Web Usability and Age:
How Design Changes Can Improve Performance

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ABSTRACT
We conducted two usability studies that included a total of 49 participants ranging in age from 20 to 82. The goal of Study 1 was to learn whether there were differences in how older adults interact with the Web and whether changes in text size would affect performance. Users completed tasks on a prototype employee/retiree benefits site using various text sizes. We learned that older users (55 years or older) had significantly more difficulty using the Web site than younger users. Text size did not significantly affect performance in any age group. In Study 2 new participants performed the same tasks on a version of the site that was redesigned to address the usability problems encountered by older users in Study 1. The goal was to learn whether we could redesign the prototype to improve the performance of older adults. Performance improved significantly for both older and younger users.

Categories and Subject Descriptors
H.5.2 [**Information Systems**]: Information Interfaces and Presentation – *user interfaces*.

General Terms
Performance, Design, Human Factors.

Keywords
Aging, Web usability, Web design, universal design, older adults, gerontechnology.

1. INTRODUCTION
Older adults represent the fastest growing demographic worldwide. As indicated in the Year 2000 U.S. Census, there are 35 million people 65 or older in the U.S. [10]. By 2030, it is estimated that there will be about 70 million older adults in the U.S., which is more than twice their number in 2000. In the year 2000, adults 65+ represented 12.4% of the U.S. population; by 2003, this number is expected to grow to be 20% of the population [9]. Statistics from other countries, including Canada [8], France [4], and England [7] reveal a similar pattern of the growing senior demographic.

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The World Health Organization estimates that by the year 2020, 24% of Europeans, 17% of Asians, and 23% of North Americans will be over the age of 60 [12]. By 2020, the world will have more than 1 billion people age 60 and over [12]. The older population is growing rapidly worldwide and is becoming an increasingly important demographic to understand. As older users are increasingly exposed to technology, understanding their unique requirements will become paramount in the design of human interfaces.

According to Coyne and Nielsen (2002), there are an estimated 4.2 million Internet users over the age of 65 in the United States [1]. This number will continue to grow internationally at a rate that reflects the overall population trends previously discussed.

Until recently, relatively few research studies have attempted to examine how older adults interact with the Web. However, a recent study by Coyne and Nielsen [1] indicated that older adults (defined as over 65) experienced about half the level of usability as compared to their younger counterparts. One study indicated that older users are less likely to use the Web [6] while another study showed that older users have unique difficulties while using the Web [5]. Contrary to these findings, at least one preliminary study suggested that older adults are more accurate, even though their task times are longer, because they take the time to read text on the screen [3]. However, few studies have attempted to control for the level of PC/Web experience between the younger and older age groups. It is therefore difficult to know whether the differences observed in these studies between younger and older users are truly age-specific differences or are simply a result of the fact that younger users are more likely to have more PC/Web experience than older users.

While several studies have recommended specific design modifications for older users, few have proven that these recommendations actually improve their performance. To do this, a baseline study must be conducted to determine if age-related performance differences exist, and then a follow-up study must be conducted on a redesigned interface to determine whether these design modifications improve the performance of older users (and how this may affect the performance of younger users). A study by Worden and associates demonstrated that design modifications that help older users often offer at least some benefit to younger users as well [11].

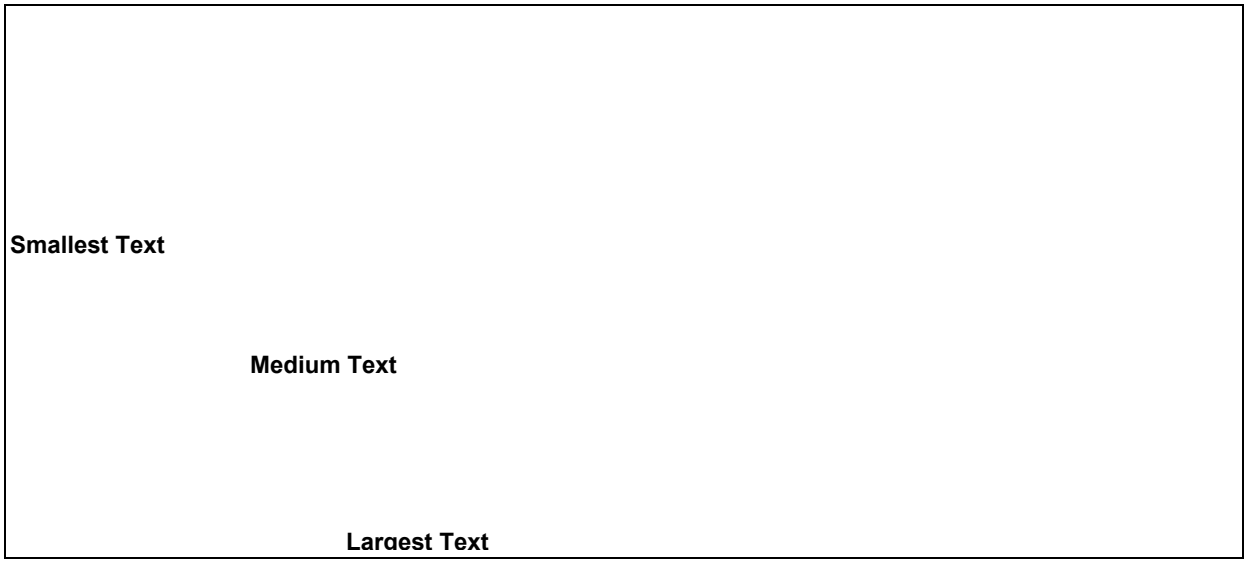

Figure 1: Prototype Versions of Site (Smallest, Medium & Largest Text Size) – Study 1

Our study attempted to at least loosely control for the variable of PC/Web experience and learn whether older adults have unique requirements that are not simply caused by less experience. Another goal was to learn whether specific design modifications could improve the performance of older users and how these modifications may also affect the performance of younger users. The study was divided into two parts: Study 1 – baseline study and Study 2 – follow-up study.

2. STUDY 1 - METHOD

Study 1 was a baseline, exploratory study to learn more about how older adults use the Web, to determine whether they have any unique requirements, and to identify those requirements. Subjects were given realistic tasks to complete on a prototype version of an employee/retiree benefits site that allows people to manage their retirement, health, and other benefits online. Level of PC/Web experience was controlled across groups. Both performance and preference data were collected.

Participants were recruited via email and phone and asked to come to our usability labs in Boston, MA, to participate in a 1.5-hour usability session of an employee/retiree benefits site. Transportation assistance was provided if necessary and subjects were allowed to bring along a friend if desired. None of the participants were employees of our company. They received a $100 gift check as compensation.

2.1 Participants

27 participants were recruited and balanced by age and overall level of PC/Web experience. PC/Web experience was measured using a 5-pt scale (0 to 4) based on frequency of use. Participants were asked to report their levels of PC experience and Web experience separately on the following scale: 0=none to 4=use daily. These scores were then added together to provide an overall PC/Web experience rating, which could therefore be from 0 to 8.

Our goal was to obtain a broad sample of ages and then balance for level of PC/Web experience so that we could ensure any differences we saw were not due to the fact that older people tended to have less experience using the Web. Therefore, to the extent possible, overall level of PC/Web experience was balanced as shown in Table 1. For purposes of data analysis, participants were divided into two age groups: under 55 and 55 +.

Table 1. Participant Demographics – Study 1

Study 1 Demographics	Age Group	
	Under 55	55 +
Average Age	35.9	69.2
PC/Web Experience (0=None to 8=High)	6.0	5.6

Participants were given a background questionnaire that included a series of additional demographic questions.

2.2 Prototype Description

The employee/retiree benefits prototype was a Web site that provides access to company benefits, including retirement savings, pension, health insurance, and payroll information (Figure 1). Users can learn about and manage benefits on this site.

Participants interacted with three text-size versions of the site (changed using the browser function View > Text Size). To determine whether text size would have an effect on user performance and preferences and whether this effect would differ with age, users completed 5 tasks on the Web site using the smallest text size, 5 tasks using the medium text size, and 5 tasks using the largest text size. The prototype's style sheet used scalable font sizes that included xx-small (legal information, footnotes), x-small (body text, table text, table headings), and medium (page titles). The font used throughout the site was Verdana. The order of presentation of text size was balanced across age groups.

Participants completed tasks on the prototype site as displayed in 800X600 resolution on a 17-inch monitor, using Microsoft® Internet Explorer version 6.0.

2.3 Tasks

Each participant was given a total of 15 tasks. The tasks were intended to represent the typical types of tasks users perform on an employee/retiree benefits site. For example:

- *You need to make some changes to your Theta 401K Plan. Take 10% of the money from your CAPITAL MID-CAP STK and invest it in CAPITAL FOCUSED STOCK.*
- *If you were to stop working at Theta Corp. today, what monthly payment would you receive from your Theta Pension Plan, assuming you retire at age 65?*

The task order was randomized by writing each task on an index card and shuffling the cards prior to each usability session. Participants were given one task at a time and asked to read it aloud.

2.4 Usability Session Structure

When participants arrived at the lab, they were given the background questionnaire. The moderator then escorted them into the testing room and provided a brief description of how the study would be conducted. The same moderator conducted every session. Participants were given a written overview for the session that included a description of the prototype site and a persona they would be assuming for the session. Participants were handed one task at a time and asked to read it aloud. Task duration, task success scores, and click data were collected along with several preference ratings. The task time started after the participant read the task aloud and ended in one of three ways:

1. The participant found the answer. A predetermined "correct" answer for each task was used to calculate task success measures.
2. The participant gave up (says they would stop or call someone).
3. The participant made 4 or more errors (wrong paths) and the moderator asked them to move on to the next task.

During the session, participants were allowed to take breaks as needed. At the end of each session, users were given a post-study questionnaire that asked them for various subjective ratings.

3. STUDY 1 – RESULTS

Older users completed fewer tasks successfully and took longer on each task (Table 2). Both age and experience correlated with overall performance, with age showing the strongest correlation. Text size was shown to have no overall effect on performance, though older users were more likely to prefer the larger text size.

Table 2: Performance Results – Study 1

	Under 55	55+
Task Success (% correct)	64.2%	44.8%
Task Duration (seconds)	109.5	148.3

3.1 Age and Task Duration

Users 55 years of age or older had significantly longer task duration times than those under the age of 55, F (1,25) = 8.57, p<.01. Task duration was correlated with actual age (r = 0.52, df = 25, p< .01). The older people were, the longer they took to complete each task.

3.2 Age and Task Success

Users 55 years of age or older had significantly lower task success rates than those under the age of 55, F (1,25) = 6.46, p<.01. Task success was correlated with actual age (r = - 0.50, df=25, p< .01). The older people were, the fewer tasks they completed successfully.

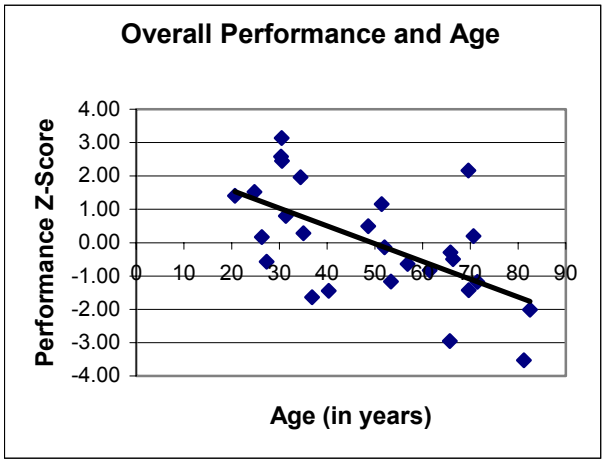

Figure 2: Overall Performance and Age – Study 1

3.3 Age and Overall Performance

By standardizing the task duration and task success scores and then combining them, an overall performance score was calculated for each participant. So that higher numerical values for task success and task duration meant better performance, the z-score for task duration was multiplied by a value of –1, thereby inverting the value so that higher z-scores meant lower task durations. Using this combined performance measure, overall performance and age were correlated (r = - 0.60, df=25, p< .01) (Figure 2). The older people were, the lower their overall performance.

3.4 Experience and Overall Performance

Using the same performance z-scores, overall performance and PC/Web experience were correlated (r = 0.49, df=25, p< .01) (Figure 3). The more experienced people were, the higher their overall performance.

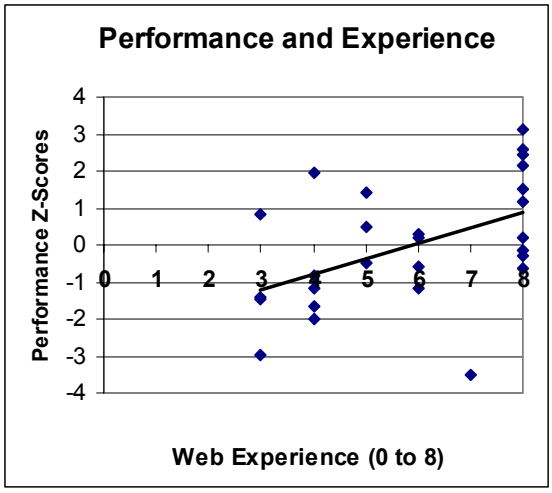

Figure 3: Overall Performance and Experience – Study 1

3.5 Age and Click Behavior

Click data was analyzed for a random sampling of the tasks and we found that older adults averaged significantly fewer clicks per minute than younger adults, F (1,23) = 4.57, p<.05 (Figure 4).

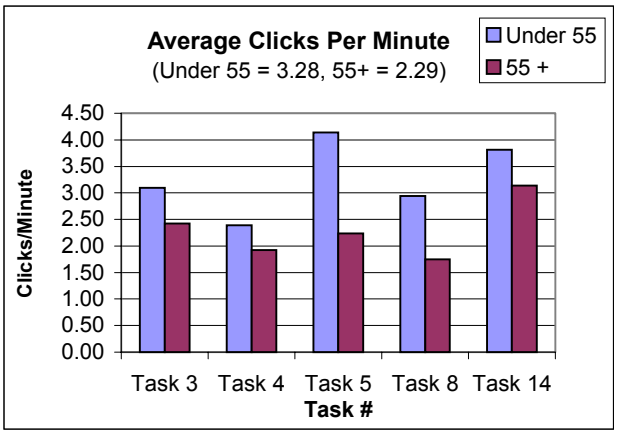

Figure 4: Average Clicks per Minute - Study 1

Older users also were more likely to click on non-links, including bullets, icons, and table headings.

3.6 Age and Text Size

Interestingly, text size did not have a significant effect on performance for any age group. Users performed equally well with the three text-size versions, with no differences between age groups. However, when users were asked which text-size version they preferred overall, older users were more likely to prefer the larger text size than younger users (X2=7.16, df=2, N=27, p<.02) (Figure 5).

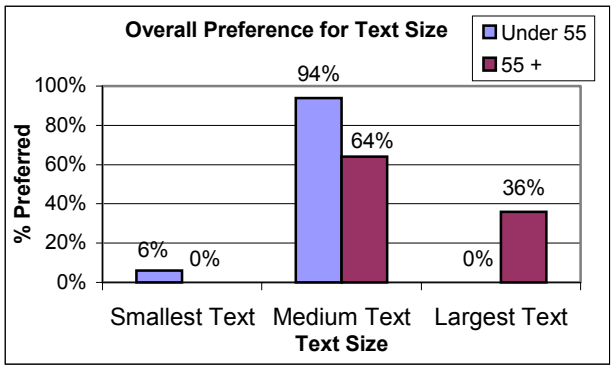

Figure 5: Text Size Preference and Age - Study 1

3.7 Age and Preference Ratings

Older adults tended to provide higher overall preference ratings (combining all text-size versions) than those under the age of 55. Single factor ANOVAs demonstrated that older adults provided significantly higher ratings on two of the three subjective ratings: visual appeal (p<.001) and readability (p<.05). It is interesting to note that while older users demonstrated more difficulty reading text in general, they provided higher overall ratings for readability.

3.8 Age Differences in Behavior

During the usability sessions, extensive observational notes were recorded in an attempt to understand the behavioral differences that might exist between younger and older adults and how these behaviors might affect performance. We observed a variety of notable differences in how older adults interacted with the Web.

3.8.1 More Cautious User Interaction Approach

Older users were far more cautious in everything they did on the Web, including clicking on links. Older users spent more time reading information before clicking and even pondering the pros and cons of clicking before attempting to click a link. We have termed this behavior as "cautious clicking." Whereas younger users clicked rather haphazardly in their attempts to find information, older users tended to be very cautious, almost as though clicking represented an action that they may not be able to reverse.

3.8.2 Clicking Non-Links

Many of the older users repeatedly clicked on items that were not links, including table headings, bullets, icons, and just plain text. Their strategy seemed to be to click on any item that seemed to meet their expectations for whatever target they were seeking. So, for example, when they were trying to change something in a retirement account, they often clicked on a table heading in the left-hand navigation that was termed "Account Management" simply because they were trying to "manage their account."

3.8.3 Accessing Highly Detailed Table Data

On pages that had large data tables, older users had significant difficulty accessing information and often could not move beyond that page while attempting to complete a task.

3.8.4 Understanding Web Terminology and Technical Jargon

Older users often did not know Web and other technical terms that younger users tended to be familiar with, like minimize or home. However, older users had a better understanding of some other terms, like pension.

3.8.5 Spend More Time Reading Text and Instructions

Older users tended to read more text and often read all the text on a screen, especially when they were being asked to input information.

3.8.6 Difficulty Understanding their Location or Path

Older users were often confused as to where they were within the context of the Web site. Several times they clicked on a link in the left-hand navigation when they were already on that page.

3.8.7 Difficulty with Window Management and Scrolling

In secondary pop-up windows that forced horizontal scrolling because they displayed less than full screen, older users did not notice the horizontal scroll bar and often never saw the information on the right side on the screen.

3.8.8 Difficulty with Tabbed Navigation (Displayed on Mouseover)

Older users demonstrated difficulty using the tabbed navigation that displayed on mouseover. It frequently took them several attempts to properly use the navigation.

The usability problems older users encountered in Study 1 were addressed in the redesign of the site in Study 2.

4. STUDY 2 – METHOD

Study 2 was a follow-up study that attempted to address the Web usability problems encountered by older users in Study 1. New subjects were given the same tasks as in Study 1 but worked with a redesigned version of the employee/retiree benefits prototype.

4.1 Participants

22 participants were recruited and balanced by age and overall level of PC/Web experience as described in Study 1 (Table 3).

Table 3: Participant Demographics - Study 1 and Study 2

	Study 1		Study 2	
	<55	**55+**	**<55**	**55+**
Average Age	35.9	69.2	34.6	65.6
PC/Web Experience (0=None to 8=High)	6.0	5.6	5.9	5.9

4.2 Prototype Description

For Study 2, participants interacted with a redesigned version of the employee/retiree benefits prototype used in Study 1 (Figure 6). Design modifications addressed specific usability problems encountered by older users in Study 1 (Table 4).

Figure 6: Redesigned Prototype - Study 2

Since no significant performance differences were found between text-size versions in Study 1, only the medium size (browser default) was used throughout Study 2. The same style sheet was used and applied as in Study 1.

Table 4: Design Changes to Prototype - Study 2

Design Solutions for Study 2
Cautious Clicking - Improved terminology, used action word links (*Go to* this account, *Move* Money, *Choose* Investments, etc.).
Clicking Non-Links - Increased # and % of links, used consistent treatment of links (blue, bold, underline, red on mouseover), made icons and bullets links.
Accessing Highly Detailed Table Data - Reduced some detail, added a "Go to this account" link, added more instructional text.
Understanding Web Terminology & Technical Jargon - Simplified terminology throughout.
Spend Time Reading Text and Instructions - Reduced some unnecessary text, added more concise instructions.
Difficulty Understanding their Location - Added titles, added explanatory text, added "active choice" indicator to top and left navigation.
Difficulty with Window Management and Scrolling - Removed any false bottoms, explicitly stated when a new window would open.
Difficulty with Tabbed Navigation (displayed on mouseover) – Simplified top navigation to a simple set of links.

4.3 Tasks

Participants completed the same 15 tasks as in Study 1 but with a few minor wording changes to make them less leading, in consideration of the changes made to some terminology in the redesigned site. Task order and presentation were as described in Study 1.

4.4 Usability Session Structure

The usability session was structured as described in the methods section of Study 1.

5. STUDY 2 - RESULTS

Overall usability improved significantly for all users independent of age. In terms of age-related trends, Study 2 results mirrored Study 1 results almost exactly (Table 5). Older users continued to experience lower usability as compared to their younger counterparts. However, overall usability improved for all ages from Study 1 to Study 2.

Table 5: Performance Results - Study 1 and Study 2

	Study 1		Study 2	
	< 55	55+	< 55	55+
Task Success (% correct)	64.2%	44.8%	80.6%	58.2%
Task Duration (seconds)	109.5	148.2	74.6	114.6

5.1 Age and Task Duration

For Study 2, users 55 years of age or older had significantly longer task duration times than those under the age of 55, F (1,20) = 6.15, p<.05 (Figure 7). Task duration was correlated to actual age (r = 0.42, df = 20, p< .05). The older users were, the longer they took to complete each task.

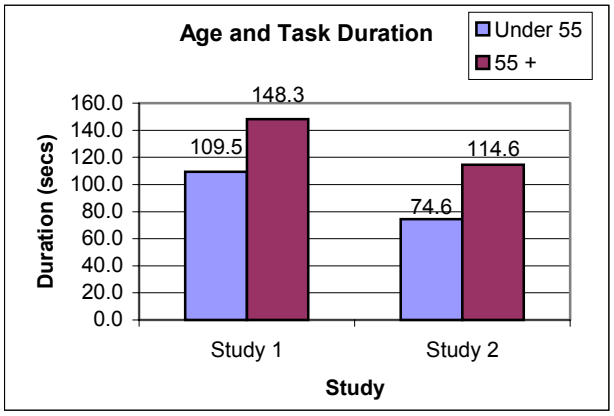

Figure 7: Task Duration - Study 1 and Study 2

A repeated measures ANOVA was conducted on task duration across both studies by age group. There were main effects of study, F (1, 45) = 11.04, p<.001, and age group, F (1, 45) = 14.56, p<.001, with interactions between study and task, F (14, 629) = 1.73, p<.05, and between age group and task, F (14, 629) = 2.3, p<.01. This demonstrates that significant differences existed between age groups in both studies and significant improvement in task duration was experienced by both age groups in Study 2.

5.2 Age and Task Success

For Study 2, users 55 years of age or older had significantly lower task success rates than those under the age of 55, F (1,20) = 7.57, p<.01 (Figure 8). Task success was correlated to actual age (r = - 0.53, df=20, p< .01). Again, as in Study 1, the older people were, the fewer tasks they completed successfully.

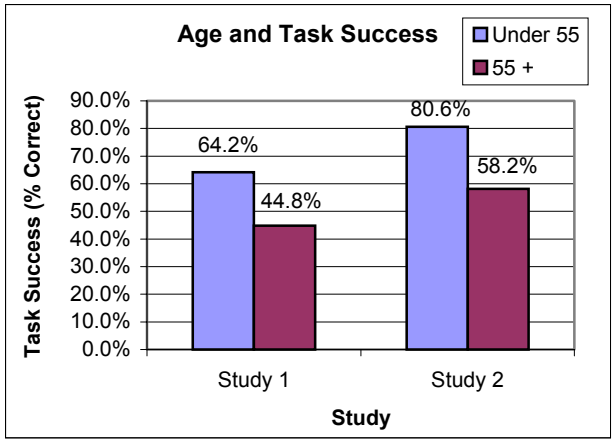

Figure 8: Task Success - Study 1 and Study 2

A repeated measures ANOVA was conducted on task success across both studies by age group. There were main effects of study, F (1,45) = 7.44, p<.01, and age group, F (1, 45) = 13.92, p<.001, with interactions between study and task, F (14, 629) = 2.36, p<.01, and between age group and task, F (14, 629) = 2.27, p<.01. This demonstrates that significant differences existed between age groups in both studies and significant improvement in task success was experienced by both age groups in Study 2.

5.3 Age and Overall Performance

Using the combined performance measure previously discussed in the Study 1, overall performance and age were correlated (r = - 0.51, df=20, p< .05).

By combining the task duration and task completion scores for all subjects in both studies and using these to standardize the data, z-scores were calculated for each subject and charted against age (Figure 9).

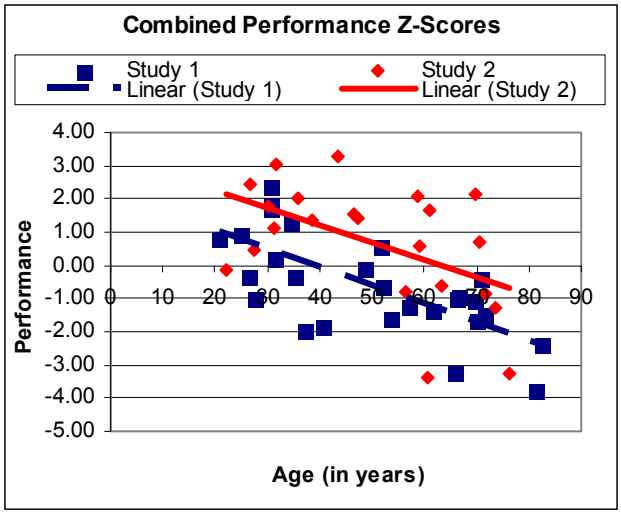

Figure 9: Performance and Age - Study 1 and Study 2

Overall performance improved for both age groups equally from Study 1 to Study 2. Therefore, the difference in performance between younger and older users persisted in Study 2, even though overall performance improved significantly.

5.4 Experience and Overall Performance

Using the combined performance measure previously discussed in the Study 1, overall performance and PC/Web experience were correlated ($r = 0.50$, $df=20$, $p< .05$). The more experienced people were, the higher their overall performance.

5.5 Age and Click Behavior

The significant difference in click behavior between younger and older users that was observed in Study 1 was not demonstrated in Study 2. Older users clicked faster (more clicks per minute) in Study 2 and there was not a significant difference between younger and older users (Table 6). The design changes implemented in Study 2, particularly the use of action word links, seemed to compel older users to click more readily with less hesitation.

Table 6: Clicks Per Minute - Study 1 and Study 2

	Study 1		Study 2	
	< 55	**55+**	**< 55**	**55+**
Clicks per Minute	3.28	2.29	3.37	3.03

5.6 Age and Preference Ratings

For Study 2, there was only one significant difference between younger and older users' preference ratings. Older adults rated ease of use *lower* than younger adults, F (1, 21) = 5.21, $p<.05$, which is a reversed finding from Study 1.

Even though older adults performed better using the Study 2 prototype, their subjective ratings of Prototype 2 were not significantly better than those for Prototype 1. This is contrary to the Coyne and Nielsen study [1] that demonstrated a positive correlation between task success and subsequent subjective ratings–they found that older adults preferred sites on which they performed best. It is possible that our data was more variable because our N was lower than the Coyne and Nielsen study.

6. DISCUSSION

This study clearly demonstrates that even when level of PC/Web experience is controlled, older adults experience significantly more usability issues on the Web than younger adults. Older adults demonstrated some unique behaviors that seemed to contribute to their lower overall performance; however, when specific design modifications were made to accommodate their unique needs, the modifications not only helped older adults, but also improved the performance of younger adults, with equal effect. We did not, therefore, "close the gap" in performance between younger and older users. When comparing Study 1 and Study 2 performance, the overall effect (or slope of the lines in Figure 8) is remarkably similar.

6.1 Controlling for PC/Web Experience

Measuring level of PC/Web experience using self-reported frequency of use was a somewhat limited means of controlling experience between age groups; however, this PC/Web experience measure and overall performance were significantly correlated in both studies. This means that the measure was at least partially effective in attempting to control for experience between age groups. Since we did control for PC/Web experience and still found a negative correlation between performance and age, we conclude that other factors are contributing to the lower performance observed in older users. In future studies, one could control for experience using more granular measures that consider other factors like long-term usage and types of activities done on the Web.

6.2 Text Size and Performance

Another interesting finding was that text size did not affect performance for any age group. This was a particularly interesting finding for the older adults. Many research studies have suggested that a major reason older adults suffer lower performance on the Web is their increased incidence of visual deficiencies. In this study, even though older adults clearly did have more difficulty reading smaller text on a screen, it did not have an effect on their overall performance. It is possible that the additional scrolling caused by larger text may have offset any beneficial effect of the larger text size. We did observe a non-significant trend for average task duration to increase as the text size increased. To further research this question of how text size may affect performance in older users, one could display the larger-size text version on a bigger screen thereby controlling for vertical scrolling between text-size versions.

6.3 Design Recommendations for Older Users

Based on the comprehensive results of this study, both empirical and observational, we developed the following list of design recommendations for older users; however, younger users will also benefit from these design approaches. While many of these recommendations are not novel, this study provides empirical support for these recommendations.

- **Use Action Word Links** - Since older adults are so cautious about clicking links, they are much more likely to click links that explicitly tell them what will happen when they click.
- **Make Link Treatments Consistent and Obvious** - Since older users do not readily recognize links, even when they are blue and underlined, it is most effective if link style is consistent and obvious throughout the site, and provides visual feedback on mouse-over.
- **Make Icons and Bullets Links** - Many older users seemed to associate bullets with buttons. By providing redundant links, older users have an increased likelihood of clicking their target and reaching their destination.
- **Use Scalable Fonts and Options to Increase Text Size** - Provide options for increasing the size of text on the site.
- **Use Concise Instructions** - Provide concise and simple instructions, to improve the likelihood of task success without adding significantly to the length of time it takes to complete the tasks.
- **Keep Terminology Simple** - Older users may not be familiar with terms like *URL*, *Home*, or *Back*.
- **Use Simple Navigation and Provide Redundant Navigational Cues** - Use navigation that does not require fine motor skills to access. Provide redundant cues that remind older users where they are and where they have been on the site.

- **Minimize the Use of Secondary Windows** - Older users were frequently confused by them and often could not get back to their primary workspace once the secondary window was maximized.

7. CONCLUSIONS

Older adults most likely experience lower usability because of a myriad of contributing factors including social, cognitive, psychological, and physical factors as well as overall differences in life experience (i.e., not using the internet at school or work).

The issue of Web experience needs additional research. Even when older adults possess similar Web usage patterns to younger adults, they are more likely to be accessing the Web exclusively from home as opposed to a more collaborative learning environment, like work or school. Surely this difference contributes to their overall level of expertise using the Web, independent of Web usage patterns. A survey by Fox [2] from the Pew Internet research group shows that fully 81% of wired seniors (65+) have access to the internet exclusively at home compared to only 45% of pre-retirement users, who are more likely to have access in other places like work and school. So, identical Web usage patterns (frequency of use, for example) may not mean identical levels of overall Web experience. A better measure of Web expertise needs to be developed in order to better control for experience across demographic groups. Preliminary results from subsequent studies conducted in our labs support that older adults with similar Web usage patterns to younger adults still score lower on a quiz that measures Web knowledge. We have also found a strong correlation between age and collaborative learning experience as well as collaborative learning experience and Web knowledge (quiz score). More research is necessary to further delineate the contributory factors that support lower Web expertise found in older adults.

Older adults are clearly the most rapidly growing Web demographic and we therefore need to learn more about their requirements. Design modifications that help older users will often help younger users, too. Additional research needs to be conducted to learn more about the senior demographic and how best to design interfaces to better meet their needs while not compromising the performance of younger users.

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