going to change as users who have had years with computers at work join the older user population.

Furthermore, experience (length of use, frequency of use, type of activities) does not seem to be the same as expertise (being able to identify elements of a Web browser, for example). Chadwick-Dias and her colleagues at Fidelity found that even when they controlled for experience, expertise scores differed and that it was expertise that correlated with age and with performance [9]. Other researchers also found that experience was not a reliable indicator of true expertise for older adults. [Chisnell, Lee, and Redish [12]; Coyne and Nielsen [13]; Hawthorn [26]]

However, measuring and controlling for computer and Web expertise may be difficult. Gregor, Newell, and Zajicek [21] discuss this issue. Chadwick-Dias, et al. in a 2004 paper on "Older users and Web usability: Is Web experience the same as Web expertise?" [9] report their work on a method for controlling for computer and Web expertise that they developed over a series of several studies.

Several studies suggest that differences in aptitude (expertise) among older adults relate to exposure to training and cooperative learning. [Chadwick-Dias, McNulty and Tullis [10]; Coyne and Nielsen [13]; Chisnell, Lee and Redish [12]; Hawthorn [26]; Maguire and Pearce [33]] Older adults who did not learn computers and the Web at work do best when they learn in cooperative, hands-on settings.

Attitude

Thinking of oneself as "young" or "old" can affect physical and mental fitness and ability – and also affects attitudes and other behaviors. For example, people in their 60s and 70s who don't perceive themselves as old are less risk-averse than people in the same age range who do consider themselves old. While they may joke about having had a lot of life experience, their attitudes about what that life experience means affects their willingness (or not) to take on new challenges such as learning to use a computer or diving into the Web. In our 2003 AARP studies, we saw attitudes of not wanting to be left behind and we saw attitudes of being afraid of appearing stupid in front of friends, family, and coworkers. Those attitudes are another factor we must consider.

How have these different factors been used in research studies?

Table 2 below shows which studies tried to control for which aspects:

Table 2. **Controls used in different studies of older adults**

Researchers	Controls
Bailey, Ahmadi and Koyani	Chronological age; computer and Web experience; general physical fitness
Bernard, Liao and Mills	Chronological age; vision impairments
Chadwick-Dias, et al.	Chronological age; computer and Web experience and expertise
Chisnell, Lee and Redish	Chronological age; Web experience
Coyne and Nielsen	Chronological age; Internet connectivity (although they don't say it, report assumes participants had Web experience)
Gregor, Newell and Zajicek	Chronological age; general fitness; memory retention
Jacko et al	Chronological age; vision impairments; physical and mental health; handedness; manual dexterity; computer experience and comfort level
Josephson and Holmes	Chronological age; computer and Web experience
Lin	Chronological age; computer and Web experience

Researchers	Controls
Zajicek and Hall	Chronological age; vision impairments (first time Web users)
Zaphiris, Kurniawan and Ellis	Chronological age; computer and Web experience; medical conditions such as physical or cognitive impairment; functional literacy

What should we do? A proposal for defining segments within the older audience and a model for measuring aspects of variety

Based on our readings for this review and our own experiences, segmenting the older adult population simply by age is not enough. A more nuanced approach is needed in order to understand the research, plan new research, and plan and design Web sites.

We propose a new approach for quantifying characteristics in combination to identify more specific audiences within the population of older adults. The tool we propose could be used by Web design teams to help them make decisions about where their users fall along these dimensions and thus how best to serve their audiences.

Our approach looks at the four factors we have been discussing:

- age: including chronological age, but taking into account life experiences
- ability: cognitive and physical
- aptitude: expertise with the technology
- attitude: confidence levels and emotional state of mind

Figure 1 shows the four factors.

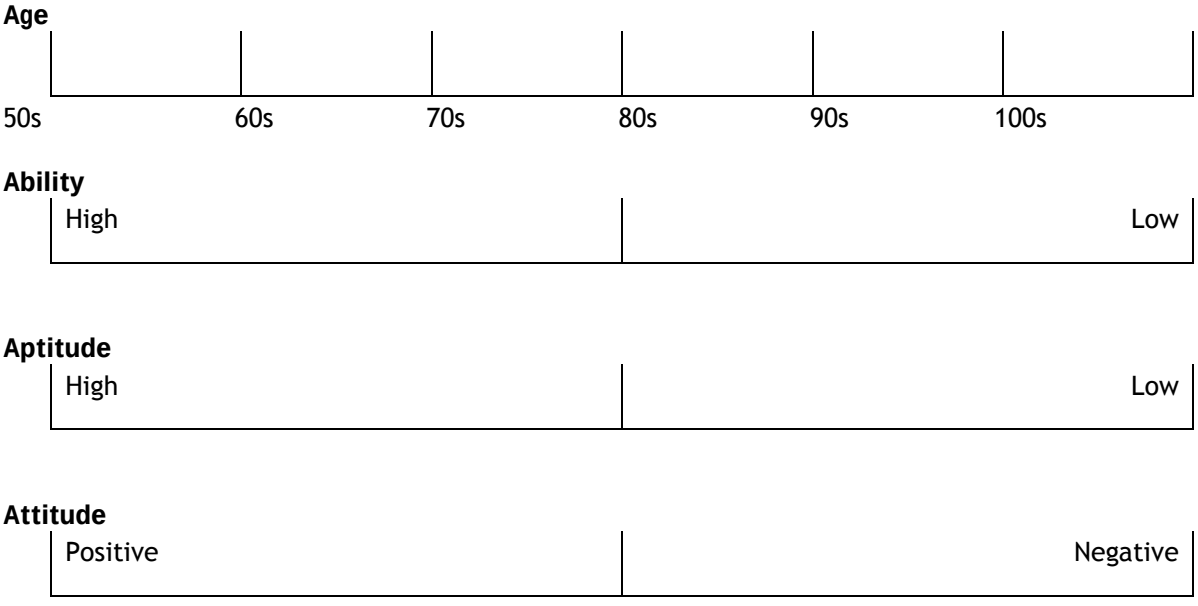

Figure 1. Four attributes for segmenting "older users" into more realistic groups for Web design

What goes into these four attributes?

Age — both chronological and experiential, along with maturity level; life events and experiences (i.e., various jobs, not just the most recent; military service; marriage, divorce, children, places lived); education level (including when it was achieved)

Ability — degrees of physical and cognitive limitations or restrictions [Theofanos and Redish [46]] requiring little remediation up to needing assisted living [Jacko, et al. for health and accessibility testing [27]]

Aptitude — expertise with computers and the Web (being more relevant than straight measures of experience) [See all of the Chadwick-Dias, et al. studies [7][9][10]]

Attitude — positive and forward looking, risk-taking and experimental — or negative, fearful, or diffident; confidence levels and emotional need for support from another human being [Gregor, Newell and Zajicek [21]; Hawthorn; Kantner and Rosenbaum [29]]

What are the implications of these four attributes?

We can use these four attributes to judge the need for support and training and the level of complexity of features and functions that different users can be expected to handle. As we move towards the right on each of these dimensions, users are likely to need more support and training and less complexity in Web sites. Users far on the left of each of these dimensions are more likely to need less support and training and be able to handle more complexity.

Of course, the interesting and important issues are the trade-offs that are likely to be necessary for people who are in different places on different dimensions. That is, increased age is likely to require less complexity, but increased aptitude allows for more complexity. Higher ability (that is, physical and mental fitness) allows for more complexity, and higher ability is likely to also correlate with lower age.

Further research is needed to assess the relative importance of the different dimensions in designing Web sites. From the research reviewed here, we know that age is less important than the other three dimensions. We do not, however, know the relative importance of, for example, attitude compared to aptitude, nor how closely those correlate with each other.

How might designers use these four dimensions?

As Web design teams develop personas of their users, the descriptions should include all four dimensions. For example, the two personas we are using in the research project for which this literature review is the first phase are Matthew and Edith. Figure 2 shows our two personas and their descriptions.

We can place each of our personas on the four dimensions to give us a sense of the differences in how they approach Web sites and what parts of the older adult audience they probably do and do not represent.

Matthew

Matthew is a 54-year old attorney from New York City. He's married, and he and his wife work full time. Their income averages six figures, and it ought to for the hours they each work.

Matthew doesn't have much time for the Web. He uses email at work, and sometimes makes vacation plans or reads the newspaper online. Mostly, it's a tool to get things done. Fast. When something doesn't work right away, Matthew moves on. He doesn't have the time or patience to figure it out.

Matthew doesn't use the AARP Web site, but he expects that when it's time to renew his membership, he'll try to do it online this year and save himself the paperwork.

Matthew is still feeling fine although his doctor says he needs to exercise more. He wears contacts; his eyes aren't what they were when he was younger.

Edith

Edith is 73 years old. She lives in Miami, Florida, with her husband of 49 years, Doug. They worked hard in the restaurant business, and she's glad that they have retired. Their income is about $40,000 a year, from Social Security and what they got when they sold the restaurant.

They used much of the money from selling the restaurant and their house up north to buy a small retirement house in Florida. They put down a lot of cash for the Florida house to keep their house payments low.

Edith and Doug like to joke that they can't count how many grandkids they have anymore. It's been too long since they've seen each other. Sometimes they get pictures through email (how do their kids do that?), and that's nice. They can print them out.

Edith really doesn't use the internet much – and neither does Doug. She's never been to the AARP Web site before. It had not occurred to her that there was such a thing until she saw something about it in the AARP magazine last month. The magazine did a special on Boulder, Colorado, as a good place to visit. Edith thinks she'd like to go there with Doug for their anniversary. She wants to find about what AARP has to say about Boulder.

Edith's hearing isn't what it used to be. She likes that her hair style covers her hearing aids. She took off her glasses for the picture, but she needs them to read or look at the computer. She has slight arthritis in her hands so sometimes using the mouse is a problem.

Figure 2. Two personas for our persona-oriented, task-based review of Web sites

Figure 3 shows two personas aligned on the four factors.
M is Matthew and **E** is Edith.

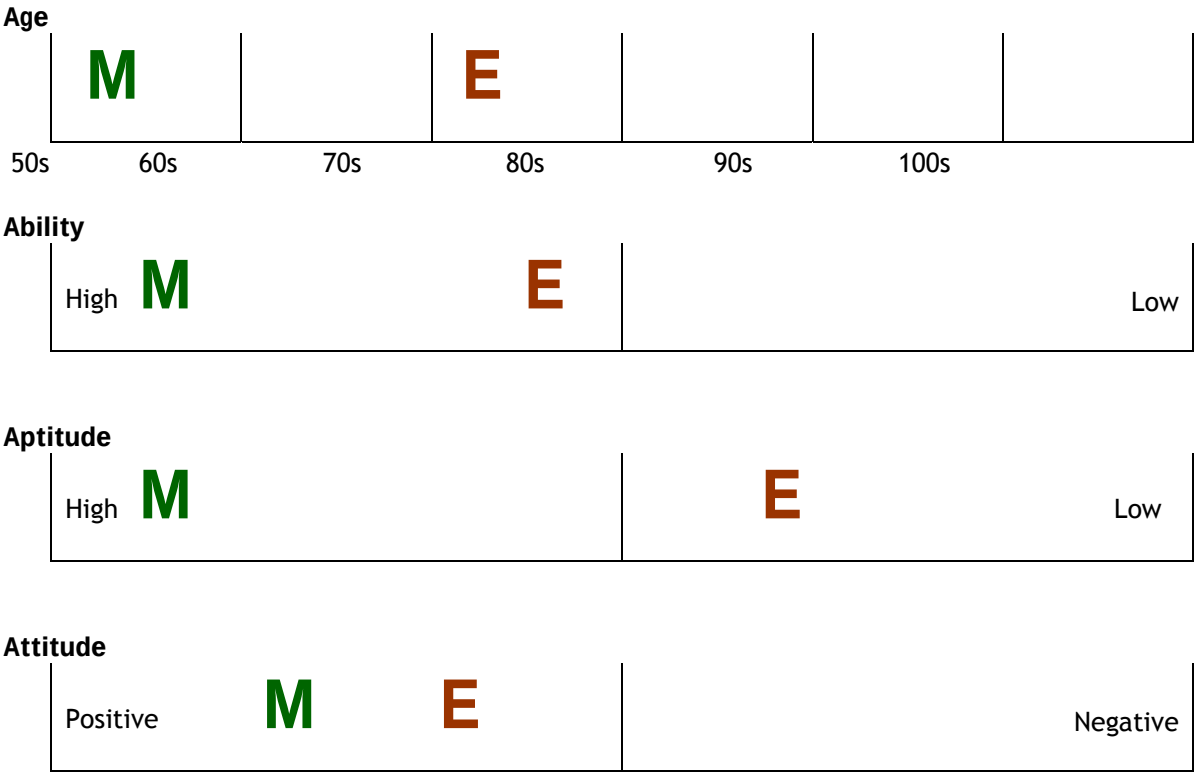

Figure 3. Two personas along each of the four dimensions

How might researchers judge where people are on the four dimensions?

Eventually, we would like to be able to quickly and easily assess where potential participants in our usability and research studies are on each of these dimensions without overburdening them. Measures for some of these exist today, for example, for the various elements that go into ability. Ability, of course, is more than a single dimension; it includes vision, cognitive, and motor impairments – and even within each of these (for example, vision) measurements for different types of problems. Chadwick-Dias and her colleagues at Fidelity are working on aptitude. There is considerable literature about users' attitudes about computers and the Web that may be transferable to assessing attitudes for the purpose of segmenting audiences.

What must we keep in mind about older adults?

Knowing that older adults who use your Web site are different from the younger adults who use it, and that they are different from one another, what can you – should you – do about it? Your Web site probably can support only a subset of the ranges of age, ability, aptitude, and attitude that exist among older adults using technology available now. Your organization must make specific decisions about the types of older adults you want to attract and support on your Web site.

Involving older users as you design

To design well for older adults, you must consider the whole experience of the older adult. To do that, you must involve older adults in the design and evaluation process. Fisk et al [17] , Morrell et al [40], and Hawthorn [26] insist that older adults be included by having them evaluate products, at least. Tedesco, Chadwick-Dias and Tullis [44] have created and tested a participatory design method that they believe lessens the stress and nervousness that many older adults feel when using a computer.

Gregor, Newell and Zajicek [21] suggest that the typical user centered design (UCD) process must be modified when older adults are involved. Because the older adult audience is so diverse, they say, classic UCD processes do not always work well. They propose User Sensitive Inclusive Design (USID), which looks at "universal usability" from a different angle – taking into account more of the specific demographic, learning, and behavioral characteristics of the older adult audience.

Battle and Hoffman [5] go further, asserting that UCD processes are rarely applied in creating accessible applications. Theofanos and Redish [46] argue that designers must rethink our approach to accessibility when audiences are highly diverse.

Taking a broad view of "user experience"

After poring through dozens of Web sites, reviewing between 50 and100 articles, reports, papers, chapters, and books for this review, and thinking about the many older adults who we've met in our studies, "user experience" seems to include these qualities:

- clear understanding by the site designers and content providers of who the users are (including demographics, domain knowledge, technical expertise, and frame of mind) and why they come to the Web site (tasks, triggers, and motivations)
- plain and immediate communication of the purpose and scope of the Web site (as shown through the visual design, information architecture, and interaction design)
- compelling, usable, desirable, useful, and possibly delightful content (including tone, style, and depth of content)

In the larger context, the user experience (or customer experience, or member experience, or citizen experience, or voter experience, or patient experience, and so on) encompasses all of the points at which you or your organization have contact with that one person – and the thoughtful consideration of what you want that contact to be like.

A useful analogy. Think about restaurant design. A lot of thought goes into how long the restaurateur wants you to stay, how much they want you to spend, and what they want you to tell your friends about what you ate and how you felt when you were there. It isn't only what the place looks like, whether the furniture is comfortable (or whether there is furniture at all), and the taste of the food. It is also what the staff looks like, how they behave, how well they know their jobs, and how they appear to interact with one another. And, let's not forget, the restaurateur has to figure out how to compel you to go to his or her restaurant. Even within types or levels of restaurants, there are different approaches to design. After all, the experience you have at TGI Friday's is pretty different from being at Taco Bell – but as a customer, you still know basically what to expect. There are parallels in Web site design.

It takes many roles to create a useful web site. There are many, many roles involved in designing and creating any "user experience" on the Web (or with any other product). At the least, creating and maintaining a Web site takes the coordination of many disciplines and professions. DUX, a conference organized by a convergence of professional organizations, suggests that all of these roles (and probably more) contribute to designing the user experience: (DUX = Designing the User Experience. See www.dux2005.org)

Animation	Graphic Design	Product Management
Anthropology	Industrial Design	Software Engineering
Branding	Information Architecture	Usability
Business Analysis	Information Design	User Interface Design
Cognitive Psychology	Interaction Design	Venture Capital
Content Strategy and Creation	Marketing	Visual Design
Ethnography	Organizational Planning	

We would also add Technical Communication, Instructional Design, and Support organizations of various kinds, such as technical support, customer support, and sales support.

Users are task-focused. When people approach a computer and the Web, they think about what is relevant to their goals – they're focused on the work they want to accomplish (tasks) not learning the tool/Web site/software application. They also bring their own experience and expectations to the task and to the Web site they're using to answer their questions. But they don't think about how the site works; they're just behaving.

The notion that users create images in their minds of how a Web site, Web page, or other system works is very system-oriented. It seems unlikely that any users come at the Web (or other systems) this way. (They don't arrive at a Web site and say to themselves, "Gee, I wonder how this site is organized." They are more likely to arrive at a Web site and say to themselves, "How do I find the information here about X?")

Instead, it seems probable that users build a *limited* idea of how a Web site is organized from the short, isolated interactions they have with the site. Users do not typically spend a lot of time exploring the site to learn it because they are focused on a task. And most older users are even less prone to exploring than younger adults are.

Coyne and Nielsen [13] and Kantner and Rosenbaum [29] note that older adults simply have not had the opportunity to grasp what more experienced computer users consider standard interaction devices (widgets) such as buttons and links, and how to react to information and error messages. The inability of some older adults to understand the underlying concepts of how computers or Web sites work could stem from

- the expectation that something will be difficult to use
- lack of experience from the rest of the world to bring to the task of using the Web
- lack of a match between how the designer conceptualized the system and how the user views the task
- issues of limitations of working memory

Evidence from the research included in this review suggests that rather than creating a fragmentary idea of how a Web site works, older adults simply avoid burdening their memory by not conceptualizing sites at all. (Because researchers who included younger participants in their studies such as Coyne and Nielsen [13] and Hawthorn [26] do not mention similar problems with younger participants, we assume that the researchers have some evidence that younger users do create conceptual models of Web sites.) It seems likely that users of all ages mentally model their *tasks* and how to accomplish those within the system they're given rather than thinking much about how each system works. We would like to see more research on whether Web users of all ages model how sites work, and if they do, how and why.

What research questions are left?

Although the literature reviewed here gives us great insight into the world of older adult Web users, many research questions remain. The existing research is not all in agreement, so studies are needed to understand the differences in these results. Our analysis over the last several pages and in the synopses that follow this page also raise questions that need further research.

Not all work about older adults is in agreement

Not everyone agrees about everything about older adults and how they use Web sites. Some findings appear to contradict each other and what we thought we knew.

For example, while nearly everyone agrees that older adults are generally slower at nearly everything than younger adults are, whether older adults are more or less prone to scrolling has shown different results. Morrell, et al. in the *Compendium* [40] observed that older users rarely scroll, and that they seem unfamiliar with the idea of scrolling. However, Coyne and Nielsen [13], Chadwick-Dias, McNulty and Tullis [10], and Chisnell, Lee and Redish [11] assert that their participants over 65 years of age seemed to scroll *more* than younger adults, especially in situations in which they were selecting products or looking for entry points to information. We need to understand these differences better. There may have been differences in ability or expertise among the participants in these different studies. The date of the studies may be a factor; usability practitioners who found very few users comfortable scrolling a few years ago now find that most users do scroll.

A few of the research questions that remain

Here is the beginning of a list of questions that remain to be answered:

- Would older users prefer larger type even if it meant they had to scroll?
- Do older users know about scrolling, know how to scroll, willingly scroll – or not?
- Do older adults who have computer and Web expertise slow down as they get older?
- Do Web users of any age actually create mental models that they can articulate of how a Web site is organized?
- How much does consistency within a Web site matter? At what levels? What aspects of consistency of visual design help or hinder older adults in getting and staying oriented within a Web site?
- How important is age as a determining factor of how much functionality, complexity, and support can and should be built into Web sites that have older adults in their audiences?

- How much does attitude affect older adults learning to use the Web quickly and effectively?

In the following sections, we summarize studies or articles to compare results and answer some of the questions we were most interested in related to Web site design and older adults.

Interaction Design: Designing the way users work with sites

The Interaction Design Group (at http://interactiondesigners.com), characterizes *interaction design* as "defining the complex dialogues that occur between people and interactive devices of many types—from computers to mobile communications devices to appliances." Humans and technology act on each other. In the case of Web sites, interaction design determines how a Web site behaves. This behavior manifests as navigation elements: scrolling, links, buttons, and other widgets, along with how they are placed on a page, what their relationships are to each other on the page, and how easily users can recognize the elements and what the elements will do for them.

The navigation schema for a Web site and its information architecture are tightly bound. Both are driven by designers understanding clearly who the users are and what tasks they want to accomplish on the site. Any processes represented in the navigation of the site must match how users think of that process. Placement and labels of navigation elements must feel "natural" and come to hand at the time the user expects to use them to perform a step in the process. In addition, these elements or widgets must behave predictably, consistently. Unfortunately, some consistency in interaction design has been purposely ignored for the sake of "design" on many, many Web sites. A notable case in point is the convention of underlining links.

A case for design conventions

Since the World Wide Web was invented, the default implementation of hypertext links on Web sites has been to show the linked text underlined and colored blue:

a conventional link

Links that have been used or "visited" turn another color, usually **purple**.

In fact, HTML coders must go to some trouble to code links to look differently. Jakob Nielsen has advocated using conventions for links for many years. Evidence from his 2002 study (with Kara Coyne [13]) with seniors supports using this convention. Many older adults do not know conventions such as this one for links, but they are drawn to highlighted items and are more likely to click on whatever looks clickable to them [Chadwick-Dias, McNulty and Tullis [10]; Chisnell, Lee and Redish [11]]. Using standard link treatments is just one example – if design elements such as links were implemented across sites in standard ways, using the sites would be easier for older adults (and probably for all users).

Why does it matter if you're not following convention as long as you're consistent within your Web site? The main reason to implement navigation in conventional ways is that between 49% [Fox, 2004 [19]] and 53% [Turns and Wagner [48]] and up to 88% (Jakob Nielsen's Alertbox, August 16, 2004 at www.useit.com/alertbox/20040816.html) of people who visit your site arrive there from a search engine. This also means they could drop in anywhere in your site, not necessarily at the home page. Older adult Web users use search engines nearly as often as younger users (76% versus 80%) to find

answers to specific questions [Fox, 2004 [19]]. According to Coyne and Nielsen [13], using search within Web sites gave seniors in their study a feeling of control.

The implication of a large number of the visitors to your site ending up there indirectly is that they must learn to use a new design every time they go to a new site. If we designers ignore convention for no serious design reason, we do all users – but especially older adults who have little Web expertise – a disservice and risk losing these visitors to sites that are designed in conventional ways.

Scrolling

There are several interesting problems with the act of scrolling:

- For older adults who are novices to computers, the concept of scrolling pages is completely outside their experience.
- Many wired older adults are using older computers with slower connections to the Internet than their younger counterparts, so loading long pages and graphics is very slow.
- General kinesthetic sensitivity (ability to control movement) degrades with age, so controlling a mouse in combination movements (such as using pull-down menus and scrolling lists) becomes difficult.

Scrolling is a learned behavior

Clearly, scrolling Web pages is a learned behavior. There's nothing intuitive about it. Morrell, et al. in their *Compendium* assert that scrolling is problematic for the old-old who are computer novices because these users don't understand the concept of scrolling. In studies leading to the *Compendium*, these participants were mystified that there might be something "below the fold." Results in iterative design and usability testing phases performed by Morrell and colleagues on NIHSeniorHealth.gov led the team to conclude that the best way to improve performance for older adults who are novice users of the Web was to eliminate scrolling of any kind.

Older users often have slow Internet connections

Another concern with long pages is loading time. For now, designers should assume that older adults have hand-me-down computers that are slower than others on the market, and older adults are using dial-up connections to the Internet rather than high-speed connections [Fox, 2004 [19]; Morrell, et al. in *Compendium* [40]; Coyne and Nielsen [13]].

But they do text-intensive activities

We know however, that a large proportion of Web-using older adults often engage in text-intensive research activities online. According to the Pew Internet and American Life Project in March 2004 [19]:

- Many get news online: 75% of older adults age 50-58; 67% of those age 59-68; 58% of those age 69 and over.
- Sixty-six percent of wired seniors had done product research online by the end of 2003.
- About 52% of wired older adults have searched for information about their hobbies online.

Plainly, these situations demand large amounts of text, not all of which can be chunked into such small units that all of the text appears "above the fold." And implementing even more pages on already large and complex Web sites would become unmanageable and difficult to navigate.

Some researchers find that older adults scroll more

Once older adults become familiar with the concept of scrolling, the challenge is to minimize scrolling and make it easier, since we know that dexterity degrades for many older adults, making scrolling and other hand-controlled actions more difficult and less precise [Fisk, et al. [17]; Morrell, et al. in *Compendium* [40]; Czaja and Lee [15]].

Coyne and Nielsen [13] found that older adults scroll and read more than younger adults, demonstrating similar conservative strategies in finding information to those observed by Chisnell, Lee and Redish [11] and Chadwick-Dias, McNulty and Tullis [10], Bailey, Koyani, et al. [3] expected and found that older users scroll more slowly than younger users. Although Ahmadi and Koyani [1] assert in their presentation to the National Cancer Institute that scrolling techniques vary by age (e.g., older adults clicking end arrows on the scroll bar), their paper for Usability University in July 2004 reported that there were no significant differences in how older adults approached scrolling from how younger adults approached scrolling.

Therefore, if you use scrolling…

Opportunities exist for minimizing and even eliminating scrolling problems *within* sites. For example, Hawthorn [26] suggests adding larger scrolling buttons in the same way that some sites have added buttons or widgets for increasing text size. Any pop-ups or secondary windows with important content should be opened wide enough to prevent the need for horizontal scrolling, and ideally should open long enough to prevent vertical scrolling [Coyne and Nielsen [13]; Chadwick, McNulty and Tullis [10]]. Rather than using pull-down menus and scrolling lists, designers should consider using drop-down menus that stay open once clicked or fields in which users can type or lists with checkboxes [Coyne and Nielsen [13]; Kantner and Rosenbaum [29]].

It would be interesting to study whether older adults would trade off having larger type for scrolling. [Chadwick-Dias, McNulty and Tullis [10]]

Buttons and links

For older adults, there is often a question of what is clickable. And, once an older adult has identified a target, there are often problems of actually hitting the linked area of the target because of problems related to fine motor movements.

Older adults, even those with some Web expertise, often try to click on anything that might be clickable, such as headings, numbered lists, and bullets in bulleted lists [Chisnell, Lee and Redish [11]; Chadwick-Dias, Tedesco and Tullis [7]; Chadwick-Dias, McNulty and Tullis [10]; Coyne and Nielsen [13]]. These researchers, therefore, recommend making graphic bullets as well as the bulleted items clickable.

When given the opportunity to design their own home pages for a financial services site, older participants were very likely to include widgets that were obviously clickable and visually looked like buttons [Chadwick-Dias, Tedesco and Tullis [7]]. Bailey, Koyani, et al. [3] found that older adults did not know how to use page-based controls – what they call widgets – as well as younger adults did. These widgets included many interaction elements used on Web sites, including buttons of different types.

Should buttons have illustrations? Battle and Hoffman [5] recommend not using buttons with icons or icons with links because the icons are usually too small for mobility-impaired users to click on. However, Holt and Morrell suggest that tight integration of text and illustration (including icons) by using text-relevant images or graphics may assist comprehension of the text and labels [also, Morrell, et al. in *Compendium* [40]]. Echt (in [39]) reports that study participants were least confused when using buttons that had both symbols and text compared to buttons with only text or only symbols. It seems as if illustrations can help – if they are relevant, immediately understandable to the user, and large enough to be easily clicked.

Because older adults often are not sure what is clickable, many determine whether clicking something triggers an action by how the cursor behaves when they move it over a screen element. Echt (in [39]) suggests that when targets react to being pointed to – such as changing the pointing arrow to a pointing finger – to indicate that true targets are indeed clickable, older adults can be more confident about clicking targets. She further suggests providing additional feedback to confirm that the item was actually clicked [also, Morrell, et al. in *Compendium* [40]]. (See also "Feedback from the system: Using multiple message modes" starting on page 23.)

Young designers with good vision and high kinesthetic ability often design buttons and links that are too small and too close together for older adults to click on accurately. Older study participants performed more effectively using large buttons – at least 180 x 22 pixels – with expanded "hot spots" that effectively made the clickable area around the button larger and with more space between targets. Older users also performed more quickly when "sticky icons" were implemented. Sticky icons slow the cursor's gain as the cursor nears a target. Then the gain goes back to normal after moving beyond the target [Bailey [2]; Bailey, Koyani, et al. [3]; Bohan and Scarlett [7]; Coyne and Nielsen [13]; Holt and Morrell in [39]; Czaja and Lee [15]].

Menus and navigation

Assuming that menus and navigation lists exist to help users understand the scope of a Web site and then retrieve content or perform an action (not as aids for memorizing what is on a Web site), there are still some cognitive issues along with motor limitations that make menus and navigation elements difficult for older adults to interact with.

While the ease of use of menus and navigation elements is highly dependent on information architecture – especially labeling – interaction schemas for navigating online content have been studied quite extensively. For a discussion of breadth versus depth of menus, see the section on information architecture. Here we discuss options for facilitating access to content, such as linear versus hierarchical menus and expandable versus non-expandable menus.

Open lists versus layered, hidden hierarchies

As the main instrument for getting to content, some sort of directory of options or content must be included in a Web site. In studies of older adults using medical information, Holt and Morrell [in [39]] relate that Westerman and colleagues found that younger and older adults completed information-finding tasks more quickly and accurately when using a list of files or topics than they did when using hierarchical structures. (Lists here refers to seeing all the options together; hierarchical here refers to a layered approach where the user chooses from a short list and the choice leads to another list to

choose from, etc.) Both participant groups also performed better when the menu was explicitly provided. They theorize that making the structure of the site obvious puts less of a burden on working (short-term) memory and demands less in the way of making inferences about the underlying content. This research supports recommendations by Wright [50], who suggests that because older adults rely more on cues in their task environments than younger adults do, implementing advanced organizers such as process bars that illustrate processes or steps and where the person is within a process will help mitigate memory and attention issues.

Static hierarchies versus cross-linked (networked) schemas

Listing the content of a Web site directory-style may not be practical for most types of sites – unless they mean to be search engines or directories such as Yahoo! Not everything can be listed on the Home page. Considering that most commercial and government Web sites are rather large, most navigation schemas must depend on at least some layering of the options – a hierarchical information architecture.

In a study reported in 2003, Dyi-Yih Michael Lin [31] investigated differences in performance for older adults who used two types of navigation schemas. One schema was strictly hierarchical; the other was networked, making use of cross-referenced links outside of a hierarchical structure. Lin concludes that a navigation schema that supports users being able to get to more topics while revisiting fewer links provides greater ease-of-use and better spatial orientation within a Web site. In his study, participants' performance suggests that the hierarchical organization was the best. However, although participants who used the hierarchical schema took the shortest path to their goals, they were not faster than the participants who used the networked schema. (In this case, that may be due to the fact that users had to go back up a level to move laterally within the hierarchy.) Lin speculates that the network schema offers too many choices to older adults causing them to become lost or to forget where they have been on the site already.

However, Allen, et al. in McDowd and Shaw's [35] review found that when using information architectures with multiple redundant targets, older users were more successful in selecting the right target more quickly. We would like to see more research on networked navigation schemas and any advantages there might be to redundant links used along with hierarchical structures.

Moving and expandable menus

Many researchers have observed that older adults often have difficulty using pull-down menus, "walking" menus (that lead from one level of a hierarchy to the next when the user clicks or moves the cursor over an item), and menus that appear or content that changes when the user hovers the cursor over a target. [Coyne and Nielsen [13]; Chisnell, Lee and Redish [11]; Chadwick-Dias, McNulty and Tullis [10]; Morrell, et al. [39] and [40]].

The main issues around these types of moving navigation elements come from managing mouse movement. Morrell, et al. recommend against "walking menus" that expand automatically because they require precision movements that are often difficult for older adults. It isn't uncommon for older adults to have arthritis or slight tremors, leaving fine movement and selection of small screen elements literally hit or miss. Static user interface elements such as drop-down lists or lists with checkboxes offer several advantages: users can see at a glance how many items are in the list; they can see which items are in the list; and they don't have to hold down a mouse button while selecting items [Coyne and Nielsen [13]; Battle and Hoffman [5]; Kantner and Rosenbaum [29]]. In addition, Coyne and Nielsen

report that participants had difficulty remembering where they saw options when menu items moved or changed.

Expandable menus (or "walking menus") can help some users infer the underlying content within a section of a Web site more quickly and confidently than only seeing the top level categories, especially if the information architecture was not carefully labeled. Zaphiris, et al. [56] studied expandable and non-expandable formats for deep and broad menu hierarchies. While all participants (24 people aged 57 and older and 24 people aged 36 and younger) in the Zaphiris, et al. study rated the shallow hierarchies as easier to use, older and younger participants had opposite preferences on the expandable and non-expandable formats: Older participants preferred the non-expandable formats; younger participants preferred the expandable formats. Interestingly, although the oldest participants preferred the non-expandable hierarchies, they were fastest performing tasks using the broad expandable hierarchy but slowest using the deep expandable hierarchy. For more on breadth versus depth of information hierarchies, see "Wayfinding and orientation" starting on page 27.

Site maps

Conventional practice demands including site maps on Web sites. To some extent these tools are stop-gap solutions when the information architecture or the interaction design (or a combination) fails users – that is, when users can't tell where content is on the Web site. The purpose of a site map is to provide a quick overview of the entirety of a Web site. Surprisingly, some cognitive scientists actually recommend against implementing large site maps, claiming that giving older adults such a view of a Web site's architecture may overload their working memory and spatial ability. [Mead, Lamson and Rogers in [39]]. However, this theory is untested. Rather, providing anything like a table of contents for Web sites seems to help searchers find their way through sites efficiently [Holt and Morrell in [39]; Fisk, et al. [17]].

The Back button

Some researchers, such as Ahmadi and Koyani [1], claim that older adults use the browser's Back button more frequently than younger adults do. Older adults also tend to use the Back button to "undo" or reverse navigation steps they have taken [Ahmadi and Koyani [1]; Coyne and Nielsen [13]]; in some cases, Back effectively becomes a "cancel" button when users reach a place they didn't expect to get to or get to content they deem not useful.

Feedback from the system: Using multiple message modes

The Web is a highly visual place. Interacting with any one Web site or Web page typically depends on the user seeing what is on the page and visually identifying which screen elements most closely match what they want to do. Users of the Web get visual feedback all the time such as color changes, pop-up dialog boxes that contain error or confirmation messages, and changes in position or proximity of page elements, and so on.

Considerable research exists on using alternative modes for *input* to software, such as voice and gesture recognition [Jacko, et al. [27]]. Since most interaction between humans and Web sites concerns the humans consuming information rather than providing it, the research that turned up for this review concerns itself with different modes of *output*, or feedback from the Web site or system.

Several researchers have experimented with incorporating auditory [Zajicek and Hall [55]; Zajicek and Morrissey [54]; Morrell, et al. [38]] and haptic (touch) feedback [Jacko, et al. [27]] in Web sites to augment the visual experience – or in some cases, to replace the visual. Some groups have implemented additional visual information in the form of video or animation to support users who don't or can't read or who simply learn differently. As Stephanie Dailey [16] related about NIHSeniorHealth.gov, the designers implemented several layers of the same information, repeated in different modes: text, video, captioning, and "talking Web." The designers were careful to create different modes to access the same information without introducing distractions or creating possibly overwhelming situations.

In the rest of this section, we discuss aspects of auditory and haptic (touch) feedback for users, alone and in combination.

Auditory feedback and assistance

A fairly common approach to enhancing the usability and accessibility of Web sites is to include auditory assistance. Many blind users of Web sites use screen reader software to hear what is on Web sites, and designers of Web sites have experimented with incorporating "talking" versions of their sites for users who have vision impairments but who don't need or use screen reading assistive technologies [Morrell, et al. [40]; Dailey [16]]. Theofanos and Redish [45], in research for the US National Cancer Institute, present 32 guidelines for making sites more accessible and usable for users of screen readers. Their primary purpose was to close the gaps between ostensible accessibility and usability of Web sites for blind and low-vision people. It seems likely that the guidelines they suggest would make Web sites easier for all users.

Morrell, et al. [38] implemented a "talking Web" on NIHSeniorHealth.gov in part to help older adults train themselves to use the site. Rather than acting as a screen reader – which starts "reading" Web pages from top down until the user takes action to change what it does – the "talking Web" announces a new page and reads what the user points to.

In an effort to better support novice users with vision impairments, Mary Zajicek and her team at Oxford Brookes University in England developed what they call a "voice help interface" for a Web browser. Zajicek and colleagues [54][55] found that processing long auditory messages was difficult for older users, and concluded that grouping messages and making them as short as possible would make the messages easier to remember and use. One tradeoff is that as the messages get shorter and are grouped, they create a deeper menu structure. The team also had to reduce the functionality available to reduce the number of conceptual groups of items available. The voice help interface was found to be helpful in training novice older users, and Zajicek proposes that it could also be useful for older adults with memory impairment. Importantly, Zajicek and Hall [55] found that older adults were unable to deal with different lengths of parallel output messages. In later research, Zajicek and Morrissey [54] tested auditory messages against text messages with novice Web users with vision impairments. They found that participants retained more information in the text message mode than they did with the voice message interface.

Of course, for older adults with hearing loss, auditory assistance may not be the best solution. Even without hearing loss, some older users may have difficulty processing machine-generated or distorted speech. And Holt and Morrell [in [39]] caution against using audio on Web sites if users must actively download the files to use it. They add that because many older users have older computers, they may

not have adequate technology and peripherals installed on their computers to be able to hear the audio provided. They further recommend in cases where video and audio are used as the primary feed for information that alternative modes be supplied such as text captioning or other alternative text. Wright [[50], [51]] found that multi-modal messaging that is identical in every mode assists older adults to perform tasks more quickly and efficiently and does not impede younger users.

Haptic (touch) and combination feedback

Many people lose auditory ability as they age. Many men who worked for most of their lives in loud manufacturing environments have hearing loss. Baby Boomers may need hearing aids at a higher rate than earlier generations because of the loud music they listened to in their youths.

Many operating systems, software programs, and Web sites incorporate auditory feedback. This type of feedback often signals confirmations or errors or indicates a change of state. However, many older users cannot hear these auditory signals. They may not have the appropriate technology installed in their computers; they may not have the technology turned on; or they may not physically be able to hear it without a hearing aid. One solution is to use pointing devices now available that provide haptic feedback -- a vibrating pulse – through the mouse at times when others would hear a sound.

Some older adults are helped by having combinations of feedback. Jacko and colleagues [27] observed 59 older adults (age 54-91, with a mean age of 76) performing drag-and-drop tasks. Each of the age groups were subdivided into groups with and without different levels of age-related macular degeneration (AMD). Each participant received three types of signals in random order alone and in combination while performing tasks.

Jacko, et al. found that when other modes of feedback supplemented visual feedback, participants' performance improved. The greater the visual impairment of the participant, the lower the performance in the condition in which they received only visual feedback. No surprise there. But their data showed further that all of the groups studied were helped when they received at least two types of feedback simultaneously. Adding feedback modes did not hinder any of the participant groups, contrary to the expectation that older adults may become overwhelmed or distracted by multiple stimuli. The most visually impaired (vision at or below 20/100) were helped most by the tri-modal condition – getting visual, haptic, and auditory feedback. The control group, all of whom had normal vision (20/20 - 20/40), performed better with a combination of auditory and haptic feedback – better than with auditory only, and much better than only visual feedback. Interestingly, the group with the least vision impairment (20/40-20/50) but with AMD present had basically the same performance across all of the conditions, from just visual feedback to all three types. However, they did slightly (but not significantly) better with the auditory/haptic combination than with the other conditions. The main conclusion: as Web users age and visual acuity degrades, these people will be helped by getting feedback in other modes in addition to visual cues.

Contending that one of the things that holds older adults back in their use of the Web is lack of training, Zajicek and Morrissey [54] tested a Web browser enhanced with voice help instructions over several iterations.

In the first study, with 15 participants in each of two groups ranging in age from 60 to 92, the experimenters added what they call Voice Help to their BrookesTalk Web browser. VoiceHelp was meant to train users to use the browser, and the researchers assumed that users would eventually

wean themselves off using the voice messages and just use the basic browser, un-enhanced. Unlike the study in [55], they trained the participants through practice exercises and as a control to make sure that there weren't major differences in memory impairment between the groups. They compared the results of the older adult participants to results from 30 young adults. Zajicek and Morrissey found that young adults did not have the same problems as older adults in remembering long messages.

In the second study, with two groups of 6 people whose age averaged 73.25 years, the experimenters gave each participant the messages in two modes of output. Group 1 got text only and mixed mode messages; Group 2 got speech only and mixed mode messages. Group 2 showed no significant difference in performance in the two modes. Group 1 (text messages) overall scored better than Group 2 (voice messages), but the difference was not statistically significant. Participants did not perform significantly better in the mixed mode, and their recall rates were slightly higher with a single output mode than in the mixed mode. The authors conclude that text "appears to be the most effective output mode for information retention" perhaps because text can be skimmed and then re-read.

The third study brought in a new group of six participants. Each participant received short messages in text and in speech outputs, in random order. Unlike the earlier experiments, some participants in this study had used a computer before to write letters in Microsoft Word but they were not trained this time. The average age was 76.33. The researchers found that participants retained more information with text presented in very large type (72 point) at high contrast than they did with pre-recorded natural speech. Participants also preferred the text output.

Because the studies included here report a range of findings about whether implementing multiple modes of feedback is truly useful for older adults, we would like to see further research that investigates multi-modal feedback for people with a broad range of abilities and expertise.

Information Architecture: Organizing the content

According to Wikipedia, *information architecture* is the organization of information to aid in information retrieval. (See http://en.wikipedia.org/wiki/Information_architecture) Much of information architecture concerns taxonomy – dividing and classifying content into categories – but the issues of information architecture are larger than that.

There are two common questions about information architecture that affect all users but affect older adults with cognitive limitations most severely:

- Should a Web site's organization of topics (its hierarchy) be broad or deep? This touches on the user's sense of orientation while navigating through a Web site.
- Is redundancy in links good? That is, are more choices in a cross-linked hierarchy helpful for finding entry points to content?

In this section, we discuss the research about labeling links, different arrangements of menu hierarchies, breadth versus depth in navigation hierarchies, and whether having multiple entry points to content works well for older audiences – and why.

Labeling

The interaction between labeling of links and arrangement of links in an information architecture has yet to be studied in depth in relation to older adults. However, Morrell, et al. [40] recommend that

designers "carefully label links" to assist users being able to predict what content they will reach. Fisk, et al. [17] assert that the information architecture must reflect users' tasks and that the process of design must also include an assessment of whether the labels used reflect language that users are familiar with. The menu label for a task must correspond to a user's label for that task. Fisk, et al. also suggest that designers use the knowledge and experience of older adults to select appropriate labels, and that, by involving older adults in the process of labeling and designing information architectures, questions about breadth and depth may be resolved along the way.

Bailey, Koyani, et al. [3] found that older users tended to get lost on Web sites much more quickly than younger users "because they were penalized much more by poor labels and headers than were the younger users" and seemed less able to recover from these types of selection mistakes. Because their research shows that Web users skim or scan pages and are attracted to visual elements such as links, Theofanos and Redish [45] suggest using highly descriptive link labels, ensuring that a link will be understandable and useful on its own. They also suggest starting links with relevant keywords and avoiding multiple links that start with the same words. This should help all types of users, not only those who use screen readers or talking versions of Web sites.

Wayfinding and orientation

Hypertext linking – the primary vehicle for navigating information architectures – offers the advantage of non-linear connections among pieces of content. First discussed in research and publications in the 1980s, the basic technology has not changed in 20 years. However, implementation techniques and arrangements have been through a few trends, and as we point out in the information design section of the review, treatment of content in general is becoming more streamlined. For example, we are all finally moving away from using links labeled "click here" for a variety of reasons.

Still, myths abound. Designers base decisions about the breadth of menu hierarchies on distorted folk lore about short term memory research (Miller, 1956)[4], when the purpose of an information architecture is to assist retrieval, not retention. That is, on Web sites, users don't have to remember all of the choices they have to select from. They only have to be fairly certain that one of the choices will get them closer to their eventual goal.

Coyne and Nielsen [13] observed two types of circumstances in which older adults made more erroneous clicks than younger adults in their study. One type of error was due to the difficulty of picking links that were within tight clusters of links (See "Visual field and white space" on page 33). However, most click errors were due to choosing a link that took participants down the wrong path. Coyne and Nielsen explain, "This is not to say that seniors aren't careful with their clicks," but they

[4] The short-term memory cliché, "seven plus or minus two" is based on research that George A. Miller published in 1956 in *Psychology Review*. In 1956, information theory was brand new. In contemplating the number seven, Miller's premise was that when measuring information input and information output in a communication system, the more input the human absorbed as transmitted information, the more likely that human was to make errors in accuracy of what psychologists call "absolute judgments." He called this measure "channel capacity," the "upper limit on the extent to which" the human can "match responses to the stimuli" given to him. Miller asserts that somewhere around seven units is the "span of immediate memory." But Miller goes on to say that the span can be extended by arranging the "task in such a way that we make a sequence of several absolute judgments in a row." We propose that good information architectures supports the extension of a span of immediate memory and that the number seven has nothing to do with how easily web site users find what they're looking for within a site's navigation schema.

found that older adults "click on any link that looks promising." We take this to mean that their study participants seemed to filter through links that were offered. Chadwick-Dias, McNulty and Tullis [10] observed that older adults were indeed very careful about what they selected, especially in comparison to younger adults. Where younger adults seemed to be willing to click on anything because they are comfortable exploring, older adults click on anything but they are also very cautious before they click. Chadwick-Dias and colleagues called this "cautious clicking." Chisnell, Lee and Redish [11] observed that participants in their 50s seemed less risk averse than participants in their 60s and older. We speculate that there are a few reasons for this:

- many older adults are afraid of making mistakes [Gregor, Newell and Zajicek [21]; Kantner and Rosenbaum [29]]
- Web sites don't use consistent, conventional presentations for links
- older adults have difficulty visualizing how the Web and how individual Web sites work [Coyne and Nielsen [13]; Hawthorn [26]; Gregor, Newell and Zajicek [21]; Zajicek and Hall [55]]
- cognitively, the oldest adults are slower to recognize the right choice (perceptual speed) [McDowd and Shaw [35]]

The difficulty often comes after users choose from the first level of menu. Web design teams also make rules for themselves that it should take no more than two or three clicks to get to the desired content. While this goal might seem unreachable for many large Web sites, there is evidence showing that all users perform better using shallower hierarchies, but that older adults are disproportionately affected by depth in hierarchies [Zaphiris, et al. [56]]. Bailey, Koyani, et al. [3] found that older adults were much more likely (58%) than younger adults (19%) to become so lost in a site that they could not answer questions in task scenarios.

As users navigate a Web site, they look forward. That is, they begin by forming questions (tasks) that are refined as they learn more and move forward through a set of information choices toward their task goals. However, if the information architecture is very deep or highly interconnected with cross-referencing links, older adults are more likely to make errors in selecting links to reach their goals, get lost, and feel disoriented [Zaphiris, et al. [56]; Lin [31]]. If users are unclear where to go from the beginning, they may wander aimlessly, unable to recognize or remember where they have already been. If there are a large number of choices about where to go, or if there are choices that are not related to the task goal, users may be attracted by those unrelated choices, forget what they meant to do and not see how to get back to the point they digressed from [Lin [31]; McDowd and Shaw [35]].

Cognitive psychologists attribute this type of disorientation to two main factors: working memory (or short-term memory) limitations and losing the ability to maintain mental focus (or attention) [Craik and Salthouse [14]; Fisk, et al. [17]; Rogers and Fisk [43]]. This does not mean that older adults are unable to memorize the options they have, but they may not remember or recognize where they have been. A related cognitive skill is the ability to make inferences, which degrades in some people as they age.

Rogers and Fisk [43] relate a study by Westerman, et al. in which the researchers assert that all participants in the study performed better when they used menus that were lists rather than hierarchies, theorizing that the straightforward quality of the lists put less of a burden on working memory. However, for most Web designers, listing all of the content in one place simply isn't practical. The question becomes how to arrange the content within categories. Fisk, et al. [17]

recommend including older adults in the design process to match information organization "to the way older adults naturally organize information."

In research by Zaphiris, et al. [56], older adults using online hierarchies rated their sense of orientation lower than younger adults. Younger and older adults rated their sense of orientation higher in shallower hierarchies. Both younger and older adults rated deep hierarchies lowest in how well oriented they felt while using them. Younger and older adults gave shallower hierarchies a higher satisfaction rating than deeper hierarchies.

In the next sections we further explore Zaphiris, et al.'s [56] findings when they examined broad versus deep hierarchies along with two formats for the menus, expandable and non-expandable. Also, Lin [31] looked at the differences in performance in two types of topologies: hierarchical, where users can only move up or down; and "referential hypertext" or networked, where any one topic can be linked to any other topic or number of topics. McDowd and Shaw [35] relate Allen, et al.'s results with older users working with multiple redundant targets.

Breadth versus depth

How broad or how deep an information architecture for a Web site or other online information source is continues to be an important question as sites grow and expand. But that question existed well before the Web became available to the general public.

As Zaphiris, et al. [56] point out, there is extensive research about selecting items or topics from deep versus broad menu hierarchies. (In fact, they cite nearly 30 studies.) The earlier research results with college aged students using mainframe software and other information systems were repeated in this experiment comparing older and younger users using Web pages. All of the research to date shows that all types of users are more likely to become lost and make more errors the deeper an information hierarchy gets. In the Zaphiris, et al. study, although all participants took longer to browse deep hierarchies, older participants were slower than younger participants using the deeper conditions.

This same body of research establishes that the broader the first level of the hierarchy (within limits), and the shallower that hierarchy is, the easier it is for users to predict the underlying content and make the right choice the first time, and then again in the subsequent steps. In the Zaphiris, et al. study, the broadest information architecture condition had eight topics and was two levels deep. The deepest condition had two categories at the top and was six levels deep. The format of the display of the broad menu condition did not seem to matter; study participants made more accurate choices than they did with deep menu conditions whatever the layout.

Having a large number of choices isn't always good, however. Lin [31] discusses findings by McDonald and Stevenson that "the larger the number of choices… the more likely users become confused as to which path would be the correct way to the goal." How the choices are arranged does seem to make a difference. Lin found in his study that older adults were less likely to become lost in a hierarchical topology than in a network topology that covered the same breadth of topics. Lin theorizes that a hierarchy places a smaller cognitive load on older adults than a network topology in which users must remember where they've already been. In his words:

> The network topology requires the user to select from plenty of route choices resulting from the cross-referential linkage among nodes. We postulate that the referential multiplicity tends to inflict the Art Museum Phenomenon[5] on older adults who are vulnerable to spatial orientation.

Zaphiris, et al. also conclude that older adults did not make more errors in using information hierarchies than the younger participants. Longer search times for older adults were not related to the number of clicks that older adults made to reach their goals. The deeper the hierarchy, the slower the older participants got. This may be one explanation for "cautious clicking" [Chadwick-Dias, McNulty and Tullis [10]; Chisnell, Lee and Redish [11]]. Dailey [16] found in usability testing NIHSeniorHealth.org that the structure of their site was originally too deep and that as participants took more steps in a path in the Web site, they were more likely to make errors and get lost.

The finding from Zaphiris, et al. may appear to contradict what Coyne and Nielsen [13] found in error rates between younger and older adults. However, it is likely that the difference in findings can be attributed to different study methodologies. The Zaphiris, et al. participants all used the same content under different (but controlled) conditions but the Coyne and Nielsen participants used at least one Web site for each of 10 tasks, one site that the research team had selected and one that the participant chose.

Lin found that while older adults opened many more nodes (clicked more choices) in a networked architecture than younger adults, older and younger adults were equally likely to complete the task with correct answers. Lin takes the measure of going to more nodes to be one of failure of the network topology, but this is unclear, considering that the outcome for older adults was more often than not a correct answer. He asserts that using a hierarchical arrangement makes it easier for older adults "to develop a more accurate mental map concerning the entire topology of hypertext." We think it is more likely that users don't create mental maps of how whole Web sites are organized but instead infer what to do next on a Web site based on what they have done so far. If Web users do indeed create conceptual models of the sites they use, the participants in Lin's study should have been faster using the hierarchy than when using the network. Contrary to what Lin had expected, older adults were not faster using the hierarchical topology than they were on the network topology.

We might draw different conclusions from Lin in this case: the network topology may have been quite useful to participants by offering redundant entry points to the same text and their clicking on more links than in the hierarchy may have represented an exercise in eliminating choices (filtering – see McDowd and Shaw [35]) or exploring the additional options. As Lin adds, the depth and breadth of his topologies may also have had effects which were not measured.

Based on the research in this review, it seems clear that having more topics closer to the surface supports users better than creating deep, narrow hierarchies of information. It's better to have lots out in the open, grouped well. Two or three clicks may not be a hard and fast rule, but shallower hierarchies (needing fewer clicks to get to the right content) are better than very deep ones. These

[5] Coined by Foss in 1989, the Art Museum Phenomenon is described as being similar to non-directed browsing. "Users may be unable to recognize which nodes have been visited or which parts remain to be seen as a result of non-specific wandering."

are good principles for all users; but probably needed even more by older adults than by younger people who are often less cautious and more willing to explore by trial and error.

Redundant links: multiple entry opportunities

The jury is out on whether having multiple links leading to the same content is good or bad for older adults. In AARP studies, what older participants said and what they did sometimes conflicted. Some participants said they were confused by having multiple similar links on a page that they guessed led to the same content. These comments usually came up while participants were reviewing pages but were not asked to take action to perform a task. When participants were performing tasks, having multiple entry points to the same content helped study participants be highly successful in reaching their task goals.

Based on cognitive research by Allen, et al. in 1992, McDowd and Shaw [35] might have predicted that in Lin's [31] study of hierarchical versus network topologies the network topology would be more difficult for older adults to use because "when both targets and distractors are present in a display, older adults will take longer and perhaps be more prone to errors because [it becomes more difficult] to discriminate between target and distractor items." However, other cognitive research by Grice and Canham in 1990 points to potential "redundancy gain"[6] in networked information architectures. Theoretically, older adults should demonstrate a greater redundancy gain when there are more items to choose from, including distractors, because they have more opportunities to find appropriate target links because there is more than one correct link to reach the target. Lin's participants may have spent more time on the hierarchical topology because they thought about their choices longer, perhaps suggesting that they were eliminating options rather than actively selecting them. Research by Mead, Lamson and Rogers [36] suggests that when using redundant links, designers can better support visual search and selection and fast language comprehension by making redundant links say exactly the same thing.

Visual Design: Designing the pages

Designing the visual aspects of a Web site takes into account form, content, arrangement, light (or contrast), and color. It includes all of the visual elements on a page. Effective visual design depends on the context of the user and the context within the Web site. According to the Microsoft Software Developers Network design specifications and guidelines, "a graphic element and its function are completely interrelated. A graphical interface must function intuitively — it should look the way it works and work the way it looks."

Some of the recent and relevant research about visual design for older adults centers on type size and legibility but there is also much here about layout and visual searching. The research is important to Web designers because the compensation measures for one part of the older adult audience may not work for other parts of the older audience – or for younger audiences.

[6] "Redundancy gain is the empirical observation of faster response times when two or three instances of a target are presented compared with trials containing only one target." McDowd and Shaw in *The Handbook of Aging and Cognition*, second edition, p 225.

Visual search and eye tracking

We have known for several years that Web site users commonly skim or scan text for keywords related to the tasks they went to the Web site to work on [Moore and Matthews [37]; Redish [42]].

Johnson and Holmes [28] found that there were no age-related differences in where participants looked on Web pages among 24 study participants with similar Web experience. Eye path sequences were similar across the three adult groups they tested, whose age ranges were 18-25, 33-45, and 55-65. (They also tested a group of children who were age 8-11.) They theorize that further testing and analysis would show that expert (or as they say, "avid") users of the Web will be able to find information on a Web page very quickly and effectively regardless of age. It would be interesting to see a comparison of eye tracking between novice and expert users at different age ranges. We don't know what types of Web pages the participants were viewing as their eye movements were tracked or whether all of the participants were looking at the same or different Web sites.

Other studies show that older adults seem to perform better on pages with fewer "distractors" [Echt (in [39])]. (See "Visual field and white space" on page 33.) Distractors are items that are not related to the current goal of the user. The lower the number of distractors on a page, the faster older adults can process the information there. [Echt (in [39]); McDowd and Shaw [35]; Mead, Lamson and Rogers [36]]. Putting advertisements and other tangential content elements on the periphery of the page – rather than in the main part – may help older adults skim pages to more quickly find what they are looking for [Mead, Lamson and Rogers [36]]. Redundant visual cues such as color coding and spatial location can also assist older adults in discriminating visual elements on a page [Wright [50]].

Bailey, Koyani, et al. [3] found that while older adults took twice as long to scan for and select keywords, they read faster than younger adults when reviewing the same content online and there was no difference in comprehension. Although older Web users are slower at performing tasks [Coyne and Nielsen [13], Morrell, et al. [40], Ahmadi and Koyani [1]], they can be better and quicker at comprehending online information than younger adults [Ahmadi and Koyani [1]; McDowd and Shaw [35]].

Fonts and type size

In our experiences with older adult Web users and across the research we reviewed, older participants express strong preference for larger type. We have often observed older users having difficulty reading smaller text as they lean closer to the computer monitor and crane their necks to read through their bifocals.

Reduction in vision is the most common side effect of aging. As Morrell discusses in the *Compendium* [40], acuity and contrast sensitivity degrade, and the ability to distinguish colors weakens. The visual field grows smaller and moving the eye grows more difficult. Fisk, et al. [17] connect these physical difficulties with cognitive limitations in *dynamic visual attention*, which they characterize as "the ability to integrate from a large visual space information that cannot be comprehended in a single glance," along with language comprehension.

Morrell, et al. [40], Fisk, et al. [17], and Coyne and Nielsen [13] all recommend using type size of at least 12-point. Wright [50] recommends against text that is very large, saying that it may actually make

text more difficult to read because less is visible on the screen at any one time. They also tend to recommend using sans serif type faces for Web sites for older adults. However, Echt (in [39]) says that body text should appear as 14-point and headings should be 18- and 24-points in size.

Indeed, Bernard and colleagues [6] found an effect for type size when they compared reading efficiency between serif and sans serif type fonts with 27 adults between the ages of 62 and 83. Overall, participants read 14-point type faster than 12-point type. When given a choice, participants also preferred 14-point type over 12-point type. However, Bernard and his team found that participants read the 14-point serif type fastest. (One untested theory is that the participants in Bernard's study may have read serif type faces fastest because they are accustomed to reading newsprint, whereas younger adults may be more accustomed to reading text in other media which tend to use sans serif typefaces.) The study also compared typefaces designed for print versus typefaces designed for computer viewing. There was no difference in efficiency or preference. Contrary to Bernard, et al, Chadwick-Dias, McNulty and Tullis [10] found no significant effect on performance for text size for any age group in their studies. However, older users were more likely to prefer larger text sizes.

Coyne and Nielsen [13] recommend that designers always offer a button for users to change the type size. Of course, there is a trade-off between having larger text and seeing more on the screen at one time [Wright [50]].

Page layout

Placement of design elements guides the eye and indicates importance, precedence, and sequence [Moore and Matthews [37]]. Grouping and proximity of page elements provide visual guidance about related topics. Density of information on the page sends a message to users about the depth and breadth of information on the Web site. Tedesco, Chadwick-Dias and Tullis [44] found that by standing back to view participants' page designs, they could gather information about what users wanted in terms of white space and placement of page elements, giving them data about how much content users could tolerate on certain page types. They do not say whether older adults designed their pages with more or less white space than younger adults in their study.

Acuity and contrast

Issues for older adults include deficits in visual acuity, contrast sensitivity, the ability to distinguish colors, and narrowing of the visual field [Morrell, et al. *Compendium* [40]; Fisk, et al. [17]; Czaja and Lee [15]]. Problems with acuity, contrast, and color mean that some older adults will have difficulty noticing very small or very subtle elements, such as buttons or links that are similarly colored to the background, or clickable bullets [Czaja and Lee [15]]. When contrast between type and background is low, users can also suffer "disability glare," causing them to "lose" letters in text passages. When users are in a situation where there is both low contrast and disability glare, younger adults average a 4 letter loss and old-old adults experienced an average loss of 25 letters. High contrast also makes it easier for older adults to remember what they've seen and read and to make inferences from text. [Echt (in [39]); Zajicek and Morrissey [54]]

Visual field and white space

Usability practitioners probably have seen all types of users focus in the center columns of pages, but physically it becomes more difficult for older adults to notice content on the periphery of where they

are looking because for some, the viewable retinal area narrows by as much as one third [Echt (in [39])]. As Morrell [40] suggests, designers may want to avoid including important information and navigation in the far left and right of the screen. A related issue is visual attention, in that older adults often don't "see" entire pages at once, such as taking in an overview of a Web-based form [Barnett [4]], so important information must be within the visual field being used for the task being performed [Wright [50]]. However, it may be unrealistic to leave the sides of the screen completely unpopulated, and a narrow page layout may cause more vertical scrolling [Coyne and Nielsen [13]]. White space is also important within the main sections of the page. Incorporating appropriate white space and line spacing facilitates clicking links, icons, and other small targets. [Coyne and Nielsen [13]; Czaja and Lee[15]]

Redish [42] calls headings "critical," and says that breaking up the text with them makes the page more skimmable and creates interest on the page. Using headings also creates needed line spacing and white space on the page. Those elements not only assist visual search but lower demands on working memory as well [Fisk, et al. [17]]. Implementing the standards for headings and subheadings provided by the W3C along with the use of style sheets means that users can more easily control how these elements look and screen reading assistive technology works better [Battle and Hoffman [5]; Moore and Matthews [37]; Theofanos and Redish [46]].

Older adult Web users often complain about crowded, busy, and cluttered pages and express feelings of being overwhelmed when they encounter pages that appear to be very dense. Because older adults are attracted by cues such as highlighting (for example, headings, links, bold) [Fisk, et al. [17]; Redish [42]], the amount of highlighting of different types can be helpful or harmful depending on how cluttered the page is perceived to be. And, when there are many choices to make on a page, older adults may have difficulty distinguishing which items might be relevant to what they are looking for. [Battle and Hoffman [5]; Coyne and Nielsen [13]; Fisk, et al. [17]; Kantner and Rosenbaum [29]; McDowd and Shaw [35]]

The research supports using white space to help direct users' attention by grouping items on a page so that users can see at a glance how items are related. In addition, spacing combined with appropriate size of text, links, and buttons will make it easier for older adults to physically select the right link. We should thoughtfully consider the many tradeoffs between bringing important topics to the surface of a Web site by offering broad, shallow information architectures and how much content (of all types) is presented on any one page.

Information Design: Writing and formatting the content

Saul Carliner tells us (at saulcarliner.home.att.net/id/newmodel.htm#definition) that information design is the act of "preparing communication products so that they achieve performance objectives established for them." He continues: "Although graphic design and document design are important aspects of it, information design has a much broader focus than the appearance of information. Its ultimate focus is on the effectiveness of that information. That's why human factors and usability, as well as human performance technology, are fundamental issues in this discipline."

Although the Pew Internet and American Life Project [Fox [18][19][20]] reports that more than half of the older adult Web users they surveyed said they have gone online for no particular reason (54%), we also know that older adults who use the Web do product research (66%), purchase items (47%), make

travel reservations (41%), visit government Web sites (60%), look up religious and spiritual information (26%), and do banking online (20%). They have tasks and goals in mind when they log on.

Skimming and scanning

Like younger Web users, older adults are just as likely to "read to do" – or skim or scan text on Web pages to get what they need as quickly as possible [Redish [42]]. Older adults can be less patient than younger users and they may abandon a site or give up on an online task quicker than younger users. Coyne and Nielsen [13] found that in cases where participants decided to stop work on tasks, 71% were 65 and older.

Skimming behavior is common among all ages of fully sighted, vision-impaired, and blind users of the Web or all ages. Fully and partially sighted users skim with their eyes (some with the help of assistive technologies ranging from eyeglasses to screen magnifiers); blind users use screen reading software and skim with their ears [Theofanos and Redish [45]].

Moore and Matthews found that headings, lists, links, form fields, and buttons were especially attractive to study participants they observed. To support skimming, Moore and Matthews [37], Redish [42], and Theofanos and Redish [45] recommend information design especially for "reading to do" that supports all types of users reaching their goals more quickly. They have found that practices such as using bulleted lists with the main points and most important key words at the beginning, and creating meaningful links and button labels lighten the cognitive load and increase the likelihood that users will find what they're looking for efficiently [also Morrell, et al. [40], Kantner and Rosenbaum [29]].

Writing for older adults on the Web

There is a very large literature about writing for the Web – including excellent articles by Jakob Nielsen, Janice Redish, and others; books by Karen Shriver, Steve Krug, Crawford Kilian, Jonathan Price, and Gerry McGovern with Rob Norton; and now several blogs, including one by Beth Mazur of AARP – which is outside the scope of this review. The Society for Technical Communication is just one source of professional research articles on the topic. A search of its archives on the words "writing for the Web" turned up more than 200 articles. Unfortunately, content development and information design are often ignored by Web design and development groups. That said, many of the studies in this review included results related to writing and content development. They are highly consistent in their findings.

To a large extent, guidelines that make print materials work well are also important on the Web. For example,

- Write in the active voice most of the time.
- Write to "you" the user.
- Use action verbs, not nouns made from verbs.
- Write short, straightforward sentences.
- Keep paragraphs very short.
- Use lists.

- Use words your readers know.

Unfortunately, many print documents are difficult for users because they don't follow these guidelines.

Gregory [22] and Redish [42] both argue that processes for developing text content and the best guidelines are similar for both print and Web. They stress further that writers should focus on genre (the type of document or information you are writing) rather than medium (print or Web). Focusing on audience and purpose leads to the best form no matter what the medium.

Specific considerations about writing for older adult audiences follow.

Language and jargon

Many studies in this review [Chisnell, Lee and Redish [11]; Lee and Chisnell [30]; Chadwick-Dias, McNulty and Tullis [10]; Coyne and Nielsen [13]] found that older study participants had difficulty with technical language and computer, Web, and domain-specific jargon. When users encounter terms they are unfamiliar with they simply skip them – often missing opportunities to get closer to their goals. Chisnell, Lee and Redish found, for example, that most older adults were unfamiliar with terms such as "URL," "browse," "log in," and "emoticon."

Writing style and reading level

Because some older adults have difficulty drawing inferences from complex text, presenting content simply and in plain language is extremely important [Morrell, et al. [39] and [40]; Fisk, et al. [17]]. Lee and Chisnell [30] recommend that writers be concise, use humor very carefully, stay away from clever terms and labels, and use technical terms with caution. Turns and Wagner suggest limiting the reading level to the lowest possible level, such as eighth grade, or testing audience literacy of the domain to ensure that the content is written to the appropriate degree of simplicity [also Craik and Salthouse [14]; Morrell, et al. [40]; Fisk, et al. [17]]. Coyne and Nielsen [13] ask content developers and information designers to "present technical information in a non-technical way that is easy to read and understand." Theofanos and Redish [45] recommend implementing short, clear, straightforward sentences. This supports ease of skimming but also supports information retention and reduces memory load.

Cognitive researchers [Morrell, et al. [40]; Fisk, et al. [17]] have found that older adults can be more easily distracted by extraneous information and that as people get older they have more and more difficulty making inferences. This can even go as far as supplying examples in forms or with fields within forms. That is, many older adults may expect that examples given are their only choices [Barnett [4]]. Casting sentences in active voice supports comprehensibility. Fisk, et al. go a bit further, suggesting that information should be organized in ways that show how the pieces are related.

Jakob Nielsen and others have long advocated using an inverted pyramid approach to writing content for the Web in which the conclusion is at the top, and the rest of the piece is written so the user/reader can determine whether to continue reading (or skimming).

Chadwick-Dias, McNulty and Tullis [10] found that older adults were particularly cautious and not confident about clicking on links that were nouns, like Accounts. When they changed those links to actions, like Go to Accounts, both older and younger users were faster and more confident. Adding verbs may have made the links less ambiguous, thus making filtering of choices easier.

Several studies in this review also found that their older adult participants read more than younger adults in their studies [Coyne and Nielsen [13]; Chadwick-Dias, McNulty and Tullis [10]] and were more likely to read messages, prompts, and pop-ups than younger study participants [Coyne and Nielsen [13]]. Comments from participants in these studies suggest that older adults feel obligated to read, perhaps out of their fear of making mistakes. We conclude that we should avoid burdening users – especially older adults – with unnecessary information that they will feel compelled to read and that may distract them from the tasks they were trying to accomplish.

Conducting Research and Usability Studies with Older Adults

Running studies with older adults – even "fit older users" – is not like running studies with younger study participants. As discussed elsewhere in this review, the older adult audience is very large and very diverse. Several researchers assert that with this group, having experience on the Web is not the same as gaining expertise. So, in screening, selecting, and scheduling study participants, researchers and practitioners face some interesting challenges and gathering data through classic methods such as think aloud protocols merits adjustment, too.

Recruiting, screening, and scheduling

Recruiting and screening

The key to any successful usability test or other type of research is to select appropriate participants for the study. To do that, you must understand thoroughly who the users are (or will be) by developing detailed lists of characteristics. We propose some factors to consider in defining audience in "What factors besides age must we consider?" starting on page 8 that can also be used for recruiting and screening. Chisnell, Lee and Redish offer some screening questions in [12]. Chadwick-Dias, Tedesco and Tullis [9] describe some tools for assessing experience and expertise.

Many of the researchers in this review found older participants at senior centers or in assisted living communities. To find participants who are appropriate for your study, consider networking with family and friends. Often, having a personal connection of some sort will make the candidate more receptive to the study experience. [Chisnell, Lee and Redish [12]; Tullis [47]]

Also consider allowing friends or spouses to join the main participant in the session, as they may work together on the computer regularly outside the study session. [Tullis [47]] [See also Kantner and Rosenbaum [29] about coaching older adults and Hawthorn [26] about including "supporters."]

Scheduling

As Coyne and Nielsen say in [13], older adults often have flexible schedules, but many are busy with work, volunteer activities, and other involvements.

When determining how much time each study session should be scheduled for, consider that older adults

- take longer to accomplish most tasks online than younger participants (up to 25% longer [Chisnell, Lee and Redish [12]])

- talk about their experiences and tell stories that may or may not have to do with the goals of the study
- almost always arrive very early for their sessions [Chisnell, Lee and Redish [12]; Tullis [47]]
- get tired more easily and sooner than younger participants

Chisnell, Lee and Redish [12] relate also that participants were often accompanied by their spouses, many prefer not to drive during rush hour or after dark, and most have higher energy and attention levels in the morning. Coyne and Nielsen [13] suggest scheduling extra time at the beginnings of sessions for getting settled and chatting.

Adjusting user-centered design practices for this audience

Gregor, Newell and Zajicek [21] suggest that the typical user centered design (UCD) process must be modified when older adults are involved. Because the older adult audience is so diverse, they say, classic UCD processes do not always work well. They propose User Sensitive Inclusive Design (USID), which looks at "universal usability" from a different angle – taking into account more of the specific demographic, learning, and behavioral characteristics of the older adult audience.

Task scenarios

Creating appropriate task scenarios is vitally important. Tasks should be succinct and easy to remember [Chisnell, Lee and Redish [12]]. Remember that the cognitive load on participants is higher during a study session than in other typical situations – the participants have to absorb and understand what you want them to do as well as try to do it on a PC that is unfamiliar to them, in a situation that may feel somewhat less comfortable than where they're used to working.

Our undocumented experience in studies for AARP has been that, unlike younger users, if older participants are not interested or inclined toward a task, they often decline to do it at all. When they do go ahead, they may not be motivated or invested, and so may not try very hard.

Think aloud protocols

Tullis [47] suggests to moderators who usually conduct sessions from another room that they conduct the session in the same room as the participant, thus putting the participant in a more comfortable situation, and making it easier for both the moderator and the participant if the participant has hearing impairments.

When working with people who have short-term memory problems, consider foregoing "think aloud" protocols. Asking older adults to tell you their every thought as they perform tasks may be taxing and distracting. Instead, consider observing closely and then asking participants to reflect on the task just completed – which may involve walking through it again step-by-step with commentary from the participant. [Chisnell, Lee and Redish [12]]

If you do decide to ask participants to think aloud, listen for silences, which can indicate difficulty performing a task. [Chisnell, Lee and Redish [12]]

Keeping the session on track

Politeness and respect count with older adults. While it may take more time to converse, Chisnell, Lee and Redish [12] suggest that being respectful without being patronizing can include using "please" and "thank you" while remaining neutral.

Tullis [47], Coyne and Nielsen [13], and Chisnell, Lee and Redish [12] all comment on how important it is to thoroughly explain what the format for the session is, how long it should take, and what the moderator expects from the participant. This is the time to explain that the session is being recorded and how the recordings will be used. They also suggest scheduling and offering breaks.

Ethics

Realize that many older adults have cognitive and other medical limitations. If possible, control for these, but remember that many older adults also take prescription medications that may affect their performance. For these reasons, it is especially important that researchers ensure that participants understand clearly what the study is for and how the data will be used. You may have to take extra steps to ensure informed consent. [Gregor, Newell, and Zajicek [21]]

Designing Web Sites for Older Adults: Annotated Bibliography

[1] Ahmadi, Michael and Sanjay Koyani. "Designing Usable and Useful Web Sites with Older Adults." Presentation, International Conference on Technology and Aging, Toronto, Canada, September 12-14, 2001.

In a presentation for the Communication Technologies Branch of the National Cancer Institute on November 7, 2001, the authors describe a usability study conducted in August 2001 in which one group of participants who were 20-30 years old and another group who were 70-80 years old used www.healthatoz.com to perform unspecified tasks. The researchers tested six hypotheses that older users would:

- scan more slowly
- not answer general questions as successfully and quickly
- not know how to use widgets as well
- read text pages for comprehension more slowly
- scroll more slowly
- make more choices in the first screenful.

Overall, older participants were slower at everything than younger participants were except for reading for comprehension. Older users made more errors in selecting links. Older users got lost sooner and were less successful at recovering, perhaps because of cognitive impairments such as working memory (short-term memory) loss. [Also see [3] Bailey, "Older Users and the Web."]

[2] Bailey, Bob. "Segmenting Adult Web Users into Meaningful Age Categories." Presentation, Usability University July 2004; jointly sponsored by GSA, HHS and AARP.

Bailey reviews a number of studies and articles to determine "how old is old?" Results showed that the Human Factors Journal articles on average classified "older" as 58 to 76 years old, middle-aged to be 40-59, and young to be 19-35. Articles in the journal Psychology and Aging classified "older" as 62-82, middle-aged as 41-57, and young as 19-30. After lengthy discussion of many factors and implications of aging, Bailey proposes four aging categories: young - 18-39; middle-aged - 40-59; older - 60-74; and old-old - 75+.

[3] Bailey, Bob with Sanjay Koyani, Michael Ahmadi, Marcia Changkit, and Kim Harley (NCI). "Older Users and the Web." Article, Usability University July 2004; jointly sponsored by GSA, HHS and AARP.

This is the same study reported in [1]; in this paper, the authors describe the study results in more detail. In a study with 16 participants, 8 of whom were between ages 70 and 80 and 8 of whom were between ages 20 and 30, Bailey, et al. tested 6 hypotheses that older users will:

- scan more slowly
- not answer general questions as successfully and quickly
- not know how to use widgets as well
- read text pages for comprehension more slowly
- scroll more slowly
- make more choices in the first screenful.

They concluded that five of their six hypotheses were true. The one exception was that older users read faster than younger users. [Also see [1] Ahmadi and Koyani, "Designing Usable and Useful Web Sites with Older Adults."]

[4] Barnett, Robert. "Forms for Aged People," in *Forms for People: Designing Forms That People Can Use*. Chapter 16, pp 241-247, Business Forms Management Association, 2005 (in press).

Barnett was inspired to write a chapter about older adults' special problems with filling out forms for the new edition of *Forms for People* after observing them during testing of paper forms that his firm designed for various purposes in Australia. He found that older adults approached form filling quite differently from younger people. While the insightful conclusions relate to paper forms, much covered in this chapter should apply to electronic forms, as well, such as:

- Older adults don't "see" the entire form at one time, but tend to focus on completing only what they think is necessary.
- Contrarily, many older adults feel they must fill in every blank, ignoring or not seeing instructions that indicate otherwise. Therefore, questions should be grouped so that there is no need to relate current questions to previous or following questions.
- Participants in studies thought that examples given were their only choices, so instructions should be kept very concise and precise.

[5] Battle, Lisa and David Hoffman. Design Patterns and Guidelines for Usable and Accessible Web Applications. Usability Professionals' Association Proceedings, 2004.

The authors, who are consultants to the Social Security Administration, explore the common belief that building an accessible web site will make it easier to use by all who use it. As Hawthorn [26] asserts, these authors discuss at some length the tradeoffs of "trying to design one solution that meets everyone's needs is likely to lead to a solution that is inadequate for everyone." They pose guidelines that take the form of interaction design patterns based on the writings of Christopher Alexander, with the goal of balancing usability and accessibility along with the different needs of different user groups. They go on to describe their vision of a future in which web site developers can "create a single piece of content that can take many different forms … to accommodate many different types of users and user interfaces." [See also Hanson [23] and [24], and Theofanos and Redish in press [46].]

[6] Bernard, Michael, Chia Hui Liao and Melissa Mills. "Effects of Font Type and Size on the Legibility and Reading Time of Online Text by Older Adults." Conference paper, ACM SIGCHI 2001. Available on the Web at http://psychology.wichita.edu/surl/usabilitynews/3W/fontSR.htm

The researchers studied reading efficiency, reading speed, and accuracy as 27 older adults (age 62-83) worked with several different serif and sans serif type fonts on-screen. To measure accuracy, the researchers substituted obviously incorrect words at ten places in each passage. The efficiency score was the percentage of incorrect words correctly identified divided by reading time.

The researchers found statistically significant effects for size but not for type font. Participants were much more efficient at 14-point than at 12-point. When the researchers measured speed of reading without consideration for accuracy, they found that participants read the 14-point serif type fastest and the 12-point serif type slowest. The difference in reading speed between the 14-

point and 12-point sans serif was not as great as it was for the serif fonts; the 14 point was read faster but that difference was not statistically significant.

When it came to preference, participants preferred the 14-point sans serif fonts to all the 12-point fonts (serif and sans serif). The 12-point serif fonts were not selected as first or second choice by any of the participants, while both of the 12-point serif fonts were chosen by some participants.

The study also compared typefaces designed for print versus typefaces designed for computer; there were no statistically significant differences in efficiency or preference.

[7] Bohan, Michael and Deborah Scarlett. "Can Expanding Targets Make Object Selection Easier for Older Adults?" Newsletter article. Software Usability Research Laboratory (SURL) at Wichita State University Usability News 5.1, February 2003.

The authors conducted a preliminary study to examine "whether older adults could adjust their initial motor response to take advantage of" larger (and dynamically enlarging) target sizes and if their performance was affected by how far beyond the actual size of the target the clickable area started. When the researchers compared 8 younger adults to 8 older adults under the same conditions, they found that all participants were able to adjust responses when targets expanded early, but that none were able to adjust when the targets expanded late. Older adults always took longer to reach the target than younger participants. This newsletter is available on the Web at http://psychology.wichita.edu/surl/usabilitynews/51/Expanding-target.htm.

[8] Chadwick-Dias, Ann with Donna Tedesco and Tom Tullis. "Demographic Differences in Preferred Website Content." Conference paper, Usability Professionals' Association Proceedings 2004.

In a study in which 30 participants designed their own financial services home pages for a Web site, 10 participants were under age 40, 10 were aged 40-64, and 10 participants were aged 65+. Forty percent of the participants in the oldest group added navigation features and widgets that resembled buttons. None of the participants in the younger age groups chose this format for navigation. Thirty percent of users in the oldest group included a Help feature on their sites compared to only 5% of users in the younger groups. The two older groups included Search on their home pages only 10% of the time, while participants who were under age 40 included Search half of the time.

[9] Chadwick-Dias, Ann with Donna Tedesco and Tom Tullis. "Late breaking result papers: Older adults and web usability: Is web experience the same as web expertise?" Conference paper, *Extended abstracts of the 2004 conference on Human factors and computing systems.* **ACM SIGCHI 2004.**

Over a series of four studies, the authors thought they were seeing a difference in web experience by age but realized that it was a difference in computer and web expertise. They define experience as what we learn when we ask about length of time using the web, frequency, and types of activities users do on the web. They define expertise as what we learn when we ask users to identify elements of a web browser, among other widgets.

The authors constructed a number of questionnaires and tools to explore the interrelationships of age, experience, and expertise as part of experiments that had nothing else to do with this exploration. Even when they were able to control for experience,, the authors found that the oldest participants still had lower scores for expertise and that younger participants always had

higher expertise scores than older participants. Furthermore, the lower expertise quiz scores correlated with lower performance in the studies these users participated in.

The authors found that "The strongest predictor of performance and [expertise] quiz score was age, independent of experience."

The authors were then interested in why expertise should correlate so well with age. Subjective feedback from participants led the authors to hypothesize that older users had not been exposed to the same learning environments that younger users had; they had not had computers at work or at school.

The authors found that expertise scores were correlated with exposure to cooperative learning. As they say, "[the] more users have collaborated with others while using the Web, the higher their quiz score will be." This also implies that the more users have collaborated with others, the better their performance will be on the Web. Older users have more usability problems than younger users do independent of usage patterns because it is expertise not simply usage that matters.

[See also these annotated references about issues connected to collaborative learning: [10] Chadwick-Dias, McNulty and Tullis; [13] Coyne and Nielsen; [21] Gregor, Newell and Zajicek; [29] Kantner and Rosenbaum; [34] Mazur and Lee; [43] Rogers and Fisk.]

[10] Chadwick-Dias, Ann with Michelle McNulty and Tom Tullis. "Web usability and age: How design changes can improve performance." Conference paper, *ACM SIGCAPH Computers and the Physically Handicapped*, **Proceedings of the 2003 conference on universal usability, Issue 73-74.**

After conducting an exploratory study to learn what differences there might be in usability for users at different ages when using a particular Web site, the team also found that older adults exhibited different usage behaviors that probably contributed to their lower performance. In a second round of study on a new prototype in which changes had been incorporated specifically to address the usability problems older adults had on the first prototype, performance for both younger and older groups improved. Older adults performed tasks more quickly on the second prototype than on the first. However, the team was unable to close the usability gap between younger and older users. In general, the older users had less expertise in using the Web. Realizing this, the authors theorize that expertise is different from experience, and that expertise is related to learning and using the Web in collaborative environments. [See also [9] Chadwick-Dias, Tedesco, and Tullis, "Late breaking result papers: Older adults and web usability: is web experience the same as web expertise?" See also these annotated references connected to collaborative learning: ; [9] Chadwick-Dias, Tedesco and Tullis; [13] Coyne and Nielsen; [21] Gregor, Newell and Zajicek; [34] Mazur and Lee; [43] Rogers and Fisk.]

[11] Chisnell, Dana with Amy Lee and Janice Redish. "Designing Web Sites for Older Users: Comparing AARP's Studies to Earlier Findings." Article. AARP. 2004. Available at www.aarp.org/olderwiserwired/oww-features/Articles/a2004-03-03-comparison-studies.html.

In comparing their findings from three exploratory studies which included 34 participants with results and design implications published by Fidelity Investments (See Chadwick-Dias, McNulty and Tullis [10]), the authors found that, although the types of web sites evaluated in the studies were different (Fidelity tested a site for managing employee benefits; AARP studied www.AARP.org), the performance and behaviors of their older adult participants were generally similar. The Fidelity

participants were age 55 and older; the AARP participants were age 50 and older. Where there are differences between AARP's findings and Fidelity's findings, the authors clearly call out what the differences were and propose possible reasons for the differences. For example, both groups found that older adults tend to

- read most of the text on most pages
- be more cautious in making selections
- prefer larger text
- click on anything that looks clickable
- exhibit lower confidence in using the Web than younger adults
- be unfamiliar with computer, browser, and Web terms
- have at least some visual impairment
- have difficulty working with dense pages

There were a few differences, including

- AARP participants skipped reading instructions that might have been helpful to them
- AARP participants in their 50s were quicker and more comfortable with trying links just to see what might be there than participants in their 60s and 70s were
- While AARP participants clicked on many elements that were not links, they also missed clicking on things that were links (including links that were presented using the conventions of being blue and underlined)
- AARP participants in their 50s were less likely to accept responsibility for the site being difficult to use than participants in their 60s and 70s were, who asserted that they would just have to spend more time to learn the site

[12] Chisnell, Dana with Amy Lee and Janice Redish. "Recruiting and Working With Older Participants." Article. AARP. 2004. Available at www.aarp.org/olderwiserwired/oww-features/Articles/a2004-03-03-recruiting-participants.html.

The authors discuss their experiences with recruiting older adults for usability studies and how doing so is different from recruiting younger study participants. They also offer pointers for scheduling sessions and working with older adults during sessions. Included are some questions they used in successful screening and selection of participants and profiles for determining "web proficiency."

[13] Coyne, Kara Pernice and Jakob Nielsen. *Web Usability for Senior Citizens.* **Report, Nielsen Norman Group. April 2002.**

For many people, this is the seminal report on seniors and usability. Twenty participants who were age 65 and older took part in a two-part study (one part quantitative, one part qualitative). Their performance and subjective ratings of Web sites were compared with a control group of 20 participants who were between 21 and 55 years of age. Coyne and Nielsen observed that older adults "tend to see the positive parts of a generally negative experience." However, overall, seniors were less satisfied than younger participants. The report finds that success and satisfaction correlated, which is different from the Chadwick-Dias, et al. findings in which participants performed better on one prototype but still rated their satisfaction as low. [See also [10], Chadwick-Dias, McNulty and Tullis, "Web usability and age: how design changes can improve performance."]

Seniors took more time to do tasks than younger participants. They scrolled more than younger participants. They were more likely to quit doing tasks without completing them than younger

participants. They made many more errors in selecting links than younger participants – 4.63 erroneous clicks on average for the seniors compared to .63 erroneous clicks on average for the younger participants.

Just as Chadwick-Dias, et al. did, Coyne and Nielsen conclude that seniors have lower expertise using the Web because they did not learn to use it in the same type of setting that younger participants did, collaborative environments at school or at work. The Nielsen-Norman report includes 46 specific guidelines for designing sites to be usable by people who are 65 and older. It also includes helpful guidance about scheduling and conducting sessions with older adults. [See also these annotated references about issues connected to collaborative learning: [9] Chadwick-Dias, Tedesco and Tullis; [10] Chadwick-Dias, McNulty and Tullis; [21] Gregor, Newell and Zajicek; [29] Kantner and Rosenbaum; [34] Mazur and Lee; [43] Rogers and Fisk.]

[14] Craik, Furgus I. M. and Timothy A. Salthouse. *The Handbook of Aging and Cognition.* **Second Edition. Lawrence Earlbaum Associates. 2000.**

Like many handbooks of this type, this one is huge in size and scope, covering 13 chapters in 755 pages. The most relevant chapters from this book for our review are:

Chapter 4, Attention and Aging: A Functional Perspective [35]

Chapter 5, Human Memory [53]

Chapter 10, Human Factors, Applied Cognition, and Aging [43]

Salthouse and Craik's closing comments also include insightful contemplations about aging and human-computer interaction.

[15] Czaja, Sara J. and Chin Chin Lee. "Designing Computer Systems for Older Adults." Chapter in *The Human-Computer Interaction Handbook: Fundamentals, Evolving Technologies and Emerging Applications***. pp 414-427. Julie A. Jacko and Andrew Sears, eds. Lawrence Earlbaum Associates, 2003.**

In examining the rate of acceptance of technologies such as the Internet and reviewing literature in the area of human-computer interaction on issues of training older adults (people 55 and older) as well as related issues of hardware and software design, the authors hope to motivate researchers and designers of systems to consider older adults in their work. Czaja and Lee find in the literature that while older workers may be slower and more error-prone at online work tasks such as data entry, updating files, and managing inventory, system designers must consider design interventions since there will be so many more older adults in the workforce than before. They also present results from a 1999 study of older adults showing that those who learned to use the Internet felt more positive and connected to other people.

As others in this review such as Hawthorn [26] and Gregor, Newell and Zajicek [21] suggest, Czaja and Lee acknowledge that "there are substantial individual differences in rate and degree of functional change" in the older adult audience. "Within any age group, young or old, there is significant variability in range of abilities, and this variability tends to increase with age."

Their findings about training older adults to use computers show

- modeling behavior (watching a video demonstrating procedures with practice exercises) in training was more effective than tutorial (computer-based interactive step-by-step instructions)

- goal-oriented training improved post-training performance over traditional lecture plus manual techniques
- procedural instructions (or action training) alone are more effective than presenting concept information or a combination of conceptual information and procedural instructions for old-old adults (age 75-89)
- practice on parts of tasks and then whole tasks worked better for older adults than only providing written instructions or written instructions that included graphics.

[16] Dailey, Stephanie. "Using Cognitive Aging and Vision Research to Develop Senior-Friendly Online Resources." Presentation, Usability University July 2004; jointly sponsored by GSA, HHS and AARP.

Dailey describes the development of a Web site for seniors age 60+ (www.nihseniorhealth.gov) based on guidelines that were generated through research sponsored by US National Institute on Aging and the US National Library of Medicine. Dailey suggests that

- consistency of placement of elements assists spatial memory
- "ample" white space and very short, chunked content assist perceptual speed and comprehension
- repetition in the form of multi-modal presentation of information assists working (short-term) memory

In testing early prototypes of the NIH Senior Health Web site, Dailey and colleagues found that writing style and layout were important to users, that small chunks of information prevented users from being overwhelmed, and the text was large enough to be read. However, the information architecture was too deep and not broad enough (that is, it took too many steps to reach the information goal). They corrected for these issues before launching the site at www.nihseniorheath.gov.

[17] Fisk, Arthur with Wendy A. Rogers, Neil Charness, Sara J. Czaja, and Joseph Sharit. *Designing for older adults: Principles and Creative Human Factors Approaches.* **Book, CRC Press LLC, 2004.**

Despite its scholarly style, this slim book is useful to practitioners as well as researchers.

Much of the research broadly applies to issues that older adults have using technology of many different types, including computers and Web sites. The first few chapters summarize research on changes that come with age in

- sensory modalities
- cognition
- movement

These summaries may serve Web designers and usability specialists as well as the much more detailed information in, for example, the book by Craik and Salthouse.

Like the Morrell book [annotated reference[39]]and Craik and Salthouse [14], there is also a whole chapter on applying user centered design processes to ensure a usable outcome for the older audience. Chapters 4 through 7 give design guidelines based on the research discussed in the first part of the book.

The chapter on input devices (pointing devices and keyboards) and output devices (screens and monitors) suggests some useful guidelines for selecting the appropriate device for specific tasks.

The chapter that is most applicable to Web site design is chapter 7, Interface Design. The authors describe the types of issues that they observed older users having when working with Web sites. This leads to three pages of basic guidelines for "effective interface design." (pp 105-107). Many of these are similar to the guidelines presented by Morrell, et al. in *Older Adults, Health Information, and the World Wide Web*. [See annotated reference [27].]

These authors, like others whose work we annotate here, advocate training for older adults to make them truly effective in using computers, Web sites, and other technology. The delivery system for the training varies depending on the medium and the task – for example, a checkout clerk could simply show a user how to use a credit card slider or a teller could demonstrate an ATM. The authors say that older adults will be most successful in using the vast resources available on the Web only with task-oriented training. They believe the training could be either assisted or self-paced and collaborative. One chapter in the Design Guidelines section describes instructional design approaches which incorporate cognitive aids for training older adults.

[18] Fox, Susannah. "Older Americans and the Internet: Reviewing Traits of This Enthusiastic Minority (and Understanding Why the 'Oldest Old' Remain Offline)." Presentation, Usability University July 2004; jointly sponsored by GSA, HHS and AARP.

This presentation is based on the report described in the next entry. In this presentation, Fox describes the demographic growth of the 65+ population who are online and discusses some of what those people do and how often. The presentation gives answers by age group for all ages 18 – 69+ to some of the questions in the Pew Internet survey.

Fox also includes eight recommendations for Web site designers. For example, she suggests that Web designers assume that people find your site via a search engine and that they will drop in at some point in the middle of a site, not the home page. Fox also says that designers should assume that older users have dial-up connections (an interesting point, considering that the Coyne and Nielsen study [13] found that people over 65 were very impatient about pages loading and other feedback from the system).

[19] Fox, Susannah. *Older Americans and the Internet.* **Report, Pew Internet and American Life Project (2004). Available at http://www.pewinternet.org/ppf/r/117/report_display.asp**

Sampling more than 2,200 adults by phone in February 2004, the Pew Internet project found that use of the Internet by seniors had grown 47% since 2000. Also, in 2000 most web users were men, but by the beginning of 2004, the percentage of users by gender was even — and equal to the general Internet-using population. Older users got more sophisticated over three years, going from surfing and research to research about specific health issues, shopping online, and doing online banking and bill paying. 95% of older web users who go online do so from home; some have multiple places to access the Internet from. 72% of seniors using the web at home do so from a dial-up connection (compared to 54% of general population). Surfing numbers were up by 1%, from 53 to 54 percent going online for no particular reason (compared to 67 percent of all Internet users). This report has much more information about what seniors do online and how often they do it than the 2000 report, which we describe in the next entry. It also has an interesting discussion about the gray digital divide: who is not online and why not.

[20] **Fox, Susannah.** *Wired Seniors: A fervent few, inspired by family ties.* **Report, Pew Internet and American Life Project. September 9, 2001. available at http://www.pewinternet.org/PPF/r/40/report_display.asp**

In phone surveys conducted between March and December 2000, the Pew Internet project found that most seniors (defined as 65+) who were online were men (60%); most seniors had been coaxed online by relatives; but most said that they would miss the Internet if they no longer had access to it. 53% of seniors said they had gone online" just for fun," and 17% went online for no special reason on any typical day. Email was the main use of the Internet.

[21] **Gregor, Peter with Alan F. Newell, Mary Zajicek. "Solutions for aging: Designing for dynamic diversity: interfaces for older people." Conference paper,** *Proceedings of the fifth international ACM conference on Assistive technologies.* **ACM digital library**.

After running studies with 200 participants to develop a Web browser for people with different levels of visual ability, the authors make a case for how conventional user-centered design (UCD) methods failed, but unconventional activities, such as collaborative learning helped users in the study learn and use the application. Their main point seems to be that even when you try to control for certain characteristics, such as ability to memorize, there is still huge diversity in the older adult population in how they think about that task (or others). In promoting what the authors call "designing for dynamic diversity" — the premise of which is that older people are much more diverse in terms of life experience and levels of capability and disability than their younger counterparts – the authors propose that UCD practices should be modified to address the many issues around designing for older adults, from awareness of user characteristics to logistics of running studies, calling their methodology User Sensitive Inclusive Design (USID).

The authors also assert that

- "universal" usability probably isn't achievable, but "inclusive" probably is
- "sensitive" demonstrates awareness of the difficulty of identifying discrete groups of users within "older adults"
- there are ethical issues with using people who have cognitive or other disabilities as "subjects"
- working with older people demands a different attitude on the part of the moderator.

[See also these annotated references about issues connected to collaborative learning: [9] Chadwick-Dias, Tedesco and Tullis; [10] Chadwick-Dias, McNulty and Tullis; [13] Coyne and Nielsen; [29] Kantner and Rosenbaum; [34] Mazur and Lee; [43] Rogers and Fisk.]

[22] **Gregory, Judy. "Writing for the Web Versus Writing for Print: Are They Really So Different?" Article. Technical Communication. Vol 51, Num 2, May 2004.**

In examining a commonly held premise that writing for the web is very different from writing for print, the author argues that seven principles held dear by web content developers and online information designers are actually based in research and long practice for writing for print

- structure and design are concerns for Web writers
- write no more than 50% of what you would write for print
- write for scannability
- the Web encourages restless reading
- split information into coherent chunks
- Web writers can't predict where their readers will start

- readers "pull" the information they need from the Web

Gregory contends that many of the guidelines she reviews are based on limited research and urges technical communicators and information designers to consider genre attending to purpose and form, regardless of medium.

[23] Hanson, V. L., Richards, J. T., Fairweather, P. G., Brown, F., Crayne, S., Detweiler, S., Schwerdtfeger, R., and Tibbitts, B. "Web Accessibility for Seniors." *Universal Access in HCI: Towards an Information Society for All.* **Stephanidis, C., Ed. Lawrence Erlbaum Associates, Mahwah. 2001; pp 663-666**.

To help people with visual impairments, the authors constructed a system that allowed users to set profiles with their preferences for font, font size, font color, and background colors. They made the preferences easy for users to select by allowing users to look at sample web pages that exemplified the options users could select. Once the user chose individual preferences, the user's profile was saved on a "proxy" server that also held Cascading Style Sheets and other tools for modifying Web pages to match the user's individual profile. With this proxy server, users could view any Web page they navigated to in a standard browser such as Netscape or Internet Explorer and those pages were changed to match the individual user's needs.

Similar to the Hawthorn [26] and Zajicek and Hall [55] research, the IBM team found that users wanted more choices as they became more familiar with the user interface.

[24] Hanson, Vicki L. and John T. Richards. "A Web Accessibility Service: Update and Findings." Conference paper, ACM SIGACCESS Accessibility and Computing, Proceedings of the SIGACCESS Conference on Computers and Accessibility, 2004.

Here the authors follow up on their 2002 paper [23]. Finding several issues with the proxy server model for transforming content to meet individual accessibility needs, including problems with transforming page content correctly (mainly because most pages are not coded conventionally), transforming content on secure Web sites, getting users to set the proxy, and questions related to copyright, the authors abandoned this architecture and set out on a new direction. Hanson and Richards also view incorporating appropriate HTML code to support accessibility standards to be a large economic burden for publishers of Web sites.

To resolve the problems they encountered and meet their goal of portable "user controlled presentation" to accommodate "dynamic diversity" [21], the team created what they call Web Adaptation Technology software as a browser plug-in that manipulates the Document Object Model (DOM) that the browser creates. Thus, rather than transforming the original document and serving up that transformed view, the new architecture transforms the browser's copy of the document when the user changes settings for colors, text sizes, banner text, image enlargement and enhancement, page layout, and ability to have the text spoken. They further surface and take advantage of browser and operating system features that otherwise are difficult for users to find and adjust to make Web pages easier to use, including keyboard and typing adjustments.

[25] Hart, Traci A and Barbara Chaparro. "Evaluation of Websites for Older Adults: How 'Senior-Friendly' Are They?" Presentation, Usability University July 2004; jointly sponsored by GSA, HHS and AARP. Based on a paper by Traci A. Hart available at http://psychology.wichita.edu/surl/usabilitynews/61/older_adults.htm

Students at the Software Usability Research Laboratory (SURL) at Wichita State University evaluated 36 Web sites directed toward older audiences to see whether they complied with the 25

guidelines developed by Morrell, et al. at the National Institute on Aging (U S National Institutes of Health). [See [40] for an annotation of the Morrell, et al. document.]

The evaluation method was a heuristic review against the 25 guidelines. Each Web site was rated against each guideline using a four-point scale from "never" to "always." The evaluators found that all the sites met a few of the guidelines; for example, they were written primarily in the active voice and did not include automatically scrolling text. Most sites avoided all capital letters in the text, presented the text left-justified (ragged-right), and used pull-down and cascading menus sparingly. However, the majority of sites did not fulfill the guidelines for text size, weight, and line spacing, which call for 12-14 point body text, medium weight, and double-spaced text.

Hart and Chaparro say that implications for performance on the sites are not clear. As of summer 2004, they were conducting follow-on studies to look at the relationships among compliance with these guidelines, performance, and preference. Their preliminary results suggest that the most compliant sites are not always the most efficient or most preferred. Results of these further studies will be available at the SURL web site: http://psychology.wichita.edu/surl/usability_news.html .

[26] Hawthorn D. "How universal is good design for older users?" Conference paper, ACM SIGCAPH Computers and the Physically Handicapped, Proceedings of the 2003 conference on universal usability, Issue 73-74.

Hawthorn found that creating an accessible email application for older adults resulted in limiting functionality and features for younger adults. Acknowledging that there are older users who do not have limitations [See also Gregor, Newell and Zajicek [21]], Hawthorn was most interested in the subgroup of people over 60 who have age related disabilities so limiting that they are unable to learn or use standard applications. He calls them "age-restricted users."

Hawthorn asserts that talking about age indicates only in a very vague way what types of limitations and disabilities a person might have. Like Gregor, Newell and Zajicek [See [21]], the author finds such diversity in the older adult population that he says it is not possible to design for this group by working from guidelines, but that users must be involved. Also, as others [See Hanson [23] and [24], Morrell [38], [39], [40]] have suggested, older adults want it simple at first with opportunities to add features after learning a basic set.

The author recommends expanding the user-centered design approach to include dealing with diversity within a user group. [Also see Gregor, Newell and Zajicek [21].]

In this paper, Hawthorn also describes in detail the cascading effects of different types of limitations that age restricted users have, what he observed during usability studies, and how he resolved the issues that users had with his SeniorMail email application. He also describes the many trade-offs, but, in the end, he sticks to his rule that simplicity trumps all.

Interestingly, Hawthorn included "supporters" of his age restricted users in his studies. While he does not talk about them much, there is information here about how much the supporters may (or may not) be able to deal with as they try to help the people they support – for example, in configuring scalable applications. Hawthorn says, applications for age-restricted users can't be scaled down from existing software but must be built from the ground up, involving appropriate users.

[27] Jacko, Julie A with Ingrid U. Scott, Francois Sainfort, Kevin P. Moloney, Thitima Kongnakorn, Brynley S. Zorich, and V. Kathlene Emery. "Effects of Multimodal Feedback on the Performance of Older Adults with Normal and Impaired Vision." Chapter, *Universal Access: Theoretical Perspectives, Practice, and Experience (7th ERCIM International Workshop on User Interfaces for All***. Paris, France, October 2002. Revised Papers.) pp 3-22***.***

This group is concerned with multimodal output from systems as opposed to multimodal input. That is, how does visual, auditory, or haptic feedback from the system help users find the correct items, avoid errors, and recover from errors? In a previous study with participants aged 21 to 36, the researchers found that visual and haptic feedback were helpful when used alone or in combination — and better than other "unimodal, bimodal, and trimodal conditions." Auditory feedback, because it is "transitory," actually hindered performance.

In a second study (reported in this paper), the researchers observed 59 people aged 54 to 91, with an average age of 76. Participants were selected for whether they had normal vision (the control group) or had impaired vision due to age-related macular degeneration (AMD). Participants had a range of computer experience before the study. Their task was to drag-and-drop a file icon onto a folder icon on a Windows desktop. Participants received randomized combinations of types of feedback from the system when the file icon was positioned correctly over the folder icon.

Participants were grouped by the severity of their visual impairment, using the measures below as well as others such as visual acuity:

Control	20/20-20/40	no AMD
Group 1	20/20-20/50	AMD
Group 2	20/60-20/100	AMD
Group 3	≥ 20/100	AMD

Participants with the worst vision, Group 3, performed the worst of the four groups with only visual feedback. These participants performed best when they had only auditory or only haptic feedback compared to the visual condition (not surprising).

However, the addition of one mode of feedback did not seem to help participants with the worst vision, but the condition under which they received all three types of feedback seemed to show the best performance.

The control group (with normal vision) also performed better when they received a combination of auditory and haptic feedback compared to only visual feedback. Adding other feedback modes did not hinder performance for any of the groups.

Group 1 (with visual acuity ranging between 20/20 and 20/50 with AMD), and Group 2, (with visual acuity ranging between 20/60 and 20/100 with AMD) showed no significant differences in performance for any of the feedback conditions, but Group 2 did slightly better than Group 1 with bimodal or trimodal feedback.

The performance of the control group and Group 3 (the most visually impaired) was similar when they received a combination of auditory and haptic feedback. Their performance was different when they all received all modes of feedback.

[28] Josephson, Sheree with Michael E. Holmes. "Age differences in visual search for information on web pages." Conference paper, *Proceedings of the Eye tracking research and applications symposium; ACM 2004.*

Using eye tracking equipment and software, the researchers recruited 24 people who regularly used the Internet and had them use three kinds of Web pages. The 24 participants fell into four age groups: 8-11; 15-25; 35-45; and 55-65. They found that there were no age-related differences in where participants looked on the Web pages: eye path sequences were similar across the three oldest age groups.

[29] Kantner, Laurie and Stephanie Rosenbaum. "Usable Computers for the Elderly: Applying Coaching Experiences." Conference paper. IEEE Professional Communication Conference (IPCC), September 2003.

In surveys and interviews with seven people who coach older adults to use computers and the Internet, the authors identified problems that older adults typically have. Coaches' ages ranged from 44 to 79. Most students of people who were coaching friends and family were over 75 years old. Most students being coached at senior centers were over 70 years old.

They identified as the top 10, those problems that four or more coaches identified in their survey responses or rated High on a scale of Low, Medium, and High) The top 10 problems were (in order of occurrence; that is, at least four coaches listed the problem or rated the item High in interviews)

- dexterity
- fear of making mistakes
- working with files and folders
- specifying searches
- too much information
- using different computers and operating systems
- vision
- working with attachments
- downloading
- typing

Among continuing problems that coaches related were issues connected to working memory and to learning concepts that are specific to computers and that have no physical analogue. Coaches observed many successes with students, too, including some tricks that seemed to open opportunities for older adult novices that they probably would not have figured out for themselves such as copying and pasting.

See also Hawthorn [26] about "supporters" included in his study and these annotated references about collaborative learning: [9] Chadwick-Dias, Tedesco and Tullis; [10] Chadwick-Dias, McNulty and Tullis; [13] Coyne and Nielsen; [21] Gregor, Newell and Zajicek; [34] Mazur and Lee; [43] Rogers and Fisk.]

[30] Lee, Amy with Dana Chisnell. "Communicating with Older Audiences." Presentation. 51st annual conference of the Society for Technical Communication. 2004. Available online at http://www.stc.org/51stConf/sessionMaterial/dataShow.asp?ID=143.

The authors present findings and Web design guidelines from three exploratory studies conducted in 2003 with older adults and how they use the Web. [See also Chisnell, Lee and Redish [11] and [12].]

[31] Lin, Dyi-Yih Michael. "Hypertext for the aged: effects of text topologies." Journal Article, *Computers in Human Behavior* Vol. 19 No. 2 (2003) pp 201-209. Elsevier Science.

In an effort to repeat the findings of earlier studies done with college students (by McDonald and Stevenson in 1996 and 1998), the researcher conducted a study to see whether a hierarchical information architecture or a network information architecture would better serve the needs of older users. There were 12 participants, aged 57 to 67; 11 men and one woman. All were Taiwanese. The participants were given task scenarios to do, to find information. The content on the site was the same; it was just presented in two different architectures.

To test his hypothesis that older users would be better oriented in the hierarchical information architecture than in the network information architecture, Lin measured

- the number of "nodes opened" (pages visited)
- the number of nodes opened repeatedly
- the number of "additional links searched"
- time spent in finding the answers to the task scenarios.

Participants using the hierarchical information architecture opened more nodes and spent significantly more time. However, the number of nodes repeatedly opened was much lower than for users of the network information architecture.

The author suggests that the result related to repeatedly opening nodes is more important. He concludes that opening more nodes repeatedly in the network information architecture shows that those participants became disoriented. Based on this finding, he suggests that the hierarchical information architecture is best.

This experiment was meant to determine whether findings from studies done by McDonald and Stevenson in 1996 and 1998, which used college students, were repeatable with older adults. McDonald and Stevenson found that users were more likely to become disoriented in the network information architecture than in the hierarchical arrangement, "due to the multiplicity of search paths the referential structure produces." Lin's study does seem to confirm that "hypertext digression for older users is more pronounced with network than with hierarchical topologies."

However, for other aspects, this study is suggestive, but not conclusive. The number of participants is very small and the author's conclusion is conjecture, not fact. He does not know why participants did what they did when they did it.

Furthermore, the results suggest that the network information architecture presented more opportunities to find the right answers and participants spent more time with the hierarchical information architecture because they selected by elimination rather than by inference. That is, they eliminated choices because they didn't see things that matched what they were looking for, whereas with more choices, they might skim and recognize more quickly. Because we don't know

what the wording in the links was, we don't know if there was any effect for vocabulary or if the labels used in the two information architectures were identical.

[See also Zaphiris, Kurniawan and Ellis [56] on breadth versus depth of information architecture hierarchies.]

[32] Lippincott, Gail. "Gray Matters: Where Are the Technical Communicators in Research and Design for Aging Audiences?" Article. IEEE Transactions on Professional Communication. Vol 47. Num 3. September 2004.

Through a wide-ranging review of literature related to older adults as an important audience for technical communicators, Lippincott puts forward a rousing call to action for more research to be done about how to meet the needs of this audience by posing four challenges to the technical communication profession:

- refine the demographic variable of age
- operationalize age to enrich current methods of audience analysis
- investigate multidisciplinary sources of aging research
- participate in international multidisciplinary research on aging

She concludes her discussion by asserting that doing this research is in our own interest – working under the assumption that we will all be fortunate enough to grow old.

[33] Maguire, Martin, Laura-Jo Pearce. "An investigation into attitudes to, and experience of, Internet shopping." Book. *Universal Access in HCI: Towards an Information Society for All***. Stephanidis, C., Ed. Lawrence Erlbaum Associates, Mahwah. 2001; pp 1088-1092.**

After surveying 56 people ranging in age from 18 to 70 about their feelings about shopping online, Maguire and Pearce observed 6 users using one of two UK supermarket web sites. Three participants were in their 50s, one was 80, another 41, and the last was 22. Two participants had never used the Internet (one had never used a computer); two are described as having minimal experience using the Internet; two appear to have had little computer experience. It was found that those with little or no computer experience needed training to be able to use the computer and to learn how to use the browser and main conventional features of web sites, such as links and typical controls such as list boxes. Those with a bit more experience needed more cues than there were in the user interface for finding the items they wanted to purchase than participants with less computer experience. There seemed to be no particular effect in this study for age, but the two participants who had used the Internet before seemed to be more successful than the participants who had not.

This study seems to confirm the insight that we discussed in "About Older Adults and Web Site Design " starting on page 4 that expertise may be as important as age – if not more important – as a user characteristic to consider when designing Web sites.

[34] Mazur, Beth and Amy Lee. "Older, Wiser, and Wired." Article, *Intercom***, pp 12-14. Society for Technical Communication. December 2003***.*

This article highlights some of the psychological and emotional aspects of older adults' experiences on the Web, from the apparent caution and thoroughness that older adults seem to approach sites with to their attitudes about aging. There is also some discussion about why older adults lack expertise with the Web – and the working hypothesis that Chadwick-Dias and her colleagues at Fidelity and others have posed that older adults were not and are not exposed to the collaborative

learning environments that many younger people experience at work or at school. [See also these annotated references about issues connected to collaborative learning: [9] Chadwick-Dias, Tedesco and Tullis; [10] Chadwick-Dias, McNulty and Tullis; [13] Coyne and Nielsen; [21] Gregor, Newell and Zajicek; [29] Kantner and Rosenbaum; [43] Rogers and Fisk.]

[35] McDowd, Joan M. with Raymond J. Shaw. "Attention and Aging: A Functional Perspective" Chapter in Craik, F.I.M. and Salthouse, T.A. *Handbook of Aging and Cognition.* **pp 223-229.Lawrence Erlbaum Associates, 2000.**

In a fascinating section on visual searching, the authors review research done by Allen, et al. to determine the cognitive reasons why older adults are slower at visual search than younger adults are. In one study in 1993, Allen, et al. hypothesized that older adults would be faster and make fewer errors in finding what they were looking for if they were presented with multiple redundant targets compared with having only one target available in groups of targets that included distractors. The experimenters determined that having a single distractor probably would not put older adults at a disadvantage, and when targets and distractors were similar perceptually, younger and older adults performed the same.

In 1994 in two experiments, Allen and colleagues followed up on the 1993 results to study three possible factors contributing to the slowness of older adults in visual searching:

- filtering processes allowing a person to ignore unneeded information
- search processes (also called "activation" by Allen, et al.) that "excite or activate the relevant target information"
- sensory-perceptual processes that determine how quickly or slowly older adults become aware of simple and complex properties of a thing (seeing the color orange versus seeing *an* orange).

They found that older adults were more successful at selecting the right target quickly when there were multiple redundant targets available, but that the overall slowness compared to younger adults was *not* in filtering or in perceiving targets. Older adults seemed to have the most difficulty with recognizing – activating – the target in the search process.

For web designers, this suggests that older adults tend to make choices more as a process of elimination (filtering) rather than by seeking out one, best way of moving forward in their tasks. From the McDowd and Shaw write-up, we don't know whether study participants chose the first target that seemed appropriate or whether they examined all of the possible targets and then selected.

Unfortunately, the review that McDowd and Shaw give us does not describe the methodology for the study. We don't actually know what the computer screen looked like and what participants were reacting to. So we do not know how similar the redundant targets were with the distractors, nor do we know how the items were laid out physically.

[36] Mead, Sherry E. with Nina Lamson and Wendy A. Rogers. "Human Factors Guidelines for Web Site Usability: Health-Oriented Web Sites for Older Adults." Chapter in *Older Adults, Health Information, and the World Wide Web***, Roger W. Morrell, ed. pp 89-107. Lawrence Earlbaum Associates. 2002.**

After briefly explaining human factors and ergonomics, the authors go on to present a hypothetical case in which a fictitious group designs a health information web site directed toward older adults. Through this case study, the authors review human factors research and present guidelines based

on their review of the research for designing web sites for older adults. There are many helpful examples of task analysis and web page designs that are supported by and not supported by published interface design guidelines. The authors also include a summary table listing modifications that can be made to web sites that should reduce the effects of age-related limitations in perception, cognition, and motor control.

[37] Moore, Jessica and Joseph Matthews. "Blind Leading the Blind: Theorizing a Web for the Visually Impaired." Conference paper, Usability Professionals' Association Proceedings 2004.

This paper presents useful guidance on how to use a content management system to implement Section 508 guidelines to make web sites accessible to low vision and blind users. . The authors show how to plan the information design of web pages so they can be rendered in different formats for users with different needs.

[38] Morrell, R.W. "Technology and Older Adults: Evolution, Myths, and Revolution." Presentation, Usability University July 2004; jointly sponsored by GSA, HHS and AARP.

In a project with the National Institutes of Health and the National Library of Medicine, Morrell and colleagues used basic and applied research on cognition, perception, and human factors related to aging to develop a set of guidelines for Web site design. They then applied the guidelines as they developed a new web site: NIHSeniorHealth.gov. In this presentation, Morrell describes usability studies in which older users were found to have difficulty navigating on most web sites. In these studies, "scrolling was a problem" on individual web pages. Also, the deeper the information hierarchy of the site, the more difficulty older users had. They also found problems with vision, memory, comprehension, and motor skills that were related to age. [Also see [28] *Older Adults and Information Technology: A Compendium of Scientific Research and Web Accessibility Guidelines*. While the Compendium seems to be directed toward information technology in general rather than just Web use, this presentation focuses on the Web.]

[39] Morrell, R.W., ed. ***Older adults, Health Information and the World Wide Web.*** **Book. Lawrence Erlbaum Associates, 2002.**

The chapters in this informative book are based on presentations made at the first conference that an organization called SPRY (Setting Priorities for Retirement Years) and the National Institutes for Health (NIH) sponsored in 1999.

Much of the research cited in this book dates from the 1980s and early 1990s, and some of it is based on print rather than online technologies. [See also Gregory [22].] Many of the guidelines in this book for selecting content and writing text repeat material that has been standard in technical communication and information design books for a long time. For example: Keep it simple. Break longer texts into chunks. Use clear headings and subheadings. Use meaningful illustrations. These are, of course, useful guidelines for Web sites – and, in these cases, the old research is as applicable online as it always was for print materials. In many ways, although the book focuses on the design of Web sites that convey health information to older adults, most of the findings discussed and the guidelines proposed in this book are relevant for any information-based Web site for any age group.

One disappointing feature of the guidelines in this book is the lack of specificity, such as the guideline to "use large icons and buttons," without specifications for dimensions. Also, in some

cases, the guidelines in the book have already become outdated because of changes in Web technology.

For example, Holt and Morrell (chapter 7, pp 109-129) present a list of design guidelines, with explanations to support their use from a cognition perspective. However, some of these guidelines are based on practices or technologies, such as the implementation of frames or tables to enforce page layouts that are no longer needed. Newer technologies, such as "liquid" layouts, remove many of the issues of the old design tools.

Similarly, Morrell's recommendation (here and in other works) to not use "walking menus" (also called "cascading menus," secondary menus that appear while you are holding the cursor over an item on the primary menu) may no longer be needed. He recommends against using walking menus because older users have problems selecting small targets that do not stay open. Now there are more attributes that can be applied to these types of navigational features to slow them down and make the cursor targets larger — which may make them usable for older adults if the attributes are implemented well.

Furthermore, some of the reasoning behind guidelines about audio and video are also outdated. Although many older adults do have older computers with older browsers and slower Internet connections, the technologies for downloading and streaming are better, smarter, and faster than they were in 1999. Getting access to those types of media is less demanding on the user because the features have been integrated more tightly with Web site design. Indeed, www.NIHSeniorHealth.gov includes video and audio.

An interesting chapter for issues of accessibility is the one by Katharina Echt (chapter 5, pp 61-87). Echt presents Web design guidelines that are based on her review of research about visual disabilities. These guidelines could be tested in usability tests and participatory design situations. However, she does not describe tests of the guidelines and it is unclear whether these guidelines were used and tested on www.NIHSeniorHealth.gov. Furthermore, Echt confesses that while the (then untested) guidelines may help users with some types of disabilities, it is possible that some may not help, and may actually hinder, users with other types of disabilities or without disabilities. [See also Theofanos and Redish [46] and Hawthorn [26] and Zajicek and Morrissey [54] for discussions about tradeoffs between accessibility with usability for older adults and functionality that a wider audience might find useful.]

[40] Morrell, Roger W.; Dailey, Stephanie R.; Feldman, Claudia; Mayhorn, Christopher B.; Echt, Katharina V.; National Institute on Aging. *Older adults and information technology: A compendium of scientific research and web site accessibility guidelines.* **Report, National Institutes of Health. Revised April 10, 2003. Organization's URL: www.nih.nia.gov.**

This is a review of research about older adults and technology use (not exclusive to using the Web). Many of the sources cited are quite old and refer to research done about teaching older adults to use computers in the age of DOS and the first GUI operating systems. Much of the review surveys technology in the lives of older adults, from assisted living monitors to ticket kiosks. Like other Morrell pieces included in this review, much of the research included here comes from disciplines of psychology and gerontology and combinations of those.

Some of the research is based on surveys and focus groups, which largely rely on self-reported behaviors and memories, as well as preferences. The authors admit that older adults often have memory limitations. Also, while we should naturally take preferences into account, it is clear from

research cited in Morrell and in many other sources that preference and performance often do not match.

The authors provide good guidelines, but many of them are based on research on print materials, also somewhat old (early and mid-1990s). Some conclusions contradict studies in this review such as about typeface [Bernard] and organizing text [Lin], but are supported by other articles included in this review [Redish, Turns and Wagner].

This Morrell, et al. review has a large section about how to train older adults to use the web. One important insight from this review is that all types of users tend to learn better when paired with someone else or in group situations.

[41] National Institute on Aging; National Library of Medicine (U.S.). *Making your web site senior friendly: A checklist*. **Pamphlet, National Institutes of Health. Organization's URL: www.nia.nih.gov or www.nlm.nih.gov; http://www.nlm.nih.gov/pubs/checklist.pdf .**

This is a list of 25 guidelines based on the Morrell, et al. *Compendium*. [See [28].]

[42] Redish, Janice C. "Letting Go of the Words." Article, *Intercom.* **Pp 5-10. Society for Technical Communication. June 2004.**

Citing research by Morkes and Nielsen, Shriver, and a case study of some of her own research on Firstgov.gov, Redish presents tested guidelines with excellent examples of good and poor practices for selecting content, designing information pages, and writing for the Web.

[43] Rogers, Wendy A. and Arthur D. Fisk. "Human Factors, Applied Cognition, and Aging" in Craik, F.I.M. and Salthouse, T.A. *Handbook of Aging and Cognition.* **Book, Lawrence Erlbaum Associates, 2000.**

This is partially a review of cognition research about older adults and partially an education piece about what the field of human factors does and is. The authors discuss "solving daily living problems for older adults" and present a process model for doing so. They also summarize briefly findings from several studies. Many of the studies were technology-related, but few included use of Web sites.

Many of the solutions for older adults that the authors present include training, and they suggest that collaborative training situations that don't force people to rely on working memory (short term memory) work best. In the studies they report, showing worked better than telling.

[See also these annotated references about issues connected to collaborative learning: [9] Chadwick-Dias, Tedesco and Tullis; [10] Chadwick-Dias, McNulty and Tullis; [13] Coyne and Nielsen; [21] Gregor, Newell and Zajicek; [29] Kantner and Rosenbaum; [34] Mazur and Lee.]

[44] Tedesco, Donna with Ann Chadwick-Dias and Tom Tullis. "Freehand Interactive Design Offline (FIDO): A New Methodology for Participatory Design." Conference paper, Usability Professionals' Association Proceedings 2004.

Realizing that many older adults experience some level of anxiety when using computers, and concerned that this anxiety might be heightened in usability testing when the older adults know they are using prototypes, the authors invented a new methodology for participatory design. In this method, participants physically select and position magnetized screen elements to create their own Web pages. Participants have the advantage of easy manipulation; researchers have the advantage of a user-designed low-fidelity prototype at the end of a session. The method can be

used with individual participants or in a group situation. [See also Chadwick-Dias, Tedesco and Tullis [7], "Demographic Differences in Preferred Website Content."]

[45] Theofanos, Mary and Janice Redish. "Guidelines for accessible and usable websites: Observing users who work with screen readers." Article, *Interactions*, X (6), November-December 2003, pp 38-51. ACM, the Association for Computing Machinery.

The authors carried out research at the U S National Cancer Institute to understand how blind users work with Web sites and to investigate the relationship between usability and accessibility. In the study reported here, 16 blind users worked with Web sites and the assistive technology (screen-reader) that they were used to. The authors present 32 guidelines for making sites both usable and accessible to screen-reader users.

[46] Theofanos, Mary and Janice Redish. "Helping low-vision and other users with web sites that meet their needs: Is one site for all feasible?" Article, in press, Technical Communication, 52, 1, February 2005.

A companion to "Guidelines for Accessible and Usable Websites" [45], this article describes research carried out at the U S National Cancer Institute on the problems of low-vision users working with Web sites. Findings demonstrate the difficulty of resolving issues for this highly diverse audience. The authors argue that we need a paradigm shift in how we think about accessibility and propose a vision for universal usability in the form of a profile that follows users around from site to site (perhaps like Hanson's proxy server; see [23], but having even more universal application such as Hanson's Web Adaptation Technology; see [24]).

[47] Tullis, Thomas S. "Tips for Conducting Usability Studies with Older Adults." Presentation, Usability University July 2004; jointly sponsored by GSA, HHS and AARP.

Tullis offers useful tips for finding and recruiting older participants as well as managing logistics in ways that may be different from procedures for studies with younger participants.

[48] Turns, Jennifer and Tracey S. Wagner. "Characterizing Audience for Informational Web Site Design." Article, Technical Communication, Volume 51, No.1, p.68-85 February 2004.

Using three methods of gathering data about the users of a web site called *Arthritis source* – logfile analysis, a 16-question online survey, and a phone interview – the authors learned about user roles, user goals, and how knowledgeable users of the site were about health issues related to arthritic conditions. This data helped the team confirm some of their beliefs about how to design the web site. The data also helped the team to develop features to dispel misconceptions they learned in phone interviews that users had about arthritis. They were able to address possible navigation issues and gained a better understanding of how visitors got to the *Arthritis source* (53% came through a search engine). More than half of the audience for this site was age 50 or older. One surprising result was that 20% of those surveyed classified themselves as "other" with respect to their role. The team had thought they had anticipated the possible roles using their web site (person with arthritis; relation of person with arthritis; medical professional; medical student; student; researcher), so finding that such a large percentage of their users did not fit into known roles they reexamined this result and analyzed its meaning.

[49] White, Linda with Jenny Jerrams-Smith and David Heathcote. "Improving access for elderly and severely disabled persons: A hybrid adaptive and generic interface." Chapter in *Universal Access in HCI: Towards an Information Society for All***. Stephanidis, C., Ed. Lawrence Erlbaum Associates, Mahwah. 2001; pp 1025-1028**.

The authors conducted empirical research to classify relevant "deficits" of software users. Understanding the classifications could be very useful to designers of Web sites. Also, the authors constructed software that finds out what limitations and impairments users have and then adjusts its own user interface to accommodate those needs. As of the date of the paper, however, the software was a prototype and had not been tested by users.

[50] Wright, Patricia. "Supportive documentation for older people." In C. Jansen, R. Punselie, & P. Westendorp (Eds.) *Interface Design and Document Design* **(pp. 31-43). Amsterdam: Editions Rodopi BV. 2000.**

Concerned with multimedia documentation of various genres in combination with the user interfaces that the documentation supports, Wright explores the many issues of designing interfaces and documentation for older adults. In creating and usability testing a memory aid on a small computer to be used by people with severe memory problems, Wright and colleagues consulted the literature on cognition and aging along with document design to determine their design directions in combining documentation and user interface for the memory aid. These are some of the design implications of Wright's study:

- Presenting online text at a height of 9 mm (16-25 point) rather than 5 mm (10-12 point) may help some older readers of print text, but type larger than that may actually make text more difficult to read online because there would be less content visible on a computer screen at one time. As Wright told us in an email, "Questions of [how large type should be] are context sensitive and depend on the readers, their visual abilities, the material and the tasks being done with it."
- Large text causes less to be visible on a screen.
- Redundant visual cues such as color coding and spatial location assist older adults in discriminating visual elements on a screen or Web page.
- Multi-modal messaging that is identical in every mode assists older adults in performing tasks more quickly and efficiently.
- Older adults benefit from starting with minimal functionality and information and then increasing complexity at their own pace.
- By establishing a learning situation in which opportunities for errors are reduced, distractions from the task goals are also reduced, better supporting the attention, memory, and recognition abilities of older adults.
- Attention is also assisted by keeping information hierarchies shallow.
- Important information must be within the visual field being used for the task being performed.
- Important details must be emphasized to mitigate memory issues and the tendency of older adults to gloss over finer points and focus on gist.
- Because older adults rely more on cues in their task environments than younger adults do, Wright recommends implementing advanced organizers that illustrate processes and where the person is within the process.

Finally, Wright concludes – as do others in this review of the research – that "When conducting user tests, it is not necessarily the case that age is the most important characteristic on which people should be matched. Peers of any age can vary widely in their cognitive abilities."

[51] Wright, Patricia and Steve Belt. "Combining language and animation in multimedia instructions benefits older people." *Gerontechnology*, **1, 60-62, 2001.**

This preliminary report presents findings from a study comparing whether 32 younger (age 20-46) and 32 older adults (age 50-83) performed better when they received instructions through animated sequences alone or in combination with spoken and written instructions. Participants performed two tasks, one with instructions that combined animation with written and spoken language and the other with either only animation or only written and spoken language. The researchers tried to determine whether

- text supplemented by speech reduced effects of sensory and cognitive impairments
- adding graphics compensated for language comprehension issues

Participants were counterbalanced in performing tasks in which they were instructed by the computer in one of the modes to rearrange seven shapes on the computer screen. The researchers found that older adults performed faster when instructions included both animation and language than when they had only animation or only language. Younger adults performed the same regardless of the mode of instruction. The researchers conclude that since the combination did not impair younger users but helped older users that "multimedia instructions should include animation together with written and spoken language."

[52] Wright, Patricia with Steve Belt and Chris John. "Fancy graphics can deter older users: A comparison of two interfaces for healthy lifestyle options." Conference paper. *People and Computers*, **Proceedings of HCI 2003.**

To determine whether a table layout or a more graphical layout for a user interface to a health decision-making tool mattered in the ease-of-use, efficiency of use, and outcomes for patients, the researchers paid 32 volunteer participants, 16 male and 16 female, 16 younger (age 20-40) and 16 older (age 61-75), to "advise" hypothetical patients using the two interfaces. With identical functionality and interaction syntax, the order of use of the two interfaces was counterbalanced across participants. While the researchers qualify their results, saying that they could be different in a clinical setting rather than a usability testing situation, they conclude that the interface did influence how the tool was used. As they state, "The data have shown that a graphic interface [combining visual representations of data as icons and bar charts] can reduce the amount of exploration undertaken by older people. This cannot be due to a reluctance to explore and modify lifestyle factors since the younger and older groups did not differ in the amount of exploration done with the tables [interface showing data as comparative percentages in lists]."

[53] Zacks, Rose T. and Lynn Hasher and Karen Z. H. Li. "Human Memory" Craik, F.I.M. and Salthouse, T.A. *Handbook of Aging and Cognition.* **Book, Lawrence Erlbaum Associates, 2000.**

In a subsection of the chapter about situational models (mental models), the authors review research about older adults' ability to create representations of text or to visualize geographic locations after reviewing a map from descriptions they've read. While older and younger adults seem to use mental models the same way, Radvansky, Gerard, Zacks, and Hasher [1990] say older adults made more errors. Morrow, et al. found that older adults took longer to memorize maps and were slower to read and answer questions about the situation posed.

[54] **Zajicek, Mary and Wesley Morrissey. "Multimodality and interactional differences in older adults." Special Issue "Multimodality: a Step Towards Universal Access' of Universal Access in the Information Society,(ed. N. Carbonell) Springer, Vol 2/2 pp 125 - 133. 2003. Available at http://cms.brookes.ac.uk/computing/speech/PDF/103 uais typeset by Springer.pdf**

This paper focuses on results of experiments with older adults using a web browser that uses voice output to instruct users. In this paper, Zajicek and Morrissey report on findings from a series of follow-up studies to [55]. This time, the experimenters were interested in

- how easily older adults remembered the voice instructions when they were shorter or longer
- whether having text instructions in addition to voice instructions helped users
- comparing the usability of text and speech output without a bi-modal (text with speech) condition

Although their major conclusion is that presenting messages in very large type at high contrast is a better mode for information for older adults with some visual impairment than voice messages are, how Zajicek and Morrissey reached their conclusion is interesting.

The authors readily admit that "the effects of ageing [sic] on learning and memory processes in connection with computer interaction are difficult to disentangle. Such impairments affect the user's ability to form conceptual models at the interface, and arguably also affect the ability of navigation and orientation." Zajicek and Morrissey hoped that by implementing a "speaking front end" in a browser that they could assist older users in creating conceptual models of the system by answering questions in the same way they would on a telephone answering system. Their results show that study participants performed better with the new Voice Help than they did with the basic BrookesTalk browser. However, when they added a text mode for messages, they found that participants' recall of instructions and functions was better than with voice messages and better than with a combination of text and voice. Like Hawthorn [26], the authors also note that there are tradeoffs between usability and functionality for older adults who are first-time users of computers and the Web.

[55] **Zajicek, Mary and Sue Hall. "Solutions for elderly visually impaired people using the Internet." In S. McDonald, Y. Waern, G. Cockton (eds) People and Computers XIV – Usability or Else!, Proceedings of HCI 2000, pp 299 - 307**

Zajicek and Hall assert that the two main factors contributing to low usability and ease-of-use for older adults are "age associated memory impairment and visual impairment" – two factors that the interface with the Web most rely on. They argue that the Web is highly visual and demands that users be able to remember where they have been within a navigational path so they can return to points within the path or to the beginning. Their hypothesis in developing screen reading software called BrookesTalk is that repeating options aurally helps older adults form a conceptual model of the web site, and may also help them bypass modeling of a web site by responding to menu items by answering questions.

Findings from a usability study with two groups of 4 elderly visually impaired computer novices give guidance about reducing memory load by grouping messages, and assisting information retention by using the fewest, shortest possible spoken messages. (Zajicek never defines what age "older adult" starts at.) Zajicek and Hall tested to find out if older adult novices

- learned more quickly and easily if they had personal support available

- learned more quickly and easily with computer based support
- "weaned themselves off the support" eventually, to use the browser by itself

One group of participants was given written instructions for using the software. The other group was given a demonstration of the software. A helper was present to answer yes or no questions. The experimenters found

- some participants performed better and more quickly having had personal support, but it was unclear whether they were helped by the demonstration or they just felt more confident because someone was readily available to answer questions
- participants who received personal support were able to "build 'crystalline' conceptual models" but users who did not receive personal help could use the enhanced version of the software, which included computer based support, but could not use the software without the computer based support.

In addition, Zajicek and Hall conclude that web interfaces should have limited functionality that can be expanded as the older adult user learns more and becomes more confident. [See also Zajicek and Morrissey [54].]

[56] Zaphiris, Panayiotis with Sri Hastuti Kurniawan, and R. Darin Ellis. "Age Related Differences and the Depth vs. Breadth Tradeoff in Hierarchical Online Information Systems." Chapter in *Universal Access: Theoretical Perspectives, Practice, and Experience* **(7th ERCIM International Workshop on User Interfaces for All. Paris, France, October 2002. Revised Papers.) pp 23-42.**

Expanding on experiments by Miller, et al. and Zaphiris, Shneiderman, and Norman about information hierarchies, these researchers added age factors and factors for whether the menu hierarchies were expandable or not.

The experimenters created two web sites with 64 pages each. The content of the web sites was the same, taken from the Senior Health section of www.dmoz.org. One web site was designed to have an expandable information structure; the other was not expandable. Although there are diagrams of the two designs in the article, they are quite small and it is difficult to discern what the differences might look like or behave like. It appears that "expandable" means that the next level in a hierarchy appears within the same page, similarly to how tree structures work in Windows applications. The non-expandable version led to a new page when a link was clicked to expose the next level of links.

Within each of the two web sites were three depth conditions:

	Number of topics		
depth	2	3	6
breadth	8	4	2

There were 24 participants who were 57 years old and older and 24 participants who were age 36 or younger. All participants had some experience with computers and the Web. Participants were asked to browse their assigned site to look for three non-health related topics. Throughout the rest of the session, participants performed 72 information search tasks – 6 tasks on each of the depth treatments on two different information hierarchies. These tasks all asked participants to search for health-related topics. The order of presentation of the conditions was counterbalanced.

As in other studies, shallower hierarchies were preferred by users and the users also performed better at the shallowest hierarchy than at the deepest hierarchy. However, overall, the older participants (57+) were slower than the younger participants (18-36), but did not make more errors than younger participants. Interestingly, the older participants were "disproportionately" affected by increasing depth. Participants did not perform significantly better in expandable hierarchies – contrary to studies by Lin [31]. In this case, this result may have been an artifact of the design of the hierarchies and the fact that they fit on a single screen when fully expanded.