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Age Differences in Web Navigation:

Is Memory for Web Content Facilitated by Navigational Aids?

by

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "Age Differences in Web Navigation: Is Memory for Web Content Facilitated by Navigational Aids?" submitted by Carl Hudson in partial fulfillment of the requirements for the degree of Master of Science.

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ABSTRACT

Web navigation performance was compared in a sample of 31 young (M = 22.79 years) and 30 old (M = 63.03 years) participants across two sessions. Participants searched a large website under one of the two experimental conditions. In the control condition, only the "back" button and other basic navigation aids were available. In the side-tree condition, a dynamic side-tree menu could also be used to navigate the site. In addition to measures of web search speed and efficiency, we also gathered data on content memory, working memory, search ability, subject matter knowledge, and web experience. Young and old adults both improved navigation performance with practice, and despite larger improvements observed for older adults in speed of navigation, age differences persisted. Older adults also showed considerable practice improvements in their memory for web content, but younger adults did not, perhaps because their memory was initially quite good. Interestingly, younger adults had significantly better content memory in the control condition than the side-tree condition. Older adults showed no advantage to either web format. Both age groups appeared to search more efficiently in the side-tree condition; however, these benefits were non-significant. Contrary to the hypothesis that older adults are more frequently disoriented in their search, age was not associated with the number of pages or repeat pages visited. Implications for web design include the implementation of navigation aids with greater environmental support to bolster performance in a variety of web searching scenarios.

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DEDICATION

I dedicate this thesis to my parents, brother, sister, and wife. All of whom have shown courage and determination through many of life's obstacles. Their perseverance and love have been my source of strength.

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Age Differences in Web Navigation: Is Memory for Web Content Facilitated by Navigational Aids?

With the increasing life expectancy of Canadians, the proportion of the population aged 65 years and over is rising (Statistics Canada, 2001). From 1966 to 2001, Statistics Canada reported the population grew from approximately 20 to 30 million people, an increase of about 50%. During this same period, the population aged 65 and older grew from 1.5 to 3.9 million, an increase of about 160%. Combined with the aging of the "baby boom" generation, this trend will be magnified in 2011 when the oldest baby boomers start to turn 65 (Statistics Canada, 2001). Similar trends have also been reported by the United States (Administration on Aging, 2002) and worldwide (United Nations Population Division, 2004). With a growing population of older adults, the emphasis on age-related research in various domains such as health, medicine, and computer interaction is expected to increase.

Advancements in computer technology have made commonplace the situations that involve human-computer interaction, even for older adults (Mead, Batsakes, Fisk & Mykityshyn, 1999). For example, computer databases with powerful search engines have replaced conventional library card catalogs. In some banks, the use of automatic teller machines is encouraged by charging extra for banking transactions with a human teller (Mead & Spaulding-Johnson, 1999). With regard to the Internet, over 92% of users are estimated to browse the World Wide Web (WWW) at least once per day (GVU, 1998). The number of older adults using the Internet and other computer applications is also on the rise (Czaja & Lee, 2001). In the year 2000, Canadians over 60 represented the fastest growing group of Internet users with nearly half of them using it daily (Silver, 2001). Similar trends have also occurred in the United States (Teel, 1995).

The WWW contains a vast amount of data in the form of text, graphics, sounds, and videos. As a result, a frequent problem faced by users is one of disorientation. Kim and Hirtle (1995) define disorientation as the difficulty users experience in deciding which link to follow next in a hypertext system. Quite often, feelings of frustration and errors are associated with disorientation (Edwards & Hardman, 1989). In 1997, Birdi and Zapf observed the reactions of young and old adults towards errors experienced during computer-based office work. Older employees were found to have stronger negative emotional reactions than their younger counterparts. In fact, older adults were less likely to attempt to solve the problem on their own. Furthermore, in terms of viable options to rectify the error, older adults were more likely to consult written documentation than to ask a fellow employee for assistance. Thus, web disorientation and general computer frustrations experienced by older adults tend to be more negative than for younger adults.

Notwithstanding this example, the rather limited extent of literature supports the notion that older adults have generally positive attitudes towards computers and are willing to learn how to use them (Czaja, 1996; Czaja & Lee, 2001; Czaja & Sharit, 1998a; Kubeck, Miller-Albrecht, & Murphy, 1999). Yet older adults are reported to have more difficulties than their younger counterparts in a variety of computer tasks including menu selection (Freudenthal, 2001; Westerman, Davies, Glendon, Stammers, & Matthews, 1995), data entry (Czaja & Sharit, 1993, 1998b), text editing (Gomez, Egan, Wheeler, Sharma, & Gruchacz, 1983), and web navigation (Hudson, Scialfa, Diaz-Marino, Laberge, & MacKillop, 2006; Kubeck et al., 1999; Laberge & Scialfa, 2005). The increasing 'graying' population combined with the growing popularity of the WWW and the greater susceptibility of older adults to computer-related usability problems has sparked research related to human-computer interaction and aging. These endeavors often strive to examine age-related deficits in task performance and in doing so, hope to develop ways to mitigate such performance decrements associated with age. Similarly, the goal of the present study is to examine age differences in web performance and to determine if the availability of navigational aids can improve memory for web content.

Before we further discuss older adults and the WWW, let us first examine the common outcomes of research associated with aging and cognition. Cognitive abilities must first be examined to gain perspective as to how older adults might adapt to the new information age. Changes in cognitive abilities, including memory and learning, are believed to influence how older adults will interact with modern technology. By identifying what cognitive factors change with age, it is possible to begin understanding how they can influence performance on specific tasks such as web navigation.

Age Differences in Memory

The majority of adults report that their memories have gotten worse as they have grown older (Ryan, 1992). Indeed, age-related declines in memory are a cause for concern with many older individuals (Craik, 1994). However, it is important to note that these memory declines associated with age are often task-specific. For example, tasks that involve explicit memory (Smith, 1996), recall (Craik & McDowd, 1987), and working memory (Salthouse & Babcock, 1991) are commonly associated with age-related declines. In contrast, tasks that involve implicit memory (Smith, 1996; Zacks, Hasher, & Li, 2000) and recognition (Botwinick & Storandt, 1980; Craik, 1977; Craik & McDowd, 1987) often show smaller or no age-related deficits.

Craik (1994) believes a functional approach may help account for age differences in memory. He argued that memory effectiveness is largely determined by context and the external environmental stimuli provided during both encoding and retrieval. That is, remembering is facilitated by environmental support. When such support is high and consistent from encoding to retrieval, memory will be facilitated. Conversely, when environmental support is low at the time of retrieval, one must rely more on internal contextual cues or "self-initiated" processing to succeed in memory retrieval. Craik argues that "age related memory decrements are associated with the type of processing operations required by the task rather than with specific stores or systems" (p. 156). For example, recognition tasks are often accompanied with high environmental support which attenuates age-related memory decrements. On the other hand, recall tasks have lower environmental support; forcing one to rely on self-initiated processing.

Craik's theory of environmental support is similar to other accounts of age-related memory differences. Hasher and Zacks (1979) examined the differences in automatic and effortful processes in memory. They suggested that age-related differences would be found primarily with memory tasks involving effortful processing. Effortful processes require deliberate use of self-initiated cognitive resources while automatic processes do not. Therefore, to minimize age-related differences in memory, one should provide appropriate environmental support to reduce effortful processing.

Age Differences in Learning

Learning is a cognitive ability closely related to memory. In fact, Botwinick (1978) considers learning and memory to be "two sides of the same coin" (p. 261). After all, if one has difficulties in learning new information, one will also experience difficulties in remembering it later. A large literature supports the view that normal aging is associated with deficits in learning that may be exacerbated by the memory failures noted above.

In general, older adults exhibit slower rates of learning than young (Botwinick, 1978; Kinsbourne & Berryhill, 1972). Yet, even when they are given longer or self-paced learning periods, older adults still show learning deficits (Arenberg, 1965; Canestrari, 1963; Eisdorfer, Axelrod, & Wilkie, 1963). Thus, these age-related learning deficits are not solely the result of differences in learning rates.

Research has also examined ways in which age-related differences in learning and memory can be attenuated. Hultsch (1971) gave participants lists of words to learn in either a sorting or non-sorting task. Results indicated that young adults had higher recall scores than old adults. However, older adults showed greater recall with the sorting task than the non-sorting task, while younger adults showed little difference between conditions. Results suggest that some form of organization was present even during the non-sorting condition; yet, less so for older adults. Therefore, a general learning strategy such as organizing the information at encoding is critical to remembering, especially for older adults. Specifically, Hultsch's findings "indicate the age-related importance of allowing the subject the opportunity to organize the material in ways that are meaningful to him" (p. 342). In a related, word-list memorization task, Craik and Masani (1967) did not instruct participants to organize information, but rather varied the degree of word-related meaning and thus the potential for organization. They found that young adults tended to memorize the list of words using an organizational strategy more often than old adults. Both studies highlight the importance of organizing information during learning to improve later memory retrieval. Similar to Craik's theory of environmental support, whereby contextual cues can facilitate better memory, meaningful organization can facilitate better learning. In sum, young and old adults both gain from meaningful organization; however, old adults are less likely to organize incoming information spontaneously. Aids which can help facilitate better organization for older adults can attenuate their disadvantage.

Age and Practice

Generally speaking, both young and old adults get better with practice on any task. On some tasks, age differences can be attenuated as familiarity increases. For example, Dixon, Kurzman, and Friesen (1993) examined handwriting performance in young and old adults. In all the performance measures, young adults consistently outperformed old adults; yet, both groups benefited from more practice. In fact, Dixon et al. observed older adults to improve at a faster rate than their younger counterparts. Albeit young adults may achieve asymptotic performance sooner than old adults, Dixon et al. determined that old adults were slower than young by a factor of only 1.02 after practice (compared to a factor of 1.60 without practice). Given a sufficient amount of learning through repetition, it appears that motor performance for older adults can 'catch-up' to their younger counterparts.

In a different motor task, Krampe and Ericsson (1996) examined the role of deliberate practice in expert and amateur pianists. They found evidence of age-related generalized slowing for both expert and amateur musicians as seen in performance on general processing speed tasks. However, performance on music-related tasks showed little to no decline for old-expert adults who practiced deliberately. Therefore, despite signs of generalized slowing as one gets older, evidence suggests that practice can minimize age-related performance decrements on specific tasks. It is important to note that these two studies, although distinct in tasks, both involved motor skills. A computer task such as navigating the WWW also requires motor skills to operate a mouse and keyboard. Therefore, web navigation tasks may show similar results due to the common motor component. Notably, a distinction needs to be made between tasks which are automatized in youth and are continued into later years (like playing the piano) and tasks which are learned later in life (like using a computer). It may be that only in the former case is aging not associated with slower performance.

Navigating the web also involves a great deal of informational searching and sorting. One must continually look for appropriate links and content until one finds the desired information. Hence, visual perception and cognition are arguably more significant components than motor skill to effective web navigation. In contrast to research on practice in motor tasks, other studies have shown that age-related differences in performance speed on visual search tasks are not always eliminated through practice (e.g., Anandam & Scialfa, 1999; Ho & Scialfa, 2002; Madden & Nebes, 1980; Salthouse & Somberg, 1982; Scialfa, Jenkins, Hamaluk, & Skaloud, 2000).

In this vein, one important aspect of web navigation is the ability to localize a visual target. Sekuler and Ball (1986) examined how young and old adults perform in localizing the position of a face in a visual display with varying amounts of visual interference. After practice, old adults improved their task performance significantly; but not to a level equivalent to that of younger adults. Salthouse and Somberg (1982) examined age-related changes in visual search across roughly 5000 practice trials. Using a consistent-mapping (CM) task, whereby visual targets and distractors do not change roles, both young and old adults were found to display similar levels of improvement. These findings complement a previous study by Madden and Nebes (1980) where a CM task was performed over a more moderate number of trials (approximately 2500). In both studies, young and old adults demonstrated similar levels of improvement with practice and consequently, age-related deficits in performance persisted.

More recent studies by Scialfa and colleagues (e.g., Anandam & Scialfa, 1999; Ho & Scialfa, 2002; Scialfa, Jenkins, Hamaluk, & Skaloud, 2000) have not found age deficits in the development of proficient visual search. For example, Ho and Scialfa found that the practice-related improvements in the CM task and the disruption of search from reversing the target and distractor were similar for young and old. With subsequent reversal sessions, less disruption occurred as both age groups were able to quickly adapt to different target features. Importantly, age differences were not observed in disruption. Thus, it appears that the development of automaticity can occur for older adults. Unfortunately, age deficits in visual search reaction time persisted after practice. Overall, young and old adults improved visual search to the same degree; however, older adults consistently had slower reaction times than young – even after 16 practice sessions (Ho & Scialfa, 2002).

Web navigation also involves abilities related to learning and memory. In a study by Rogers, Hertzog, and Fisk (2000), participants received extensive practice in a noun-pair task in which yes/no responses indicated if the probe noun-pair correctly matched one of the noun-pairs in the key at the top of the computer screen. Response time and accuracy were recorded. Participants could complete the task in either a visual-scanning strategy (visually compare the noun-pair probe to the above key) or in a memory-retrieval strategy (compare the noun-pair probe from memory). Both age groups improved with more practice. Interestingly, in the consistently mapped task version, older adults displayed greater reaction time improvements than their younger counterparts; yet young adults still outperformed older adults. Again, age differences in performance can be reduced with practice, but not entirely eliminated.

Rogers et al. (2000) also measured learning gains after each practice set using recall and recognition memory tests for the noun-pairs. For both recall and recognition, memory performance improved with practice. Specifically, an interaction showed that older adults had improved significantly more than young adults. Despite greater improvements, older adults still had significantly worse memory performance than their younger counterparts at the end of training. As expected, age differences were found to be more pronounced for recall performance. Interestingly, when adults were further classified as either retrievers (individuals who retrieved information from memory to make mental comparisons to the noun-pair probe) or scanners (individuals who viewed the on-screen key to make visual comparisons to the noun-pair probe), age differences in recall and recognition were attenuated to nonsignificance. That is, older retrievers 'caught-up' to performance levels of younger retrievers. Therefore, when older adults can adopt similar task strategies to that of young adults, age-related differences in memory abilities can be eliminated.

Only a handful of studies have examined the age-related differences in practice on computer-based task performance. Czaja and colleagues have compared younger and older users on data entry (Czaja & Sharit, 1998b; Czaja, Sharit, Nair, & Rubert, 1998), customer service representative information search/retrieval (Czaja, Sharit, Ownby, Roth, & Nair, 2001), and account balancing tasks (Czaja & Sharit, 1999 as cited in Czaja, 2001). For all three tasks, young adults consistently outperformed old adults in terms of work output, but not in accuracy (the number of errors made; Czaja, 2001). Age differences in performance persisted even after nine hours of practice (Czaja & Sharit, 1998b). Czaja and colleagues petition for future studies involving longer periods of practice to determine if age differences could be attenuated, as their findings demonstrated that older adults had not yet reached asymptotic levels of performance. To date, it is uncertain if older adults can 'catch-up' to computer performance levels of their younger counterparts or if age deficits will persist despite copious amounts of practice. By contrast, Czaja and Sharit (1998b) found older adults to have greater job knowledge improvements over the three days of practice than young or middle-aged groups. Although task performance was not equal, older adults can acquire similar levels of conceptual and procedural knowledge of the task. Despite the limited research examining age differences and practice effects on computer tasks, one can still predict practice benefits in both young and old adults. Importantly, the present study attempts to determine the extent to which older adults can eliminate deficits associated with web navigation performance with two sessions.

In summary, practice improves performance across the lifespan. However, depending on the type of task, age-related differences in performance can be attenuated to varying degrees. In visual-motor tasks such as handwriting (Dixon et al., 1993), age-related performance decrements can be minimized and older adults can achieve levels of performance equivalent to (or near to) that of younger adults. In visual search tasks, age-differences can also be attenuated, but not always to equivalent levels (e.g., Rogers et al., 2000). With respect to computer tasks, Czaja and Sharit (1998b) suggest that with more practice and experience, older adults can reach adequate work output levels and may reach comparable performance to that of young adults. Thus, age-related performance deficits on tasks such as navigating the WWW could be attenuated with sufficient practice.

Using the World Wide Web

Disorientation and the World Wide Web

Disorientation occurs when the user 'gets lost' in a website. Again, Kim and Hirtle (1995) describe it as difficulties deciding which link to follow next in hypertext system. The complexity of a website's organization or topology is one of the main contributing factors to disorientation (Kim & Hirtle, 1995; Lin, 2003a, 2003b, 2004; McDonald & Stevenson, 1998). Wayfinding literature of the physical environment has been used to apply analogous concepts to the navigation of hyperspace (for a review see Kim & Hirtle, 1995). Although the spatial metaphor is useful for the application of cognitive research in spatial processes and wayfinding to hypertext systems; there are however, limitations. For instance, wayfinding maps are only useful in web topologies where path, direction, and distance strategies still apply (Parunak, 1989). Thus, the general spatial metaphor must be complemented with a task specific approach to examine the task factors and specific cognitive aspects involved.

With respect to aging, little research has examined disorientation in the WWW. Older adults have been observed to experience greater disorientation than their younger counterparts (e.g., Lin, 2003a). Once more, factors such as subject matter knowledge, web experience, working memory, processing speed, and spatial abilities have been associated with age-related performance differences (Laberge & Scialfa, 2005). As an example, web navigation is considered a very spatially demanding task (Dillon et al., 1990; Kim and Hirtle, 1995; Pak, 2001) and difficulties in spatial abilities have been associated with aging (Laberge & Scialfa, 2005). Thus, it is likely that such factors play a role in the disorientation older adults experience on the WWW. Unfortunately, the little literature that exists on web disorientation has not examined the aging aspect in any detail.

Navigating the WWW can be a very complex task. In fact, Kim and Hirtle (1995) identified three subtasks that must be conducted concurrently while using the WWW:

1. Informational tasks such as reading and comprehending webpages for content.
2. Navigational tasks such as planning and executing routes through the website.
3. Task management or the coordination of subtasks 1 and 2.

Furthermore, great cognitive effort is necessary in order to perform well on these tasks (Conklin, 1987; Foss, 1989). The task of coordination compels a tradeoff between navigational and informational demands due to a scarcity of cognitive resources. If the demands of a web task exceed the resources available, then either one or both subtasks will suffer. Successful task management can mitigate such losses, but coordination may also involve sacrificing performance on one aspect in order to sustain proficient levels on others.

Past research has examined performance related to both informational and navigational aspects of using the WWW. Most studies that examine information learning on the WWW spawn from the education and communication domains. Recently, the layout of hypertext or web typology and its power to facilitate learning have been examined. Web typology refers to the classification or organization of pages within a website. Different typologies offer varying structural layouts as to how pages are linked together within a website. For example, linear typologies link pages of a website in a sequential fashion, much like a book, whereas nonlinear layouts link pages in a web of networks (see bottom portion of Figure 1). Another common web typology is the hierarchical form (top portion of Figure 1) which follows a rigid tree-like structure. The structural layout of the website can dictate the navigational freedom afforded to web users; and so, it is believed that web typology can not only enhance navigation performance, but also act upon the amount of information learned.

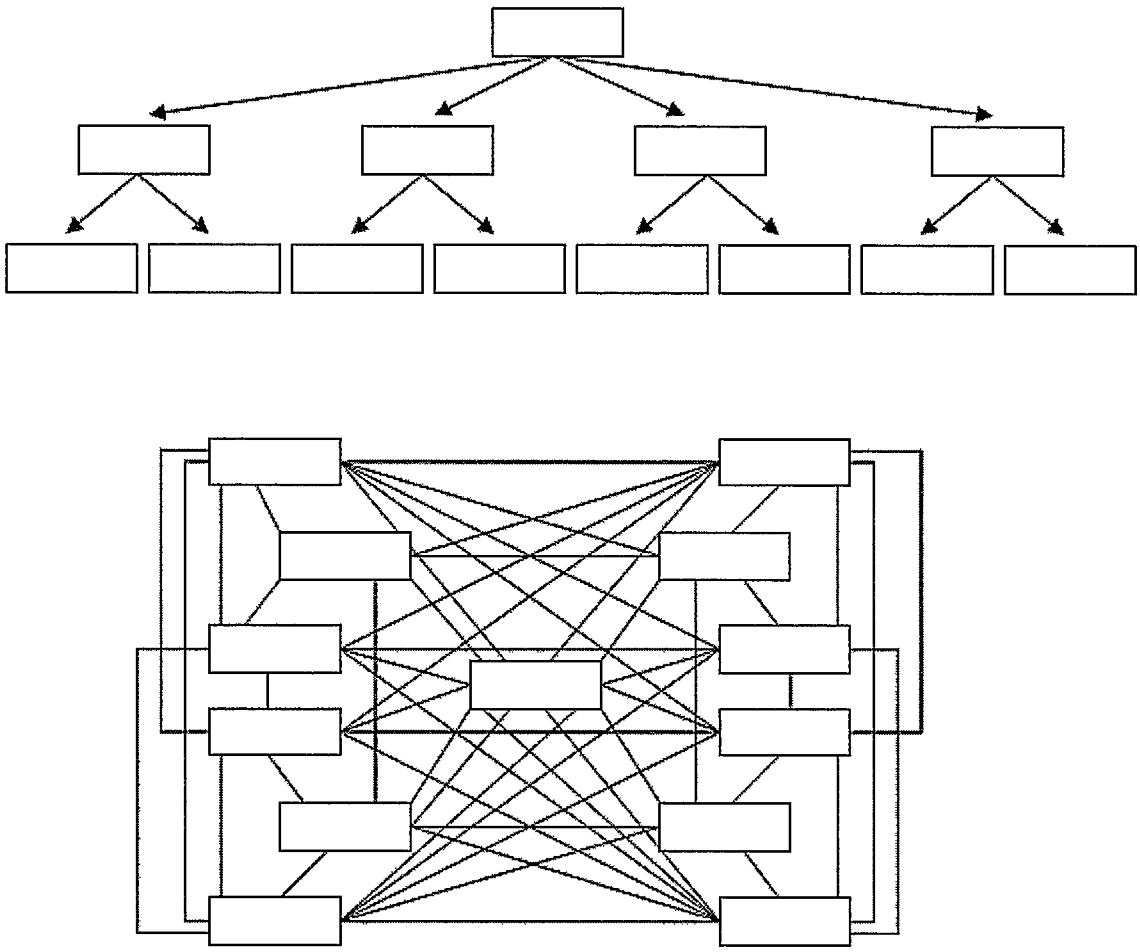

Figure 1. Examples of a hierarchical (top) and network (bottom) typologies. Note that both typologies have the same number of links (nodes).

Studies have suggested that the typological structure of a website can influence how well the content information is learned. Eveland, Cortese, Park, and Dunwoody (2004) examined free recall by asking participants to list as many related concepts as possible after browsing a website. No difference was found between linear and nonlinear web topologies in the number of concepts recalled. However, they also measured the amount of factual knowledge obtained (using a mix of true-false, multiple-choice, and fill-in-the-blank questions) and found an advantage for the linear web typology. Despite such mixed findings, it is important to note that these two measures cannot be equated or compared. That is, recalling a list of concepts does not necessarily equate to knowledge of these concepts or the relationships among them. These mixed results suggest that one must first operationally define informational learning. If defined as factual knowledge of the relationships between concepts, the linear web topology seems best suited for learning. Even so, their study is not necessarily reflective of real websites or typical navigation behaviour. First, 'natural' websites would usually fall between their linear and nonlinear conditions (Eveland et al., 2004). Second, the tasks required participants to browse the website haphazardly; yet users often navigate the web with specific goals in mind – in search of answers to specific questions.

In a related study, Eveland and Dunwoody (2001) compared learning of information in print versus varying web typologies: linear, nonlinear, and advisement (a hybrid of the linear and nonlinear topologies). Their results found traditional print to facilitate better learning than the linear and nonlinear web typologies; however, the hybrid typology was comparable to print (as seen by recognition scores).

Although the studies by Eveland and colleagues reveal rather mixed results, both experiments suggest that learning via the web is a viable option. Yet in order for the WWW to facilitate proficient levels of learning, appropriate website design will be necessary to organize the content in a meaningful manner. Studies by Eveland and colleagues also demonstrate how web typology is closely linked to how the content of the web can be organized purposefully and thereby improve learning. Dillon and Gabbard (as cited in Eveland & Dunwoody, 2001) also compared hypermedia to print and found no evidence of a learning difference across media. Such findings indicate that the WWW is a promising new means of disseminating information.

In addition to examining how various web typologies can facilitate better learning/memory of information, other studies have examined how web typology can improve navigation performance. Studies by Lin (2003b, 2004) have shown that a hierarchical typology is best suited for older adults than a referential network or even hybrid typology (Lin, 2003a). In contrast, McDonald and Stevenson (1998) have observed the hybrid typology to be best suited for ameliorating navigation performance in young adults. Although the above results may seem mixed, one can generally suggest that the simple structure of a hierarchical typology is superior to a referential network typology with a near countless number of links (see Figure 1). This general conclusion seems valid as the referential network consistently appears to fair among the worst out of the three typologies investigated. When incorporating elements of both typologies, care must be taken to properly balance the constrained movement in a hierarchical structure (which can reduce disorientation, but limit efficiency) and the boundless navigational freedom of a network (which can improve efficiency, but increase disorientation). While findings are still rather mixed, it does appear that integrated typologies can improve web navigation performance across the lifespan.

Older Adults and the World Wide Web.

Few studies have specifically examined the age differences associated with navigating the WWW. Previous research by Scialfa and colleagues has investigated predictors of web navigation performance in young and old adults. Laberge and Scialfa (2005) studied the influence of several predictors on web navigation including age, subject matter knowledge, working memory, reading ability, spatial ability, and processing speed. Using a stand-alone tourism website, participants were asked to navigate the site to find answers to specific questions. Navigation performance was measured in three ways: time per trial, total number of pages per trial, and number of repeat pages per trial. Age-related differences in web navigation were found in task speed but not in the other efficiency measures. Thus, the possibility exists, at least for healthy older adults, that navigation performance is relatively stable across the lifespan. Perhaps older adults do not experience more disorientation than their younger counterparts, but simply take longer to make navigation decisions. Alternatively, disorientation may still be experienced by the elderly as reflected by the additional time required to resolve navigational uncertainty. Such findings may also convey the common strategy older adults adopt during web navigation; that is, older adults may sacrifice speed to maintain accuracy.

Additional analyses revealed that the effect of age can be eliminated once processing speed, working memory, spatial ability, web experience, and subject matter knowledge were controlled. Laberge and Scialfa also measured the participant's recall of the page details (i.e., recall of the main topical links and their related sub-links). Old adults were found to have poorer memory for page details than young adults, confirming age deficits commonly associated in memory and learning. Finally, one of the design recommendations from Laberge and Scialfa was the implementation of navigation aids to reduce cognitive demands such as working memory. We conducted a follow-up study to examine the validity of this suggestion (Hudson et al., 2006).

In Hudson et al. (2006) we tested whether navigation aids can enhance web performance via reducing task-related cognitive demands like working memory. A modified version of the tourism website used by Laberge and Scialfa (2005) was developed in which the web format manipulated the presence of navigation aids in two ways. First, there was a control condition that had a menu or 'side-bar' with links to the main topical categories of the site (see Figure 2). This design was identical to the original study by Laberge and Scialfa (2005). In the second manipulation, an augmented web format provided two navigation aids: a breadcrumb and a side-tree. Breadcrumbs are a series of links conveying the superordinate or 'parent' pages related to the current page. For example, "Attractions → Attractions in Calgary and Area → Aerospace Museum of Calgary" are breadcrumbs where the "Aerospace Museum of Calgary" is the current page and the remaining underlined links are parent pages (see arrow in Figure 3). Side-trees operate in a similar fashion. Websites typically have menus or side-bars which have static links to the main topical areas (such as in the control condition). Side-trees are dynamic menus whereby a 'clicked' link expands a list of links related to that category or topic (see the menu in Figure 3). These characteristics of navigation aids are thought to facilitate better navigation performance.

As suggested by Laberge and Scialfa (2005), navigation aids are believed to reduce cognitive load such as the demands on working memory. Navigation aids are also believed to facilitate better performance in a number ways. First, navigation aids provide visual cues regarding the organizational structure of the website. Second, they convey the relative location of the current page to other pages in the website, increasing awareness of one's orientation. Lastly, they can speed up the backtracking process typically carried out by the 'back' button by allowing users to 'jump' or take shortcuts to desired pages in fewer steps. Against expectations, results from Hudson et al. (2006) indicated that breadcrumbs were scarcely used by participants and so their contribution to enhanced navigation performance never came to fruition. Although these findings were also consistent with a previous pilot study examining an additional breadcrumb only condition, breadcrumbs are not necessarily discounted altogether. Users may still use the breadcrumb as a visual reminder of the website's organization or as a cue to their present location even though improved navigation efficiency did not come to pass. Breadcrumbs may also prove more useful in other web media (e.g., mobile phones or Personal Digital Assistants). On the other hand, side-trees were found to significantly reduce the number of total and repeat pages visited. Thus, research evidence supports the notion that side-trees can reduce disorientation for both young and old adults.

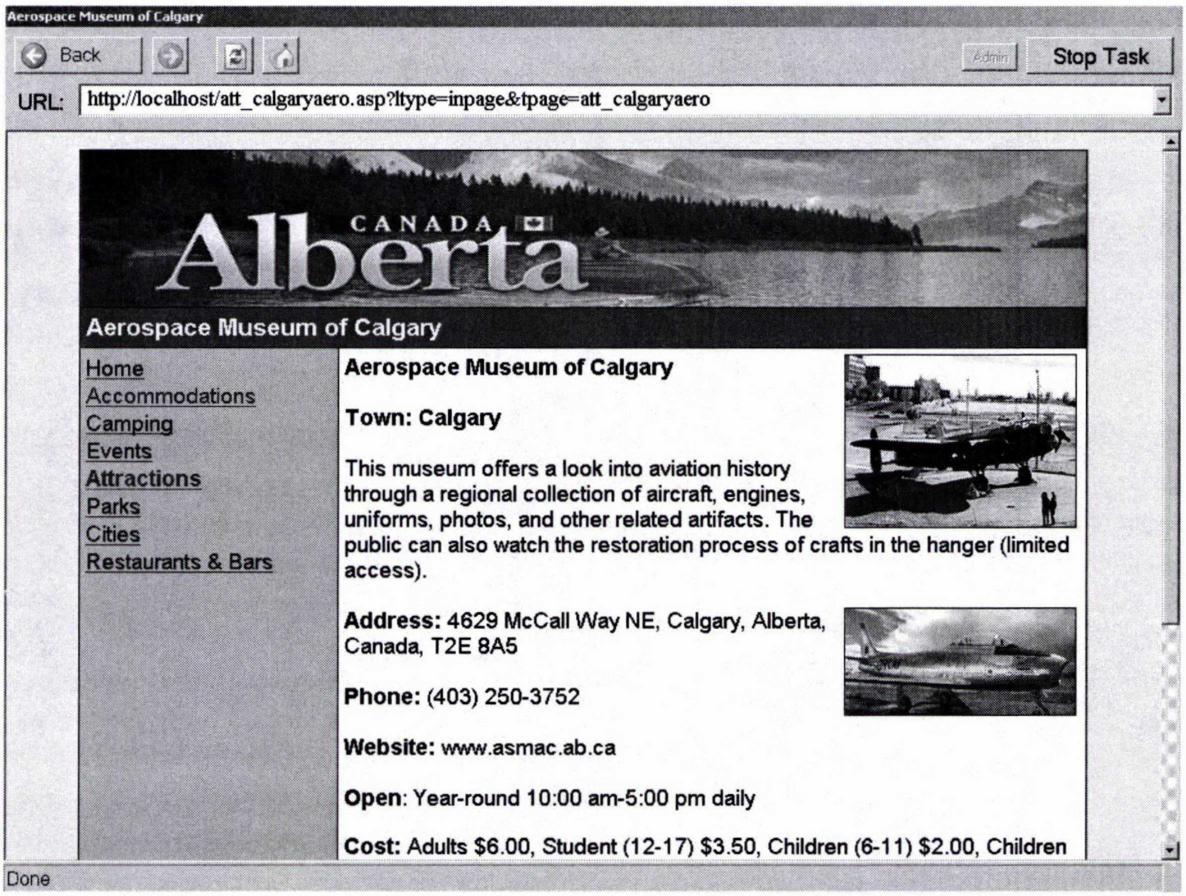

Figure 2. The control condition used in the present study whereby the side-menu is a static side-bar. The browser (SurfDB) is custom made for the study. Note that this condition is identical to that of Laberge and Scialfa (2005) and the control condition used in Hudson et al. (2006).

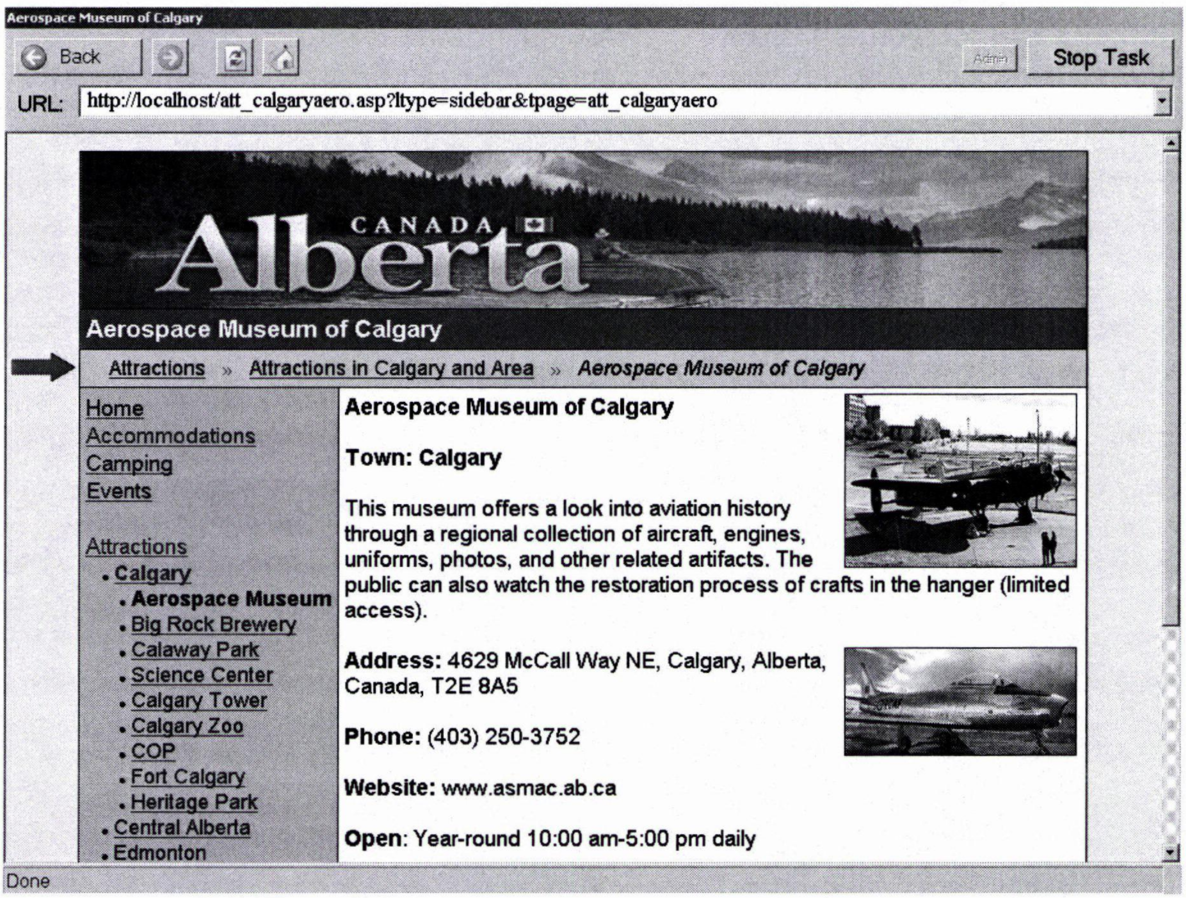

Figure 3. The augmented condition used in Hudson et al. (2006) whereby the side-menu is a dynamic side-tree accompanied by a breadcrumb toolbar indicated by the arrow.

Notably, the design recommendations from Laberge and Scialfa (2005) were only partially supported. As discovered by Hudson et al. (2006), side-trees did improve performance; however, it did not seem to be a result of reducing demands on working memory. Efficiency measures of performance that were observed to have strong correlations with web format manipulation did not have the same strong links to any of the working memory measures. Moreover, older adults in the augmented condition had lower memory scores for the website's structure than older adults in the control. In contrast, memory of young adults was not influenced by the web format manipulation. Therefore, side-trees appear to be linked to reducing the number of total and repeat pages visited per trial; however, the observed performance improvements do not appear to be related to working memory.

Nonetheless, side-trees may still reduce overall cognitive load. Side-trees may help redistribute the way in which cognitive resources are allocated for informational, navigational, and coordination subtasks. Again, side-trees improve navigation performance as seen by fewer repeat and total pages visited per trial (Hudson et al., 2006). In doing so, it is possible that navigational demands are also lightened. By 'freeing-up' cognitive resources otherwise used for navigational tasks, one can now reallocate them towards informational tasks. With more resources available for webpage content, better learning and retrieval of information can be expected.

In past aging and web research, navigation ability has been measured by testing one's navigational or structural knowledge of the website (e.g., Hudson et al., 2006; Laberge & Scialfa, 2005). Typical age differences in memory are found for the links and pages involved in executing various routes throughout the website. However, such studies (Hudson et al., 2006; Laberge & Scialfa, 2005) did not measure the *informational* knowledge gained during web navigation. Memory tests have not been used to assess the amount of content attained on a particular subject (i.e., traveling in Alberta). In addition to one's knowledge of the website's hierarchical structure, one should also consider the amount of content acquired during navigation as it is an essential purpose to navigating the WWW. After all, if one did not successfully learn and retain the information sought (even for a short time) why bother using the WWW as a resource? Although side-trees do not seem to aid the navigation subtasks and thus fail to ameliorate one's structural knowledge of the website's organization (as seen by non-significant memory improvements in young adults and worsened memory for old adults by Hudson et al.), perhaps navigation aids have some benefit in assisting users on the informational subtasks. In other words, the possibility exists that side-trees can facilitate superior content memory. The present study continues our previous research (Hudson et al., 2006) by examining side-trees in relation to content memory.

The Current Study

The purpose of the current study was to understand if and how navigation aids, such as side-trees, can improve navigation performance and facilitate better retention of web content. Rather than testing navigational memory for the website's structure as in prior research (e.g. Hudson et al., 2006; Laberge & Scialfa, 2005), the present study examined content memory via recognition and recall. Similar to previous study (Hudson et al.), web performance was compared using individual groups of young and old adults while manipulating the web format. Yet in the present study, participants used either the control (Figure 2) or side-tree (Figure 4) web formats across two sessions. Participants were tested in two sessions to examine effects of practice on navigation performance and information (content) memory. The following outcomes were predicted for both navigation and information components. These predictions were based largely on the literature previously discussed regarding aging, cognition, and human-computer interaction.

Predictions for Measures of Navigation Performance

Time per Trial

Hypothesis 1a. The generalized slowing hypothesis (Myerson & Hale, 1993; Salthouse, 2000) predicted that young adults would take less time in completing a navigation task than old adults.

Hypothesis 1b. From Hudson et al. (2006) the side-tree and control web formats required similar amounts of time to complete a task. It is possible, however, that because format is predicted to influence repeat pages (Hypotheses 2) and total page (Hypotheses 3) that speed could have been similarly affected.

Hypothesis 1c. Participants were predicted to take less time per trial in session 2 than in session 1; that is, a practice effect was predicted.

Hypothesis 1d. There was no age difference in the effect of format, as found by Hudson et al. (2006).

Hypothesis 1e. Practice effects were expected to be greater in the dynamic side-tree condition than in the control condition.

Hypothesis 1f. Older adults have been found to have less web experience than young (Kubeck et al., 1999; Laberge & Scialfa, 2005; Hudson et al., 2006) and thus have more potential 'room' for improvement. Therefore, old adults were predicted to have greater improvements in speed with practice (Rogers et al., 2000). A related question is if age differences in performance remain over time. Age differences in reaction time have persisted in visual search tasks (e.g. Ho & Scialfa, 2002; Rogers et al., 2000).

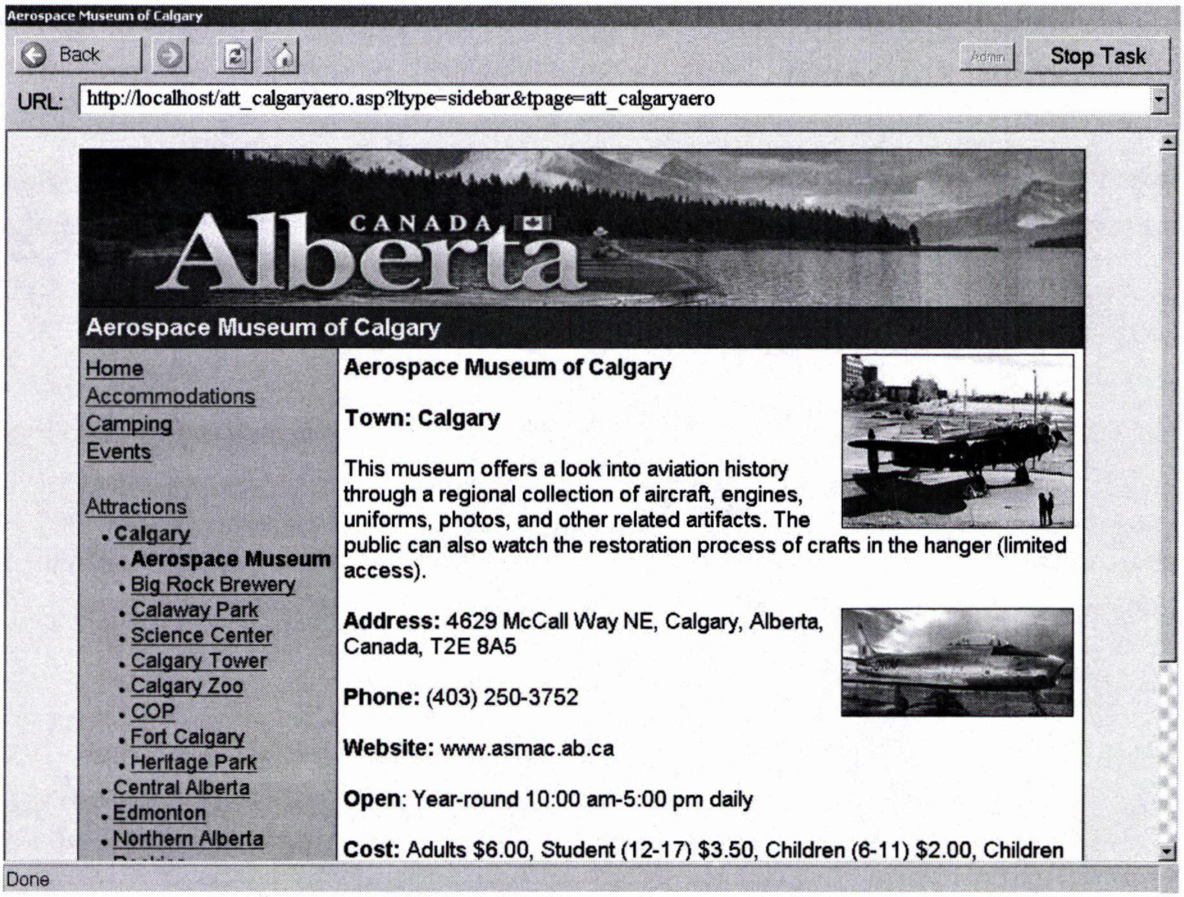

Figure 4. The side-tree condition used in the present study whereby the side-menu is a dynamic side-tree. The browser (SurfDB) is custom made for the study.

Number of Repeat Pages Visited per Trial

Hypothesis 2a. The number of repeat pages visited was expected to be similar for younger and older adults (Hudson et al., 2006).

Hypothesis 2b. The side-tree format was predicted to produce fewer repeat pages than the control format (Hudson et al., 2006).

Hypothesis 2c. The number of repeat pages visited per trial was predicted to diminish with practice.

Hypothesis 2d. Young and old adults were expected to show a similar format effect (Hudson et al., 2006).

Hypothesis 2e. The control condition was predicted to yield greater improvements from session 1 to session 2 than the side-tree condition. Results from Hudson et al. (2006) revealed a very low number of repeat pages per trial in the side-tree condition. In contrast, the control condition had a higher number of repeat pages. Thus, there is greater potential for improvement in the control condition. A related question is whether there is a simple main effect of format on repeat pages after practice.

Hypothesis 2f. Older and younger adults were predicted to show equivalent practice effects on repeat pages visited (Ho & Scialfa, 2002).

Total Number of Pages Visited per Trial

Hypothesis 3a. The total number of pages visited was expected to be similar for younger and older adults (Hudson et al., 2006).

Hypothesis 3b. The side-tree format was predicted to produce fewer total pages than the control format (Hudson et al., 2006).

Hypothesis 3c. The total number of pages visited per trial was predicted to diminish with practice.

Hypothesis 3d. Young and old adults were expected to show a similar format effect (Hudson et al., 2006).

Hypothesis 3e. The control condition was predicted to yield greater improvements from session 1 to session 2 than the side-tree condition. Results from Hudson et al. (2006) revealed a low total number of pages per trial in the side-tree condition. In contrast, the control condition had a higher total number of pages. Thus, there is greater potential for improvement in the control condition. A related question is whether there is a simple main effect of format on total pages after practice.

Hypothesis 3f. Older and younger adults were predicted to show equivalent practice effects on total pages visited (Ho & Scialfa, 2002).

Predictions for Measures of Information Learning

Recall Scores

Hypothesis 4a. Young adults were predicted to generally have better recall scores than old adults (Craik & McDowd, 1987).

Hypothesis 4b. Side-trees were predicted to alleviate some of the navigational demands during the web task and thereby allow cognitive resources to be reallocated for informational task components such as memory for content. Thus, recall scores were expected to be better in the side-tree condition than in the control condition.

Hypothesis 4c. Recall scores were predicted to improve with practice.

Hypothesis 4d. An Age x Format interaction was expected wherein younger adults would have similar recall scores in both formats while older adults would have higher recall scores in the side-tree condition. This was because in the control condition, older adults would allocate scarce resources to navigation, with detrimental effects on recall. In contrast, the side-tree condition would help them navigate and would allow more resources to be available for content memory.

Hypothesis 4e. Again, reduced navigational demands are predicted to allow for the reallocation of cognitive resource to informational tasks such as memory for content. Navigational demands reduced by side-tree (Hypothesis 4b) and through practice (Hypothesis 4c) could have been amplified when in combination. Therefore, practice effects would have been greater in the dynamic side-tree condition than in the control condition.

Hypothesis 4f. Older adults have been found to have less web experience than young (Kubeck et al., 1999; Laberge & Scialfa, 2005; Hudson et al., 2006) and thus have more potential 'room' for improvement. Therefore, old adults were predicted to have greater improvements in recall with practice.

Recognition Scores

The following hypotheses mimic those for recall scores (hypotheses 4). However, an important distinction was that many of the expected differences (e.g. between young and old adults) were predicted to be smaller in recognition scores than in recall. This discrepancy was largely due to the greater availability of environmental support in recognition, which can help 'jog' the memory of participants who may otherwise not remember through self-initiated or effortful cognitive processes alone.

Hypothesis 5a. Not unlike hypothesis 4a, young adults were predicted to generally have better recognition scores than old adults (Craik & McDowd, 1987).

Hypothesis 5b. Side-trees were predicted to alleviate some of the navigational demands during the web task and thereby allow cognitive resources to be reallocated for informational task components such as memory for content. Thus, recognition scores were expected to be better in the side-tree condition than in the control condition.

Hypothesis 5c. Recognition scores were predicted to improve with practice.

Hypothesis 5d. An Age x Format interaction was expected wherein younger adults would have similar recognition scores in both formats while older adults would have higher recognition scores in the side-tree condition. This was because in the control condition, older adults would allocate scarce resources to navigation, with detrimental effects on recognition. In contrast, the side-tree condition would help them navigate and would allow more resources to be available for content memory.

Hypothesis 5e. Again, reduced navigational demands would allow for the reallocation of cognitive resource to informational tasks such as memory for content. Navigational demands reduced by side-tree (Hypothesis 5b) and through practice (Hypothesis 5c) could also be amplified when in combination. Therefore, practice effects would be greater in the dynamic side-tree condition than in the control condition.

Hypothesis 5f. Older adults have been found to have less web experience than young (Kubeck et al., 1999; Laberge & Scialfa, 2005; Hudson et al., 2006) and thus have more potential 'room' for improvement. Therefore, old adults were predicted to have greater improvements in recognition with practice.

METHOD

Participants

A total of 61 participants, 27 males and 34 females, volunteered for this study which was approved by the Conjoint Faculties Research Ethics Board for the University of Calgary (see Appendix E). Young adults ranged from 18 to 33 years, with an average of 22.79 years (SD = 4.17 years), while older adults ranged from 54 to 76 years, with an average of 63.03 years (SD = 6.18 years). All were recruited from either the University of Calgary or from senior citizens' organizations within the Calgary community. Each participant received $10 (CDN) per hour for their involvement.

Participants were only considered for the study if they were experienced with using computers, the WWW, and were familiar with using a mouse and keyboard. All participants were fluent in English. Mean education level was 15.88 years (SD = 2.21) and participants had been using computers an average of 13.18 years (*SD* = 5.71). They used computers and email an average of 19.93 (*SD* = 13.26) and 5.26 (*SD* = 4.08) hours per week, respectively. All participants had corrected or uncorrected acuity of 20/40 or better at the 50 cm test distance (*M* = 1.17 minutes of arc, *SD* = .33 minutes of arc) and had normal colour vision. The average self-reported health rating on a 5-point Likert scale (1 = *very poor* to 5 = *excellent*) was 4.25 (*SD* = .77).

Means and standard deviations of these demographic measures for young and old adults are shown in Table 1. In general, young and old adults had similar levels of education ($p = .68$). Older adults had significantly more years of computer experience than younger adults ($p = .01$); however, younger adults used computers on a regular weekly basis more often than older adults ($p < .01$). No difference was observed in the number of hours per week used for email ($p = .30$). This is fairly consistent with the notion that email, newsgroups, and online forums are communication technologies in which older adults can see a clear benefit and are very likely to adopt (Horgas & Abowd, 2004). Young and old adults had similar years of web experience ($p = .24$); yet, young visited more websites per week than old ($p < .01$). Young adults also spent more hours per week using the WWW ($p < .01$) and generally developed more websites than old adults ($p < .01$). Overall self-reported health ratings for old adults were comparable to those of young adults ($p = .90$).

To determine if the groups were equivalent in their demographic characteristics, an Age x Web Format ANOVA was conducted on our demographic variables. Results indicated a significant difference in the number of different sites visited each week between the control (*M* = 15.72, *SD* = 14.81) and side-tree conditions (*M* = 9.62, *SD* = 5.15), $F(1, 57) = 5.20$, $p = .03$. A significant effect of web format was also observed for the average self-reported health rating, $F(1, 57) = 4.67$, $p = .04$, and for the average number of days spent traveling in Alberta, $F(1, 57) = 4.85$, $p = .03$. Individuals in the control condition reported higher self-reported health ratings (*M* = 4.45, *SD* = .62) than those in the side-tree condition (*M* = 4.03, *SD* = .85); yet, those in the control generally traveled less in Alberta (*M* = 11.94, *SD* = 8.75) than the side-tree condition (*M* = 18.11, *SD* = 13.44). One significant Age x Web Format interaction was also found to be significant for the number of years of education, $F(1, 57) = 4.36$, $p = .04$. For young adults, individuals in the control had more education (*M* = 16.38, *SD* = 1.96) than their young counterparts in the side-tree condition (*M* = 15.11, *SD* = 1.88). In contrast older individuals in the control generally had less education (*M* = 15.47, *SD* = 2.37) than their counterparts in the side-tree condition (*M* = 16.53, *SD* = 2.48). Practically, one should bear in mind that the magnitude of such group differences are quite trivial. The remaining effects of Web Format and Age x Web Format interactions revealed nonsignificant differences in the demographic data (*ps* = .07).

Table 1. Means and Standard Deviations (SD) for Participant Demographics

	Age			
Variable	Young ($n = 31$)		Old ($n = 30$)	
Females	16		18	
Age (years)**	22.79	(4.17)	63.03	(6.18)
Education level (years)	15.76	(1.99)	16.00	(2.44)
Computer experience (years)**	11.43	(3.59)	14.99	(6.89)
Computer use (hrs/week)**	25.01	(13.70)	14.68	(10.65)
Email use (hrs/week)	4.72	(2.49)	5.82	(5.24)
Web experience (years)	7.35	(1.94)	8.20	(3.49)
Web use (hrs/week)**	15.85	(10.74)	3.60	(3.52)
Number of website developed**	0.95	(1.07)	0.01	(0.03)
Number of websites visited (per week)**	17.27	(13.59)	8.02	(6.06)
Health rating (1 = *very poor* to 5 = *excellent*)	4.26	(0.77)	4.23	(0.77)

* $p = .05$. ** $p = .01$.

One young adult reported being treated by a doctor for both osteoarthritis and Reflex Sympathetic Dystrophy (RSD). Another young adult was being treated for ulcerative colitis. We included both individuals' data as they did not perform poorly on any of the experimental tasks.

Two older participants reported recently being treated by an eye doctor. One was treated for glaucoma, and another for blepharitis. However, the acuity for these individuals was 20/40 or better and because none of the tasks were performed poorly, we included the participants' data.

Older adults reported experiencing a variety of illnesses during the past year. Seven older adults were treated for high blood pressure/hypertension, five for high cholesterol, two for prostate problems, five for arthritis, three for acid reflux/heartburn, three for a thyroid condition, three for diabetes, two for depression, two for osteoporosis, and one for headaches/migraines. Five older adults reported receiving medication for other conditions such as mild epilepsy, sleeping disorders, Temporo-Mandibular Joint (TMJ) disorder, and Raynaud's. Our data roughly correspond with prevalence rates in Canada (Heart and Stroke Foundation of Canada, 2005; Osteoporosis Society of Canada, 2005; Statistics Canada, 1999a, 1999b).

Apparatus and Materials

Working memory and web tasks were completed using a personal computer (AMD Athlon XP processor at 1.8 GHz with 256 MB of RAM). Stimuli were shown on a 17 in. (43.18 cm) LG Flatron monitor set at a resolution of 1024 X 768 pixels with 32-bit color depth and a refresh rate of 85 Hertz. Participants used a standard keyboard and a Microsoft Optical Wheel Mouse to make responses.

The web task was completed using a custom web browser called SurfDB (Figure 2 and Figure 4). The software is an updated version of the Surf application (see Laberge and Scialfa, 2005) with built-in logging capabilities made using Microsoft's C# programming language. The browser contained six buttons, including back, forward, refresh, home, start, and stop. With the exception of the start and stop buttons, the buttons functioned in a manner consistent with a standard web browser (Microsoft Internet Explorer or Netscape Navigator). The start and stop buttons were pressed at the beginning and end of each navigation task and were used to determine task completion times. The browser did not include any additional navigation aids (i.e., history feature or favourites).

The browser also supported automatic counting and summarizing of raw test data to quicken data collection and analysis. The summaries for each trial included elapsed time in seconds, number of back, forward, refresh button presses, number of pages visited, number of pages visited more than once (repeat pages), number of links clicked within the page content area (inpage clicks), and number of links clicked from the menu (either static side-bar or dynamic side-tree).

The Travel Alberta website by Laberge and Scialfa (2005) and Hudson et al. (2006) was used in the present study. The Alberta travel domain was chosen to ensure that participants are familiar with the information and that the tasks given were representative of those that participants might complete in the real world. The navigation, content, and page layout was modeled from three existing websites that contain travel information for Alberta (www.discoveralberta.com, www.explorealberta.com, www.travelalberta.com). The website was developed for the study rather than using an already existing site in hope of avoiding site design, structure, or content changes mid-way through the study and to facilitate experimental control of design and navigation variables.

The website contained pages related to seven main structural navigation links including accommodations, camping, events, attractions, parks, cites, and restaurants and bars. These links were always located in the navigational side-menu and outlined the overall structure of the site. Clicking on one of the main structural links would result in the presentation of a page with additional links relevant to the selected topical domain. All unvisited webpage links were underlined and in blue text whereas visited links were underlined and in purple text. All text was presented in 14-point sans-serif font. The website contained a total of 420 pages, with an average of 117 words per page (range = 52 to 711). All pages were designed using a common template that is divided into three regions, including site header (approximately 840 x 170 pixels), navigation (approximately 175 pixels wide), and content areas (approximately 665 pixels wide). The length (height) of each page varied with the amount of text and graphics included. Therefore, some pages required scrolling to view the answer; however, the majority of answers were located in the upper portion of the page.

Previous studies have used only text-based pages (e.g., Lin, 2003a, 2003b; McDonald & Stevenson, 1998). In contrast, we have balanced the text with white space and graphics within the content area of each page. This is done to ensure the website is more representative of the diverse content of the current WWW. For each content page, approximately 65% of the page was filled with text and graphics, 20% was used for navigation, and the remaining 15% was white space. These values roughly correspond with established recommendations (Nielsen, 2000).

The site used a semi-rigid hierarchical structure that is common on the WWW (Nielsen, 2000). The website was augmented with ASP technology by being placed into a prototype version of the ASP SERUM framework (Diaz-Marino, in preparation). This allowed us to keep the page content the same, but change the layout and behavior of the website's features, such as the navigational menu and breadcrumb tools.

The Alberta site was presented in two different web formats that varied in their navigational side-menu: either a static side-bar (control) or dynamic side-tree. The control condition was similar to that of Laberge and Scialfa (2005) and identical to the control in Hudson et al. (2006). It contained links to the seven main structural links. These links remained static as a user navigated through the website. The dynamic side-tree condition contained links that are dynamic or dependant on where one is located in the website. As the user navigates, the side-menu would expand and contract to reveal more subcategory links related to the current level within which a person was working. Text and graphic content was constant between versions. The two web formats can be seen in Figure 2 (control) and Figure 4 (side-tree).

Procedure

All participants were tested in two 120 minute sessions. The experimental tasks carried out in the two sessions are outlined in Figure 5. In the first session, participants were first introduced to the study and were presented with an informed consent form to read (Appendix A). Following their signed consent, they completed a WWW experience, health, and demographic questionnaire (Appendix B). Next, we tested for static visual acuity (Landolt C's at 50 cm), and anomalies in colour vision (Farnsworth D15 Test). Participants then completed the web task using either the control or side-tree web format. Participants used the same web format condition across the two sessions. Lastly, a post-web quiz was completed testing their recall and recognition memory of the information searched in the website (Appendix C). The second session was identical to the first but forwent the demographic questionnaire and visual tests and instead included a measure of search ability (Trail Making Test, part B) and visuospatial working memory ("Concentration" Game). Following the post-web quiz in session 2, participants filled out a quick post-navigation survey (Appendix D). All measures are described in greater detail below.

Session One	Session Two
☐ Demographic Questionnaire	☐ Search Ability (Trails B)
☐ Acuity (Landolt C)	☐ Visuospatial Working Memory (Matching "concentration" Game)
☐ Colour Vision (Farnsworth D15)	
☐ 40 Navigation Trials (What are the hours of operation of Canada Olympic Park?)	☐ 40 New Navigation Trials (What are the hours of operation of the Aerospace Museum of Calgary?)
☐ 28 Recognition Questions (multiple-choice)	☐ 28 New Recognition Questions (multiple-choice)
☐ 12 Recall Questions (short-answer)	☐ 12 New Recall Questions (short-answer)
	☐ Post Navigation Questionnaire

Figure 5. Experimental tasks for session one and session two.

WWW experience. WWW experience was measured with four questions: the number of hours per week spent using the WWW, the number of years of WWW experience, the number of websites developed, and the number of different websites visited per week. A principal components analysis produced two significant components that accounted for 36.9% and 28.7% of the variance in all the questions (using a cutoff eigenvalue of 1.0). The first component seemed to reflect the participants' current habits and usage of the WWW. The second component seemed to reflect the participants' knowledge of web design and WWW experience in general (see Table 2). Component scores were calculated for each participant based on these component loadings and were used in subsequent analyses as an index of WWW experience. Larger positive scores represented more WWW usage and experience than average.

Subject matter knowledge. Because the site used in this study was based on subject matter that may have been familiar to the participants, it was important to obtain an indicator of subject matter knowledge. This was measured with five questions: the number of years living in Alberta, number of days per year spent traveling in Alberta, number of different Alberta cities/towns lived in, number of Alberta cities/towns visited, and the number of events attended per year in Alberta. Like WWW experience, all five questions were subject to a principal components analysis (again, using a cutoff eigenvalue of 1.0). One significant component emerged that accounted for 42.6% of the variance (see Table 3). Component scores were calculated for each participant based on component loadings and used together in subsequent analyses as indices of subject matter knowledge. Higher positive scores represented more knowledge of the Alberta.

Search Ability. In web navigation, users are often seeking an appropriate link to a particular webpage or for a certain item of information. Quite often, a series of links must be sequentially accessed in order to arrive at the desired webpage. Similarly, the Trail Making Test part B (Reitan, 1992; Reitan & Wolfson, 1985) requires participants to search for items given a particular sequence. Search ability was measured using the time required to draw lines between 25 target items. The sequence required participants to connect items in ascending order while alternating between number and letter targets (e.g. 1 to A, A to 2, 2 to B, B to 3, 3 to C, etc). Alternating between number and letter targets adds to the complexity of the task requiring a significant amount of working memory. Likewise, it is believed that working memory demands are also required to navigate the WWW (Kubeck et al., 1999; Laberge & Scialfa, 2005). Faster times correspond to better search ability.

Table 2. Principal component analysis for web experience.

Measure	Principal Component One	Principal Component Two
How many hours per week do you spend using the World Wide Web?	-.02	.79
How many years have you been using (browsing, shopping, banking, etc.) the World Wide Web?	.85	.06
How many websites have you developed?	.42	-.65
How many different websites do you visit each week?	.76	.31

Table 3. Principal Component Analysis for Subject matter knowledge.

	Principal Component
Measure	One
How many years have you been living in Alberta?	.82
How many days of the year do you travel in Alberta?	.56
How many different Alberta cities/towns have you lived in?	.65
How many different events (i.e. Klondike Days, Ponoka Stampede, Canadian Finals Rodeo, etc.) do you attend per year in Alberta?	.44
How many different Alberta cities/towns have you visited?	.72

Visuospatial working memory. A visuospatial working memory test was administered to examine the high spatial demands often associated with web navigation (e.g., Dillon et al., 1990; Kim and Hirtle, 1995; Pak, 2001). Visuospatial working memory was defined as the ability to remember object identity and spatial location while simultaneously processing new visual information in a variant of the "Concentration" game (see Pringle, 2000). Performance was measured using the time required to complete the task and the efficiency of search defined relative to optimal performance.

Web Task. The web task required participants to find answers to questions such as "What are the hours of operation for Canada Olympic Park?" All participants were asked to locate the answer to each question which was found on a single page of the website. Each question was presented one at a time on a piece of paper, and participants first pressed the start button on the browser to begin. After finding the answer to the question and reporting it verbally to the experimenter (who confirmed the accuracy of the response) the participant pressed the stop button to end the trial. Because completion time was a criterion variable, participants were told they cannot ask questions once the start button was pressed but can ask questions between trials. All participants were randomly assigned to a web format condition (control or side-tree) and completed the trials at a test distance of approximately 50 cm from the computer screen.

Special care was taken to equate the level of difficulty of the two navigation sessions. First, 40 pairs of questions were made. Questions were considered a pair if they closely resembled each other in the phrasing of question, the location of the answer, and the type of answer. For example, "What are the hours of operation for Canada Olympic Park?" and "What are the hours of operation for the Calgary Zoo?" are considered a pair as they both have similar phrasing, answer locations on the website (attractions in Calgary), and answer types (time open to close). Next, pairs were divided into two sets (set 'A' and set 'B'); one for each session, 40 experimental trials each. For both sets, the sequence in which trials were completed was kept constant. The order in which participants received set one and set two were also counterbalanced. There were two practice and 80 experimental trials in total. See Appendix C to view questions for set A and B.

Recall and Recognition Memory Tasks. After completing the navigation task, participants were asked to answer the same questions again without the aid of the website. Twelve questions were randomly presented in a short-answer fashion (recall task) while the remaining twenty-eight were presented in a multiple choice fashion (recognition task; see

Appendix C). Recall and recognition scores were calculated as a percentage correct out of their respective totals. In each session, participants were informed of the memory tests prior to starting the web task.

Post Navigation Questionnaire. After the memory task in the second session, participants were asked to complete a ten question opinion survey (Appendix D). Participants would read each statement one at a time, and would indicated their extent of agreement or disagreement by using a 5-point Likert scale (1 = *strongly disagree* to 5 = *strongly agree*). This was done to examine how realistic the web tasks were to our participants and gauge general feelings about the Travel Alberta website.

RESULTS

Performance Measures

Three measures of navigation performance were evaluated and are reported as an average across trials. To make the criteria comparable across participants, performance was expressed based on valid trials only. Valid trials were those without missing data. Data was missed because participants forgot to press the start and stop buttons, hints were given in order to complete the trial successfully, or participants failed to answer. Over the two sessions, there were a total of 5002 trials of which only 19 were invalid. This corresponds to 0.4% of the total data. Older adults accounted for 63.2% of these invalid trials which suggests they have a greater difficulty in successful web navigation. Nevertheless, we forwent further analysis of invalid trials due to their rarity and the difficulties such rarity imposes on systematic analyses.

The first performance measure was time per trial and was calculated as the average time required to complete a trial. The second performance measure was number of pages visited per trial. This was calculated as the total number of pages visited (including repeat pages) divided by the number of trials. Thirdly, the number of repeat pages per trial was calculated by taking the total number of repeat pages divided by the number of trials. A repeat page was any page visited after the first time it was seen. We chose these performance measures because they have been shown to reflect the effects of disorientation in hypertext navigation (e.g., Laberge and Scialfa, 2005, Lin, 2003a, 2003b; McDonald and Stevenson, 1996, 1998a, 1998b).

Two measures of web content performance were also evaluated: recall (short answer) and recognition (multiple choice) questions. However, there were issues with nearly half the recall questions. Namely, some recall questions could be answered based on one's existing semantic knowledge and not strictly on one's content memory from the actual website itself (e.g. What day is El Sombrero Mexican Restaurant closed in Calgary?). Because our aim was to examine the content memory solely attained from the Alberta website, and with the large number of problematic recall questions, we decided to forgo the recall analyses. In contrast, recognition questions did not have the same concerns as there were strong distractors among the multiple-choice options (e.g. What night is "wing-night" at Hudson's Canadian Taphouse in Edmonton? A. Sunday; B. Monday; C. Tuesday; or D. Wednesday). Thus, it is unlikely that using any existing semantic knowledge would be able to deduce the correct answer. Recognition memory scores are calculated as a percentage of correct responses out of a total of 28 questions. Table 4 gives the means and standard deviations for the performance measures.

Results Overview

Because of the large number of analyses to follow, we first provide an overview of the results. Participants were found to improve in all aspects of navigation performance with practice. An age difference was found with time per trial, whereby young adults could navigate faster than old adults. An Age x Practice interaction was observed for time per trial whereby both young and old adults significantly improved, and despite larger improvements observed by older adults, age differences persisted. No age differences were found with either the number of repeat or total pages visited per trial. Although it was predicted, and to a small degree observed, that the side-tree condition would yield fewer pages and repeat pages visited, these differences in web format were nonsignificant.

As predicted, younger adults had superior recognition memory for the web content than older adults. More importantly, an Age x Web Format x Practice interaction was observed once four demographic characteristics were used as covariates in our model (the number of years of education, the number of different sites visited each week, the average self-reported health rating, and for the average number of days spent living in Alberta). Although older adults improved recognition memory with practice, no Web Format effect or Web Format x Practice interaction were observed. In contrast, young adults did not improve with practice; yet, a significant Web Format effect and a marginally significant Web Format x Practice interaction were observed. Young had better recognition scores when using the control condition as opposed to the side-tree condition. Finally, the age-related variance in search time and recognition memory appear to be related to age deficits in working memory, search ability, WWW experience (usage).

Table 4. Means and Standard Deviations (SD) for Performance Measures

Variable	Young				Old			
	Control ($n = 16$)		Side-tree ($n = 15$)		Control ($n = 15$)		Side-tree ($n = 15$)	
Session 1								
Time per Trial	25.02	(5.81)	26.56	(4.77)	39.67	(13.09)	42.60	(10.49)
Repeat Pages per Trial	3.72	(1.08)	3.09	(0.96)	3.27	(0.88)	3.38	(1.24)
Total Pages per Trial	5.92	(1.40)	5.12	(1.01)	5.20	(0.89)	5.30	(1.28)
Recognition Memory	75.51	(9.63)	73.57	(8.83)	66.35	(11.59)	65.71	(12.13)
Session 2								
Time per Trial	20.06	(4.35)	20.90	(4.01)	30.32	(7.35)	33.16	(7.76)
Repeat Pages per Trial	2.89	(0.79)	2.17	(0.58)	2.47	(0.62)	2.40	(0.60)
Total Pages per Trial	4.94	(0.89)	4.25	(0.71)	4.52	(0.71)	4.43	(0.63)
Recognition Memory	80.08	(7.39)	69.76	(9.81)	68.98	(8.97)	68.57	(8.23)

Age x Web Format x Practice Analyses of Variance

Three-way mixed model analyses of variance (ANOVAs) were performed on each of our performance measures to examine the relationship between Age (young versus old adults), Web Format (side-tree versus control condition), and Practice (session 1 versus session 2). The results of the ANOVA for each performance measure are described in more detail below.

Time per trial. The results of a three-way ANOVA revealed no statistically significant Age x Web Format x Practice interaction, $F\,(1, 57) = .06$, $p = .81$; $\eta_p^2 < .01$. No two-way effects were observed for the Web Format x Practice interaction, $F\,(1, 57) = .10$, $p = .76$; $\eta_p^2 < .01$, nor the Age x Web Format interaction, $F\,(1, 57) = .20$, $p = .66$; $\eta_p^2 < .01$. An Age x Practice interaction was found to be significant, $F\,(1, 57) = 10.25$, $p = .002$; $\eta_p^2 = .15$. The main effect of Web Format was not significant (Figure 6), $F\,(1, 57) = 1.17$, $p = .29$; $\eta_p^2 = .02$; yet, the main effect of Practice was significant (Figure 7), $F\,(1, 57) = 133.15$, $p < .001$; $\eta_p^2 = .70$. In general, participants improved their average time per trial from session 1 ($M = 33.33$, $SD = 11.87$) to session 2 ($M = 26.01$, $SD = 8.28$). Once more, the main effect of Age was also found to be significant (Figure 8), $F\,(1, 57) = 49.87$, $p < .001$; $\eta_p^2 = .47$. On average, young adults ($M = 23.12$, $SD = 4.72$) finished trials faster than old adults ($M = 36.44$, $SD = 9.66$).

To further examine the Age x Practice interaction, two simple effects tests were conducted. A Bonferroni correction ($p = .025$) was used to control Type I error rates. As seen in Figure 9, young adults were found to significantly improve their times from session 1 ($M = 25.77$, $SD = 5.30$) to session 2 ($M = 20.46$, $SD = 4.14$), $F\,(1, 30) = 61.90$, $p < .001$; $\eta_p^2 = .67$. Similarly, old adults were found to significantly improve their times from session 1 ($M = 41.14$, $SD = 11.75$) to session 2 ($M = 31.74$, $SD = 7.56$), $F\,(1, 29) = 77.36$, $p < .001$; $\eta_p^2 = .73$. In the first session, young adults ($M = 25.77$, $SD = 5.30$) were faster than old adults ($M = 41.14$, $SD = 11.75$) in web tasks, $F\,(1, 59) = 43.84$, $p < .001$; $\eta_p^2 = .43$. Interestingly, age differences remained significant in session 2, $F\,(1, 59) = 52.62$, $p < .001$; $\eta_p^2 = .47$. Despite improvements attained by older adults ($M = 31.74$, $SD = 7.56$), they were still slower than their younger counterparts ($M = 20.46$, $SD = 4.14$).

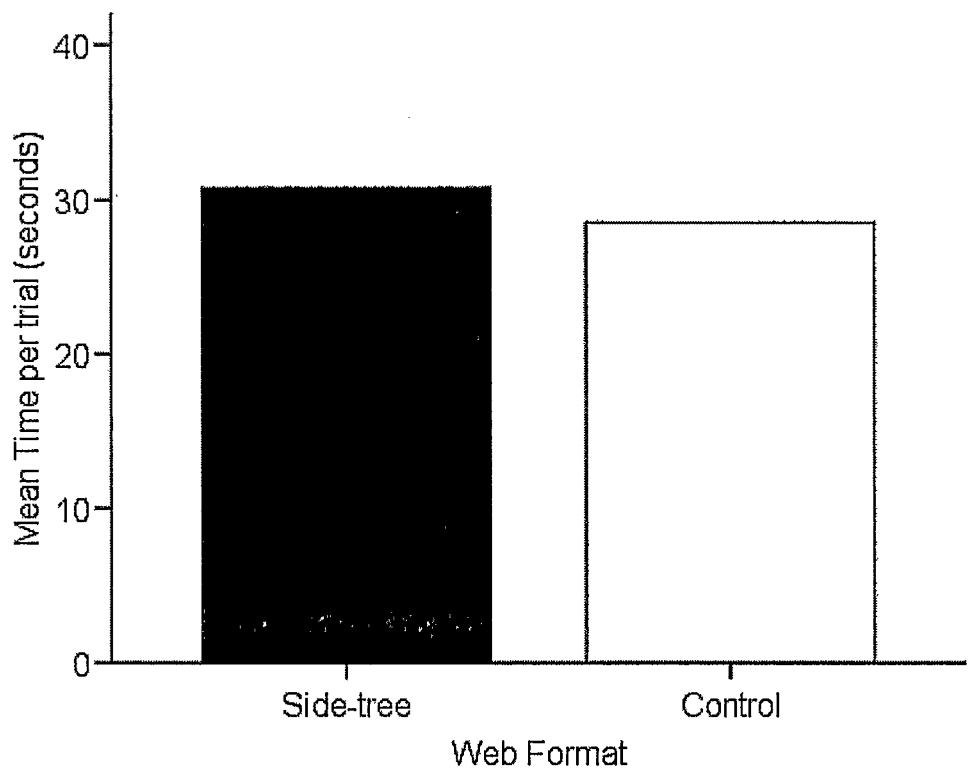

Figure 6. Mean time per trial (seconds) as a function of web format.

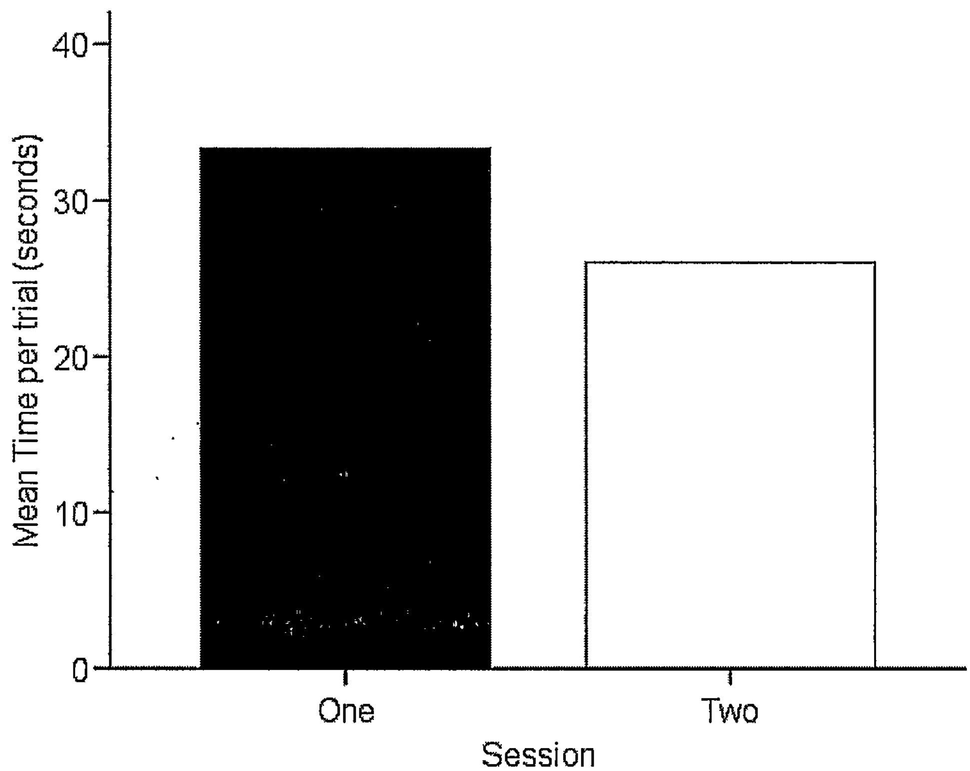

Figure 7. Mean time per trial (seconds) from session one to session two.

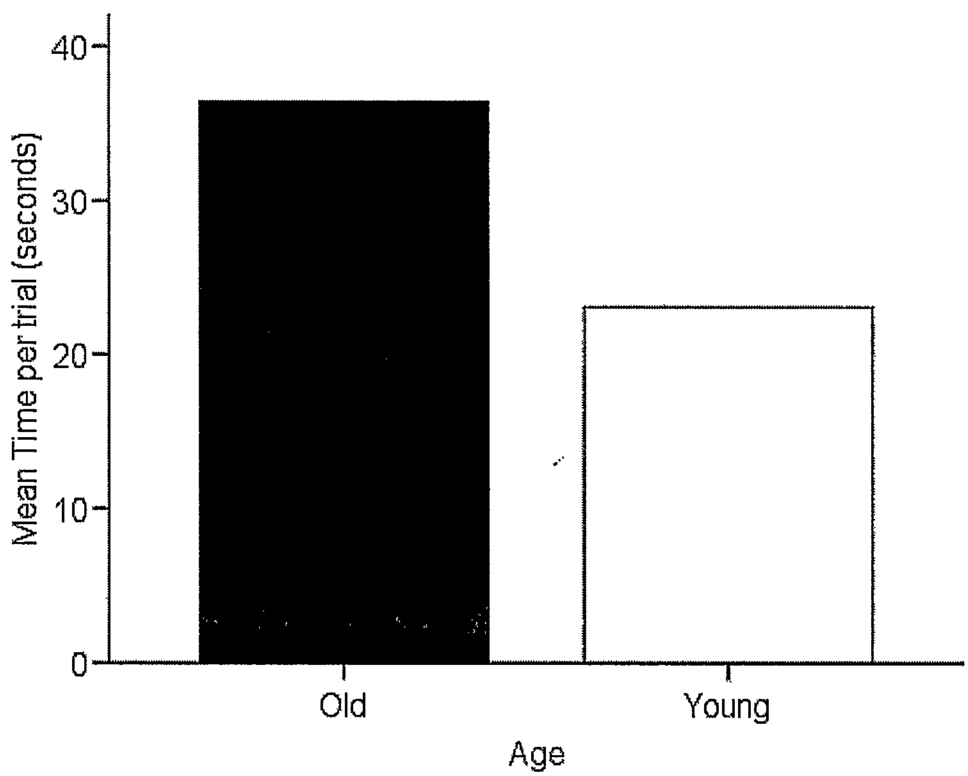

Figure 8. Mean time per trial (seconds) for younger and older adults.

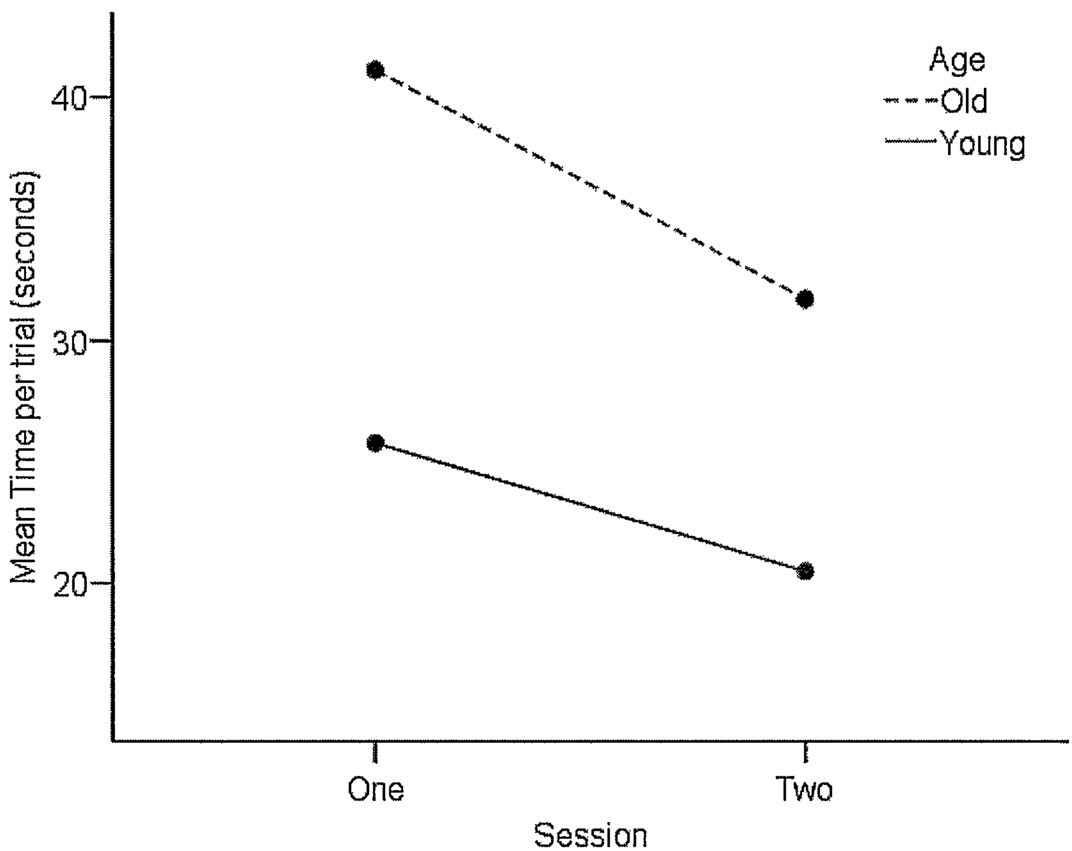

Figure 9. Mean time per trial (seconds) from session one to session two as a function of age.

Number of repeat pages visited per trial. The results of a three-way ANOVA revealed no statistically significant Age x Web Format x Practice interaction, F (1, 57) = .06, p = .82; $\eta_p^2 < .01$. No two-way effects were observed for the Web Format x Practice interaction, F (1, 57) = .47, p = .50; $\eta_p^2 < .01$, the Age x Practice interaction, F (1, 57) = .004, p = .95; $\eta_p^2 < .01$, and the Age x Web Format interaction, F (1, 57) = 2.91, p = .09; $\eta_p^2 = .05$. A non-significant main effect was also observed for Age (Figure 10), F (1, 57) = .19, p = .66; $\eta_p^2 = .01$; yet, a significant effect of Practice was observed (Figure 11), F (1, 57) = 82.59, $p < .001$; $\eta_p^2 = .59$. In general, participants reduced the number of repeat pages per trial from session 1 (M = 3.37, SD = 1.05) to session 2 (M = 2.49, SD = .69). Importantly, participants who used the side-tree condition visited fewer pages (M = 2.76, SD = .84) than those who used the control (M = 3.09, SD = .87); however, contrary to our predictions, this effect was not significant, F (1, 57) = 2.64, p = .11; $\eta_p^2 = .04$ (Figure 12).

Total number of pages visited per trial. The results of a three-way ANOVA revealed no statistically significant Age x Web Format x Practice interaction, F (1, 57) = .44, p = .51; $\eta_p^2 < .01$. No two-way effects were observed for the Web Format x Practice interaction, F (1, 57) = .05, p = .83; $\eta_p^2 < .01$, the Age x Practice interaction, F (1, 57) = .44, p = .51; $\eta_p^2 < .01$, and the Age x Web Format interaction, F (1, 57) = 2.80, p = .10; $\eta_p^2 = .05$. A non-significant main effect was also observed for Age (Figure 13), F (1, 57) = .76, p = .39; $\eta_p^2 = .01$; yet, a significant effect of Practice was observed (Figure 14), F (1, 57) = 57.61, $p < .001$; $\eta_p^2 = .50$. In general, participants reduced the number of pages per trial from session 1 (M = 5.39, SD = 1.18) to session 2 (M = 4.54, SD = .77). Importantly, participants who used the side-tree condition visited fewer pages (M = 4.77, SD = .90) than those who used the control (M = 5.15, SD = 1.02); however, contrary to our predictions, this effect was not significant, F (1, 57) = 2.75, p = .10; $\eta_p^2 = .05$ (Figure 15).

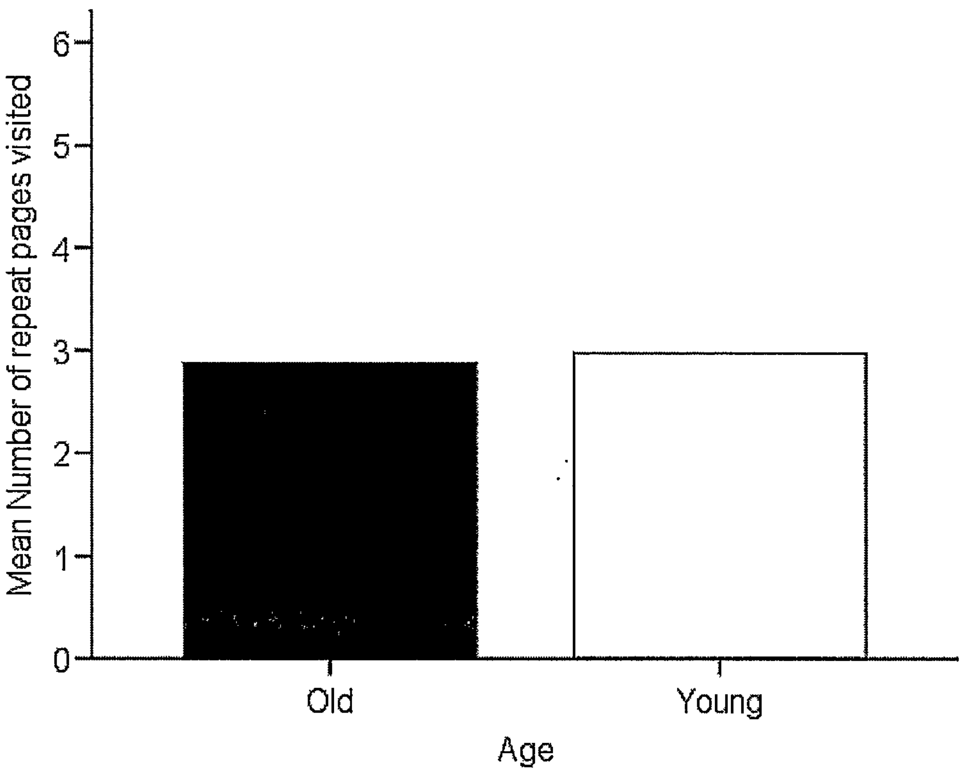

Figure 10. Mean number of repeat pages visited per trial for younger and older adults.

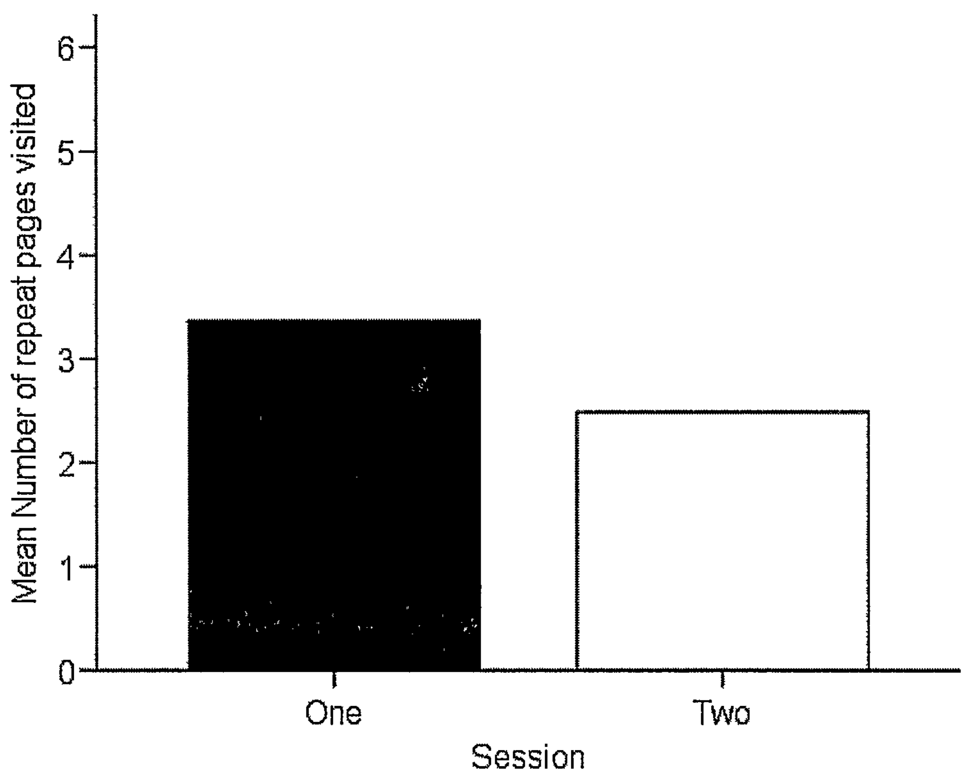

Figure 11. Mean number of repeat pages visited per trial from session one to session two.

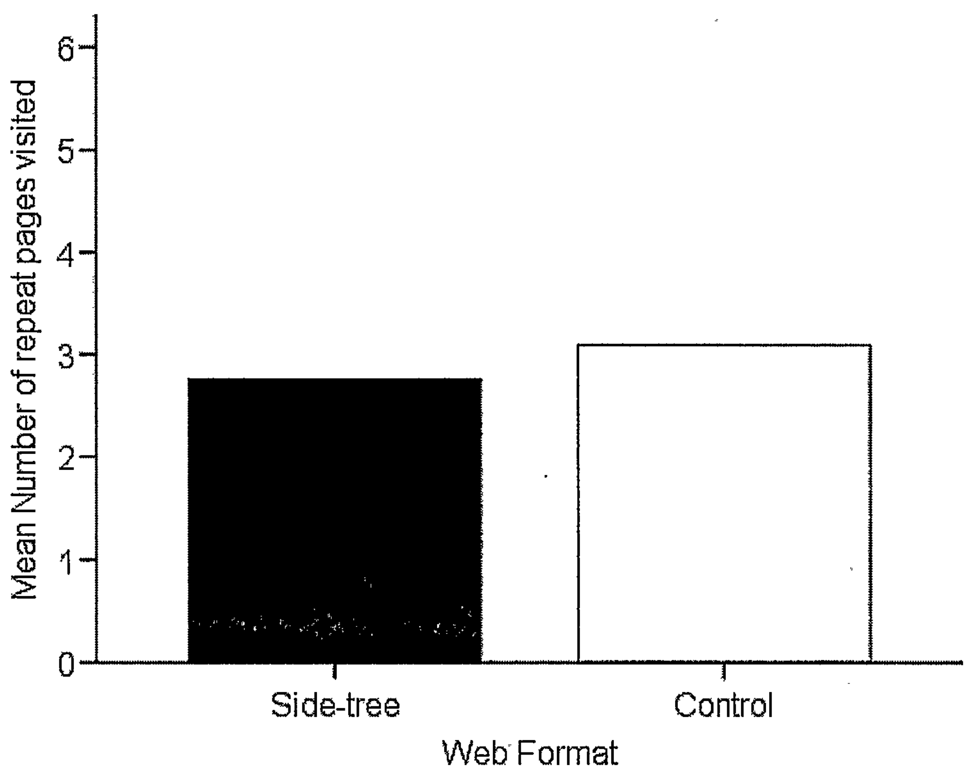

Figure 12. Mean number of repeat pages visited per trial as a function of web format.

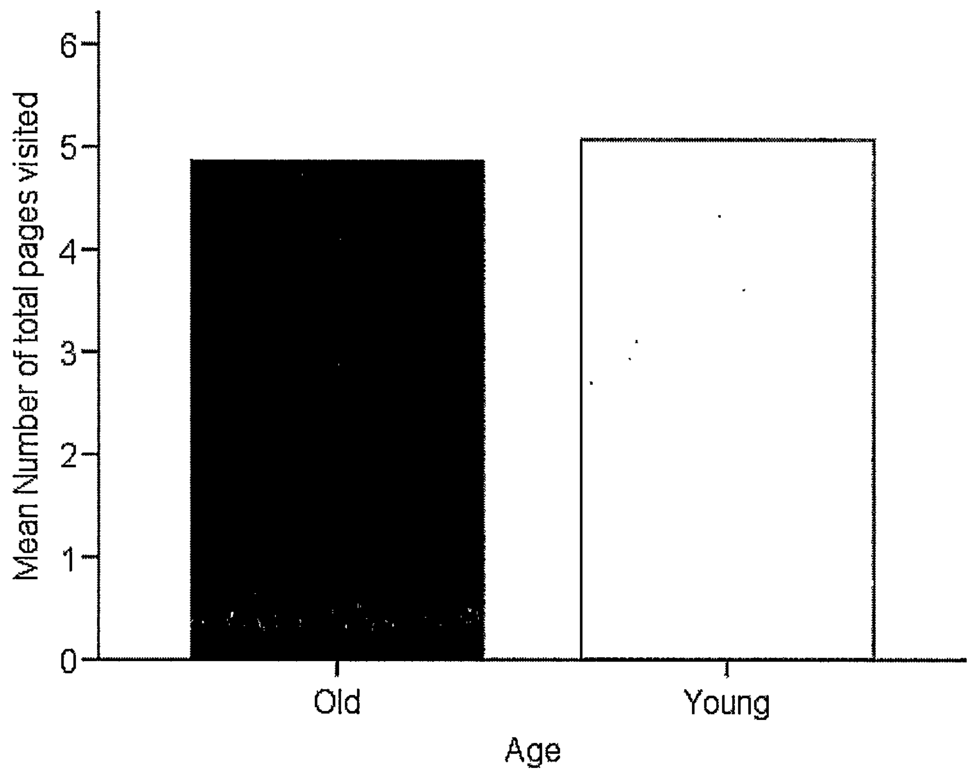

Figure 13. Mean number of total pages visited per trial for younger and older adults.

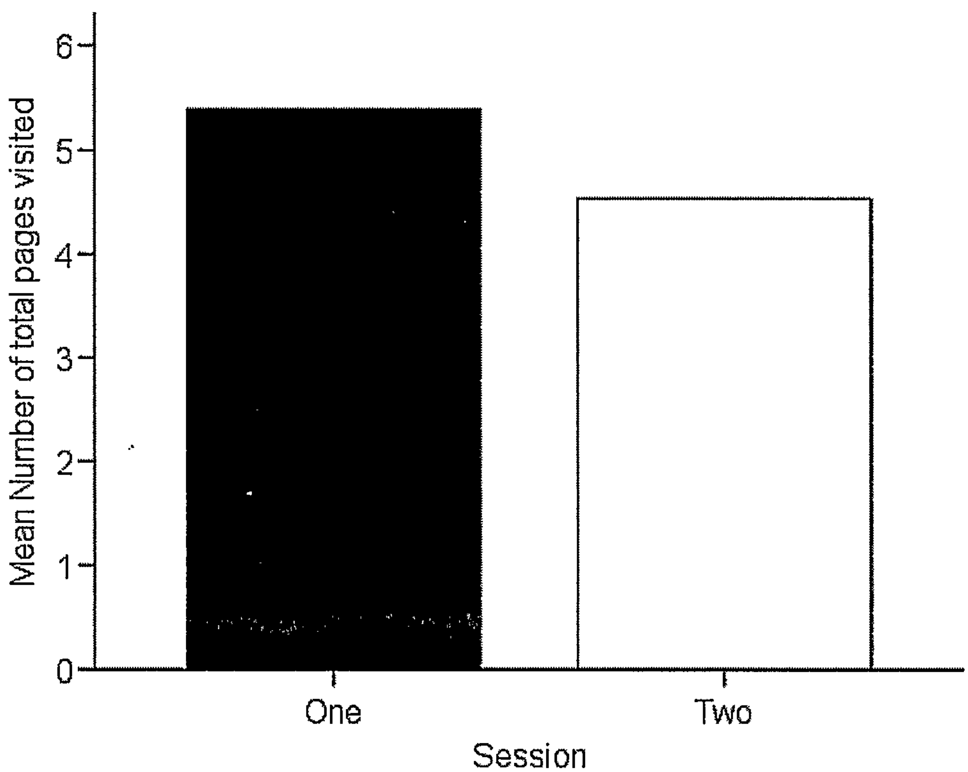

Figure 14. Mean number of total pages visited per trial from session one to session two.

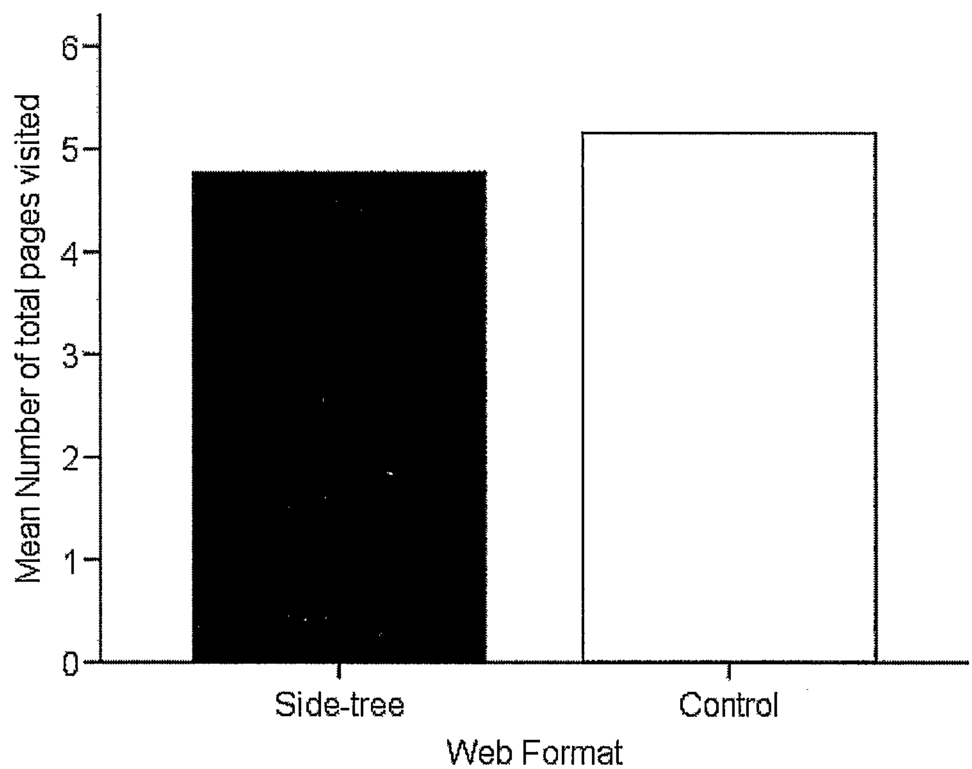

Figure 15. Mean number of total pages visited per trial as a function of web format.

Recognition memory. The results of a three-way ANOVA revealed no statistically significant Age x Web Format x Practice interaction, F (1, 57) = 2.03, p = .16; η_p^2 = .03. No two-way effects were observed for the Web Format x Practice interaction, F (1, 57) = 1.82, p = .18; η_p^2 = .03, the Age x Practice interaction, F (1, 57) = .62, p = .44; η_p^2 = .01, and the Age x Web Format interaction, F (1, 57) = 2.04, p = .16; η_p^2 = .03. A non-significant main effect was also observed for Web Format (Figure 16), F (1, 57) = 2.86, p = .10; η_p^2 = .05, and for Practice (Figure 17), F (1, 57) = 1.07, p = .31; η_p^2 = .02. Only a significant main effect of Age was found in recognition memory (Figure 18), F (1, 57) = 13.89, p < .001; η_p^2 = .20. As expected younger individuals, in general, had better recognition memory (M = 74.83, SD = 9.57) than older individuals (M = 67.40, SD = 10.06).

Group Differences in Demographic Characteristics

As previously mentioned, an Age x Web Format ANOVA was conducted to determine if the groups were equivalent in their demographic characteristics. Again, results revealed significant differences in web format for variables including the number of different sites visited each week, the average self-reported health rating, and the average number of days spent living in Alberta. One significant Age x Web Format interaction was also found to be significant for the number of years of education. Because of these differences between our group characteristics, three-way mixed model analyses of covariance (ANCOVAs) were also performed using the aforementioned demographic variables as covariates. Importantly, the results of the three-way ANCOVAs did not differ greatly from the reported three-way ANOVAs with the exception of the recognition memory variable. The results of the ANCOVA performed on the recognition measure are now discussed.

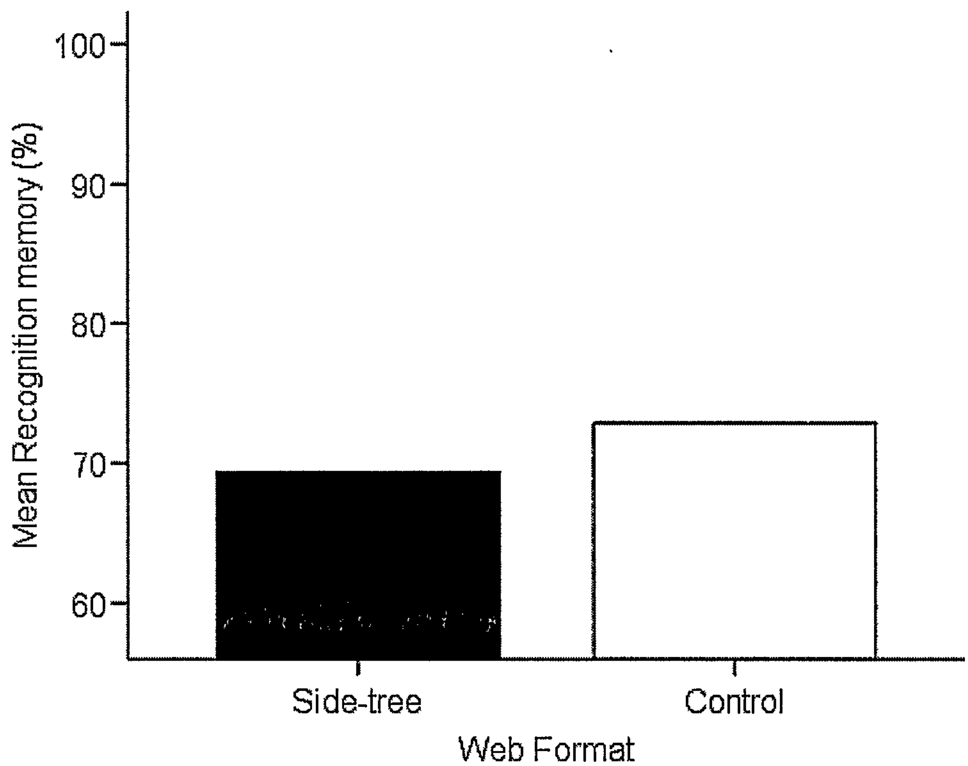

Figure 16. Mean recognition memory scores (%) as a function of web format.

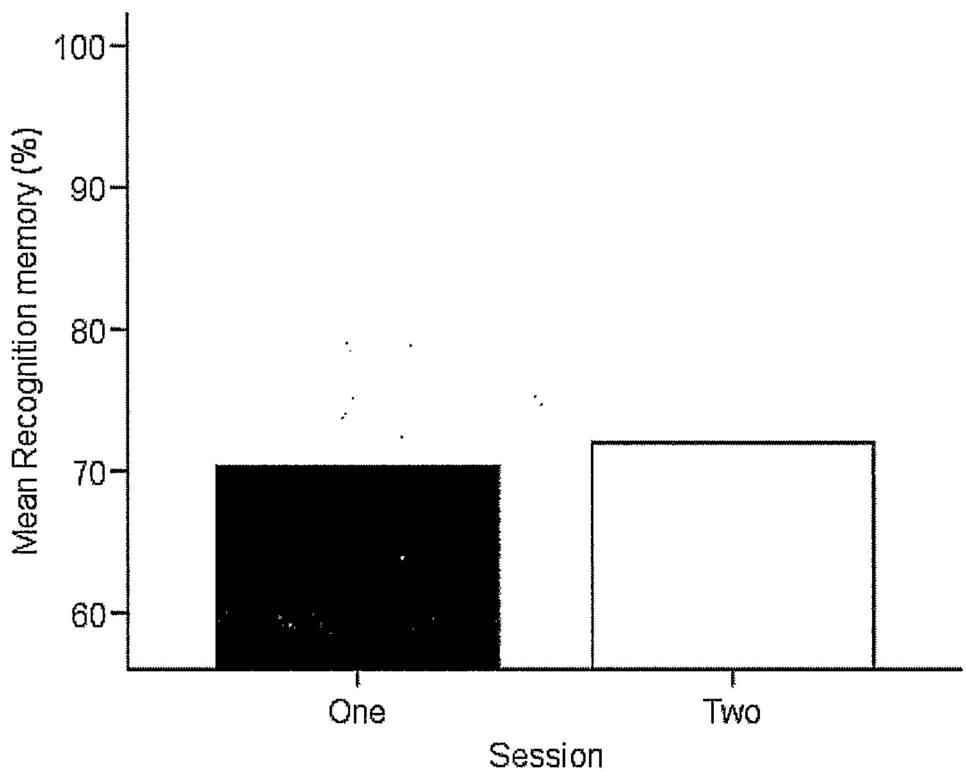

Figure 17. Mean recognition memory scores (%) from session one to session two.

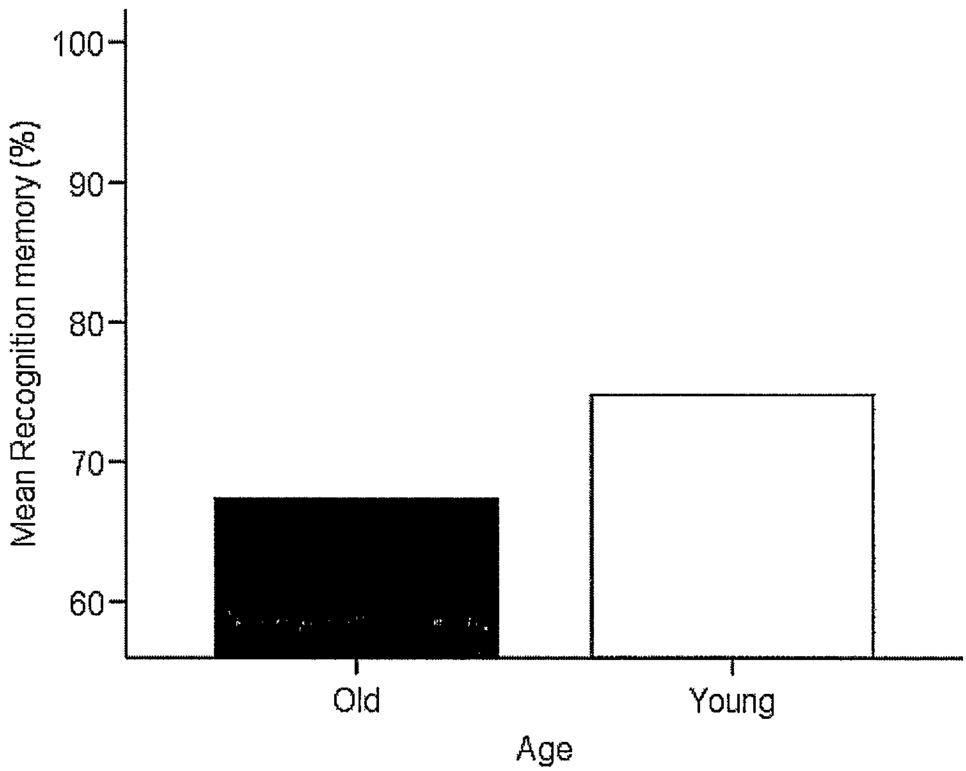

Figure 18. Mean recognition memory scores (%) for younger and older adults.

Age x Web Format x Practice Analyses of Covariance

Recognition memory. The results of a three-way ANCOVA revealed a statistically significant Age x Web Format x Practice interaction, $F\ (1, 53) = 5.32, p = .03; \eta_p^2 = .09$. No two-way effects were observed for the Web Format x Practice interaction, $F\ (1, 53) = 2.14, p = .15; \eta_p^2 = .04$, the Age x Practice interaction, $F\ (1, 53) = .15, p = .70; \eta_p^2 < .01$, and the Age x Web Format interaction, $F\ (1, 53) = 3.15, p = .08; \eta_p^2 = .06$. A significant main effect was observed for Web Format, $F\ (1, 53) = 7.90, p < .01; \eta_p^2 = .13$. Contrary to our predictions, the control condition ($M =$ 72.89, $SD = 10.63$) yielded better recognition memory scores than the side-tree condition ($M =$ 69.40, $SD = 10.04$). Practice effects were also observed to be significant, $F\ (1, 53) = 4.38, p = .04;$ $\eta_p^2 = .08$. Recognition memory appears to have improved from session 1 ($M = 70.37, SD = 11.23$) to session 2 ($M = 71.98, SD = 9.73$). Finally, Age effects were also found to be significant, F (1, 57) $= 17.20, p < .001; \eta_p^2 = .25$. As expected younger individuals, in general, had better recognition memory ($M = 74.83, SD = 9.57$) than older individuals ($M = 67.40, SD = 10.06$).

To further examine the Age x Web Format x Practice interaction, simple effects tests were conducted (Figure 19). A Bonferroni correction ($p = .025$) was used to control Type I error rates. Among older adults, no Web Format x Practice interaction or Web Format effects were observed ($ps = .47$). Older adults were found to significantly improve recognition memory with practice, F $(1, 24) = 5.99, p = .02; \eta_p^2 = .20$. For young adults, no Web Format x Practice interaction was observed ($p = .07$). However, young adults had significantly better recognition scores when using the control condition ($M = 77.80, SD = 8.51$) as opposed to the side-tree condition ($M = 71.67, SD =$ 9.32), $F\ (1, 25) = 10.02, p = .004; \eta_p^2 = .29$. In contrast with older adults, younger adults were not found to significantly improve recognition memory with practice, $F\ (1, 25) = .11, p = .74; \eta_p^2 < .01$.

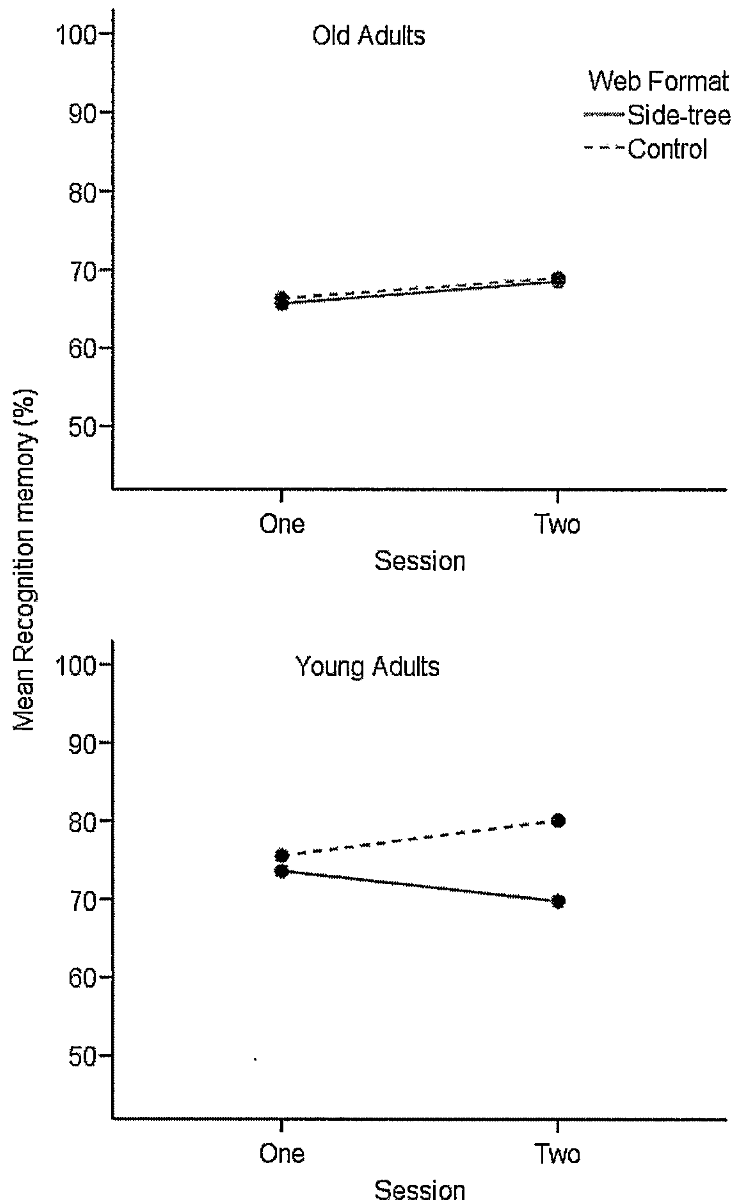

Figure 19. Mean recognition memory (%) for younger and older adults as a function of practice and web format.

Group Differences in Predictor Variables

An Age x Web Format ANOVA was used to examine any group differences on our predictors. No significant Age x Web Format interactions (*ps* = .11) or main effects of Web Format (*ps* = .27) were observed. The one exception was for web usage which revealed a significant effect of Web Format (F (1, 57) = 6.85, p = .01; $\eta_p^2 = .11$) and Age x Web Format interaction, F (1, 57) = 4.62, p = .04; $\eta_p^2 = .08$. Young participants in the control condition (M = 1.08, SD = 1.02) had significantly more web usage than young participants in the side-tree condition (M = .29, SD = .49), F (1, 29) = 7.55, p = .01; $\eta_p^2 = .21$. However, for older participants there was no effect of web format, F (1, 28) = .24, p = .63; $\eta_p^2 < .01$. Predictor variables also showed significant age differences. As expected, young adults had faster search ability ($p < .001$) and stronger working memory (*ps* = .001) than old adults. Young adults also had more web experience (usage; $p < .001$) while old adults had more web experience (knowledge; p = .04) and greater knowledge of Alberta ($p < .001$). Table 5 provides the means and standard deviations for the predictor variables.

Proportion of Navigation Methods Used

Figure 20 shows the percent of navigation tools used by young and old adults for the two web formats. It was calculated as the total distribution of all navigation aids used across all trials. As An Age x Web Format ANOVA revealed no significant interaction for any of the navigation methods used (*ps* > .08). Age differences were found significant only for menu clicks, F (1, 57) = 4.33, p = .04. Older adults (41.4%) appear to use the menu more often than their younger counterparts (36.6%).

Web Format effects were observed for the back button, F (1, 57) = 4.55, p = .04, menu, F (1, 57) = 91.97, $p < .001$, and inpage clicks, F (1, 57) = 99.76, $p < .001$. The back button was used more often by participants in the control condition (13.4%) than those in the side-tree condition (9.7%). Participants in the side-tree condition relied more on the dynamic side-tree (51.1%) while those in the control relied more on inpage links (62.3%).

Table 5. Means and Standard Deviations (SD) for Predictors.

Variable	Young: Control ($n = 16$)		Young: Side-tree ($n = 15$)		Old: Control ($n = 15$)		Old: Side-tree ($n = 15$)	
Subject matter knowledge of Alberta	-0.72	(0.69)	-0.42	(0.64)	0.50	(0.79)	0.68	(1.10)
WWW experience (Usage)	1.08	(1.02)	0.29	(0.49)	-0.68	(0.50)	-0.76	(0.38)
WWW experience (Expertise)	-0.03	(0.90)	-0.50	(1.13)	0.10	(0.88)	0.43	(0.95)
Trails B (time)	59.88	(15.98)	54.67	(14.28)	80.67	(23.73)	83.20	(24.65)
Visuospatial working memory (time)	81.89	(15.66)	80.70	(14.72)	131.60	(26.02)	134.53	(35.57)
Visuospatial working memory (efficiency)	36.62	(4.95)	38.28	(6.09)	33.13	(6.72)	30.07	(8.17)

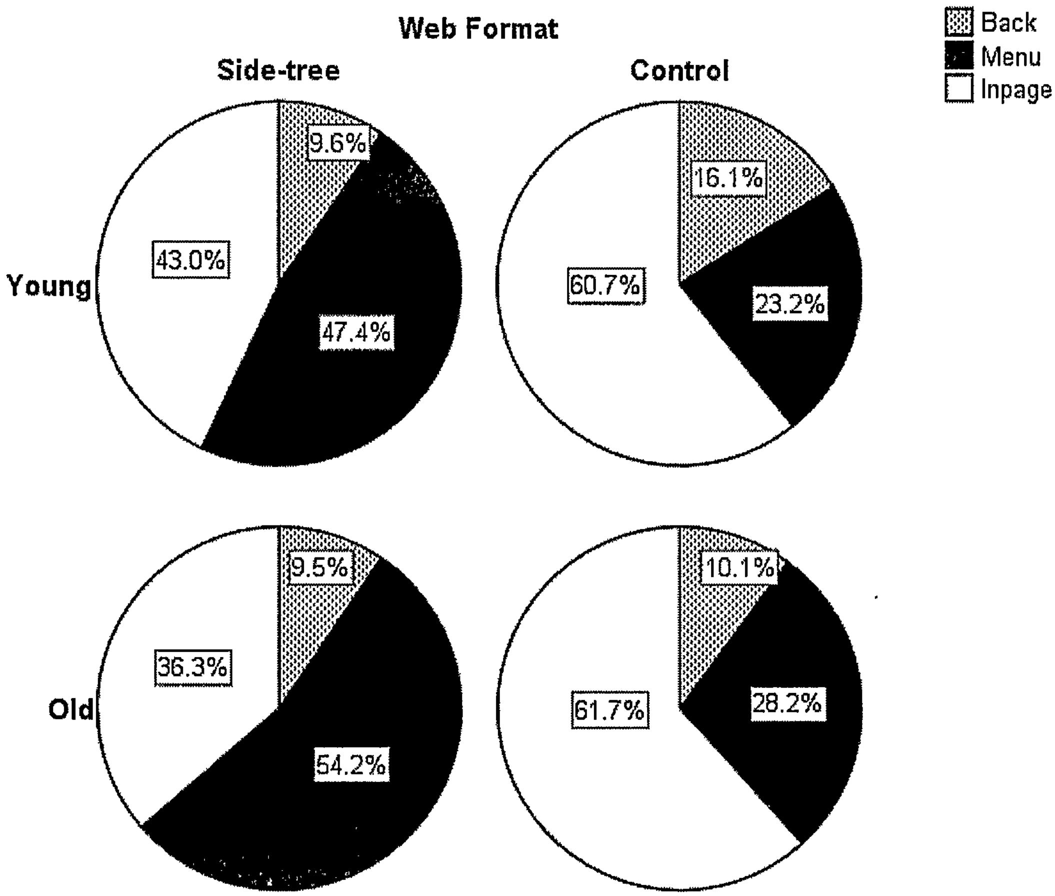

Figure 20. Proportion of Navigation Tool Use by Age and Web Format.

Table 6. Correlation Matrix for Predictor Variables

	Variable								
Variable	1	2	3	4	5	6	7	8	9
1. Age	-								
2. Gender[a]	-.16	-							
3. Web Format[a]	-.02	-.05	-						
4. Subject matter knowledge of Alberta	.54**	-.17	-.13	-					
5. WWW experience (Usage)	-.68**	.11	.24	-.49**	-				
6. WWW experience (Expertise)	.24	-.05	.03	-.01	.00	-			
7. Trails B (time)	.52**	-.25*	.02	.24	-.39**	.13	-		
8. Visuospatial working memory (time)	.71**	-.18	-.02	.46**	-.69**	.11	.67**	-	
9. Visuospatial working memory (efficiency)	-.36**	-.07	.05	-.18	.40**	-.25*	-.42**	-.70**	-

[a] Point-biserial correlation (r_{pbis}).
* $p < .05$ (two-tailed). ** $p < .01$ (two-tailed).

Table 7. Correlations Between Predictor Variables and Measures of Web Navigation Performance

Variable	Session 1				Session 2			
	Time per Trial	Repeat Pages per Trial	Total Pages per Trial	Recognition Memory	Time per Trial	Repeat Pages per Trial	Total Pages per Trial	Recognition Memory
1. Age	.64**	-.04	-.11	-.35**	.67**	-.09	-.10	-.27*
2. Gender [a]	-.10	.11	.17	.06	-.10	.04	.04	.17
3. Web Format [a]	-.10	.13	.15	.06	-.12	.29*	.26*	.29*
4. Subject matter knowledge of Alberta	.28*	-.22	-.28*	.04	.28*	-.36**	-.38**	-.06
5. WWW experience (Usage)	-.54**	.12	.23	.28*	-.56**	.28*	.27*	.25*
6. WWW experience (Expertise)	.11	.16	.13	-.19	.08	.19	.18	-.32**
7. Trails B (time)	.64**	.14	.08	-.47**	.60**	.12	.12	-.28*
8. Visuospatial working memory (time)	.69**	-.04	-.12	-.45**	.66**	-.09	-.09	-.28*
9. Visuospatial working memory (efficiency)	-.46**	-.10	-.05	.40**	-.42**	-.08	-.07	.33**

[a] Point-biserial correlation (r_{pbis}).

* $p < .05$ (two-tailed). ** $p < .01$ (two-tailed).

Table 8. Correlations Between Measures of Web Navigation Performance

	Session 1				Session 2			
Variable	1	2	3	4	5	6	7	8
Session 1								
1. Time per Trial	-							
2. Repeat Pages per Trial	.43**	-						
3. Total Pages per Trial	.35**	.94**	-					
4. Recognition Memory	-.53**	-.17	-.14	-				
Session 2								
5. Time per Trial	.92**	.42**	.35**	-.54**	-			
6. Repeat Pages per Trial	.24	.71**	.70**	-.21	.34**	-		
7. Total Pages per Trial	.24	.68**	.69**	-.23	.34**	.99**	-	
8. Recognition Memory	-.20	-.05	-.03	.36**	-.22	-.09	-.09	-

* $p < .05$ (two-tailed). ** $p < .01$ (two-tailed).

Table 9. Means and Standard Deviations (SD) for Post Navigation Questionnaire

Statement	Young		Old	
	Control (n = 16)	Side-tree (n = 15)	Control (n = 15)	Side-tree (n = 15)
1. The layout of the travel Alberta website is very typical of other travel websites I visit.	3.44 (0.81)	3.47 (0.52)	3.47 (0.83)	3.40 (0.74)
2. The layout of the travel Alberta website is very typical of other websites I visit in general.	3.31 (1.20)	3.67 (0.62)	3.73 (0.88)	3.53 (0.64)
3. The travel Alberta website was easy to ***use***.	4.00 (1.03)	4.40 (0.83)	4.47 (0.52)	4.13 (0.83)
4. The travel Alberta website was easy to ***learn***.	4.06 (0.77)	4.60 (0.51)	4.27 (0.59)	4.47 (0.64)
5. The travel Alberta website is ***organized*** very well.	3.50 (0.97)	4.13 (0.64)	4.27 (0.80)	4.00 (0.85)
6. Relative to other websites I use, the travel Alberta website is ***designed*** very well.	3.38 (0.96)	4.00 (0.53)	3.93 (0.88)	3.80 (0.77)
7. I would use the study's travel website for information about Alberta.	4.13 (0.72)	4.53 (0.52)	4.27 (0.80)	4.27 (0.80)
8. I would recommend the study's travel website to friends/family.	3.81 (0.91)	4.13 (0.83)	4.20 (0.77)	4.13 (0.64)

Table 9. Means and Standard Deviations (SD) for Post Navigation Questionnaire - Continued

Statement	Young		Old	
	Control ($n = 16$)	Side-tree ($n = 15$)	Control ($n = 15$)	Side-tree ($n = 15$)
9. The problems I encountered on the travel website are ***similar*** to problems I encounter on other websites.	3.00 (0.89)	3.20 (1.15)	3.20 (0.86)	3.53 (1.06)
10. On average, the problems I encountered on the travel website are				
a. ***more*** difficult than problems faced on other websites.	2.13 (0.50)	2.40 (0.91)	2.27 (0.59)	2.07 (0.88)
b. ***less*** difficult than problems faced on other websites.	3.50 (0.73)	3.53 (0.64)	3.87 (0.64)	3.73 (0.80)

Correlations Amongst Variables

The intercorrelations among predictors are shown in Table 6. As expected from past research, increased age was associated with less WWW experience (GVU, 1998), decreased memory (Craik and Jennings, 1992), and longer search times (e.g. Fisk & Rogers, 1991; Ho & Scialfa, 2002; Rogers & Fisk, 1991). As found by Laberge and Scialfa (2005), older age was also related to one's knowledge of Alberta. The correlation between Trails B and the time needed to complete the visuospatial working memory task emphasized the common time element of both measures. All the memory tests were moderately correlated which suggested a common memory component.

Table 7 shows the correlations between the predictors and each performance measure. Increased age was associated with longer times per trial and poorer recognition memory. Different correlations were observed between the predictors and each performance measure, with time per trial showing the strongest relationship with the majority of the predictors, suggesting a common speed element in our variables. Visuospatial working memory and search ability both showed a significant relationship with time per trial and recognition. Web format also correlated with recognition, the number of pages per trial, and the number of repeat pages per trial for session two. Interestingly, the correlations between Web Format and these performance measures in session one were not significant. This finding suggests that Web Format benefits from the side-tree were more pronounced in the second web task.

Table 8 shows the correlations between performance measures. High correlations were observed between performance measures at session 1 and the same measure at session 2. Moderate to strong relationship exist between all performance measures with the exception of the correlations between recognition memory and both the number of pages and repeat pages per trial.

Post Navigation Questionnaire

Table 9 shows the means and standard deviations for the post navigation questionnaire. The questionnaire was completed using a 5-point Likert scale (1 = *strongly disagree* to 5 = *strongly agree*). Individuals only rated the web format in which they were given as this was a between-subjects manipulation. An Age x Web Format ANOVA was conducted on each statement to examine any differences that may exist between groups. No age differences were found on any of the survey statements ($ps = .12$). Only one significant effect of Web Format was found for the statement: "The travel Alberta website was easy to learn", $F\,(1, 57) = 5.09$, $p = .03$. This seems to suggest that the side-tree condition (4.53) was easier for one to learn than the control condition (4.16). One significant Age x Web Format interaction was found for the statement: "The travel

Alberta website is organized very well", F (1, 57) = 4.55, p = .04. Young adults appear to believe the side-tree condition (4.13) was better organized than the control (3.50). In contrast, old adults appear to think the control condition (4.27) was better organized than the side-tree condition (4.00). All other main effects of Web Format (ps = .24) and Age x Web Format interactions (ps = .07) were nonsignificant. In general, both young and old had similar agreement about the two web formats.

Response frequencies for each question can be found in Appendix D. The travel website used in the study was fairly typical of travel websites and other website in general (Less than 10% of participants disagreed). Once more, the majority of participants agreed that the travel Alberta website was easy to use, easy to learn, was organized, and was designed very well. Over 91% of participants agreed they would use the website for information about Alberta and over 86% agreed they would recommend it to friends or family members. Approximately 44% agreed that the problems they encountered on the travel website were similar to the problems they encountered on actual websites. Many individuals did not see the problems they faced any more difficult than the problems faced on other websites; whereas, many individuals agreed that the problems were actually less difficult. Thus, although the website appears to generalize well to others, the problems encountered in real-life websites may be greater. Greater real-life difficulties may reflect a larger variability in web design, organization, size, and complexity of actual sites.

DISCUSSION

The current study examined the influence of age and web design on the task of WWW navigation. Overall, age differences were observed in the time taken to find information and the later recognition memory of that information. However, age constancy was seen in other performance measures. Below is a brief summary of our results with respect to our predictions.

Time per trial. As predicted, younger adults took less time to complete a navigation task than older adults (Hypothesis 1a). In general, both the side-tree and control web formats required similar amounts of time to complete a task (Hypothesis 1b) and faster times were observed with practice (Hypothesis 1c). No age difference in the effect of web format was also observed (Hypothesis 1d). Counter to expectations, practice effects were not observed to be greater in either web format (Hypothesis 1e). However, older adults were observed to have greater improvements in speed with practice than their younger counterparts (Hypothesis 1f).

Number of repeat pages visited per trial. As predicted, the number of repeat pages visited was similar for younger and older adults (Hypothesis 2a). In general, the side-tree format did produce fewer repeat pages than the control format; however, against expectations, this difference was nonsignificant (Hypothesis 2b). The number of repeat pages visited was found to diminish with practice (Hypothesis 2c); and, no age difference in the effect of web format was also observed (Hypothesis 2d). Counter to expectations, practice effects were not observed to be greater in either web format (Hypothesis 2e). Finally, the prediction that older and younger adults would show equivalent practice effects on repeat pages visited was supported (Hypothesis 2f).

Total number of pages visited per trial. As predicted, the total number of pages visited was similar for younger and older adults (Hypothesis 3a). In general, the side-tree format did produce fewer total pages than the control format; however, against expectations, this difference was nonsignificant (Hypothesis 3b). The total number of pages visited was found to diminish with practice (Hypothesis 3c); and, no age difference in the effect of web format was also observed (Hypothesis 3d). Counter to expectations, practice effects were not observed to be greater in either web format (Hypothesis 3e). Finally, the prediction that older and younger adults would show equivalent practice effects on the total pages visited was supported (Hypothesis 3f).

Recognition memory. As predicted, younger adults, in general, had better memory than older adults (Hypothesis 5a). Counter to expectations, recognition scores were no better in the side-tree condition than in the control (Hypothesis 5b). In general, recognition memory was observed to improve with practice (Hypothesis 5c). Yet against expectations, no age difference in the effect of web format was also observed (Hypothesis 5d); and, practice effects were not observed to be greater in either web format (Hypothesis 5e). Finally, the prediction that older adults would show greater improvements in recognition with practice than their younger counterparts was not supported (Hypothesis 5f). Surprisingly, a 3-way interaction was observed, whereby older adults improved with practice, but neither web format yielded superior recognition memory over the other. In contrast, younger adults did not significantly improve with practice; but, showed superior improvements in recognition memory while using the control condition (as opposed to the side-tree condition).

Our findings were consistent with other gerontological research on computer usage. For example, Westerman et al., (1995) showed that older adults were slower in retrieving information from a computer database, but observed no age differences in accuracy or efficiency. Our findings also mirrored those of Laberge and Scialfa (2005) and Hudson et al. (2006), wherein age-related differences were observed in the time to locate information on a website, but not in the number of pages or repeat pages visited. Results suggest that older adults might sacrifice their speed to maintain accuracy (but see Mead et al., 1997). An alternate explanation is that older adults are efficient in web navigation; they are simply slower than young adults.

The study was also consistent with cognitive aging research (Craik, 1994; Craik & McDowd, 1987). A rather large age difference was found in recognition memory. While age differences can be small in recognition memory, the magnitude of the age deficit depends on task difficulty. In the present study, the similarity of targets and distractors in the multiple-choice options made the task quite difficult. In order to correctly answer a question, participants needed a strong episodic recollection of the answer and could not simply eliminate the distractors by chance or intuition. In light of the task difficulty, it was not surprising that age differences were observed.

With respect to practice, both young and old have shown to benefit from practice in a variety of tasks (e.g., Dixon et al., 1993; Ho & Scialfa, 2002; Krampe & Ericsson, 1996; Rogers et al., 2000) including computer based tasks (e.g., Czaja, 2001). Our study demonstrated that practice led to improvements in all examined aspects of performance. An Age x Practice interaction for time per trial was also observed whereby older adults demonstrated greater improvements than their younger counterparts; however, the age differences in speed of navigation still persisted. In fact, age differences persisted on all measures of performance. The only exception to this general trend was for the number of repeat and total pages visited per trial in which age deficits were never observed. The lack of such age-related performance deficits is consistent with past research (Hudson et al., 2006; Laberge & Scialfa, 2005). Our results suggest that people at various ages can benefit from practice using the WWW. In general, practice improvements in web navigation are not specific to any particular age.

In addition, our study was, to a small degree, consistent with that of Hudson et al. (2006). Results from both studies demonstrated some benefit to a web design with navigation aids like the side-tree; however, unlike Hudson et al., the benefits observed by the current study were nonsignificant. Although this may contradict the notion that side-trees are an effective navigational aid, it is important to look at the differences in the two methodologies. Namely, the navigation trials in Hudson et al. were given to participants in a semi-random order:

> Questions were divided into blocks based on which of the main start categories the answer could be found in (e.g. 'Attractions' is the start category to find the hours of operation for the Aerospace Museum of Calgary). Trials within the blocks were then randomized as well as the order of the blocks themselves. . . . With questions grouped into blocks, participants that used these navigation tools could traverse between pages in fewer clicks (Hudson et al., 2006, p. 16)

If questions were grouped into related blocks, users could use the end page of the previous question as a better starting point (than, say, the home page) for the succeeding question. And, with the use of navigational aids, users could take greater advantage of this starting point. In contrast, questions not grouped into related categories would not necessarily provide a better starting point for the succeeding question. In the present study, randomized questions were not grouped into blocks. Thus, less navigational benefit could arise from the use of the side-tree.

We believe that people often search the WWW in a semi-random fashion. As people search for information and perform tasks on the WWW, their tasks are frequently grouped together and are often part of a line of questioning. For example, if you wished to plan a visit to Banff, you might want to know what kinds of attractions are available, their location, hours of operation, admission costs, and so on. Therefore, the randomization of questions in the current study is methodologically sound but may not match navigation behaviours in the real world.

Combining results from both studies suggest the performance benefits from navigation aids depend largely on the web task(s) at hand and the order in which they are completed. If tasks are done in a disorderly fashion, benefits from side-trees are minimal. But, if they are performed in some organized fashion, benefits from side-trees can be greater. That is, the potential benefit from having side-trees as part of a website's design are closely linked to the user's goals. Further research should examine the relationship between side-tree performance benefits and the influence of question order.

As one of the main goals of the current study was to examine the informational learning that may be influenced by factors such as age and web design, it is important to re-address the results found in the significant three-way interaction observed for recognition memory. For older adults, recognition memory appeared to improve with practice; yet, for young adults improvements were nonsignificant. This suggests that young adults are near asymptotic performance levels while older adults are not. Again, for older individuals, there was no significant Web Format effect or Web Format x Practice interaction associated with recognition. In contrast, the recognition scores of young adults appeared to be influenced by the web condition to which they were exposed. Surprisingly, young adults using the side-tree condition had poorer recognition than those in the control. Interestingly, these results run counter to our hypothesis that freeing working memory (via the web format manipulation) would improve memory. And so, we speculate that for young adults, the lightening of working memory demands and cognitive load in general has perhaps led to less task engagement. Loss of situational awareness and other out-of-the-loop performance problems have been documented in areas such as automation (e.g., Kaber, 1997).

Another intriguing finding was the relationship between recognition memory and time per trial. In the first session, a strong relationship existed whereby longer times corresponded to poorer recognition memory; yet, in the second session this relationship disappeared (refer to Table 8). One explanation is that as participants increased their familiarity with the Alberta website, individuals improved their speed of navigation in session 2; and in doing so, the web tasks became less cognitively demanding. As a result, cognitive demands may have been 'freed up', but were not reallocated towards improved recognition memory. As web tasks become easier, it may be the case that people are disinclined to exert as much energy. Alternatively, it could be theorized that resource reallocation may not be as interchangeable from one cognitive system to another. Although this notion is highly speculative, we feel that further research and exploration is justified.

The correlations between Web Format and some of the performance measures in session one were nonsignificant (recognition memory, the number of repeat, and total pages visited). In contrast, the correlations between performance and Web Format were significant in session two (refer to Table 7). Therefore, it appears that once users are more familiar with the layout of the website, they can use the side-tree and benefit greatly from it. It is true that no significant Web Format x Practice interactions were observed on any of the performance measures (*ps* = .15). However, exploratory analyses of a Age x Web Format ANOVA for session two performance variables reveal a significant effect of Web Format for both the number of pages visited, $F(1, 57) = 4.31$, $p = .04$; $\eta_p^2 = .07$, the number of repeat pages visited, $F(1, 57) = 5.50$, $p = .02$; $\eta_p^2 = .09$, and recognition memory, $F(1, 57) = 5.88$, $p = .02$; $\eta_p^2 = .09$. The side-tree condition seemed to yield more efficient navigational performance whereas the control condition seemed to yield better recognition memory. Thus, an emerging pattern marginally supports the belief that side-trees can yield better performance; yet, they do not necessarily yield better memory. Moreover, the effects were superseded by a significant Age x Web Format interaction for recognition memory, $F(1, 57) = 5.03$, $p = .03$; $\eta_p^2 = .08$; whereas a marginally significant interaction was observed for repeat pages, $F(1, 57) = 3.66$, $p = .06$; $\eta_p^2 = .06$. In contrast, these effects and interactions were not significant on performance measures in session one ($ps = .14$). In light of these results, it appears that Web Format benefits may be more pronounced in the second session. Indeed, further examination is warranted regarding such speculations.

Navigation Tool Usage

Individuals who worked in the control condition used the back button and inpage links significantly more often than those in the side-tree condition. In contrast, individuals in the side-tree condition relied on the use of the menu more often. These findings were consistent with those of Hudson et al. (2006). Although significant performance advantages were not seen in the side-tree condition, navigation aids do appear to influence general navigation behaviours, and to a small extent, some of the performance associated with these changes in behaviours. The side-tree menu was utilized over 50% of the time compared to the control menu which was used roughly 26% of the time for navigation. Therefore, if navigation aids like side-trees are incorporated into a design, they will certainly be put to good use.

As mentioned, older adults were found to use the navigation menu more often than their younger counterparts. This finding suggests that older adults rely more on the menu to assist in navigation, perhaps because it provides greater environmental support during navigation. In contrast, young adults do not necessarily rely on environmental support to the same degree that old adults do. The side-tree condition is believed to provide a greater amount of environmental support than the control condition as it provides more information about the website's structure and a greater number of links for an individual to utilize during navigation. With greater environmental support, it is believed that less self-initiated and effortful processing is necessary. Less reliance on self-initiated processing would be of particular benefit to older adults that commonly have age-related memory problems.

Implications

The current study contributes to a variety of research domains. Knowledge from the psychology of aging and cognition have been broadened from a basic to a more applied setting. Ideas such as Craik's concept of environmental support (Craik, 1983, 1994) have been examined in a realistic web navigation task. Although side-trees may provide greater environmental support than the control condition, no clear performance benefits were observed. Therefore, if navigation aids are to improve web performance through environmental support, significantly greater amounts of support are required.

Alternatively, certain web tasks benefit more from navigation aids than others. When similar tasks are group together, or with particular kinds of tasks, performance benefits associated with dynamic side-trees may be larger than in other web task situations.

Side-trees may offer greater environmental support and as a result, may bring about less cognitive load. Yet, this does not necessarily transfer the available resources from the lightened navigational subtask to the informational subtask. Users may simply find the task less taxing. In the current study there is some support to this claim. Namely, the post-navigation questionnaire generally had similar agreement with regards to the two web formats; yet, individuals with the side-tree condition gave significantly higher agreement ratings in terms of how easy the website was to learn compared to individuals rating the control condition (see Table 9, statement #4). Thus, the side-tree condition may very well be less taxing; however, the extent to which it is easier than the control condition is open to debate.

Another optimistic implication is that practice-related improvements are not age-dependant. With the exception of time per trail, young and old adults appear to improve at similar rates. Web developers can expect young and old users to improve at comparable rates despite numerous declines related to aging. This claim comes with some qualifiers. For instance, not all websites are organized in a hierarchical manner like the one used in the present study. Thus the learning curve of some websites may or may not be age-dependant. Furthermore, the group of older adults was a fairly experienced and healthy sample. Thus, different web organizations and more heterogeneous groups of older individuals may have smaller practice improvements than their younger cohorts. Conversely, a more heterogeneous sample of older adults may improve much faster because the greatest performance improvements typically occur early in training. Certainly, future research pertaining to aging and web use should incorporate a more diverse and thereby representative sample of older adults.

Limitations

One drawback form the present study is the unfortunate elimination of the recall analysis. The recall measure would not have portrayed an accurate representation of episodic memory as a large number of questions could have also been answered based on semantic knowledge. Indeed, future research is warranted in this area as memory recall is of great interest to both gerontological and educational fields of research. Future endeavours should be designed meticulously to accurately measure this particular aspect of memory.

Due to time constraints of the experiment, memory for the website's organizational structure was not measured. Indeed, the relationship between memory for the website's organization and its informational content is an important consideration. Specifically, working memory has been shown to predict navigation performance (Hudson et al., 2006; Laberge & Scialfa, 2005) and if working memory is a global, undifferentiated ability, then a positive correlation should exist between memory for structure and memory for content. Once more, a manipulation of web design that compromises working memory can thereby cause deterioration in both content and site memory. Ambitious efforts that examine this relationship will help build a theoretical model of web navigation.

It is important to make the distinction between content memory (as in recognition) and the comprehension of that content. As already discussed, the current study found age differences in the former, but did not examine the later. It is possible that age may also effect how easily one can comprehend the content of the website. If so, it can be assumed that working memory and other cognitive factors play a contributing role. Therefore, it may be the case that navigation aids can also help ease of comprehension by reducing such cognitive demands. Studies in the future should examine the relationship between content memory and comprehension as well as the influence of age and cognitive factors on them.

It is also important to remember that the results were obtained in relatively homogeneous, healthy, web experienced, and high functioning groups of young and old individuals. Presumably, age differences found in performance would be greater in more heterogeneous samples. It is also conceivable that with more naïve users, web format effects would be much larger. Therefore, it is important for future research to test more diverse groups of people to not only verify these greater differences in performance, but to also assess the extent of web usability across less healthy, less web experienced, and lower functioning adults. That is, future research should examine the extent to which interface designs can support and accommodate more heterogeneous groups of individuals.

Finally, it is crucial to keep in mind that websites on the WWW come in a wide variety of designs and styles. Although participants found the site to be very typical of travel and other websites in general, the problems they faced were either similar or less difficult than those they would encounter on actual websites (see Appendix D). Again, this may reflect the greater range in site design, organization, size, and complexity out on the WWW. Indeed, the study's website does not represent all the web styles commonly employed on the WWW, nor does it reflect the full design of many actual sites. It does, however, reflect a hierarchical web design which is common to a large number of web users. Future investigations should examine a wider variety of web designs and styles to tease out the characteristics of an effective and efficient website.

Future Directions

There is a great deal of research to be done in the area of aging and web navigation. Other measures such as user satisfaction and perceived level of disorientation should also be considered. Future research can explore such variables using qualitative approaches like usability testing, surveys, and focus groups. As mentioned, the current study examined groups of fairly knowledgeable users, both to the Alberta domain and the WWW. Future work should also examine naïve users that are less knowledgeable about the domain and less experienced with the medium. It is possible that naïve users show larger benefits from navigation aids than their more advanced counterparts. Once more, individuals with cognitive impairments like deficits in memory may also show greater benefits from navigation aids. Such cognitive declines are common to older populations. Thus, by extending the current study to more diverse groups we can further our understanding of web design and ameliorate navigation performance.

Conclusions

The present study showed that increased age was associated with slower times to search the web, but not with problems in the number of total or repeat pages visited. Increased age was also associated with poorer recognition memory for the website content. Dynamic side-trees show very small evidence that they limit disorientation by reducing the number of total and repeat pages visited. More research is needed to understand the characteristics of older adults that interact with various aspects of design and the tasks commonly completed on the WWW.

Future endeavors should investigate how design modifications can reduce cognitive demands. The relationship between content comprehension and the memorization of content should be further explored. In addition, the interaction between memory for the website's structure and web content should also be examined. By studying the relationships between various cognitive aspects involved during web navigation, future studies can help ameliorate WWW usage.

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Appendix A

Name of Researcher, Faculty, Department, Telephone & Email:
Carl Hudson, Faculty of Graduate Studies, Department of Psychology, 220-4951, cehudson@ucalgary.ca
Supervisor:
Charles Scialfa, Department of Psychology
Title of Project:
Memory and Practice as Predictor of Web Navigation Performance
Sponsor:
Natural Sciences and Engineering Research Council of Canada (NSERC)

This consent form, a copy of which has been given to you, is only part of the process of informed consent. If you want more details about something mentioned here, or information not included here, you should feel free to ask. Please take the time to read this carefully and to understand any accompanying information.
The University of Calgary Conjoint Faculties Research Ethics Board has approved this research study.

Purpose of the Study:
The present study examines the factors that influence web navigation performance. Specifically, this study wishes to determine which navigation tools are the most effective in improving web navigation and facilitating better learning of page content.

What Will I Be Asked To Do?
Participants are asked to complete several tasks including a web experience and medical questionnaire, tests of vision, memory and search ability. On the questionnaire, you will be asked to give information regarding your age, education, medical/visual health history, computer experience, and history of travel/living in Alberta. Participants are also asked to complete several web navigation tasks. This requires navigating a website to find information needed to answer questions. Finally, participants will be asked to complete a quiz (e.g. short-answer and multiple-choice questions) about the information sought during the previous web task. Because you will be seated in front of a computer for many of the tasks, we encourage you to rest frequently to avoid any strain on your eyes or body. The study will consist of two similar sessions each with a web task followed by a related quiz. The duration of each session is approximately 120 minutes (4 hours for the entire study). Participation is voluntary and you may withdraw from the study at any time without penalty or loss of benefits to which you are otherwise entitled.

What Type of Personal Information Will Be Collected?
No personal identifying information will be collected in this study, and all participants shall remain anonymous. Should you agree to participate, you will be asked to provide your gender, age, years of education, experience living in Alberta, computer experience/attitudes, general health and medical information. Medical questions will help determine your eligibility to our study. For instance, if you had surgery for a major condition/illness (e.g., heart attack) or are being treated for a serious condition/illness (e.g., cataract); you will not be able to participate in this particular study. As well, people who are taking any medication that disrupts their concentration, memory or movements will not be eligible.

Appendix A – Continued

Are there Risks or Benefits if I Participate?
There are no reasonably foreseeable risks, harms, or inconveniences to you. You will be paid $10 per hour (Canadian) for you participation regardless of whether or not you complete the study.

What Happens to the Information I Provide?
Participation is completely voluntary, anonymous and confidential. You are free to discontinue participation at any time during the study. Should you choose to withdraw partway through the study; data collected up to the point of withdrawal will still be retained and may be used for analysis. No one except the researcher and his supervisor will be allowed access to your performance on the tasks or the answers to the questionnaire. There are no names on the questionnaire. Your information provided may contribute to group data in presenting the findings. Only group information will be summarized for any presentation or publication of results. Please note that your unique information will not be presented and will always remain anonymous. The questionnaires are kept in a locked cabinet only accessible by the researcher and supervisor. The anonymous data will be stored for five years on a computer disk, at which time, it will be permanently erased.

Signatures (written consent)
Your signature on this form indicates that you 1) understand to your satisfaction the information provided to you about your participation in this research project, and 2) agree to participate as a research subject.
In no way does this waive your legal rights nor release the investigators, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw from this research project at any time. You should feel free to ask for clarification or new information throughout your participation.
Participant's Name: (please print) ____

Participant's Signature ____Date: ______________

Researcher's Name: (please print) ____

Researcher's Signature ____Date: ______________

Questions/Concerns
If you have any further questions or want clarification regarding this research and/or your participation, please contact:

Mr. Carl Hudson cehudson@ucalgary.ca
Department of Psychology, University of Calgary
Phone: (403) 220-4951, Fax: (403) 282-8249.

Dr. Charles Scialfa scialfa@ucalgary.ca
Department of Psychology, University of Calgary
Phone: (403) 220-4951, Fax: (403) 282-8249.

If you have any concerns about the way you've been treated as a participant, please contact Bonnie Scherrer, Research Services Office, University of Calgary at (403) 220-3782; email bonnie.scherrer@ucalgary.ca.
A copy of this consent form has been given to you to keep for your records and reference. The investigator has kept a copy of the consent form.

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Appendix B

Perceptual and Cognitive Aging Laboratory
Department of Psychology

Background Questionnaire

Part I. Demographic Information

1. Are you? ☐ Male ☐ Female
2. Age:___________ years
3. Number of years of education: High school: ____________ years
   Post-Secondary: ____________ years
4. Is English your first language? Yes ☐ No ☐
   If no, what is your first language?________________________
5. How many years have you been living in Alberta?___________
6. How many days of the year do you travel in Alberta?_________
7. How many different Alberta cities/towns have you lived in?_________
8. How many different events (i.e. Klondike Days, Ponoka Stampede, Canadian Finals Rodeo, etc.) do you attend per year in Alberta?________
9. How many different Alberta cities/towns have you visited?__________

Part II. Computer Experience and Attitudes

10. How many years have you been using a computer? ______ years
11. How many hours per week do you spend using a computer? ______ hours per week
12. How many hours per week do you spend using email? _______ hours per week
13. How many years have you been using (browsing, shopping, banking, etc.) the World Wide Web? ______ years
14. How many hours per week do you spend using the World Wide Web? ______ hours per week

15. Have you ever developed or created a website?

Yes ☐ No ☐

If yes, how many websites have you developed?______

16. How many different websites do you visit each week?________

17. What is your primary computing platform? Please check one.

- ☐ DOS
- ☐ Windows
- ☐ Macintosh
- ☐ WebTV
- ☐ Unix
- ☐ Don't Know
- ☐ Other:______________________

18. Which web browser do you primarily use? Please check one.

- ☐ Internet Explorer (Microsoft)
- ☐ Netscape Navigator
- ☐ Lynx
- ☐ Mozilla
- ☐ Other:____

Part III. Medical Information

19. Have you been hospitalized during the past year for a serious medical condition or illness (for example depression, Parkinson's disease, etc.)?

☐ Yes No ☐

If yes, please explain____

____

____

Appendix B – Continued

20. Are you currently under a doctor's care for a serious medical illness or condition (for example, stroke, pneumonia, bypass surgery, etc.)?

☐ Yes No ☐

If yes, please explain____

____

____

21. Are you regularly taking any prescribed medications?

☐ Yes No ☐

If yes, please provide a name and indicate what the medication is used for:

Name of Medication	Purpose

22. If you are regularly taking any prescribed medications, have you noticed any of the following side effects (check all that apply)?

☐ Drowsiness
☐ Dizziness/Disorientation
☐ Memory problems
☐ Aches/Pains
☐ Uncontrolled movements
☐ Speech problems
☐ Vision problems
☐ Mood problems
☐ Attention problems
☐ Other:____________________
☐ Other:____________________
☐ Other:____________________

23. Please rate your physical health on a scale from 1 to 5 (circle one).

1	2	3	4	5
Very Poor	Poor	Average	Good	Excellent

Part IV. Visual Information

24. Are you currently being treated by an eye-care doctor for vision or eye problems?

Yes ☐ No ☐

If you are being treated by an eye-care doctor, please indicate the eye problem(s) being treated (check all that apply):

- ☐ Cataract
- ☐ Glaucoma
- ☐ Detached retina
- ☐ Age-related Macular Degeneration
- ☐ Other:__________________
- ☐ Other:__________________
- ☐ Other:__________________
- ☐ Other:__________________

25. Date of last eye exam (mm/dd/yy)____________________________

26. Do you use glasses (or contact lenses) for distance? Yes ☐ No ☐

27. Do you use glasses (or contact lenses) for reading? Yes ☐ No ☐

28. Do you use bifocals or other variable focus lenses? Yes ☐ No ☐

Thank you for filling out this questionnaire!

Appendix C

Quiz A

What is the toll-free phone number of the Calgary Marriott Hotel?

A. 1-888-896-6878
B. 1-800-866-9878
C. 1-800-896-6878
D. 1-888-866-9878

Who maintains and operates the Oil Sands Discovery Centre in Fort McMurray?

A. Bill Wallace
B. Government of Alberta
C. Fort McMurray Historical Society
D. Kananaskis Camping Inc.

What months of the year is the Protection Mountain Campsite open?

A. September - December
B. Year Round
C. July - August
D. April - August

In what town/city is the Midtowner Motel located?

A. Fairview
B. Grand Prairie
C. Lethbridge
D. Medicine Hat

What is the address to the Caledonia Restaurant & Grill in Jasper?

A. Whistlers Inn, 600 Connaught Dr
B. Whistlers Inn, 800 Connaught Dr
C. Whistlers Inn, 600 Cougar Dr
D. Whistlers Inn, 800 Cougar Dr

How much is it to camp at the Rosebud Valley Campground near Didsbury?

A. Free
B. $23.00
C. $9.00
D. $13.00

What year was Edmonton's Devonian Botanic Garden first established?

A. 1967
B. 1959
C. 1957
D. 1969

What year was the Sidetrack Café & Bar (a venue for live music in Edmonton) first established?

A. 1977
B. 1961
C. 1981
D. 1947

Appendix C - Continued

What days of the year does the Canmore International Ice Climbing Festival occur?

A. January 3 - 5
B. February 22 - 24
C. February 3 - 5
D. January 22 - 24

What is the senior cost of admission for the Calgary Tower?

A. Free
B. $5.00
C. $10.00
D. $15.00

What is the price range for a single room at the Delta Bow Valley Hotel?

A. $129 - 200
B. $169 - 245
C. $129 - 245
D. $129 - 169

What are the current hours of operation for the Alberta Sports Hall of Fame in Red Deer?

A. 9:00 am - 4:00 pm
B. 10:00 am - 5:00 pm
C. 10:00 am - 4:00 pm
D. 9:00 am - 5:00 pm

What is the cost of a single occupancy at the Badlands Motel?

A. $50
B. $60
C. $70
D. $80

What is the estimated travel time to the Banff Caribou Lodge (Hotel) from Calgary?

A. 1 hour, 00 minutes
B. 1 hour, 47 minutes
C. 1 hour, 27 minutes
D. 1 hour, 17 minutes

In what historic building is Murrieta's Bar & Grill (a popular venue for live music in Calgary) located?

A. Alberta Hotel
B. Canadian Pacific Railway Hotel
C. Hudson's Bay Trading Post
D. Canadian Imperial Bank of Commerce

What time does the daily lunch buffet start & end at the Jewel of Kashmir Indian Restaurant in Edmonton?

A. Noon - 2:00 pm
B. Noon - 3:00 pm
C. 11:00 am - 2:00 pm
D. 11:00 am - 3:00 pm

What are the camping fees for Cypress Hills Provincial Park?

A. $19.00 - $32.00
B. $9.00 - $32.00
C. $9.00 - $22.00
D. $19.00 - $22.00

Appendix C - Continued

What is the phone number to Ceili's Irish Pub in Calgary?

- **A.**403 508-9999
- **B.**403 805-9999
- **C.**403 508-7777
- **D.**403 805-7777

Where in Edmonton is the Canadian Finals Rodeo held?

- **A.**Edworthy Park
- **B.**Winston Park
- **C.**Southlands Park
- **D.**Northlands Park

What night is "wing-night" at Black Dog Pub in Edmonton?

- **A.**Wednesday
- **B.**Tuesday
- **C.**Monday
- **D.**Sunday

How many square kilometers is Calgary?

- **A.**670
- **B.**721
- **C.**707
- **D.**717

When was Red Deer originally settled?

- **A.**1852
- **B.**1882
- **C.**1876
- **D.**1846

What type of live music is at the Tapas Bar in Canmore?

- **A.**Country Western
- **B.**Classical Guitar
- **C.**Blues
- **D.**Spanish Guitar

What does the city name "Airdrie" mean?

- **A.**King's Height
- **B.**Knight's Head
- **C.**King's Head
- **D.**Knight's Height

What is the phone number to the Broken Plate Greek Restaurant in Calgary?

- **A.**403 236-8300
- **B.**403 283-6300
- **C.**403 263-8300
- **D.**403 238-6300

How many campsites does the Athabasca Rivers Edge Campground have?

- **A.**25
- **B.**35
- **C.**30
- **D.**20

Appendix C - Continued

Who operates the Peter Lougheed Provincial Park?

A. Government of Alberta
B. Fort McMurray Historical Society
C. Kananaskis Camping Inc.
D. Bill Wallace

How many kilometers is Elk Island National Park from Edmonton?

A. 130 km
B. 120 km
C. 100 km
D. 110 km

What day is El Sombrero Mexican Restaurant closed in Calgary?

What year did the Frank Slide (rockslide-avalanche) occur?

What is the cost of admission to the Banff Natural History Museum?

How many square kilometers is Lethbridge?

The Miette Hot Springs construction project in the 1930s was designed for what purpose?

What 2 things are required to dine at La Chaumiere French Restaurant in Calgary?

What is the distance from Edmonton to Jasper National Park?

What days in the summer is the Fringe Theater Festival held in Edmonton?

When are "happy-hour" drink specials at the Whistle Stop Pub in Jasper?

In what city is the Cat's Meow B&B located?

What is the address to Fausto's Italian Restaurant in Edmonton?

What days of the year does the Calgary International Jazz Festival occur?

----- END -----

Quiz B

How many kilometers is Wood Buffalo National Park from Fort McMurray?

A.568 km
B.528 km
C.548 km
D.508 km

How many campsites does the Grande Prairie Rotary Park Campground have?

A.54
B.49
C.59
D.64

What is the phone number to the Pegasus Greek Restaurant in Calgary?

A.403-229-1231
B.403-229-5205
C.403-579-1231
D.403-579-5205

What is the price range for a single room at the Bayshore Inn Hotel?

A.Single $ 95 - 135
B.Single $ 135 - 225
C.Single $ 175 - 225
D.Single $ 115 - 175

What months of the year is the Tunnel Mountain Village Campsite open?

A.Open: June 1 - Aug. 30
B.Open: Year Round
C.Open: May 1 - Sept. 30
D.Open: Apr. 1 - Sept. 30

What are the camping fees for Aspen Beach Provincial Park?

A.$17.00 to $33.00 per night
B.$7.00 to $23.00 per night
C.$7.00 to $33.00 per night
D.$17.00 to $23.00 per night

What is the estimated travel time to the Amethyst Lodge (Hotel) from Calgary?

A.3 hours, 49 minutes
B.4 hours, 29 minutes
C.5 hours, 29 minutes
D.4 hours, 49 minutes

What are the current hours of operation for the Fort Normandeau Historic Site in Red Deer?

A.Noon - 5:00 pm
B.10:00 am - 4:00 pm
C.10:00 am - 5:00 pm
D.Noon - 4:00 pm

Appendix C - Continued

What is the name of the Café which the Beat Niq Jazz & Social Club/Bar (in Calgary) is located under?

- **A.** Brass Café
- **B.** Sax Café
- **C.** Piq Niq Café
- **D.** Jazz Café

What is the phone number to the Cat 'n Fiddle Pub in Calgary?

- **A.** 403-867-2901
- **B.** 403-289-0414
- **C.** 403-867-0414
- **D.** 403-289-2901

Who maintains and operates the Heritage Park in Fort McMurray?

- **A.** Fort McMurray Historical Society
- **B.** Bill Wallace
- **C.** Government of Alberta
- **D.** Kananaskis Camping Inc.

What is the cost of a single occupancy at the Park Avenue Motel?

- **A.** Single $ 53
- **B.** Single $ 83
- **C.** Single $ 73
- **D.** Single $ 63

Who operates the Red Lodge Provincial Park?

- **A.** Fort McMurray Historical Society
- **B.** Bill Wallace
- **C.** Government of Alberta
- **D.** Kananaskis Camping Inc.

When does the daily lunch buffet start & end at the Haweli Indian Restaurant in Edmonton?

- **A.** 10:00 am - 2:00 pm
- **B.** 10:00 am - 3:00 pm
- **C.** 11:00 am - 3:00 pm
- **D.** 11:00 am - 1:00 pm

What is the address of the Jack Pine Restaurant in Banff?

- **A.** Lynxridge Lodge, 378 Wolf Ave
- **B.** Rundlestone Lodge, 537 Banff Ave
- **C.** Lynxridge Lodge, 416 Bear Ave
- **D.** Rundlestone Lodge, 245 Moose Ave

In what town/city is Michael's Motel located?

- **A.** Medicine Hat
- **B.** Calgary
- **C.** Lethbridge
- **D.** Canmore

When did Grand Prairie become a city?

- **A.** 1962
- **B.** 1942
- **C.** 1938
- **D.** 1958

Appendix C - Continued

What days of the year does the "Ice Magic" - Annual Ice Sculpture Competition & Exhibition occur?

- **A.** February 4 - 6
- **B.** January 18 - 20
- **C.** December 18 - 20
- **D.** January 4 - 6

What is the Blackfoot translation for the city name "Medicine Hat"?

- **A.** Ponoká
- **B.** Mamíí
- **C.** Omitaa
- **D.** Saamis

Where in Edmonton is the Symphony Under the Sky Festival held?

- **A.** Hawrelak Park Heritage Amphitheatre
- **B.** Eliston Park Amphitheatre
- **C.** Fort Edmonton Park Amphitheatre
- **D.** Heritage Park Amphitheatre

What is the senior cost of admission for the Calgary Science Centre?

- **A.** Senior (65+): $ 3.00
- **B.** Senior (65+): $ 7.00
- **C.** Senior (65+): $ 13.00
- **D.** Senior (65+): $ 17.00

How many square kilometers is Edmonton?

- **A.** 840 square km
- **B.** 970 square km
- **C.** 670 square km
- **D.** 740 square km

What year was the Alberta Railway Museum in Edmonton first opened?

- **A.** 1981
- **B.** 1971
- **C.** 1976
- **D.** 1986

What night is "wing-night" at Hudson's Canadian Taphouse in Edmonton?

- **A.** Wednesday
- **B.** Monday
- **C.** Sunday
- **D.** Tuesday

What is the toll-free phone number of the Argyll Plaza Hotel?

- **A.** 1-800-737-6878
- **B.** 1-800-866-3783
- **C.** 1-800-896-6878
- **D.** 1-800-737-3783

What type of live music is at the French Quarter Café & Bar in Canmore?

- **A.** Jazz
- **B.** Classical
- **C.** Country Western
- **D.** Jive/Swing

Appendix C - Continued

What year was the Uptown Folk Club & Bar (a venue for live music in Edmonton) first established?

- **A.** 1987
- **B.** 1977
- **C.** 1965
- **D.** 1995

How much is it to camp at the Fairfax Lake Campground near Hinton?

- **A.** Free
- **B.** 15
- **C.** 10
- **D.** 5

In what city is Eleanor's House B&B located?

What is the cost of admission to the Environmental Training Centre in Hinton?

How many square kilometers is Fort McMurray?

What year was the Head-Smashed-In Buffalo Jump designated as a UNESCO World Heritage Site?

What is the distance from Lethbridge to Waterton/Glacier National Park?

What is one of the "most popular" signature dishes at Le Resto-Bar Élisabelle in Calgary?

What day is Juan's Mexican Restaurant closed in Calgary?

What days of the year does the Edmonton International Street Performers Festival occur?

When are "happy-hour" drink specials at the Rose & Crown Pub in Banff?

What days in the summer is Afrikadey held in Calgary?

The Canmore Nordic Centre was originally developed for what purpose?

What is the address to the Sicilian Pasta Kitchen (an Italian Restaurant in Edmonton)?

------ END ------

Appendix D

Perceptual and Cognitive Aging Laboratory

Department of Psychology

Post Navigation Questionnaire

Instructions: For each of the statements below, please indicate the extent of your agreement or disagreement by circling the appropriate selection.

1. The layout of the travel Alberta website is very typical of other ***travel*** websites I visit.

0.0%	9.8%	39.3%	47.5%	3.3%
Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree

2. The layout of the travel Alberta website is very typical of other websites I visit ***in general.***

3.3%	8.2%	24.6%	57.4%	6.6%
Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree

3. The travel Alberta website was easy to ***use.***

0.0%	6.6%	4.9%	6.6%	42.6%
Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree

4. The travel Alberta website was easy to ***learn.***

0.0%	1.6%	4.9%	50.8%	42.6%
Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree

5. The travel Alberta website is ***organized*** very well.

1.6%	4.9%	13.1%	55.7%	24.6%
Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree

Appendix D – Continued

6. Relative to other websites I use, the travel Alberta website is ***designed*** very well.

1.6%	4.9%	23.0%	55.7%	14.8%
Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree

7. I would use the study's travel website for information about Alberta.

0.0%	3.3%	4.9%	50.8%	41.0%
Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree

8. I would recommend the study's travel website to friends/family.

1.6%	3.3%	8.2%	60.7%	26.2%
Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree

9. The problems I encountered on the travel website are ***similar*** to problems I encounter on other websites.

4.9%	18.0%	32.8%	37.7%	6.6%
Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree

10. a) On average, the problems I encountered on the travel website are ***more*** difficult than problems faced on other websites.

11.5%	60.7%	24.6%	1.6%	1.6%
Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree

b) On average, the problems I encountered on the travel website are ***less*** difficult than problems faced on other websites.

0.0%	6.6%	27.9%	59.0%	6.6%
Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly Agree

Appendix E

UNIVERSITY OF CALGARY

MEMO

CONJOINT FACULTIES RESEARCH ETHICS BOARD
c/o Research Services
Main Floor, Energy Resources Research Building
3512 - 33 Street N.W., Calgary, Alberta T2L 1Y7
Telephone: (403) 220-3782
Fax: (403) 289 0693
Email: bonnie.scherrer@ucalgary.ca
Monday, April 03, 2006

To: Carl E. Hudson
Psychology

From: Dr. Janice P. Dickin, Chair
Conjoint Faculties Research Ethics Board (CFREB)

***Re:* Certification of Institutional Ethics Review:** Memory and Practice as a Predictor of Web Navigation Performance

The above named research protocol has been granted ethical approval by the Conjoint Faculties Research Ethics Board for the University of Calgary.

Enclosed are the original, and one copy, of a signed **Certification of Institutional Ethics Review**. Please make note of the conditions stated on the Certification. A copy has been sent to your supervisor as well as to the Chair of your Department/Faculty Research Ethics Committee. In the event the research is funded, you should notify the sponsor of the research and provide them with a copy for their records. The Conjoint Faculties Research Ethics Board will retain a copy of the clearance on your file.

Please note, an annual/progress/final report must be filed with the CFREB twelve months from the date on your ethics clearance. A form for this purpose has been created, and may be found on the "Ethics" website, http://www.ucalgary.ca/UofC/research/html/ethics/reports.html

In closing let me take this opportunity to wish you the best of luck in your research endeavor.

Sincerely,

B Scherrer.

Bonnie Scherrer
For:
Janice Dickin, Ph.D., LLB., Faculty of Communication and Culture and
Chair, Conjoint Faculties Research Ethics Board

Enclosures(2)
cc: Chair, Department/Faculty Research Ethics Committee
Supervisor: Charles T. Scialfa

Appendix E – Continued

UNIVERSITY OF CALGARY
Celebrate 40 years 2006

CERTIFICATION OF INSTITUTIONAL ETHICS REVIEW

This is to certify that the Conjoint Faculties Research Ethics Board at the University of Calgary has examined the following research proposal and found the proposed research involving human subjects to be in accordance with University of Calgary Guidelines and the Tri-Council Policy Statement on *"Ethical Conduct in Research Using Human Subjects"*. This form and accompanying letter constitute the Certification of Institutional Ethics Review.

File no:	**4766**
Applicant(s):	**Carl E. Hudson**
Department:	**Psychology**
Project Title:	**Memory and Practice as a Predictor of Web Navigation Performance**
Sponsor (if applicable):	

Restrictions:

This Certification is subject to the following conditions:

1. Approval is granted only for the project and purposes described in the application.
2. Any modifications to the authorized protocol must be submitted to the Chair, Conjoint Faculties Research Ethics Board for approval.
3. A progress report must be submitted 12 months from the date of this Certification, and should provide the expected completion date for the project.
4. Written notification must be sent to the Board when the project is complete or terminated.

Janice Dickin

Janice Dickin, Ph.D, LLB,
Chair
Conjoint Faculties Research Ethics Board

Date: 30 March 2006

Distribution: (1) Applicant, (2) Supervisor (if applicable), (3) Chair, Department/Faculty Research Ethics Committee, (4) Sponsor, (5) Conjoint Faculties Research Ethics Board (6) Research Services.

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