THE IMPACT OF AGE ON WEB SITE USABILITY

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By

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ABSTRACT

As older adults increasingly make use of the Internet to enhance their personal and professional lives, the study of web site usability for older adults is becoming increasingly relevant. Web site usability is concerned with both utilitarian (i.e. functional) and hedonic (i.e. pleasure-related) aspects. This study explores the impact of age on select utilitarian (mental model accuracy and performance) and hedonic (disorientation and engagement) measures of web site usability, and the subsequent impact of these utilitarian and hedonic measures on user satisfaction. A laboratory experiment was conducted where 50 younger and 51 older participants interacted with an experimental web site. The results of the PLS analysis suggest that age has a more pronounced impact on utilitarian constructs than hedonic ones. Specifically, older adults were less able to create an accurate mental model of the web site and in turn had poorer performance with the web site. In terms of impact on user satisfaction, the contribution of hedonic constructs was significant while the impact of utilitarian constructs was not.

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Chapter 1: Introduction

As the world's population ages, a similar aging trend exists in users of computers and the Internet (Chevalier & Rossetti, 2010; Stevens, 2010). Older adults are increasingly venturing online to enhance both their personal and professional lives. As such, the topic of web usability for older adults is becoming increasingly relevant. Older adults have unique needs in this context as a result of the natural changes caused by the aging process (Hawthorn, 2000). In particular, declining spatial ability has been identified as a challenge for older adults in terms of computer and Internet use (Pak, Czaja, Sharit, Rogers, & Fisk, 2008). This dissertation research explores the impact of age and spatial ability on web usability as measured by both utilitarian (functional) and hedonic (pleasure-related) outcomes for this substantial and growing group of users.

1.1 Aging Internet Users

The populations of most of the worlds' developed nations are experiencing an increase in average age (OECD, 2006). In Canada, the 55-64 age cohort is the fastest growing population in the country by far, followed by the over 80 cohort (Alphonso & Bonoguore, 2007). For the first time, there are more than four million Canadians over the age of 65, and the proportion of seniors is expected to double in the next few decades (Alphonso & Bonoguore, 2007). Canada has one of the youngest population averages of the G8 nations, indicating that this trend is wide spread (Cowan, 2007). This

shift in average population age can be attributed to increased life expectancy and declining birth rates (Alphonso & Bonoguore, 2007).

A logical consequence of the increasing age of the population is the increasing age of computer users. Older adults now make up the fastest growing consumer segment of computer buyers and Internet users (Chevalier & Rossetti, 2010; Stevens, 2010). Use of the Internet can help older adults to enhance their independence by reducing the barriers caused by lack of mobility, expanding educational and communication opportunities, augmenting memory though reminders, and providing an electronic link to health care (Czaja, 1997). The most common personal uses of the Internet by older adults are communication (mainly email); researching news, finances, healthcare, and hobbies; shopping; and banking (Hough & Kobylanski, 2009; Pernice & Nielsen, 2005).

Older adults are also using computers in a work context as there is an increasing tendency for workers to remain in the workforce past the traditional retirement age (Purcell, 2006). Nowadays, many workers are using computers on a daily basis to do their jobs (Nord, McCubbins, & Nord, 2006). As firms move increasingly towards a web services-based architecture (Huang & Hu, 2004), increased computer use in the workplace equates to increased Internet use. As the Internet becomes an increasingly integral part of the daily lives of older adults, the study of Internet usability by older adults is becoming an increasingly relevant field of study.

An interesting aspect of exploring usability for older adults concerns the question: what constitutes older? As described in Wagner, Hassanein, & Head (2010), the term older has been used to describe a range of computer users from "over 40" on the lower end to "over 75" on the higher end, making the term "older user" fairly ambiguous. Further, many researchers assert that age is much more than a chronological measure and that the use of chronological age in research is a limitation (Morris & Venkatesh, 2000). Older adults (of any chronological age) are a very heterogeneous group since they have more varied life experiences than younger adults and are affected by age-related deterioration and illnesses at different rates (Dickinson, Arnott, & Prior, 2007; Lippincott, 2004). This study gathers data concerning multiple conceptualizations of age in an effort to explore this heterogeneity in a web usability context.

1.2 Usability

Although usability is a key concept of Human-Computer Interaction (HCI) research (Hornbaek, 2006), its application in the Information Systems (IS) literature has been limited to date (Venkatesh & Ramesh, 2006). More recently, usability is gaining traction in IS as researchers realize its potential to bring new perspectives to IS research (Tung, Xu, & Tan, 2009). For example, in a recent web site study Venkatesh & Ramesh (2006) found that the usability theoretical lens outperformed the popular Technology Acceptance Model in terms of richness and variance explained in a web site study.

Although usability has been defined a variety of ways in numerous contexts (Tung et al., 2009), the definition developed by the International Standards Organization (ISO) is most often adopted. The ISO defines usability as the "effectiveness, efficiency, and satisfaction with which specified users can achieve goals in particular environments" (ISO, 1998, p. 2). In practice, effectiveness and efficiency are often referred to collectively as performance. These definitions of usability and performance have previously been applied in IS research when examining phenomena through an HCI or usability lens (Agarwal & Venkatesh, 2002; Venkatesh & Agarwal, 2006), and will be applied in this research. A list of the definitions applied in this research is provided in Appendix A.

Usability has been recognized as an important aspect in the study of online behaviors in IS and HCI literature (Venkatesh & Agarwal, 2006). It has been associated with important outcomes such as error reduction and positive attitudes (Venkatesh & Agarwal, 2006), and has been shown to increase users' intentions to use computers as well as subsequent usage behavior (Legris, Ingham, & Collerette, 2003; McCloskey, 2006; Venkatesh, Morris, Davis, & Davis, 2003). Thus, improved web usability for older adults will facilitate their use of the Internet, thereby enhancing their personal and professional lives.

Usability is a multifaceted concept in that it considers both utilitarian and hedonic aspects. In the definition above, utilitarian and hedonic aspects are considered through performance and satisfaction respectively. In order to have a full picture of the

usability of a web site, both performance and subjective assessments in the form of user perceptions should be considered (Agarwal & Venkatesh, 2002; Hornbaek, 2006). Historically, usability evaluation has primarily concerned itself with performance-based measures of usability (Hornbaek, 2006; Otter & Johnson, 2000). More recently, however, researchers have emphasized the importance of bringing more focus to the hedonic considerations (O'Brien & Toms, 2008). This research explores multiple aspects of web site usability for older adults, measuring both utilitarian and hedonic outcomes, and their impact on user satisfaction. Usability is particularly important in the context of older users since they tend to be more severely impacted by usability problems than younger users. This has been shown to be true for both utilitarian and hedonic considerations (Pernice & Nielsen, 2005).

1.3 Unique Needs of Older Adults

The interface usability concerns of older computer users are distinct from those of younger ones as a result of the physical and cognitive changes associated with the natural aging process, which become more noticeable at roughly 45 years of age (Hawthorn, 2000). Each of these changes has implications for the usability of computer interfaces. For example, physical changes associated with aging include declines in vision, hearing, and psychomotor coordination (Hawthorn, 2000). Thus, interfaces will be more usable for older users if they make use of features like larger fonts, sounds within certain frequency ranges, and layouts that require less precise mouse movement.

Similarly, cognitive changes such as reduced attention span, declines in memory, and changes in spatial abilities create a need for interfaces that have fewer distractions, provide memory cues, and are simple to learn and understand (Hawthorn, 2000).

In particular, spatial ability has long been suspected of impacting the performance of computer tasks (Czaja, 1997) and several studies have found this to be the case (Benyon & Murray, 1993; Egan & Gomez, 1985; Vicente & Williges, 1988). While all these examples illustrate the importance of spatial ability for the performance of offline tasks, similar findings have been observed in web-based studies: spatial ability leads to better performance in hypertext navigation tasks (Höök, Dahlbäck, & Sjölinder, 1996); and age, spatial visualization ability and working memory had the strongest impact on performance of a complex online grocery store task (Sjolinder, Höök, & Nilsson, 2003). Spatial ability is known to decline with age and is resistant to training (Salthouse, 1982), making it an especially important consideration in web usability for older users.

Spatial abilities are believed to support web site navigation by enabling users to create a mental representation of the system's structure (Nielsen, 1995). Users who are unable to construct a mental representation are more likely to feel lost, or disoriented, within a web site. As a result of the decline in spatial abilities with age, disorientation has been found to be a more severe issue for older users (Lin, 2003a).

Disorientation has been recognized as one of the most significant issues with web navigation (Webster & Ahuja, 2006), yet it has not been explicitly included in

usability measures proposed in the IS literature (Agarwal & Venkatesh, 2002). Agarwal & Venkatesh (2002) did, however, include perceived ease of use in their conceptualization, which has been found to be similar yet distinct from disorientation (Ahuja & Webster, 2001). It has been argued that different contexts of use require new measures of usability to adequately capture what is considered important in the particular context (Hornbaek, 2006). Given the importance of the issue of disorientation, and particularly its impact on older adults, this study considers disorientation in relation to web site usability for older adults.

1.4 Research Objectives

Despite the growing level of interest and research in issues relating to older adults and computers (Goodman & Lundell, 2005), there remain a number of gaps in the literature (Wagner, Hassanein, & Head, 2007; Wagner et al., 2010). Empirical usability research in particular has been skewed toward the characteristics and attitudes of highly educated young people through the use of student samples (Dickinson et al., 2007). Given the uniqueness of older adults in comparison to younger adults, there is a plethora of opportunity for empirical research in this crucial area. Further, the majority of the research concerning computer use by older adults examines utilitarian outcomes such as performance (Wagner et al., 2010), while hedonic aspects are largely unexplored.

To date, a considerable amount of effort has been dedicated to exploring web usability issues for older adults and a number of guidelines have been developed (Morrell et al., 2003; Zaphiris, Kurniqwan, & Ghiawadawala, 2007). While some of these guidelines are very specific (i.e. font size, typeface, colors, etc.), the recommendations for other aspects, such as navigation systems, site topologies, and accommodation of changes in spatial abilities, are much vaguer. Further, many of these guidelines are based on extrapolations from the study of older users using offline applications, as well as general research on aging. This lack of empirical testing creates many opportunities for future research in the area of web usability for older users. To help fill this gap, this research seeks to explore web site usability for older adults, considering both utilitarian and hedonic aspects and their impact on user satisfaction, through an experimental research study. In particular, aspects of usability that are impacted by the declining spatial abilities of older adults will be addressed.

From a theoretical perspective, this study will contribute to our knowledge concerning older adults' web site usability experiences in two ways. First, since this is an empirical study, it will add to the rather limited body of literature outlining empirical results for older adults. Secondly, by exploring hedonic considerations, it will add to our understanding of older adults' experiences outside of the typically studied utilitarian perspective.

From a practical perspective, this study will add to the body of web site usability guidelines for older adults. In particular, by considering age-related declines in spatial

ability and the resulting impact on mental representation and disorientation (as discussed in section 1.3), this research will add clarity to some of the vaguer guidelines on these topics.

The remainder of this dissertation proceeds as follows: Chapter 2 discusses the relevant body of literature concerning computer use by older adults. Chapter 3 presents the theoretical model for the study and outlines the hypotheses to be explored. Chapter 4 describes the methodology followed for the usability experiment that was conducted. Chapter 5 presents the analysis of the data that was collected during the experiment with respect to the proposed research model. Chapter 6 contains a discussion of the results of the experiment, the limitations of the study, the theoretical and practical contributions of the research, and suggestions for future research.

Chapter 2: Literature Review

The age-related changes experienced by older adults and their implications for computer use have been studied by many different researchers in many different contexts. The literature review presented in this chapter has been published as Wagner, Hassanein, & Head (2010)[1,2]. It examines the existing research concerning computer use by older adults and provides a holistic view of the field. Since the study of computer use by older adults is a multidisciplinary topic by nature, a synthesis of the findings from across these many disciplines is provided, and gaps in the existing literature are highlighted. The findings are examined through the lens of Social Cognitive Theory in an attempt to illustrate the means through which older adults can be encouraged to use computers and the Internet.

Social Cognitive Theory (SCT) is a widely accepted model of individual behavior (Chan & Lu, 2004). Developed by Albert Bandura (Bandura, 1986), the roots of SCT lie in the domain of social learning theory. The theory, however, has been applied in various other disciplines including Information Systems (e.g. Bolt, Killough, & Koh, 2001; Compeau, Higgins, & Huff, 1999).

SCT is "based on the premise that environmental influences such as social pressures or unique situational characteristics, cognitive and other personal factors

[1] Wagner, N., Hassanein, K., & Head, M. 2010. Computer use by older adults: A multi-disciplinary review. ***Computers in Human Behavior***, 26(5): 870–882.

[2] The right to reproduce this article in my thesis is retained, as described in the journal's policy for author's rights at http://www.elsevier.com/wps/find/authorsview.authors/authorsrights

including personality as well as demographic characteristics, and behavior are reciprocally determined" (Compeau & Higgins, 1995). In other words, individuals choose their environment and also are influenced by it; individual behavior is influenced by personal factors, which are in turn influenced by behaviors; and behavior may be influenced by environmental factors while having their own impact on the environment. This "triadic reciprocality" is illustrated in Figure 1.

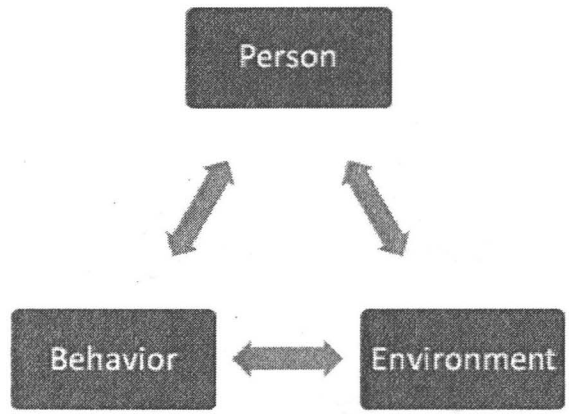


Figure 1: Triadic Reciprocality or Reciprocal Determinism of SCT
Sourced from Wagner et al. (2010), page 871

In the context of this review, the Person construct refers to the computer using older adult, Behavior refers to computer use, and Environment refers to the computer system. The extant literature concerning older adults and computer use is examined across various disciplines through the SCT framework to understand the extent to which the relationships illustrated in Figure 1 have been investigated. Further, since SCT provides a basis for behavior intervention strategies (Bandura, 1997), the concepts of SCT are used to illustrate potential ways to encourage computer use by older adults.

2.1 Methodology

The articles for this review were gathered by searching various databases for peer reviewed journal articles on the subject of computer use by older adults. Since this topic is multi-disciplinary in nature, eleven different databases were searched to cover all of the relevant disciplines: business (ABI/Inform, and Business Source Premier); information technology (Inspec); social sciences (Social Sciences Abstracts, Social Sciences Citation Index, and the Applied Social Sciences Index); gerontology (Age Line and Abstracts in Social Gerontology); education (Education Resources Information Center); psychology (PsychINFO); and Scopus (multi-disciplinary, including full coverage of MedLine for healthcare topics). These databases include the core or essential databases in their respective subject areas, as described by electronic library collection development guides (Kovacs & Robinson, 2004).

Search strings included reference to aging (age or aging or old or older or senior) as well as reference to computer use (computer or Internet or web or interface). A cut-off starting point of 1990 was selected for analysis since this approximates the widespread use of personal computers. In total, 151 articles covering the period 1990-2008 were reviewed.

As one would expect, given the multi-disciplinary nature of this topic, articles were found in a diverse range of journals. To enable analysis by discipline, a classification scheme for the list of journals was sought. Although a listing was found

that contained each of the relevant journals (Ulrich's Periodical Directory), the resulting categories were too broad to be useful for this purpose. As an alternative, a panel of four experts was consulted in order to categorize the journals. The four selected experts were researchers in the field of Information Systems (two PhD students and two established faculty members) with expertise in topics including human-computer interaction, individual differences (including gender and age), user adoption, and social issues related to information technology. In order to categorize the journals, each expert was provided with a list of the journals, the journal's description from its web site, and a list of eight possible disciplines to assign it to: i) business, ii) communication, iii) education, iv) gerontology, v) human-computer interaction (HCI), vi) healthcare, vii) information systems (IS), and viii) psychology. This list of potential disciplines was similar to the categories found in Ulrich's with the exception of HCI and IS which were added to permit a more granular analysis in the area of computer science. Inter-rater reliability was found to be 0.72, as calculated using a variant of Cohen's kappa (Fleiss' kappa) to accommodate four raters. This reliability was above the recommended minimum of 0.70 (Straub, Boudreau, & Gefen, 2004). A complete list of the journals, along with their corresponding disciplines and the number of related articles found in each, is provided in Appendix B.

2.2 Literature Analysis

2.2.1 Publication Trends

In general, the study of computer use by older adults has received increasing attention over time. As illustrated in Figure 2, interest in this subject has increased steadily over the time period studied (1990-2008). Although the figure is presented in year ranges for clarity, it is interesting to note that prior to 1997, 1994 was the only year with publication of more than one article in this area. In 1997, the first wave of Baby Boomers became 50 years of age (Foot, 1996). It is not likely a coincidence that the number of articles published on this topic per year increased to at least 5 in that same year. As this large cohort continues to age and remain in the workforce, research on the topic is likely to continue this upward trend.

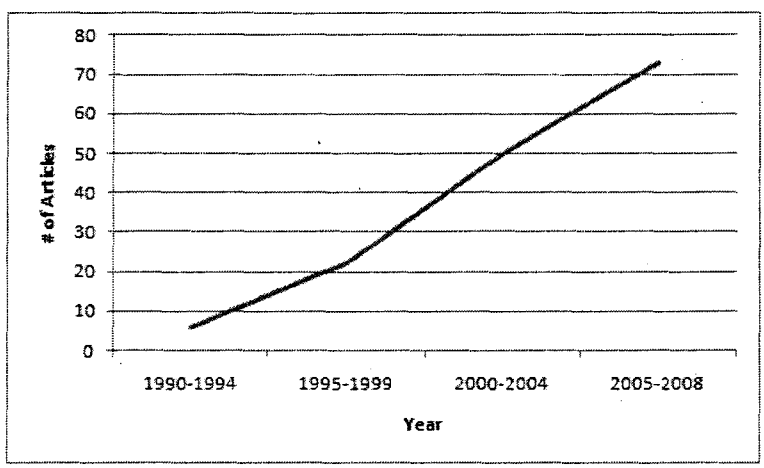


Figure 2: Articles published by year
Sourced from Wagner et al. (2010), page 871

It is also interesting to observe the publication trends within each discipline, as illustrated in Figure 3. Over time, the Business discipline has paid increasing attention to

the issues of older computer users. Interest began in the Marketing-oriented journals, recognizing older computer users as a potential target audience for marketers. Later Business focus began to include labour-oriented journals, which investigated older computer users in the workforce. Communication journals were later to take older adults into consideration, with the first publications not appearing until 1999. Interest from the communications discipline has been fairly limited, with only seven articles found in total. Gerontology as a discipline has been one of the main contributors to research in this field. With a total of 40 articles, it is second only to HCI with 56 articles. Both of these significant contributors have shown increasing publications in this area over time, particularly HCI in the last few years. IS has begun to pay more attention to older users in the past few years, with seven of the eleven articles found in that discipline published between 2005 and 2008. Psychology has contributed modestly with one publication per year in most recent years. This low level of publication in Psychology is somewhat surprising since, in general, age differences have been of great interest to psychology researchers for decades (Morris & Venkatesh, 2000). The Healthcare discipline was late to join this area of research with the first article not appearing until 2000, however, interest has been increasing steadily since that time. The Education discipline has shown surprisingly little interest in this area, especially considering that continued learning is often listed as a way in which computers and the Internet can be of the most assistance to older adults (Bitterman & Shalev, 2004; Morrell, Mayhorn, & Bennett, 2000).

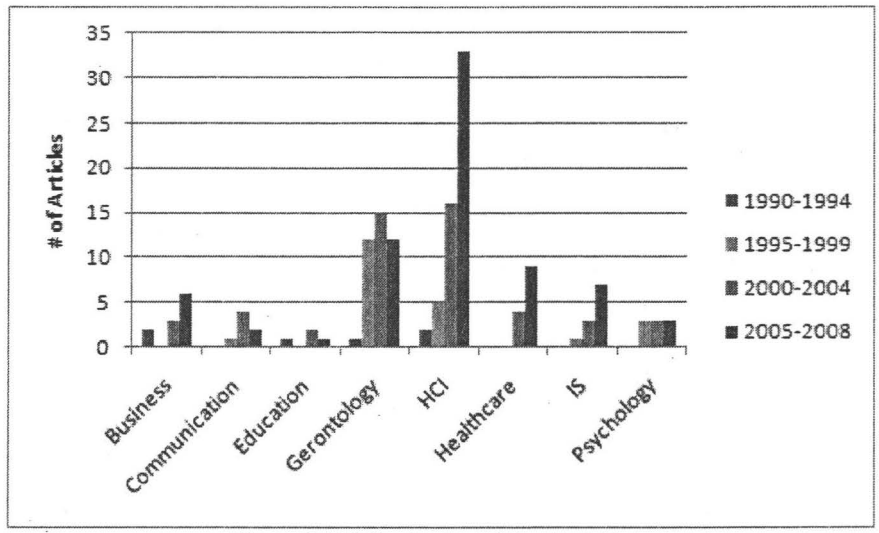


Figure 3: Publication trends by discipline
Sourced from Wagner et al. (2010), page 872

2.2.2 Analysis of Research Findings

As discussed, SCT offers an explanation of individuals' patterns of behavior. In this section we utilize SCT theory as a lens to analyze and organize the literature related to computer use by older adults. SCT was chosen from a list of 83 theories listed at a wiki summarizing *Theories Used in IS Research*[3]. Of the 83 theories, 38 examined individual level phenomenon, of which two were sufficiently broad to examine this diverse body of literature. SCT was chosen over Actor Network Theory for its simplicity and emphasis on behavior.

The findings of the analysis are discussed in detail in the following sections. First the literature covering the main elements of SCT theory (i.e. Person, Behavior and Environment) is examined. Then the literature covering the reciprocal relationships

[3] http://www.fsc.yorku.ca/york/istheory/wiki/index.php/Main_Page

between those elements is discussed. To facilitate readability in the analysis below, references that are included in the tables are not duplicated in the text.

2.2.2.1 SCT Main Elements

Person In this context, Person refers to the older adult, including all of the physical, cognitive, and emotional attributes that make up this individual. The literature examined discusses Person attributes primarily related to the emotions of the older adult toward computers. Table 1 summarizes the relationships observed among Person attributes in the literature.

As Table 1 illustrates, there are only a few instances where the relationship between the same two variables has been studied more than once. As a result, it is difficult to make any confident assertions about many of these relationships. The most commonly studied Person attribute is attitude toward computers. In general, it seems that as age increases, attitudes toward computers tend to become more negative. Czaja & Sharit (1998), however, found that only particular dimensions of attitude (i.e. comfort, competence, and control) are negatively affected by age. Two studies have examined the impact of gender on attitudes, but results have been inconclusive with one study showing that males have more positive attitudes and the other finding no relationship. And last, two studies examined the relationship between experience and attitudes, finding that those with more positive attitudes had more experience.

Variable 1	Correlation*	Variable 2	Reference
Age	-	Experience	(Laberge & Scialfa, 2005)
	-	Attitudes	(Baack & Brown, 1991) (Kubeck, Miller-Albrecht, & Murphy, 1999) (Morris & Venkatesh, 2000)
	-	Confidence in computer knowledge	(Marquié, Jourdan-Boddaert, & Huet, 2002)
	+	Anxiety	(Laguna & Babcock, 1997) (Dyck, Gee, & Smither, 1998)
	+	Trust	(Ho, Wheatley, & Scialfa, 2005)
	NR	Trust	(McCloskey, 2006)
	NR	Attitudes	(Czaja & Sharit, 1998)
Anxiety	NR	Experience	(Hogan, 2005)
	-	Life satisfaction	(Karavidas, Lim, & Katsikas, 2005)
Attitudes	+	Experience	(Dyck & Smither, 1996) (Festervand & Meinert, 1994)
Computer knowledge	+	Self-efficacy	(Karavidas et al., 2005)
	-	Life satisfaction	(Karavidas et al., 2005)
	-	Computer anxiety	(Karavidas et al., 2005)
Gender (male)	-	Anxiety	(Karavidas et al., 2005) (Hogan, 2005)
	+	Attitudes	(Dyck & Smither, 1996)
	NR	Anxiety	(Laguna & Babcock, 1997)
	NR	Attitudes	(Czaja & Sharit, 1998)
Outcome expectations	+	Intention of Internet use	(Lam & Lee, 2006)
Satisfaction with computer ability	+	Perception of importance of a computer	(Marchant, Tiernan, & Mann, 2005)
	+	Perception of performance	(Marchant et al., 2005)
Self-efficacy	+	Intention of Internet use	(Lam & Lee, 2006)
	+	Outcome expectations	(Lam & Lee, 2006)

Table 1: Correlations observed between Person attributes
*NR= no relationship; Sourced from Wagner et al. (2010), page 873

In addition to the quantitative studies summarized in Table 1, a number of qualitative studies have also been conducted in an effort to more thoroughly understand the attitudes of older adults toward computers. These studies have found that: attitudes are forming and not yet strong (Festervand & Meinert, 1994); many older adults believe that they will benefit from computer use while others are skeptical about the benefits (Saunders, 2004); older adults may feel alienated by or too old to learn to

use computers (Turner, Turner, & Van de Walle, 2007); and older adults have more negative emotional reactions to making computer errors (Birdi & Zapf, 1997; Saunders, 2004). One recent study included the development of a new measure for attitudes toward computers specifically developed for older adults (Lagana, 2008), indicating that there is ongoing research interest in this topic.

Apart from attitude toward computers, few relationships have been examined in multiple studies. From the literature reviewed, it seems that increasing age may lead to increased computer anxiety. Also, computer anxiety may be more significant for males, although one study found no relationship. Morris, Venkatesh, & Ackermann (2005) found gender to play a more prominent role with increasing age, in moderating the impact of attitude, subjective norms and perceived behavioral control on behavioral intention to use IS.

Overall, research in this literature examining the older adult covers a variety of topics, with few studies examining the same relationships and thus little validation of results. In some cases where the same relationships were studied multiple times, inconsistent results were found. Future research dedicated to clarifying these inconsistencies and validating previous findings will help paint a more accurate picture of this group of users. Further, some authors suggest that existing scales may not be appropriate for use by older adults and recommend the creation of new measures specifically for this group (Lin, 2003b; Lagana, 2008). This recommendation should be considered by researchers of older adults.

Behavior In this context, the Behavior of interest is computer use by older adults. In general, older users have joined the computer and Internet community to a lesser extent than younger adults, yet their segment is growing most quickly (Hart, Chaparro, & Halcomb, 2008). Studies often found older adults to be keen users (Juznic, Blazic, Mercun, & Plestenjak, 2006; Tak & Hong, 2005; Vuori & Holmlund-Rytkönen, 2005) with evolving motivational reasons for their use (Ng, 2008). Amount of use was not found to vary by gender among older adults (Karavidas et al., 2005). One of the key indicators of ongoing use is short-term use (Bickmore, Caruso, Clough-Gorr, & Heeren, 2005; Morris et al., 2005), indicating that encouraging initial use is crucial to subsequent computer use by older adults.

Older adults often use computers and the Internet for the same activities that younger users are known to, but do different activities to varying extents (Vuori & Holmlund-Rytkönen, 2005). The main activities this group engages in are summarized in Table 2. Although their activities are similar, older users tend not to take advantage of many of the more advanced tools available online as much as their younger counterparts (Bucur, Renold, & Henke, 1999).

Activity	Reference
Communication and social support	(McMellon & Schiffman, 2000) (Morrell et al., 2000) (Opalinski, 2001) (Mann, Belchior, Tomita, & Kemp, 2005) (Thayer & Ray, 2006) (Alexy, 2000)
Leisure and entertainment	(McMellon & Schiffman, 2000) (Opalinski, 2001) (Campbell, 2008)
Information seeking- Health	(Morrell et al., 2000) (Tak & Hong, 2005) (Flynn, Smith, & Freese, 2006) (Campbell, 2008) (Macias & McMillan, 2008)
Information seeking- Education	(McMellon & Schiffman, 2000) (Opalinski, 2001) (Dorin, 2007)
Productivity	(White & Weatherall, 2000) (Campbell, 2008)

Table 2: Most common computer uses for older adults
Sourced from Wagner et al. (2010), page 873

The most common use of computers and the Internet for older adults appears to be for communication and social support. Benefits include increased contact with family and friends (Thayer & Ray, 2006), especially grandchildren (White & Weatherall, 2000), coping with grief (Opalinski, 2001), and dealing with geographic boundaries or limited mobility (Alexy, 2000). Different types of online communication are used including email, instant messaging, and online forums, each being used to support different social interactions (Xie, 2008). Computer-mediated social support for older adults is another topic for which a new measure has recently been developed, indicating the ongoing popularity of this research topic (Nahm, Resnick, & Gaines, 2004).

Other common uses of computers and the Internet by older adults include: leisure and entertainment, which tends to be related to offline interests and hobbies

such as genealogy (White & Weatherall, 2000); and information seeking (Blake, 1998; Opalinski, 2001), particularly in the areas of health related information, education, and productivity, including mental stimulation (Rosenthal, 2008; White & Weatherall, 2000).

The surveyed literature also discusses reasons for non-use, or barriers to computer use by older adults, as summarized in Table 3. Melenhorst, Rogers, & Bouwhuis (2006) assert that while it is commonly believed that costs deter older adults from using new technologies, it is actually the lack of perceived benefit that is to blame. Either the technology does not meet the needs of the user, or they do not understand the technology sufficiently to appreciate the benefits. In any case, there are a variety of issues to address in order to encourage older adults to use computers.

Barrier to use	Reference
Perceived lack of benefit	(Mann et al., 2005) (Melenhorst et al., 2006)
Lack of interest or motivation	(Selwyn, Gorard, Furlong, & Madden, 2003) (Carpenter & Buday, 2007) (Morris, Goodman, & Brading, 2007) (Peacock & Kunemund, 2007)
Lack of knowledge	(Opalinski, 2001) (Peacock & Kunemund, 2007) (Ng ,2008)
Lack of access	(Peacock & Kunemund, 2007)
Cost	(Festervand & Meinert, 1994) (White & Weatherall, 2000) (Opalinski, 2001) (Saunders, 2004) (Mann et al., 2005) (Carpenter & Buday, 2007)
Fear of hardware being outdated quickly	(Saunders, 2004)
Perceived barriers due to physical limitations	(Carpenter & Buday, 2007) (Saunders, 2004)

Table 3: Barriers to computer use by older adults
Sourced from Wagner et al. (2010), page 874

Environment In this context, the Environment of interest is the computer system used by the older adult. The term system is used in its broad context, including the hardware,

software, people interactions, and context of use involved. As a result, the coverage of Environment in this literature includes topics such as training, support, and measures of usability such as performance and satisfaction.

The discussion of Environment is unique in this context because of the physical and cognitive changes that older adults experience as a result of the natural aging process. These changes result in a unique set of needs for this user group. A number of papers discuss these changes and the implications that they have for communicating with older adults (Charness & Holley, 2004; Lippincott, 2004; O'Hara, 2004) and developing interfaces for older adults (Czaja & Hiltz, 2005; Furlong, 1997; Hawthorn, 2000; Morris, 1994; Zajicek, 2004). Others go a step further and provide specific guidelines for the development of interfaces for older adults (Bitterman & Shalev, 2004; Hutchison, Eastman, & Tirrito, 1997; Naditz, 2005; Zaphiris et al., 2007), and a few studies have examined how well existing web sites conform to these published usability guidelines (Becker, 2004b, 2005; Hart et al., 2008).

A number of papers describe the development of specific systems for older adults in order to provide insights for developers of future systems. Topics include healthcare management (Alemagno, Niles, & Treiber, 2004; Deatrick, 1997), email applications (Dickinson, Eisma, Gregor, Syme, & Milne, 2005), web sites (DeGraves & Denesiuk, 2000; Ellis & Kurnlawan, 2000; Given, Ruecker, Simpson, Sadler, & Ruskin, 2007; Morrell, 2005; Nahm et al., 2004), accessibility tools (Becker, 2004a), personalization tools (Hanson & Crayne, 2005), cognitive exercises (Merzenich, 2007),

authentication (Renaud & Ramsay, 2007), and learning applications (Hawthorn, 2007). Mead, Batsakes, Fisk, & Mykityshyn (1999) make recommendations for conducting research for computer use by older adults, taking into considerations the unique characteristics of this participant group.

Training older adults to use computers is another popular research topic. Given the changing cognition of older adults, researchers suggest that training should be specifically tailored to this group (Aula, 2005). A number of papers suggest models or frameworks for consideration when designing training materials (Baldi, 1997; Chaffin & Harlow, 2005; Jones & Bayen, 1998; Mayhorn, 2004) and others provide specific recommendations as to how best to provide training through traditional means (Dickinson et al., 2005; Hollis-Sawyer & Sterns, 1999; Kelley & Charness, 1995; Lustbader, 1997; Mayhorn, 2004) or through e-learning (Stoltz-Loike, Morrell, & Loike, 2005; Trentin, 2004). Several studies mention that providing adequate support is very important when training this unique group (Vuori & Holmlund-Rytkönen, 2005; Ng, 2008; Rosenthal, 2008).

Studies examining older adults' performance when using computers describe how performance is impacted by different system characteristics, as summarized in Table 4. These relationships between the interface and usability measures highlight the importance of good design for this group.

Observation	Reference
Different web interface personalization instruments impact user satisfaction	(Kurniawan, King, Evans, & Blenkhorn, 2006)
Lack of boundaries and ability to use external reminders impact usability	(Curzon, Wilson, & Whitney, 2005)
Advanced functionality causes usability issues	(Mead, Sit, Rogers, Jamieson, & Rousseau, 2000)
Information presentation mode: animation lead to best information retention	(Lin, 2004)
Feedback condition: haptic feedback improved performance more than visual or auditory	(Jacko et al., 2004)
Web site layout: performance was best in the hierarchical typology when compared with hybrid and network topologies	(Lin, 2003b; Lin, 2004)
More supportive interfaces result in better performance	(Charness, Kelley, Bosman, & Mottram, 2001)

Table 4: Performance impacts of system characteristics
Sourced from Wagner et al. (2010), page 874

2.2.2.2 SCT Reciprocal Relationships

Having examined the extant literature on computer use by older adults covering the main elements of SCT, we now examine the literature covering the reciprocal relationships between those elements. An overview of the research covering these relationships in the literature is provided in Figure 4.

The most commonly studied relationships are those where Person attributes influence Behavior and Environment attributes. In other words, researchers in this field have primarily been interested in determining what Person attributes lead to computer use by older adults as well as what Person attributes influence the success of the system Environment, particularly as measured by user performance. Relatively little research has examined how Behavior and Environment may influence the Person, or how Environment and Behavior interact with one another. While the importance of these less often studied relationships may not be as intuitive, given the triadic reciprocality of

SCT they may offer alternative routes for influencing the computer use behaviors of older adults. Each type of relationship is discussed in detail in the following sections.

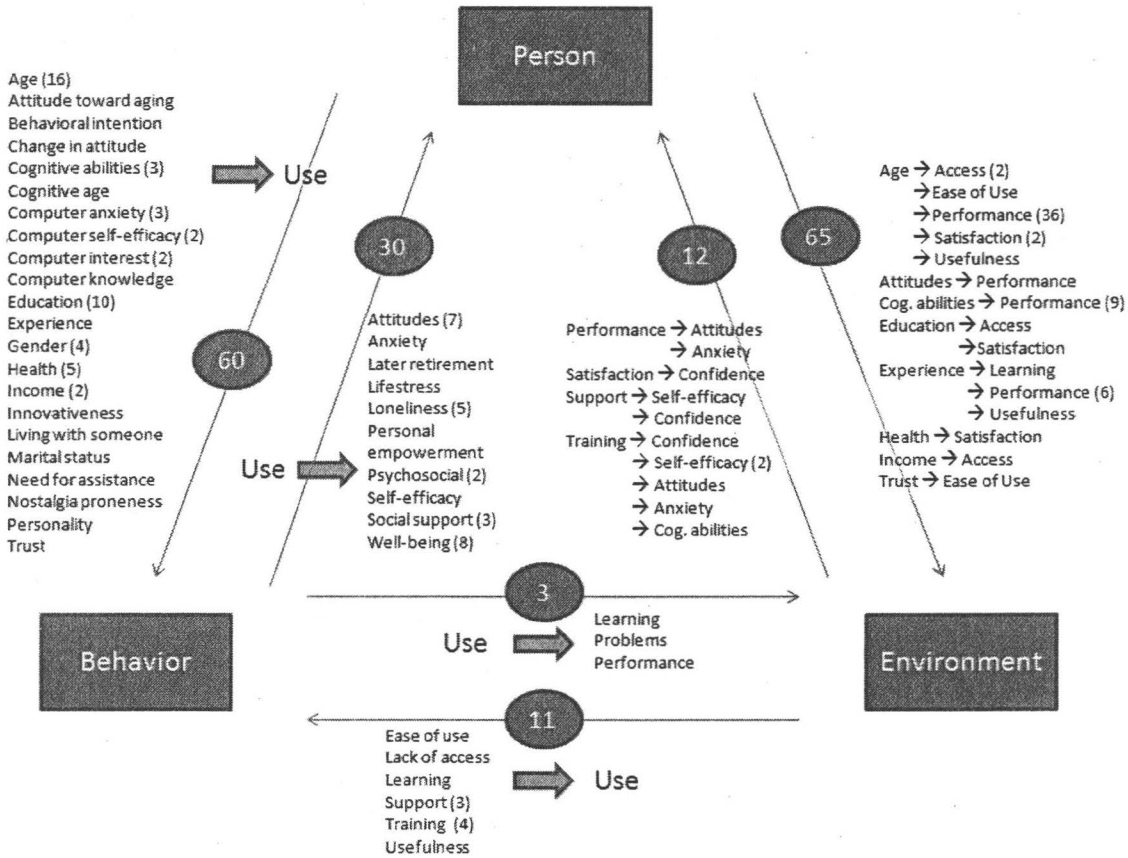


Figure 4: SCT as observed in the studied literature
Sourced from Wagner et al. (2010), page 875

2.2.2.2.1 The Influence of Person

Person → Behavior

The influence of Person attributes on Behavior, or computer use by older adults, has been widely studied. As summarized in Table 5, a broad range of influences on

computer use have been studied to varying degrees. Most commonly studied is the influence of age on computer use. In most cases, increasing age indicated decreasing computer use, yet a few studies found no relationship. Apart from age, a few other Person attributes have been examined in multiple studies. Cognitive abilities, computer self-efficacy, computer interest, education, health, and income seem to be positively related to computer use. In other words, older adults who use computers tend to have higher levels of cognitive abilities, computer self-efficacy, and computer interest; tend to be more educated, in better health, and have higher incomes. Conversely, users tend to have lower levels of computer anxiety. The influence of gender on computer use is particularly uncertain with two studies finding that male older adults are more likely to use computers compared to their female counterparts, while two studies found no influence of gender. Each of the remaining independent variables listed in the table were examined in a single study, thus the findings may carry less weight. These attributes present opportunity for further research in order to validate the findings of these existing studies.

Independent Variable	Impact*	Dependent Variable	References
Age	-	Use	(Chen & Persson, 2002) (Selwyn et al., 2003) (Cutler, Hendricks, & Guyer, 2003) (Friedberg, 2003) (Schleife, 2006) (Morrell et al., 2000) (Thayer & Ray, 2006) (Morris & Venkatesh, 2000) (Czaja et al., 2006) (Carpenter & Buday, 2007) (Peacock & Kunemund, 2007) (Juznic et al., 2006) (Morris et al., 2007) (McCloskey, 2006)
	NR	Use	(Knight & Pearson, 2005) (Tian & Robinson, 2008)
	NR	Continuance	(White et al., 2002)
Attitude toward aging	+	Use	(Cody, Dunn, Hoppin, & Wendt, 1999)
Behavioral intention	+	Use	(Morris et al., 2005)
Change in attitudes	NR	Continuance	(Kelley, Morrell, Park, & Mayhorn, 1999)
Cognitive abilities	+	Use	(Czaja et al., 2006) (Freese, Rivas, & Hargittai, 2006) (Kelley et al., 1999)
Cognitive age	-	Use	(Eastman & Iyer, 2005)
Computer anxiety	-	Use	(Cody et al., 1999) (Knight & Pearson, 2005) (Czaja et al., 2006)
Computer self-efficacy	+	Use	(Cody et al., 1999) (Czaja et al., 2006)
Computer interest	+	Use	(Kelley et al., 1999)
	+	Continuance	(Kelley et al., 1999)
Computer knowledge	+	Use	(Morrell et al., 2000)
Education	+	Use	(Chen & Persson, 2002) (Selwyn et al., 2003) (Cutler et al., 2003) (Schleife, 2006) (Morrell et al., 2000) (Czaja et al., 2006) (Carpenter & Buday, 2007) (Tak & Hong, 2005) (Juznic et al., 2006)
	NR	Continuance	(White et al., 2002)
Experience	+	Continuance	(White et al., 2002)
Gender (male)	+	Use	(Selwyn et al., 2003) (Morris et al., 2005)

	NR	Use	(Knight & Pearson, 2005) (Hogan, 2005)
Health	+	Use	(Chen & Persson, 2002) (Carpenter & Buday, 2007) (McMellon & Schiffman, 2000)
	NR	Use	(Selwyn et al., 2003)
	NR	Continuance	(White et al., 2002)
Income	+	Use	(Chen & Persson, 2002) (Schleife, 2006)
Innovativeness	+	Use	(Reisenwitz, Iyer, Kuhlmeier, & Eastman, 2007)
Living with someone	+	Continuance	(White et al., 2002)
Marital status (married)	+	Use	(Selwyn et al., 2003)
Need for assistance	NR	Continuance	(White et al., 2002)
Nostalgia proneness	-	Use	(Reisenwitz et al., 2007)
Personality	NR	Use	(Chen & Persson, 2002)
Trust	+	Use	(McCloskey, 2006)

Table 5: Articles studying the impact of Person on Behavior
*NR= no relationship; Sourced from Wagner et al. (2010), page 875

While Table 5 describes the univariate relationships observed in the literature, studies often took several indicators of computer use into account simultaneously. For example, Czaja et al. (2006) found that both attitudinal and cognitive variables were necessary to predict computer use since cognitive ability was necessary but not sufficient to predict. The same study concluded further that there was a strong age effect, independent of the effect of attitudes and cognitive ability, thus suggesting an answer to a question often posed in the literature: is there an independent effect of age, or can age effects be explained by other variables?

One context of particular interest is computer use in the workplace. Friedberg (2003) found that rates of computer use in the workplace were similar for all but the oldest workers, who exhibited lower levels of use. This study found that upcoming retirement, not simply age, may influence an older worker's computer use patterns.

Alternatively, Morris et al. (2005) examined gender differences in computer use among older workers. They found that gender differences became more pronounced among older workers, where older male workers were more likely to be computer users than older female workers. This pattern did not, however, exist among younger workers.

Person → Environment

The influence of Person attributes on Environment has also been widely studied. In this case, one particular relationship has dominated the research: the impact of age on performance. As illustrated in Figure 4, over half of the empirical results in this category (36 of 65) examine this particular relationship. The literature strongly indicates that there is a negative relationship between age and performance (see Table 6 below). In particular, as age increases, correct answers, browsing efficiency, overall efficiency, quality, and work output tend to decrease. Similarly, number of errors, amount of support sought, and time to complete exercises all increase with age. While a few studies found no relationship when studying these constructs, findings have otherwise been quite consistent in this area.

Independent Variable	Impact*	Performance Measure	References
Age	-	Correct answers	(Echt, Morrell, & Park, 1998) (Laguna & Babcock, 1997) (Reed, Doty, & May, 2005) (Charness et al., 2001) (Sharit et al., 2008)
	-	Browsing efficiency	(Graff, 2005) (Lin, 2003a) (Fukuda & Bubb, 2003)
	-	Efficiency	(Sjolinder, Höök, Nilsson, & Andersson, 2005) (Charness et al., 2001)
	-	Quality	(Kubeck et al., 1999)
	-	Work output	(Czaja & Lee, 2001)
	+	Errors	(Echt et al., 1998) (Ho et al., 2005) (Czaja & Sharit, 1993) (Charness et al., 2001)
	+	Support sought	(Kressig & Echt, 2002) (Birdi & Zapf, 1997)
	+	Time	(Echt et al., 1998) (Freudenthal, 2001) (Laguna & Babcock, 1997) (Sayers, 2004) (Sjolinder et al., 2005) (Grahame, Laberge, & Scialfa, 2004) (Stronge, Rogers, & Fisk, 2006) (Czaja & Sharit, 1993) (Charness et al., 2001) (Fukuda & Bubb, 2003) (Sjolinder et al., 2003) (Lindberg, Nasanen, & Muller, 2006) (Laberge & Scialfa, 2005)
	NR	Correct answers	(Stronge et al., 2006) (Webster & Martocchio, 1993)
	NR	Browsing efficiency	(Laberge & Scialfa, 2005)
	NR	Errors	(Birdi, Pennington, & Zapf, 1997)
	NR	Time	(Kressig & Echt, 2002)
Attitudes	+	Correct answers	(Shoemaker, 2003)
Cognitive abilities	+	Browsing efficiency	(Freudenthal, 2001)
	+	Correct answers	(Dyck & Smither, 1996)
	+	Efficiency	(Jimison, Pavel, McKanna, & Pavel, 2004)
	+	Work output	(Czaja et al., 2001)
	-	Errors	(Echt et al., 1998)
	-	Time	(Sjolinder et al., 2003)

			(Laberge & Scialfa, 2005)
	NR	Errors	(Kressig & Echt, 2002)
	NR	Quality	(Czaja et al., 2001)
	NR	Time	(Kressig & Echt, 2002) (Priest, Nayak, & Stuart-Hamilton, 2007)
Experience	-	Time	(Kressig & Echt, 2002) (Priest et al., 2007) (Sjolinder et al., 2003) (Jacko et al., 2004) (Czaja & Sharit, 1993)
	-	Need for support	(Kressig & Echt, 2002)

Table 6: Articles studying the impact of Person on Performance Measures
*NR= no relationship; Sourced from Wagner et al. (2010), page 876

Computer performance among older adults has been found to vary widely (Czaja, Sharit, Ownby, Roth, & Nair, 2001; Lindberg et al., 2006), suggesting that predictions should not be based solely on chronological age. Some suggest that age effects are largely mediated by contextual factors such as experience and cognitive abilities (Czaja et al., 2001). Charness et al. (2001) found that age and experience trade off with roughly equal weight, while Czaja & Sharit (1993) found that experience accounted for the largest portion of variance. The most recent study, by Sharit et al. (2008) found that after accounting for knowledge and cognitive ability factors, the influence of age was negligible. While the relative importance of each is uncertain, age and experience certainly have strong implications on computer performance by older adults.

Table 6 also summarizes the empirical findings in relationships between other Person attributes and performance using computers. As is often the case in this body of literature, there are few cases where results have been validated. Time (to complete

exercises) is the only performance outcome studied multiple times along with Person attributes other than age. Findings indicate that as experience increases, time decreases. The relationship between cognitive abilities and time is less clear with two studies finding a negative relationship and two others finding no relationship. Although there is little validation and some results are inconsistent, in general it seems that higher levels of cognitive abilities and experience both have a positive impact on performance measures.

Apart from studies examining the impact of Person attributes on performance, relatively little research has been conducted concerning the relationship between Person and Environment. The remaining studies are summarized in Table 7. Again, most relationships are studied only once. There is some support to suggest that as age increases access to computers decreases, and that age is not directly related to satisfaction.

Independent Variable	Impact*	Dependent Variable	References
Age	-	Access	(Loges & Jung, 2001) (Cutler et al., 2003)
	-	Ease of use	(McCloskey, 2006)
	NR	Satisfaction	(Fukuda & Bubb, 2003) (Gagliardi, Mazzarini, Papa, Giuli, & Marcellini, 2008)
	NR	Usefulness	(McCloskey, 2006)
Education	+	Satisfaction	(Gagliardi et al., 2008)
	+	Access	(Cutler et al., 2003)
Experience	+	Learning	(Shoemaker, 2003)
	+	Usefulness	(McCloskey, 2006)
Health	+	Satisfaction	(Gagliardi et al., 2008)
Income	+	Access	(Cutler et al., 2003)
Trust	+	Ease of use	(McCloskey, 2006)

Table 7: Articles studying the impact of Person on Environment
*NR= no relationship; Sourced from Wagner et al. (2010), page 877

2.2.2.2.2 Influence on Person

Although the influence of the Person element has been studied most in this literature, researchers have also been interested in discovering what factors have an influence on Person. As illustrated in Figure 4, a variety of Behavior and Environment factors potentially impacting Person have been examined.

Behavior → Person

This category of study is concerned with how the use of computers by older adults has impacted their personal attributes. Compared to areas of the literature discussed thus far, this particular area has placed more emphasis on validation of results, as summarized in Table 8. While there has been considerable effort toward validation many of the results have been inconsistent, creating some controversy, particularly concerning the impact of computer use on psychosocial indicators. Several studies have found that computer use has a positive impact on psychosocial outcomes; improving general well being, reducing life stress, and loneliness. In some of the cases where positive impacts were not found, researchers indicated that was likely a result of "ceiling effects" of the measures (Chen & Persson, 2002; White et al., 2002; White et al., 1999), meaning that participants had relatively high scores on the measures prior to the intervention and as a result the intervention did not produce statistically significant results. That being said, a review study by Dickinson & Gregor (2006) examined articles which claim that computer use has a positive effect on the well being of older adults. They concluded that the results of these studies were flawed for a variety of reasons

and that computer use in fact did not have a positive impact. It should be noted that many of the papers that support the notion that computer use improves well being are qualitative in nature rather than controlled experiments and thus were not considered by Dickinson & Gregor. While the empirical results may be inconclusive, qualitative descriptions about the impact of computer use on the lives of older adults are generally positive.

Independent Variable	Impact*	Dependent Variable	References
Use	+	Attitudes	(Kubeck et al., 1999) (Kelley et al., 1999) (Czaja & Sharit, 1998) (Osman, Poulson, & Nicolle, 2005) (Smith, 2005) (Lagana, 2008)
	+	Later retirement	(Friedberg, 2003) (Schleife, 2006)
	+	Personal empowerment	(McMellon & Schiffman, 2002)
	+	Self-efficacy	(Lagana, 2008)
	+	Social support	(Cody et al., 1999) (Wright, 2000) (Blit-Cohen & Litwin, 2004)
	+	Well being	(Osman et al., 2005) (Xie, 2007) (Shapira, Barak, & Gal, 2007)
	-	Anxiety	(Cody et al., 1999)
	-	Life stress	(Wright, 2000)
	-	Loneliness	(White et al., 1999) (Bickmore et al., 2005) (Sum, Mathews, Hughes, & Campbell, 2008) (Shapira et al., 2007) (Blit-Cohen & Litwin, 2004)
	NR	Attitudes	(Dyck & Smither, 1996)
	NR	Psychosocial	(Kelley et al., 1999) (White et al., 2002)
	NR	Well being	(Chen & Persson, 2002) (Bickmore et al., 2005) (Dickinson & Gregor, 2006) (Dorin, 2007) (Smith, 2005)

Table 8: Articles studying the impact of Behavior (Use) on Person
*NR= no relationship; Sourced from Wagner et al. (2010), page 877

Another effect of computer use often studied is attitudes toward computers. The findings for this attribute have been much more consistent, almost unanimously indicating that use of computers improves attitudes toward computers among older adults. Studies also suggest that use of computers leads to increased social support. One particularly interesting article discussed the use of computers and the Internet for meeting romantic partners, finding that older adults develop meaningful and long-lasting relationships online (Malta, 2007).

Environment → Person

Studies in this area are concerned with how the system Environment impacts the older adult, as summarized in Table 9. While again there is little validation of results, it seems that high quality systems have a positive impact on the older adult. For example, higher levels of performance and satisfaction have a positive impact on older adults by improving their attitudes and confidence, and reducing their anxiety towards computer use. The support and training provided for the system also seem to be very important, with good support and training leading to higher levels of self-efficacy, confidence, attitudes, and reduced anxiety.

Independent Variable	Impact	Dependent Variable	References
Performance	+	Attitudes	(Czaja & Sharit, 1998)
	-	Anxiety	(Laguna & Babcock, 1997)
Satisfaction	+	Confidence	(Leung, Ko, Chan, Chi, & Chow, 2007)
Support	+	Self-efficacy	(Lam & Lee, 2006)
	+	Confidence	(Osman et al., 2005)
Training	+	Confidence	(Osman et al., 2005)
	+	Self-efficacy	(Hollis-Sawyer & Sterns, 1999) (Segrist, 2004)
	+	Attitudes	(Hollis-Sawyer & Sterns, 1999)
	+	Cognitive abilities	(Gunther, Schafer, Holzner, & Kemmler, 2003)
	-	Anxiety	(Hollis-Sawyer & Sterns, 1999)

Table 9: Articles studying the impact of Environment on Person
Sourced from Wagner et al. (2010), page 877

2.2.2.2.3 Interaction between Environment and Behavior

The relationship between the system Environment and use of computers by older adults has received relatively little research attention thus far.

Behavior → Environment

Research in this area examines how the use of computers impacts the system Environment. The few studies conducted indicate that increased use of computers improves learning outcomes and improves performance, as summarized in Table 10.

Independent Variable	Impact	Dependent Variable	References
Use	+	Learning	(Oermann, Hamilton, & Shook, 2003)
	+	Performance	(Czaja et al., 2001) (Mead et al., 2000)
	-	Technical problems	(White et al., 1999)

Table 10: Articles studying the impact of Behavior (Use) on Environment
Sourced from Wagner et al. (2010), page 878

Environment → Behavior

The articles in this area generally discuss elements of the system Environment that encourage computer use by older adults, as summarized in Table 11. Of particular importance are support and training. As suggested by Aula (2005), access to computers is not sufficient for older adults; they need support and need to be motivated to undertake their first experience.

Independent Variable	Impact*	Dependent Variable	References
Ease of use	NR	Use	(McCloskey, 2006)
Lack of access	-	Use	(Morrell et al., 2000)
Learning	+	Use	(Kelley et al., 1999)
Support	+	Use	(Freese et al., 2006) (Rosenthal, 2008) (Aula, 2005)
Training	+	Use	(White et al., 2002) (White et al., 1999) (Leung et al., 2007) (Trentin, 2004)
Usefulness	+	Use	(McCloskey, 2006)

Table 11: Articles studying the impact of Environment on Behavior (Use)
*NR= no relationship; Sourced from Wagner et al. (2010), page 878

2.3 Literature Gaps

In this literature review, the extant multi-disciplinary literature concerning computer use by older adults has been examined through the lens of SCT. Through this approach, it has been shown that older adults, their computer use, and their computer systems exist in a triadic reciprocality. Observing the literature through this lens demonstrates that there is great potential for future research in this subject area. As illustrated in Figure 4, the influence of Person on Behavior and Environment are the only

two relationships that have received considerable research attention. There remains plenty of opportunity in the other SCT relationships, particularly in those between Behavior and Environment. Literature gaps, or potential research topics, can fairly easily be extracted from Figure 4 in three different ways, as described below.

First, many of the relationships between constructs belonging to the main SCT elements that are studied in one direction could also be studied in the other direction, where appropriate. For example, the impact of computer use (the Behavior construct) on the loneliness of the older adult (a Person construct) has been studied, but could feelings of loneliness also impact computer use?

Second, researchers could identify constructs that have been studied in relationships between two of the main SCT elements for potential relationships with constructs in the third SCT element. For example, the impacts of different Person constructs on Satisfaction (an Environment construct) were considered in a few papers. Researchers could then consider studying the impact of Use (the Behavior construct) on Satisfaction or the impact of Satisfaction on Use.

Third, there are potential constructs belonging to the various SCT elements that are not included in Figure 4 because they have not been observed in the reviewed literature. Researchers could identify such constructs as belonging to one of the main SCT elements and study their relations with constructs in the other two main SCT elements. For example, the level of social presence of the online interface (an Environment construct) has been shown to positively impact antecedents to attitudes

towards shopping web sites using student samples (e.g. Hassanein & Head, 2007). This construct may then be studied to identify its potential impacts on constructs belonging to the other two main elements of SCT (i.e. Person and Behavior) for an older adult population.

This dissertation sought to address some of these gaps in the existing body of literature. The main focus was the impact of age (a Person construct) on usability (an Environment construct). As discussed in section 1.3, the declining spatial ability associated with aging is of particular interest. In terms of Figure 4, the influence of spatial ability is a component of the influence of cognitive abilities, which have received some research attention. Thus, the Person constructs considered in this study (age and spatial ability) are not new to this body of literature.

Recall from section 1.2 that usability is defined as the "effectiveness, efficiency, and satisfaction with which specified users can achieve goals in particular environments" (ISO, 1998, p. 2), and that effectiveness and efficiency are often referred to collectively as performance. Thus, usability is concerned with performance and satisfaction, or more generally, utilitarian (functional) and hedonic (pleasure-related) aspects. In addition to performance and satisfaction, this study considered other utilitarian and hedonic usability constructs that are related to spatial ability. Specifically, the ability to generate an accurate mental representation (utilitarian) and the resulting impact on the disorientation that the user experiences (hedonic) were considered. As Figure 4 demonstrates, mental model accuracy and disorientation have not been

studied in this context before. Thus the third method for identifying research topics as described above is utilized here: the study of constructs that have not been examined in this context to date. Further, some findings already reported in the literature were also validated in this context, such as the impact of age on performance. The next chapter discusses the development of the research model for the experiment and the associated hypotheses in detail.

Chapter 3: Development of Theoretical Model

As the world's population ages and older adults increasingly make use of the Internet, web site usability (encompassing both hedonic and utilitarian aspects) for older adults is increasingly important. Usability for older adults is unique because of the age-related physical and cognitive changes experienced by this group. Declining spatial ability is of particular interest in this context because of the implications for developing a mental representation of a system, as discussed in section 1.3.

This study explores the web site use of older adults through the theoretical lens of usability. This theoretical lens has been applied in previous IS research, such as Venkatesh & Agarwal (2006). As discussed in section 2.3, application of the usability lens involves consideration of both utilitarian and hedonic aspects, and their ultimate impact on user satisfaction. As such, this research sought to answer the following research questions within the context of understanding older adult experiences with web sites:

1. What utilitarian and hedonic usability factors influence user satisfaction?
2. What relationships exist between utilitarian and hedonic usability antecedents to satisfaction?
3. How does age influence the hedonic and utilitarian usability antecedents to satisfaction?
4. How can mental model accuracy be measured and what role does it play in influencing the user experience?
5. How do younger and older adults differ in terms of hedonic and utilitarian usability antecedents of satisfaction?

In order to answer these questions, a causal research model was developed. In this model, age and its associated impact on spatial ability were explored as antecedents to utilitarian and hedonic usability factors. The impact of these usability factors were then examined in relation to user satisfaction.

Utilitarian factors were examined through two constructs: performance and mental model accuracy (MMA). Performance includes measures of both efficiency (time) and effectiveness (score), which is typical in usability studies (Hornbaek, 2006). MMA is a novel construct, included to objectively assess the impact of older adults' declining spatial aptitude on their ability to create an accurate mental representation of the web site structure, and assess the impact of that mental model on their performance and disorientation within the web site. It follows that disorientation is explored as a construct on the hedonic side of the research model. Disorientation is considered a hedonic construct since it is associated with the emotion of frustration (Lazar, Bessiere, Ceaparu, Robinson, & Shneiderman, 2003; McDonald & Stevenson, 1998). Disorientation was found, in a previous IS study (Webster & Ahuja, 2006), to influence both performance and engagement with a web site. On this basis, engagement is also considered in this research as having a hedonic influence on usability.

The research model for this study is shown in Figure 5. The following sections describe the theoretical justification for each of the constructs and associated hypotheses in detail.

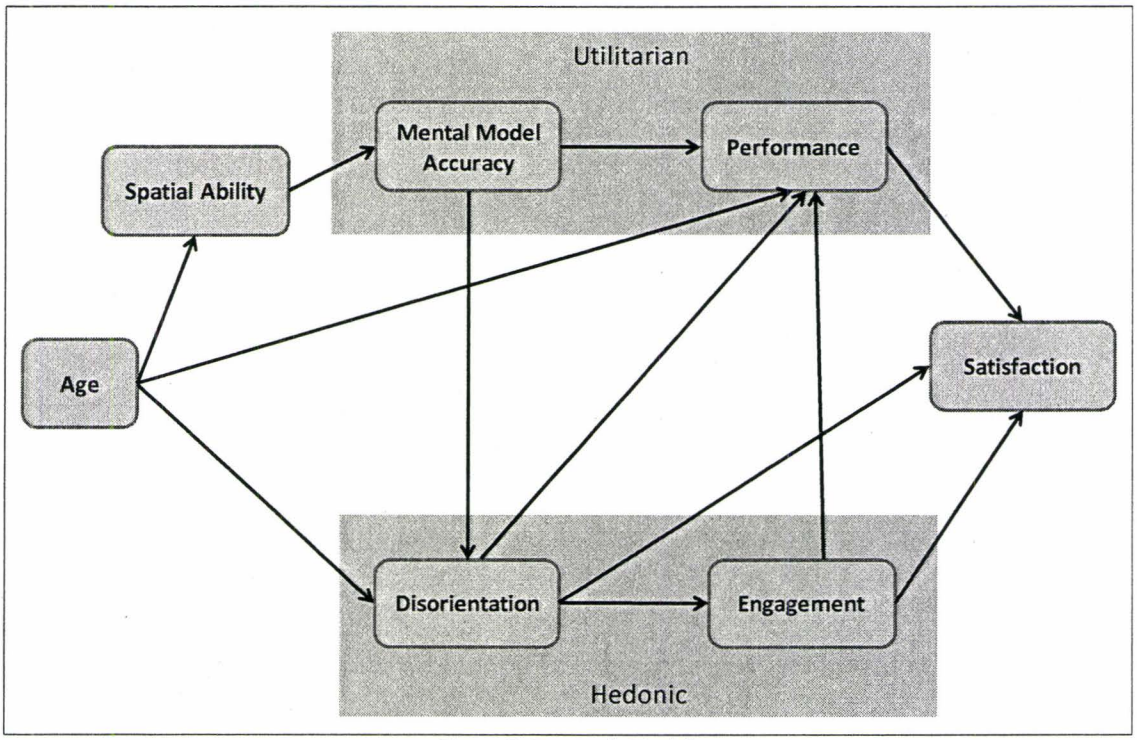


Figure 5: Research Model

3.1 Satisfaction

Satisfaction finds its roots in the Consumer Behavior literature where it has been described as a complex emotional response following an experience with a product (Oliver, 1981). When adapted for the Information Systems (IS) field, satisfaction was described as the "affective attitude towards a specific computer application by someone who interacts with the application directly" (Doll & Torkzadeh, 1988). And finally, when applied to web sites in particular, web site satisfaction is described as "the attitude toward the web site by a hands-on user of the web site" (Muylle, Moenaert, & Despontin, 2004). This final definition of Satisfaction was applied in this research.

As discussed in section 1.2, usability is measured by performance (effectiveness and efficiency) and satisfaction. Satisfaction has been described as being caused by effectiveness and efficiency (Pernice & Nielsen, 2005). Thus, while this research considers all three components of the definition of usability, satisfaction is the most appropriate endogenous construct in the research model.

A great breadth of antecedents of Satisfaction have been studied in the IS literature. Some of these antecedents include information and system quality (Petter & McLean, 2009), perceived benefits and organization support (Mahmood, Burn, Gemoets, & Jacquez, 2000), and usability related considerations such as perceived ease of use (Bhattacherjee, 2001). This study focuses on the usability and user experience domain of antecedents. As in Webster and Ahuja (2006), performance, engagement, and disorientation are all considered. In addition, this study examines the indirect influence of age, spatial ability, and mental model accuracy on satisfaction. As illustrated in Figure 5, the research model explores two paths between age and satisfaction: a utilitarian path and a hedonic path. Each of these will be discussed separately in the following sections.

3.2 Utilitarian Path

3.2.1 Performance

The measurement of user performance is the most common benchmark for usability in hypertext (Otter & Johnson, 2000). As discussed above in section 1.2, the

ISO definition of performance encompasses both efficiency and effectiveness. Further, effectiveness is described as the "accuracy and completeness with which users achieve specified goals" and efficiency as the "resources expended in relation to the accuracy and completeness with which users achieve goals" (Hornbaek, 2006). In this study, effectiveness was characterized by participants' ability to complete search tasks correctly and efficiency was determined by the time taken to complete these tasks. These are standard measures for these considerations in usability studies (Hornbaek, 2006).

3.2.1.1 Performance → Satisfaction

Typically, either satisfaction or performance is the main focus of a usability study. This study also explores the relationship between the two, as some others have done in the past. For example, it has been found that users who were able to use a system with greater efficiency reported higher levels of satisfaction (Simon, Grover, Teng, & Whitcomb, 1996) and users preferred sites in which they performed best (Coyne & Nielsen, 2002; Parton, Huffman, Pridgen, Norman, & Shneiderman, 1985; Pernice & Nielsen, 2005). Therefore it is hypothesized that:

H1: Higher levels of user performance within a web site will lead to higher levels of user satisfaction with the site.

3.2.2 Mental Model Accuracy

In the most general sense, a mental model is "an internal, symbolic representation of some part of the external world" (Danielson, 2003). This symbolic representation aids individuals in understanding, explaining, or predicting how things work (Slone, 2002). These models are acquired through experience and create frames of reference for new experiences (Otter & Johnson, 2000). Mental models can be conceptualized at any number of levels. For example, a computer user may apply the understanding that they have of how one software application works when using a different application; e.g. have a conviction that clicking on the "x" in the top right-hand corner of an application window will generally close the window.

Korthauer & Koubek (1994) propose a framework of mental model development in a hypertext context, shown in Figure 6. In this model the inherent structure, or underlying organization of information embedded in the hypertext, is conveyed to the user through the explicit structure, or navigation structure and links, of the hypertext. Users that are new to a body of hypertext have no mental model of the domain, so they use the explicit structure of the hypertext (navigation structure) to form their own mental model. In this framework, the user's resulting mental model is composed of declarative, structural, and procedural knowledge. Declarative knowledge refers to definitions, facts, data; procedural knowledge refers to understanding how to apply knowledge; and structural knowledge is concerned with organizing declarative and procedural elements into a unified body of knowledge (Korthauer & Koubek, 1994).

Essentially, a hypertext or web site user is learning about the topic and structure of the web site when navigating.

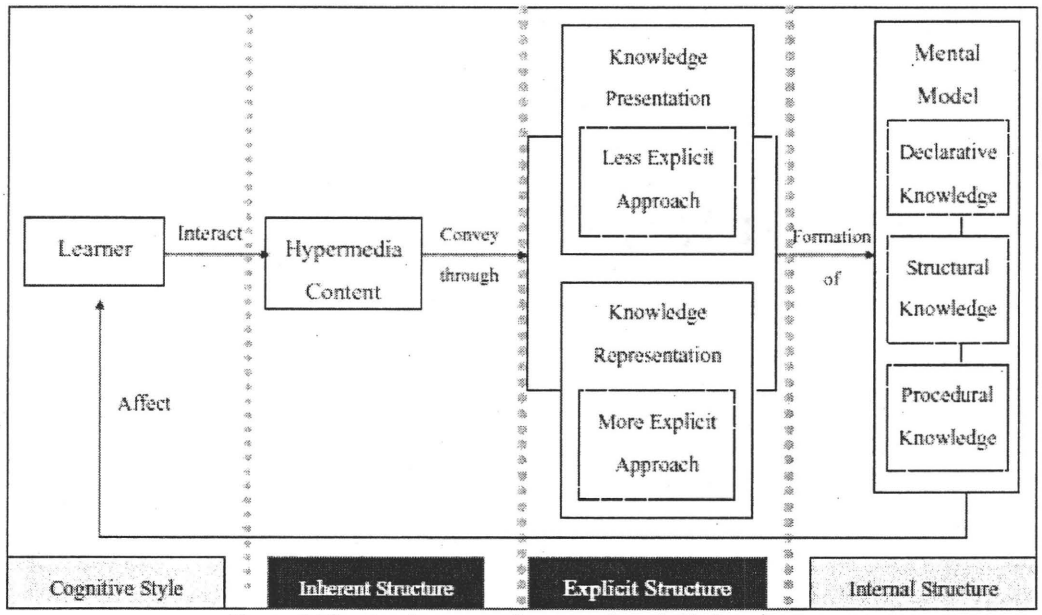


Figure 6: The development of a mental model in hypertext
Sourced from Lee & Boling (2008)

In the context of this study, mental model refers to the users' understanding of the structure of the web site, or how the nodes within the hierarchy of the site relate to one another. In other words, it is their structural knowledge regarding the web site. This is a common definition for the mental model of a web site (Otter & Johnson, 2000; Simpson & McKnight, 1989). As described by Edwards & Hardman (1989), individuals attempt to create cognitive representations of the hypertext structures in the form of a survey-type map. Thus, users with high mental model accuracy have a thorough understanding of the underlying structure of the web site.

3.2.2.1 Mental Model Accuracy → Performance

The accuracy of the mental model that a user develops has been found to impact the effectiveness and efficiency of their navigation in previous studies. In Galletta, Henry, McCoy, & Polak (2006) users' mental model of the subject matter of the web site, as measured by their self-assessed familiarity level, had a positive influence on their performance in the site. In, Ziefle & Bay (2006), users who were provided with structural indicators about the menu structure (i.e. structural knowledge) in a mobile application had better performance. Thus, it is hypothesized that:

H2: Higher levels of mental model accuracy will lead to higher levels of user performance within a web site.

3.2.2.2 Mental Model Accuracy → Disorientation

Disorientation, as described in Woods (1984), occurs when "the user does not have a clear conception of relationships within the system" (Woods, 1984, p. 229). In other words, disorientation occurs when the user has an inaccurate mental model of the system. Users who are familiar with the structure of a web site, or have a more accurate mental model, are less likely to become confused or lost (Galletta et al., 2006; Otter & Johnson, 2000). Thus it is hypothesized that:

H3: Higher levels of mental model accuracy will lead to lower levels of disorientation while using a web site.

MMA is not expected to impact engagement or satisfaction directly, since the development of a mental representation is not a conscious effort while browsing. Rather, the disorientation experienced based on the accuracy of the user's mental model is expected to mediate the relationships.

3.2.3 Spatial Ability

Spatial abilities are cognitive functions concerning an individual's ability to conceptualize the spatial relationships between objects in space (Dillon, Richardson, & McKnight, 1990; Sjolinder, 2006; Westerman, Davies, Glendon, Stammers, & Matthews, 1995). They also enable awareness of location within a space relative to other objects (Sjolinder, 2006). These abilities have obvious relevance for web use, creating the ability to understand the relationships between pages in a web site, and the awareness of which page is currently being viewed in relation to the other pages in the site (Ziefle & Bay, 2006). Spatial abilities are resistant to training and decline as age increases (Salthouse, 1982), which is unfortunate for computer users given the apparent importance of these abilities for computer and internet use as discussed in section 1.3.

3.2.3.1 Spatial Ability → Mental Model Accuracy

Spatial ability is closely related to the notion of a mental model (Höök et al., 1996). In a general context, users with lower spatial ability tend to have more difficulty creating a mental model of an environment (Egan & Gomez, 1985; Kim & Hirtle, 1995; Vicente & Williges, 1988). Spatial abilities specifically advantage navigation

performance by supporting users in constructing a proper mental representation of the systems' structure (Nielsen, 1995). Studies have shown that individuals with low spatial ability were more likely to report being lost within the structure of a system because they could not understand it (Ziefle & Bay, 2006), which implies that their mental model was poor. Therefore it is hypothesized that:

H4: Higher levels of spatial ability will lead to higher levels of mental model accuracy.

Since spatial ability is so closely related to mental models, it is expected that the effects of spatial abilities on the remaining constructs in the model will be fully mediated by MMA.

3.3 Hedonic Path

3.3.1 Engagement

Engagement is a construct that has been described in a variety of ways in the IS literature. Historically, it has been used fairly interchangeably with concepts like cognitive absorption, flow, and playfulness. These constructs have considerable overlap and all represent intrinsic motivation (Agarwal & Karahanna, 2000). While engagement received relatively little research attention for a period of time, there has been a resurgence of activity on the topic as researchers attempt to reduce the ambiguity surrounding the construct (O'Brien, 2010; O'Brien & Toms, 2008, 2010; Scott & Walczak, 2009).

Scott & Walczak (2009) provide a means for distinguishing between engagement, cognitive absorption, flow, and involvement in a table in their article, reproduced in Table 12. All four of the constructs involve the attention element, which is the only requirement for Involvement. The remaining three constructs all involve some description of enjoyment (intrinsic interest, pleasure), which has also been described as a sense of playfulness (Webster & Martocchio, 1993). Engagement and cognitive absorption also share the attribute of curiosity. And finally, cognitive absorption and flow also involve control and temporal dissociation.

Attribute	Engagement	Cognitive Absorption	Flow	Involvement
1. Attention	Attention focus	Focused immersion	Total absorption	Attention focus
2. Enjoyment	Intrinsic interest	Heightened enjoyment	Pleasure and enjoyment	
3. Curiosity	Curiosity	Curiosity		
4. Control		Control	Control	
5. Temporal dissociation		Temporal dissociation	Transformation of time	

Table 12: Differentiation among Engagement, Cognitive absorption, Flow, and Involvement Constructs
Sourced from Scott & Walczak (2009)

Agarwal & Karahanna (2000) define these attributes as follows:

- Focused immersion (attention)- the experience of total engagement where all other attention demands are ignored
- Enjoyment: the extent to which an IT activity is perceived to be enjoyable in its own right, apart from any performance consequences
- Curiosity: the extent that the experience arouses a user's sensory and cognitive curiosity
- Control: the user's perception of being in charge of the interaction
- Temporal dissociation- inability to register the passage of time when engaged

Although the above concepts are quite similar, engagement is the most appropriate construct to use in the context of this study, as it was in Webster & Ahuja (2006). Since the participants in this study will be participating in experimenter-directed (as opposed to self-directed) web searches, there will be reduced control over the interaction. Also, since the exposure to the experimental web site is quite limited, temporal dissociation is unlikely. Both of these aspects of this study make cognitive absorption and flow less appropriate constructs than engagement. Although enjoyment (Li, Hsieh, & Rai, 2009) and playfulness (Moon & Kim, 2001) are often used to measure intrinsic motivation, they are conceptually included in this definition of engagement. Further, engagement's inclusion of attention focus is intriguing in the study of older adults since some aspects of attention have been shown to decline with age (Whitbourne, 2002).

Since engagement has been described by a variety of terms in the literature, past research findings concerning constructs named as enjoyment, positive affect, playfulness, flow may be relevant to the hypothesis development surrounding engagement. Further, enjoyment is described as the opposite of frustration (Blythe, Reid, Wright, & Geelhoed, 2006), making frustration a relevant term also.

3.3.1.1 Engagement → Satisfaction

As discussed at the beginning of this chapter in section 3.0, Webster & Ahuja (2006) provide the motivation for including engagement in this research model. In their

study, they hypothesized and confirmed that engagement related positively to future intention within the context of e-learning. It is expected that engagement will relate positively to satisfaction in the current study since satisfaction and future intention are related constructs. Both Doll & Torkzadeh (1988) and Bhattancherjee (2001) found that satisfaction is indicative of future intention.

Engagement and its related constructs (as described above) have consistently been found to indicate future intention. Experimental studies have shown that intrinsic motivation (Davis, Bagozzi, & Warshaw, 1992), enjoyment (Agarwal & Karahanna, 2000; Childers, Carr, Peck, & Carson, 2001; Davis et al., 1992; Koufaris, 2002; Turel, Serenko, & Bontis, 2010), cognitive absorption (Agarwal & Karahanna, 2000), affective appraisal (which includes enjoyment) (Lee & Kozar, 2009), and playfulness (Moon & Kim, 2001) each contribute to usage intentions.

Although studies explicitly examining engagement and satisfaction could not be found, a number of studies examining engagement-related constructs indicate that a positive relationship with satisfaction is likely. For example, cognitive absorption (Roca, Chiu, & Martinez, 2006), cognitive involvement (Patwardhan, 2004), and playfulness (Lin, Wu, & Tsai, 2005) have each been found to lead to satisfaction. Since engagement and its related constructs have been found to consistently influence both satisfaction and the related construct of future intention, it is hypothesized that:

H5: Higher levels of user engagement with a web site will lead to higher levels of user satisfaction with the site.

3.3.1.2 Engagement → Performance

Webster & Ahuja (2006) also hypothesized and confirmed that engagement related positively to performance within an e-learning context. As discussed in Webster & Ahuja, previous studies examining the relationship between engagement and performance were not found. There have, however, been studies examining the relationship between related concepts such as flow and enjoyment (Trevino & Webster, 1992; Webster & Martocchio, 1995) and performance, where the engagement-related concept had a positive relationship with performance. Thus it is hypothesized that:

H6: Higher levels of user engagement with a web site will lead to higher levels of user performance within the site.

3.3.2 Disorientation

The discussion of disorientation in hypertext came to the forefront of hypertext research in 1987 with Conklin's seminal article, "Hypertext: An Introduction and Survey" (Conklin, 1987). In this article he presented a review of existing hypertext systems at that time and described their advantages and disadvantages. Here "disorientation" or "getting lost in space" was identified as the main inherent disadvantage of hypertext, one so serious that it "may in fact ultimately limit the usefulness of hypertext" (p. 38). Disorientation in hypertext is generally conceptualized as not knowing where to go next, knowing where to go but not how to get there, or being unaware of location within the structure (Danielson, 2003; Lee & Boling, 2008; Webster & Ahuja, 2006). Despite

research efforts to date to reduce disorientation through interface design elements, disorientation remains a significant issue with web navigation (Ahuja & Webster, 2001; Otter & Johnson, 2000; Webster & Ahuja, 2006).

Most often, disorientation is estimated through objective action-based measures such as number of repeated visits to a particular node during the same search task. Some argue, however, that disorientation is best measured by user perceptions since this relates to their understanding of the structure of the web site and how the site works (Otter & Johnson, 2000; Webster & Ahuja, 2006). For instance, users exploring the content of a web site may be rated as disoriented based on their page viewing behaviors even though they may be experiencing no feelings of disorientation (Smith, 1996). In fact, it has been argued that beliefs, or subjective measures, are meaningful in their own right since there are often differences between perceived and actual measures (Davis, 1989). For example, a user that perceives their performance to be poor is less likely to use an application, regardless of their actual performance (Davis, 1989). This inclination to act according to beliefs will likely apply in the realm of disorientation. If a user perceives that they are disoriented while using a web site, they are less likely to experience satisfaction with the site, regardless of the implications of their objective disorientation measures. Thus, the notion of perceived disorientation will be used in this study.

3.3.2.1 Disorientation → Satisfaction

The relationship between disorientation and satisfaction has not yet been studied in experimental research. Perceived disorientation is a conceptually similar yet distinct construct to perceived ease of use (PEOU) in that if a web site is easy to use, a user is less likely to feel lost (Ahuja & Webster, 2001). Thus, studies concerning PEOU and satisfaction are relevant here also. A review by Roca et al. (2006) found several studies where PEOU led to satisfaction, which was also confirmed in their own study and Sjolinder (2006). Since PEOU is conceptually similar to disorientation, it is hypothesized that:

> *H7: Higher levels of disorientation while using a web site will lead to decreased user satisfaction with a site.*

3.3.2.2 Disorientation → Performance

As discussed earlier, objective measures of disorientation examine apparent inefficiencies in user navigation. By definition, less efficient navigation results in poorer performance, indicating a causal relationship between objective measures of disorientation and performance (Galletta et al., 2006; Lee & Boling, 2008; McDonald & Stevenson, 1996; Otter & Johnson, 2000; Roca et al., 2006). Interestingly, some studies have found that the relationship between perceived disorientation and performance is stronger than the relationship between objective measures of disorientation and performance (Ahuja & Webster, 2001; Otter & Johnson, 2000). Thus it is expected that

participants that perceive themselves to be disoriented will have poorer performance in this study and hypothesized that:

H8: Higher levels of disorientation while using a web site will lead to decreased user performance with the site.

3.3.2.3 Disorientation → Engagement

Disorientation is expected to influence engagement such that users who feel more disorientation will be less engaged with the web site as in Webster & Ahuja (2006). Although disorientation has not been studied elsewhere with engagement, it has been studied with engagement-related constructs. Disorientation can lead to loss of interest in a web site (McDonald & Stevenson, 1998), abandonment or disengagement with a site (Ahuja & Webster, 2001; Jacques, Preece, & Carey, 1995), and frustration (Lazar et al., 2003; McDonald & Stevenson, 1996).

Perceived disorientation is a conceptually similar yet distinct construct to perceived ease of use (PEOU) (Ahuja & Webster, 2001). Thus, studies concerning PEOU and engagement-related constructs are relevant here also. Jacques et al. (1995) assert that if users of a web site do not feel that it is easy to navigate or are uncomfortable with its structure, they will not be sufficiently engaged. A number of studies have also shown that a web site that is difficult to use is a barrier to engagement (O'Brien & Toms, 2008). Further, PEOU has been shown to influence enjoyment (Agarwal & Karahanna, 2000; Roca et al., 2006; Venkatesh, 2000; Yi & Hwang, 2003) and playfulness (Chung &

Tan, 2004; Moon & Kim, 2001), which are engagement-related constructs. Therefore it is hypothesized that:

H9: Higher levels of disorientation while using a web site will lead to decreased engagement with the site.

3.4 The Influence of Age

As discussed in the literature review in Chapter 2, age has been shown in empirical research to impact computer use in a variety of ways as a result of changes caused by the natural process of aging. Based on this previous research, several hypotheses are made in this section in conjunction with age. Since age was a central focus in this study, it was appropriate to include an age construct in the research model, as was done in McCloskey & Leppel (2010). In some cases, however, prior research does not exist as a foundation for hypothesis between age and other model constructs. In particular, there has been a lack of research concerning the impact of age on hedonic constructs. Thus no hypotheses are proposed between age and engagement or satisfaction. In the case of satisfaction, two previous studies found no relationship with age (see Table 7 for details), suggesting that the full mediation of the relationship between age and satisfaction proposed in this research may be more appropriate.

3.4.1 Age → Spatial Ability

The decline of spatial ability with age has been well documented, as discussed in section 3.3 and summarized in (Ziefle & Bay, 2006). Spatial abilities have consistently

been found to increase during adolescence, reach their peak during the second or third decade of life, and decrease steadily after that (Salthouse, 1982). Thus, it is hypothesized that:

H10: Older adults will exhibit lower levels of spatial ability than younger adults.

Older adults tend to have more difficulty creating an accurate mental model than younger adults (Sjolinder et al., 2005). This difficulty is associated with the age-related decline in spatial ability; therefore the relationship between age and MMA is fully mediated by spatial ability in the research model.

3.4.2 Age → Performance

As summarized in Chapter 2, a large portion of the literature concerning computer use by older adults focuses on performance evaluation. Although performance is measured in a number of ways (including measures of efficiency and effectiveness; see Table 6 for details), there is consistent evidence that performance declines as age increases, including in a web site context. Therefore it is hypothesized that:

H11: Older adults will have lower levels of performance within a web site than younger adults.

3.4.3 Age → Disorientation

General web usability studies have found that disorientation is more severe for users with deterioration in cognitive function, such as older users (Ziefle & Bay, 2006).

This is related to the fact that it is more difficult for older user to learn the spatial structure of new environments, and thus tend to become disoriented (Lin, 2003a). Several studies have found disorientation to be more severe for older users than younger ones. For example older users had more difficulty recalling previous actions and the locations of previously viewed information and they returned to previously visited pages while performing a single search task significantly more often than younger adults (Agarwal & Karahanna, 2000; Lin, 2003a, 2004; Mead et al., 1999; Meyer, Sit, Spaulding, Mead, & Walker, 1997; Morrell et al., 2003; Pernice & Nielsen, 2005). Also, older users tended to require more navigational steps to accomplish the same task (Fukuda & Bubb, 2003; Meyer et al., 1997) and attempted unsuitable navigation steps such as clicking on a navigational link for the page they are currently on (Chadwick-Dias, McNulty, & Tullis, 2003). While most studies compare the disorientation of older and younger users on objective measures, older adults have also been shown to exhibit higher levels of perceived disorientation (Pernice & Nielsen, 2005). Therefore it is hypothesized that:

H12: Older adults will perceive higher levels of disorientation while using the web site than younger adults.

Chapter 4: Methodology

In order to test the theoretical model discussed in the previous chapter, a laboratory experiment was conducted. Ethics approval was obtained prior to running the pilot and full studies. This chapter describes the experiment in detail.

4.1 Participant Groups

Since exploring the differences between older and younger users is of primary concern of this study, participants across a wide age range were recruited for the experiment. Specifically, half of the participants were between the ages of 18 and 35, and the other half were over 55. These age groups were selected based on the age at which declines in spatial ability occur. Since decline begins after the third decade of life (Salthouse, 1982), significant differences between the older and younger groups on this important measure were expected.

4.2 Experimental Web Site

Measurement of the participants' mental model development required that participants had not seen the experimental web site before, thus a new web site was designed and built for this experiment. The content chosen for the experimental web sites was healthy living information. In their review, Wagner et al. (2010) discussed a number of web site experiments using older and younger participants. Although the content of the web sites in the experiments varied widely, health information was one

domain used in multiple studies. It is believed that this topic should have fairly equal appeal to the older and younger participants in this study. Although Otter & Johnson (2000) suggest that disorientation does not appear to be related to the content of hypertext, it is relevant in this study since users' engagement is often triggered when the topic is of personal interest (O'Brien & Toms, 2008).

Selecting the breadth and depth of the web site structure was an exercise in balancing between being complicated enough to create some variance in measures of perceived disorientation and simple enough to make it possible for participants to complete the Mental Model Accuracy (MMA) exercise (which is described in detail in section 4.4 below) in a timely fashion. Users tend to have increasing difficulty with disorientation as depth increases (Galletta et al., 2006). Although an ideal depth or breadth of a web site cannot be determined (Galletta et al., 2006), "when the depth goes to four or five (levels), there is a good chance of users becoming lost or disoriented" (Shneiderman, 1998 p. 249). The structure of the final version of the site is shown in Figure 7. The first version of the site had nine additional pages, which created a fourth level in the third section of the site. This simplification was made when the first two participants in the pilot study (discussed further in section 4.7) found the MMA exercise too onerous. The site is purely hierarchical (each page has only one parent) to facilitate the MMA exercise.

The experimental web site is called "HealthyBurlington.ca". A description of the content from the site's homepage is shown in Figure 8. Once the content for the site

was developed, a panel of six subject matter experts was consulted to judge content for correctness, logic of layout, and appropriateness of labels. Each expert self-assessed their level of knowledge at five or six on a seven point scale, which indicates a high level of expertise. No significant changes were suggested for the content.

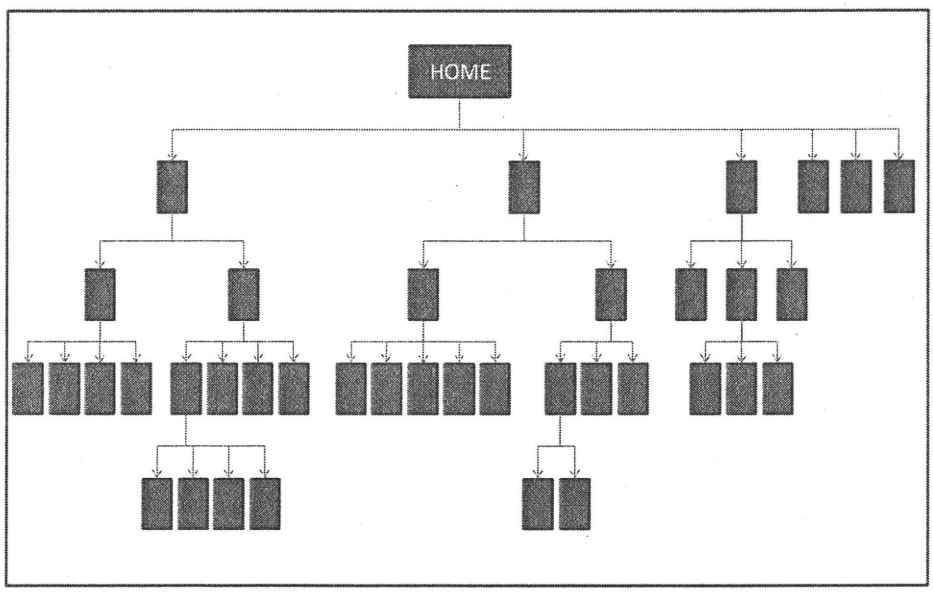


Figure 7: Underlying page structure of experimental web site

HealthyBurlington.ca is a guide to local options for healthy living. If you're interested in learning more about healthy living options in the Burlington, Ontario area then you've come to the right place.

Visit our **Healthy Food** section to discover local options for healthier food choices, such as where to find organic produce.

Visit our **Healthy Activity** section to learn about local options for getting active, such as where to find hiking trails.

Visit our **Healthy Nutrition** section for information on a variety of healthy living topics.

Visit our **Healthy Events** section to find out about current local events related to healthy living.

Join our **Healthy Community** to get on our mailing list and receive regular information from our local healthy living partners.

Contact Us to let us know about local options that we may have missed or any other ideas that you have to make our site better.

Figure 8: Description of experimental web site's content

In an effort to increase the generalizability of the findings across different types of popular web site navigation schemes, two versions of the web site were developed. Each site had identical content, labels, and underlying structure, but different navigation layouts. The navigation layouts reflect the two basic variations of the standard hierarchical structure: expandable and non-expandable hierarchies (Zaphiris, Kurniawan, & Ellis, 2003). The Menus layout is non-expandable and the Tree layout is expandable. In the Menus layout, the navigation options available to the user are found along the top and left hand side of the screen, as shown in Figure 9. The options on the top of the screen allow the user to select from pages on the same hierarchical level as the page that they are currently viewing, while the options on the left of the screen allow the user to navigate down to the next level. The current page is indicated by the absence of a link (its label is not underlined) as well as the title on the page in blue font.

In the Tree layout, the navigation options available to the user appear as a collapsible tree on the left hand side of the page as shown in Figure 10. Users can expand the tree by clicking on the "+" or the label of the page they wish to navigate to. The content on the right hand side of the page changes only when a label is clicked. Thus the user may expand the tree to view the page labels without necessarily viewing the content of the associated pages. In this layout, the current page of the user is indicated solely by the title in blue font since they are able to choose which labels are visible on the left hand side.

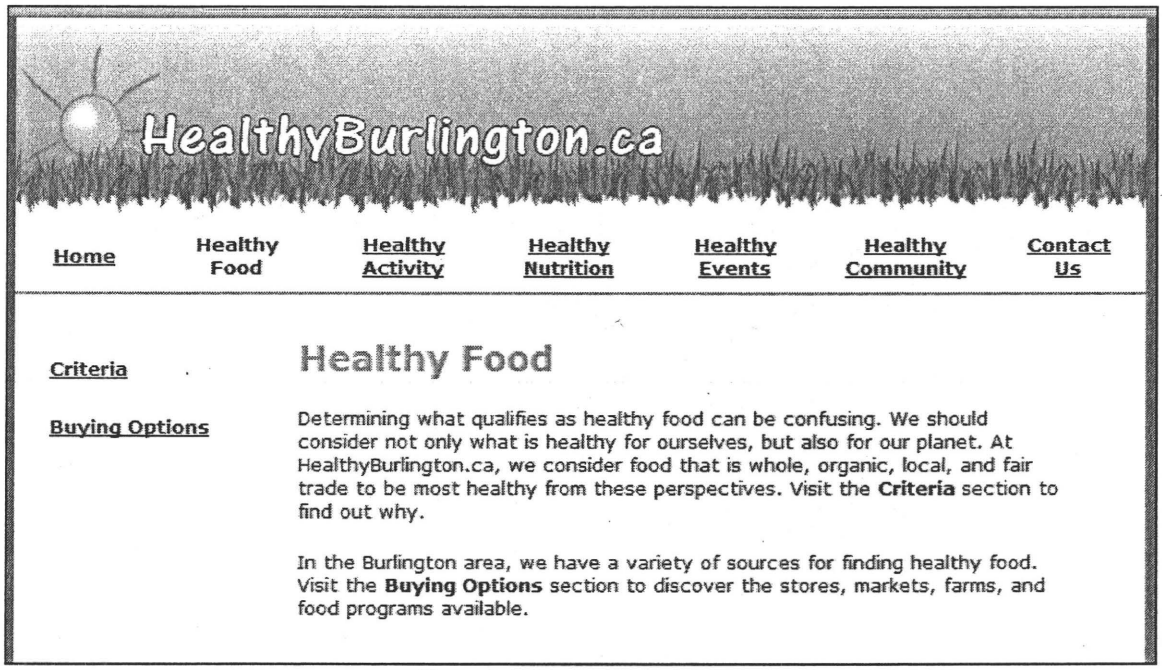


Figure 9: Menus web site layout

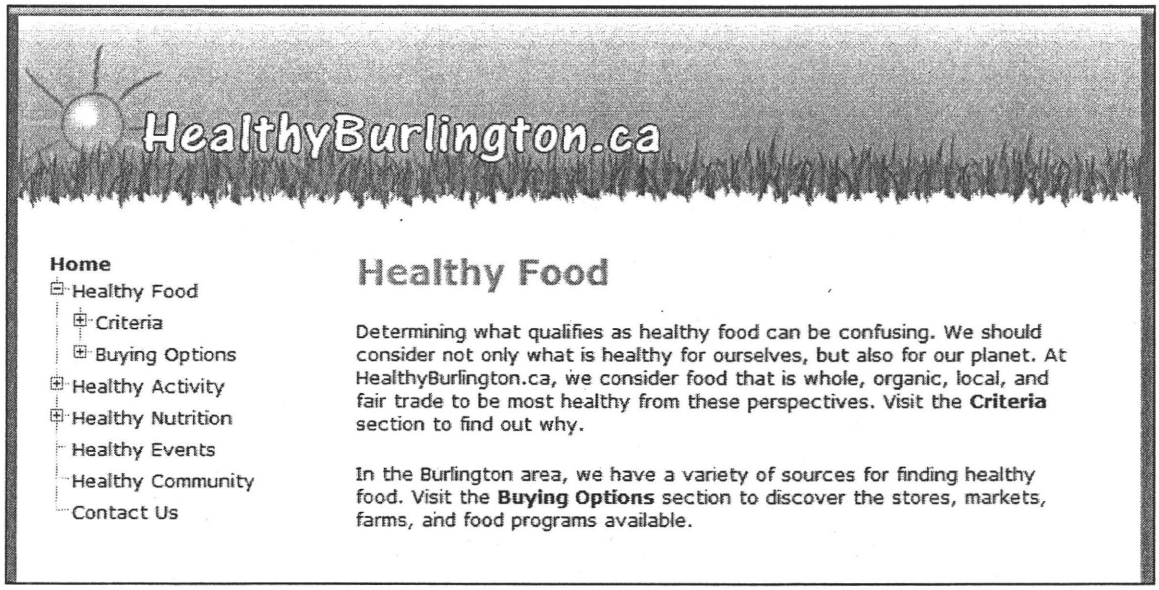


Figure 10: Trees web site layout

Usability guidelines were consulted in the development of the site including Zaphiris et al. (2007) and Morell (2005) to ensure that the web sites did not

disadvantage older adults. This includes aspects such as font size and colour, background, contrast, etc.

4.3 Experiment Procedure

Upon arriving at the experiment site, participants were provided a brief description of the experiment and presented with a consent form. The experimenter walked through the content of the consent form with the participant, which described the experimental procedure in more detail. The participant was asked to sign and date the form for the experimenter to retain and was provided with a copy for them to keep for their reference.

Next, the participant completed a demographic questionnaire, which asked questions concerning their gender, age, well being, Internet experience, education, and subject matter expertise. The questionnaire can be found in Appendix C.

The two assessments of spatial ability were administered next, one at a time (see Spatial Ability in section 4.4 for further details). Each assessment consisted of three sheets of paper: instructions followed by two pages of exercises. Participants were requested to read through the instructions and ask the experimenter any questions they had about how to do the exercises. When the participant was ready to begin, they were given three minutes to complete each page of exercises, as prescribed by the measurement test. Participants were warned prior to completing the exercises that most people are only able to complete about half of each page in an effort to reduce the

stress that may result from perceptions of poor performance, particularly among the older participants (Dickinson et al., 2007).

Next, participants were provided with a laptop (with the experimental web site open in the browser) and instructed to explore the web site for five minutes. This length of time was deemed to be reasonable as a result of the pilot study (discussed in detail in section 4.7). The web site files were stored locally on the laptop to ensure fast and consistent navigation. The specific instructions provided to participants were that they wanted to get a feel for how the web site worked and what sort of information was in it, and that next they would be asked to do some specific search tasks in the site. In some cases participants indicated that they did not need the full five minutes, but they were asked to continue browsing for consistency between participants. Once five minutes had passed, the participant was asked to return to the home page to begin the tasks.

In total, six tasks were given to the participants, one at a time. The tasks served two purposes: to generate performance data and to ensure site coverage for the MMA exercise. The tasks were simple questions whose short (one word, number or phrase) answer could be found on one page of the web site. The questions were:

1. How many yoga studios are listed in Burlington?
2. What is an example of a whole food?
3. How many regional conservation areas are located near Burlington?
4. What is one of the health benefits associated with vegetarianism?

5. Are there any natural food stores located in Dundas? (circle one) Yes No

6. What is the first principle of organic agriculture?

These questions were selected to ensure that the participants visited all of the deeper levels of the web site at least once. To illustrate, the location of the correct response for each question is indicated on the hierarchy in Figure 11.

For each of the six tasks, the participant was instructed to read the question, find the answer in the web site, write their answer on the slip of paper provided, and return to the home page to indicate that they are finished. The order of the tasks was consistent across participants to enable comparison between participants. The experimenter recorded the time from when the participant was provided with the task until they returned to the home page.

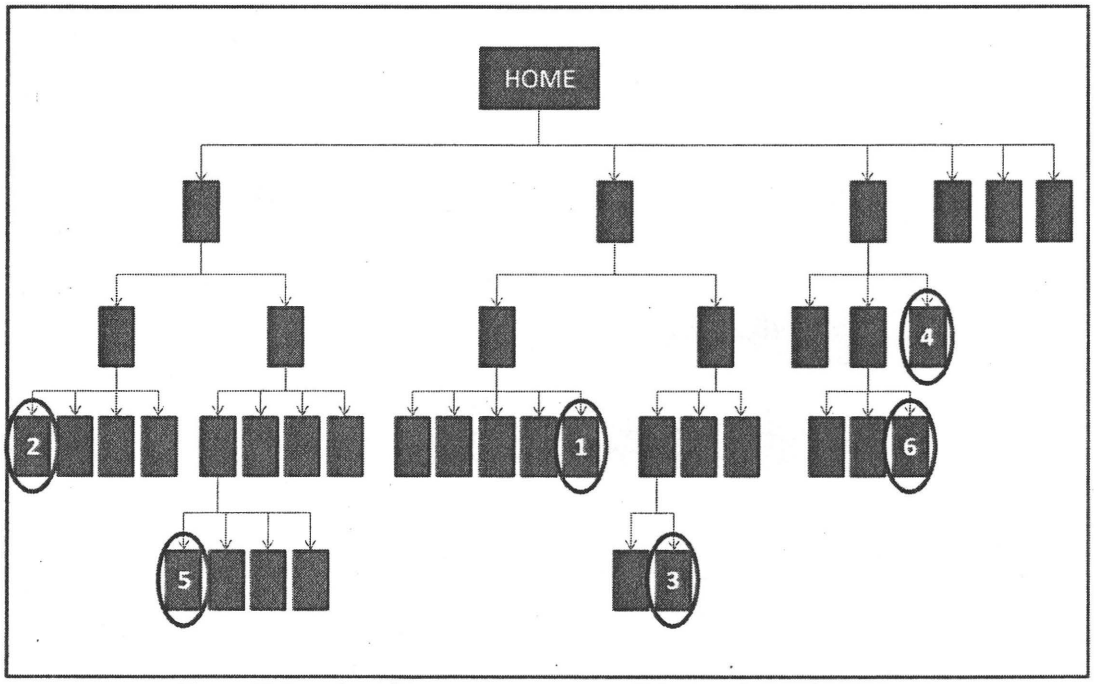


Figure 11: Location of correct task answers within experimental web site

Once the tasks were completed, the participant moved on to the MMA exercise. Here they were provided with a large magnetic white-board and a set of 39 small cards with magnets on them. Each card had the label from one of the pages in the web site on it. Participants were instructed to arrange the cards on the board in order to recreate the hierarchy of the web site as they understood it. Similar methodology has been used in previous studies (Edwards & Hardman, 1989; Otter & Johnson, 2000; Simpson & McKnight, 1989). Participants were assured that the order of pages within a section was not important and they should only be concerned with creating the correct parent-child relationships between the pages. Participants were allowed up to fifteen minutes to complete the exercise. This length of time was deemed to be reasonable as a result of the pilot study. Once the participant had completed this exercise, the experimenter drew lines on the white board (in consultation with the participant) to illustrate the relationships between the pages, and took a digital photograph of the participant's solution for later scoring.

Finally, participants were asked to complete the post-experiment questionnaire. This questionnaire collected their responses concerning the perceived constructs in the research model (disorientation, engagement, and satisfaction) and a few other items concerning their experience with web sites of similar content and structure. The full questionnaire can be viewed in Appendix D. Once the final questionnaire was complete, participants were compensated $15 for their time and thanked for their participation.

4.4 Operationalization of Constructs

The constructs in this study are both formative and reflective in nature. Age, spatial ability, mental model accuracy, and performance are modeled as formative, while disorientation, engagement, and satisfaction are modeled as reflective. A summary of the scales and their associated items is provided in Appendix E.

The constructs in this study are also both objective and subjective in nature. A balance between objective and subjective measures is particularly important when conducting experiments with older adults since self-reports of older adults are more likely to be inconsistent with observations than those of younger adults (Dickinson et al., 2007).

Age

For purposes of the research model, age was operationalized by asking the participant for their chronological age. However, to enable more detailed exploration of the impact of age in the post-hoc analysis, other conceptualizations of age were also collected. As discussed in Kooij et al. (2008), chronological age is one of five conceptualizations of aging. Other conceptualizations include functional (performance based), subjective (perceived), organizational (in an employment context), and life span. Here the functional and subjective conceptualizations were relevant as they may relate to utilitarian and hedonic factors, respectively. Subjective Age was collected by asking

the participant how old they feel, and Functional Age was collected by asking the participant about their health status, as described in Kooij et al. (2008).

Spatial Ability

Although a great variety of tests of spatial ability exist (Eliot & Smith, 1983), these tests can be clustered into three categories (Sjölinder, 1998, p. 48):

1. Spatial perception: the ability to determine spatial relations despite distracting information
2. Spatial visualisation: the ability to manipulate complex spatial information when several stages are needed to produce the correct solution
3. Mental rotation: the ability to rotate, in imagination, quickly and accurately two- or three-dimensional figures, while maintaining orientation

Two aspects of spatial ability have been determined to be most relevant for technology-based performance: spatial orientation (i.e. mental rotation) and spatial visualization (Wu, Zhang, & Zhang, 2009). In this study, two tests were chosen from Ekstrom et al.'s (1976) Kit of Factor-Referenced Cognitive Tests: *VZ-2: Paper Folding* was selected for spatial visualization and *S-1: Card Rotations* was selected for spatial orientation. These tests have been commonly used in the Information Systems literature (Ziefle & Bay, 2006). The full tests, including instructions and exercises, are shown in Appendix F. As recommended by the publisher of the tests, the participants score for each assessment is the percentage of questions answered correctly on each assessment.

Mental Model Accuracy

MMA was assessed by asking participants to recreate the hierarchy of the web site using cards on a whiteboard. When this methodology has been used in the past (Edwards & Hardman, 1989; Otter & Johnson, 2000; Simpson & McKnight, 1989) scoring was done by giving one point for each card linked to the correct parent. Attempting this method with the pilot study data revealed some issues. Specifically, the ranking of participants created by this scoring method was not consistent with the experimenter's perceptions of the participants' mental model accuracy. In particular, the participant whose web site representation appeared almost entirely correct was scored at only 64%. The issue was that having an error in the upper level of the hierarchy created a number of cards that had incorrect parents, regardless of the correctness of the representation in the lower levels of the hierarchy. Thus, a new evaluation method was sought that would give appropriate credit for this lower level correctness.

The method selected for scoring the MMA exercise was Tree Edit Distance. This method is used in a variety of disciplines for calculating the difference (or distance) between two hierarchical trees (Bille, 2005), but had not been used previously for assessing users' mental model of a web site. Essentially, a tree distance algorithm calculates the number of moves required to get from one tree to the other, or in this case from the participants hierarchy to the correct hierarchy. To implement this scoring method, a java applet was acquired which implements Zhang and Shasha's (1989)

algorithm for ordered trees. Processing each participant's tree involved the following steps:

1. Label the pages of the participant's hierarchy with the appropriate page letters. These letters are derived from the correct hierarchy, which has been labelled (from top to bottom, left to right) with letters from a-z and aa-mm. A sample labelled participant tree is illustrated in Figure 12.

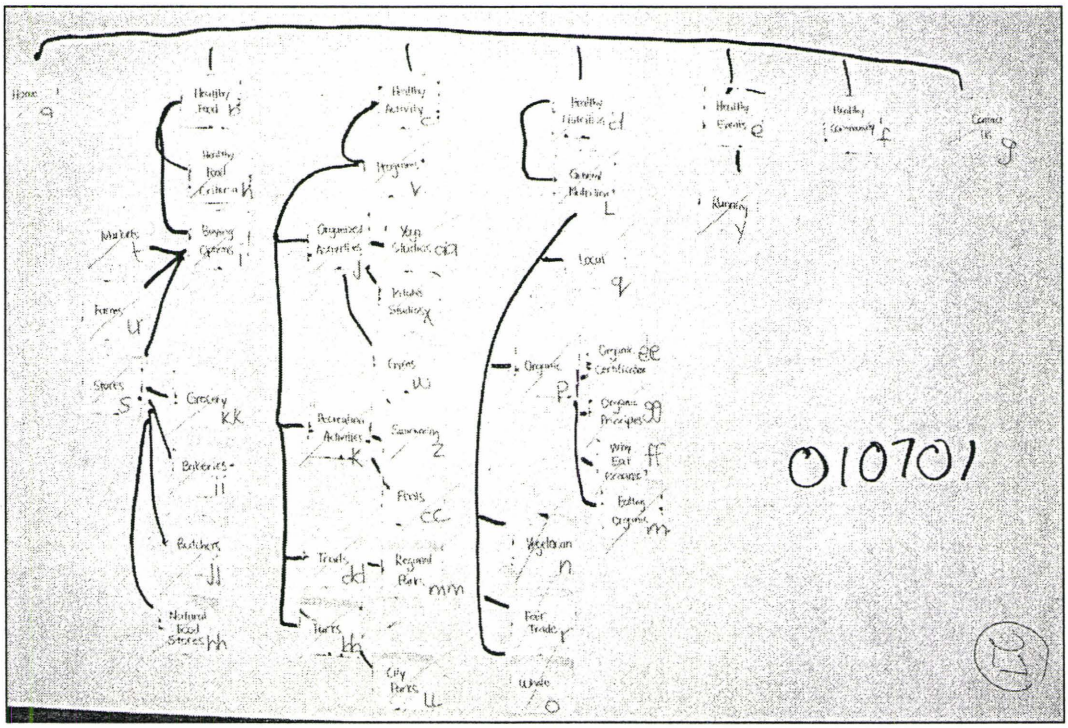


Figure 12: Sample labeled participant tree

2. Redraw the participant's hierarchy taking order into consideration (since the algorithm processes ordered trees, this will prevent penalizing for order when that was not required of the participants). Essentially, this means that the hierarchies were redrawn with the sibling pages in the correct order in cases

that they were not, and in a more consistent format. Figure 13 illustrates the sample tree from Figure 12 once redrawn.

3. Create groups of correct pages in the participant's hierarchy, label each group with the lowest letter of the grouped pages; create the corresponding group on the correct hierarchy. This grouping is what eliminates the problem discovered in the pilot analysis, since each group (rather than each page) will be counted as a move toward the correct hierarchy. Figure 13 illustrates how the sample participant tree from Figure 12 looked after being redrawn as an ordered tree and having the pages grouped. Figure 14 illustrates how the same groupings were made on the correct tree.

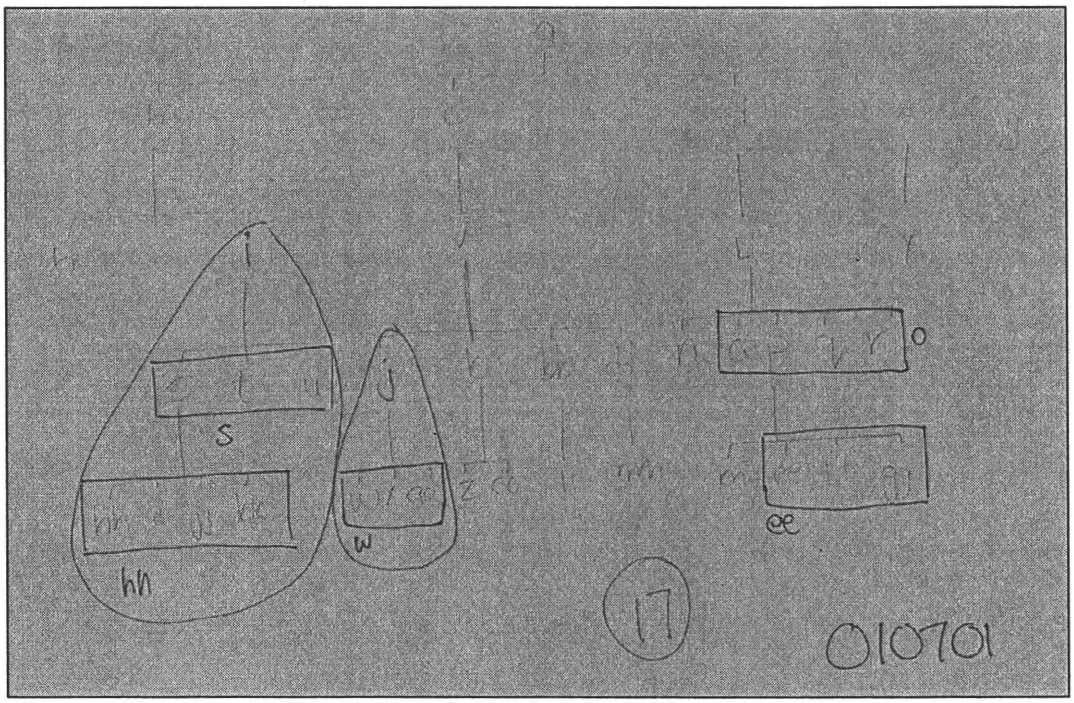


Figure 13: Sample participant tree with groupings

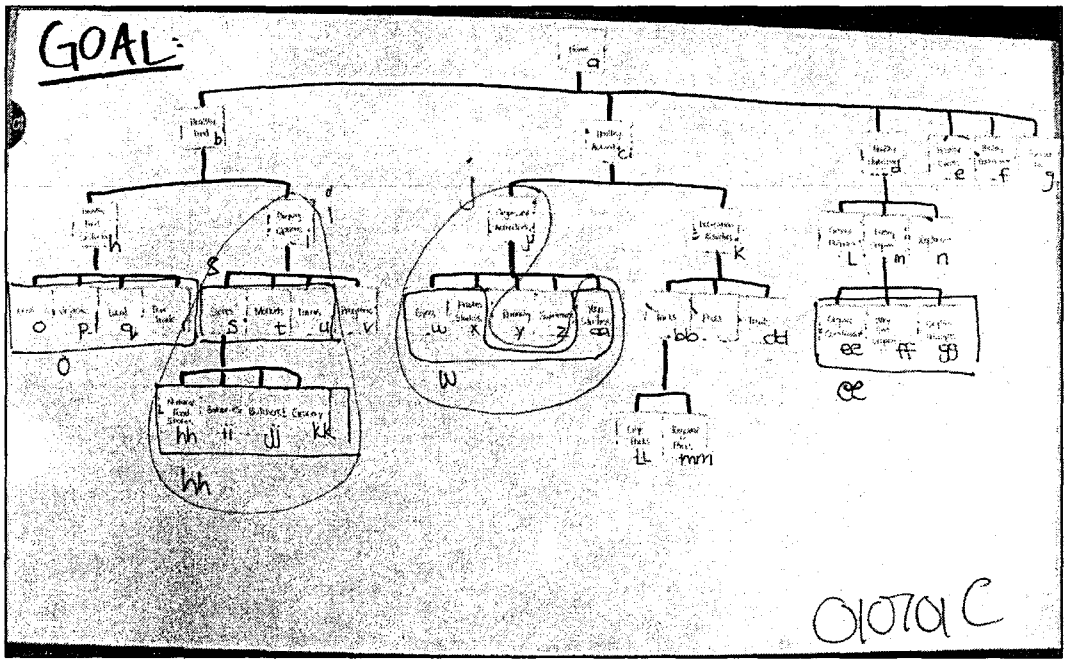


Figure 14: Correct hierarchy with groupings

4. Create the character strings for the resulting participant and correct hierarchies for entry into the tree distance algorithm. These character strings summarize the parent-child relationships in each tree and are in the form "from_node-to_node;". The resulting character strings for the sample participant are shown in Figure 15.

correct:	a-b;a-c;a-d;a-e;a-f;a-g;b-h;b-i;c-j;c-k;d-l;d-m;d-n;h-o;i-v;j-y;j-z;k-bb;k-cc;k-dd;m-ee;bb-ll;bb-mm
participant:	a-b;a-c;a-d;a-e;a-f;a-g;b-h;b-i;d-l;e-y;c-j;c-k;c-bb;c-dd;l-n;l-o;k-z;k-cc;bb-ll;dd-mm;o-m;o-ee
distance:	17

Figure 15: Participant and correct character strings

5. Run the algorithm, which will result in a tree distance number. The lower the number, the more accurate the participant's tree.

Performance

As discussed earlier, performance in this study is assessed along two criteria: efficiency and effectiveness. Efficiency is defined as the speed with which the participant completed the search tasks, or their total task time as recorded by the experimenter. Effectiveness is defined as the participants' ability to answer the search task questions correctly. Correctness was determined by whether or not the participant concluded their search at the page that the answer was located. Participants browsing sessions were monitored by Wrapper (Jansen, 2006), a browser logging application, allowing the experimenter to verify that the correct page was attained after the session.

Disorientation

Disorientation was measured using the same seven items as in Webster & Ahuja (2006), a previously validated scale from Ahuja & Webster (2001). The items are listed in Appendix D.

Engagement

Engagement was measured using the same seven items as in Webster & Ahuja (2006), a previously validated scale from Webster & Ho (1997). The items are listed in Appendix D.

Satisfaction

Satisfaction was measured in this study using the four item scale from Bhattacherjee (2001), which adapts a previously validated scale for overall satisfaction to a web site context. This operationalization of Satisfaction is concerned solely with

the user's overall perception of the web site. Items concerning information quality, connection, or support (which are included in some other operationalizations of satisfaction such as Doll & Torkzadeh (1988)) are not relevant in the context of this study. The items are listed in Appendix D.

4.5 Open-Ended Questions

Two open-ended questions were asked of the participants at the end of the post-experiment questionnaire, as shown in Appendix D. The purpose of these questions is to collect some contextual information concerning the participants' closed-ended responses to earlier questions about their experience with the web site.

4.6 Structural Equation Modeling

The data analysis in this research was conducted using Structural Equation Modeling (SEM). These second generation data analysis techniques provide the benefit of analyzing the measurement model and structural model simultaneously rather than in separate analyses, as was required with first generation techniques (Gefen, Straub, & Boudreau, 2000). Within the options for SEM analysis, Partial Least Squares (PLS) was chosen over the alternative covariance-based techniques for a number of reasons (Gefen et al., 2000):

1. PLS supports exploratory and confirmatory research whereas covariance-based techniques are intended for confirmatory research. Since some of the

hypothesized relationships in the research model are exploratory in nature, PLS is more appropriate.

2. The distributional assumptions of PLS are more relaxed than those of covariance-based techniques resulting in more reliable results should the data be non-normally distributed.
3. The sample size required for PLS is generally smaller than that required for covariance-based techniques. Since the research design in this study was very time intensive, this was certainly important.
4. PLS supports the modelling of formative and reflective constructs simultaneously while covariance-based techniques do not. Since the research model involves both formative and reflective variables, PLS is more appropriate.

The minimum suggested sample size for PLS modelling is the greater of 1) ten times the number of items in the most complex construct in the model, or 2) ten times the number of paths leading to the dependent variable in the model with the most independent variables (Chin, 1998; Gefen et al., 2000). In this case, the most complex construct in the model has seven items (both disorientation and engagement) and satisfaction has the most independent variables with four. Thus, according to the guideline, the minimum suggested sample size is 70. A total of 101 individuals participated in the experiment, resulting in 97 usable cases. Thus, the sample size for data analysis using PLS is sufficient.

4.7 Pilot Study

A pilot study was conducted prior to the full study to ensure that the experimental procedure was appropriate and that the wording of the questions was not confusing. Two sessions were held on the first day of the pilot test and indicated that some minor changes were required. First, these initial participants were asked to browse the web site for ten minutes, yet both felt that this time period was far too long. Second, the structure of the site was deemed too complicated for reasonable completion of the MMA exercise. Finally, it was determined that a time limit needed to be set for the MMA exercise to keep the experiment session to roughly 60 minutes in length. As a result the following changes to the procedure were made: the browsing time was reduced to five minutes, the web site was reduced to 39 pages, and a 15 minute time limit was set for the MMA exercise. Using these new constraints, the remaining 13 pilot sessions ran smoothly and the procedure was deemed appropriate.

Further, pilot study participants were also asked open-ended questions to determine whether or not they had difficulty with any parts of the experiment or questionnaire. Once the issues from the first day were resolved, the remaining participants did not have any concerns or suggestions. It was concluded that the exercises and questionnaires were clear and appropriate for the full study.

Chapter 5: Data Analysis and Results

5.1 Data Collection

Data collection for the experiment took place between November 2009 and April 2010. Participants were recruited through a variety of sources: postings on two campus web sites, posters at two campus research centres, and posters in local seniors' centres, libraries, and in a few small businesses. Most of the younger participants responded to web site advertisements, whereas the older participants responded to a variety of ads. Sessions of the experiment were held in locations convenient to the participants. Many came to the usability lab on campus, some took place in rooms rented at libraries and seniors' centres, and some took place in the participants' homes. One-way ANOVA tests confirmed that there was no statistical difference between the performance of those who participated in the comfort of their homes and those that did not.

Participants were randomly assigned using the random number generating function in MS Excel to a web site condition (either Menu or Tree as discussed in section 4.2). The total recruitment goal for the experiment was 100 participants to ensure sufficient sample size for the PLS analysis. These 100 participants were to be distributed evenly between the four cells in the 2x2 design (two age groups and 2 web site conditions), thus 25 participants were sought for each of the cells. Once the recruitment goal for a cell was met, the participant was assigned to the other web site condition for their age group. In the end, 87 were randomly assigned and 14 were

assigned by default. Male and female participants were accepted on a first come, first serve basis. In order to achieve a reasonable gender balance among the participants, a cap of 60% or 60 individuals (15 per condition) was set per gender. A total of 101 individuals were recruited in total, broken down as shown in Figure 16.

		Web site Condition	
		Menu	Tree
Age Group	Younger	Female: 15 Male: 11 26	Female: 15 Male: 10 25
	Older	Female: 15 Male: 10 25	Female: 15 Male: 10 25

Figure 16: Participant Recruitment by Age and Condition

5.2 Data Screening

The collected data was screened for missing data, and univariate and multivariate outliers.

5.2.1 Missing Data:

A total of 13 items were missed on the post-experiment questionnaire across 10 participants. Substitutions for these missing items were made as illustrated in Table 13. In most cases, participants had missed one item from the measure, thus the substitution was the average of their other responses on the measure. In the one case where 3 out of 4 items for the measure were missing (participant 83), the item averages for all

subjects in the respective condition were substituted. This is consistent with appropriate substitution methods as described in Tabachnick & Fidell (2001).

Participant	Condition	Item	Participant avg. on measure	Item avg. for condition	Substitution
43	M,O	DIS5	3.50	2.31	3
		EOU3	2	1.77	2
47	M,Y	DIS4	5	1.92	5
69	M,Y	ENG5	3.17	3.80	3
71	T,Y	DIS1	1	1.80	1
76	M,Y	EOU2	1	2.00	1
82	T,O	DIS3	1.83	1.76	2
83	T,O	SAT1	3	2.24	2
	T,O	SAT3	3	2.44	2
	T,O	SAT4	3	2.84	3
92	M,O	ENG3	2	2.96	2
93	M,O	DIS2	2.50	1.77	3
96	T,O	BI4	1.8	2.08	2

Table 13: Substitutions for missing data

A total of 13 tasks were abandoned across 12 different participants. Although task times were recorded for these abandoned tasks, these are not an accurate reflection of the participant's task performance since they did not arrive at a response. In each case, the participant's task score was changed to the average time on that task for the condition that the participant is in, multiplied by a factor representing their overall performance relative to the other participants in their condition:

assigned score = avg time for the task in that condition * total time for participant on the remaining tasks / avg total time on the remaining tasks

The resulting assigned scores are summarized in Table 14.

Participant	Task	Condition	Time abandoned	Average time for condition	Participant total for other tasks	Average total for other tasks	Assigned score
34	5	M,O	219	59.73	682	269.73	151
43	3	M,O	52	71.35	382	258.12	106
44	2	M,O	98	52.88	261	276.58	50
59	2	T,O	360	34.60	648	257.84	87
69	3	M,Y	90	35.76	157	143.64	39
85	1	M,O	104	38.88	346	290.58	46
87	3	T,O	66	51.00	307	241.44	65
88	3	T,O	47	51.00	208	241.44	44
90	2	T,O	75	34.60	425	257.84	57
93	2	M,O	32	52.88	115	220.23	28
	6	M,O	28	56.35	115	220.23	29
94	5	M,O	98	59.73	254	269.73	56
99	3	T,O	74	51.00	159	241.44	34

Table 14: Substitutions for abandoned tasks

In addition, three older participants did not answer the question "How old do you feel?" In each case, the participants' actual age was substituted.

Finally, the card sorting exercise was abandoned by one participant. This participant (82) was removed from the data since no substitution for this measure was deemed appropriate.

5.2.2 Outliers

Univariate outliers were investigated by conducting a z-test for extreme values. In this test, the participant scores on each measure were standardized and those with z-scores exceeding the critical value of 3.29, as recommended by Tabachnick & Fidell (2001), were considered outliers. Each of the variables from the research model was investigated for outliers: Spatial1, Spatial2, MMA, Time, Correct, Disorientation, Engagement, and Satisfaction. This test resulted in three outliers:

- Participant 34 is an outlier on Time (high)
- Participant 59 is an outlier on Time (high)
- Participant 81 is an outlier on Disorientation (high)

Next, the Mahalanobis Distance procedure was conducted to identify any multivariate outliers. In this procedure, a distance was calculated between a particular score and the centre cluster of remaining cases. A subject's score was considered an outlier if its distance score exceeded a critical value, which is determined by the Chi-square statistic with degrees of freedom equal to the number of variables being considered and $p<0.001$ (Tabachnick & Fidell, 2001). In this case, 8 variables are examined (Spatial1, Spatial2, MMA, Time, Correct, Disorientation, Engagement, Satisfaction, and Performance) so the critical value is 26.13. The Mahalanobis Distance scores were calculated by running a linear regression in SPSS and saving the score to a data file. This analysis identified three multivariate outliers:

- Participant 34- score 26.17
- Participant 59- score 34.50
- Participant 81- score 35.28

Since these three participants were both univariate and multivariate outliers, they were excluded from the data set. As a result the final data set consists of 97 individuals. Unless otherwise indicated, all discussion that follows concerns this reduced data set.

5.3 Participant Demographics

In addition to the model variables, a number of demographic items were collected from the participants. Since age is such an important aspect of this study, participants were asked a number of questions about their age. Using the conceptualizations of age from Kooij et al. (2008), participants were asked:

Conceptualization:	**Question:**
Chronological Age	Age: ____ (years)
Subjective Age	How old do you feel? ____ (years)
Functional Age	How is your health in general?

The chronological age of the younger group ranges from 19-34 years of age, and participants feelings of their age range from 36% younger to 38% older than their actual age. As the histograms in Figures 17 and 18 illustrate, most of the participants in the younger group are in their early twenties, and feel roughly their age if not slightly older.

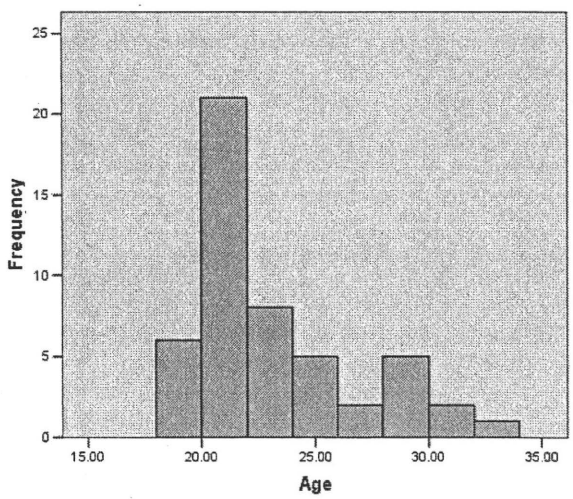


Figure 17: Age distribution of younger group

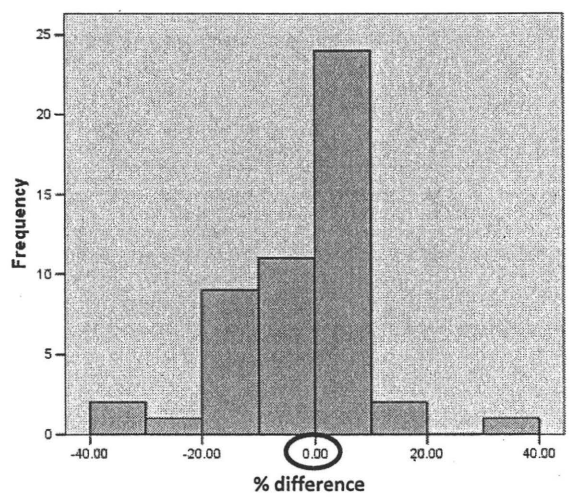


Figure 18: Subjective age distribution of younger group
[feels percent older (+) or younger (-)]

The chronological age of the older group ranges from 55-82 years of age, and participants feelings of their age range from 55% younger to 18% older than their actual age. As the histograms in Figures 19 and 20 illustrate, the age distribution in the older group is much broader and participants tend to feel younger than their actual age.

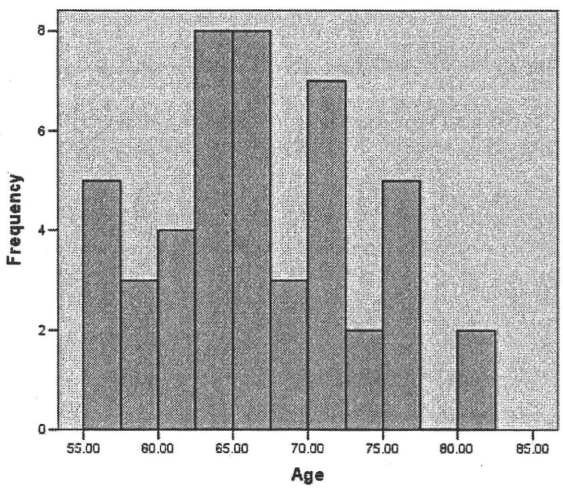


Figure 19: Age distribution of older group

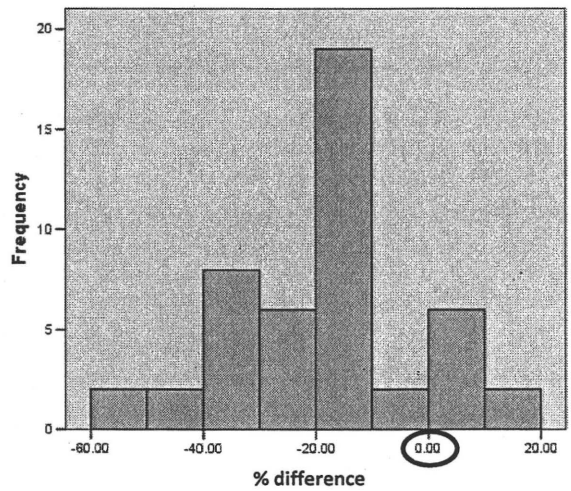


Figure 20: Subjective age distribution of older group
[feels percent older (+) or younger (-)]

Other demographic items, as well as a description of the participants' functional health are described in Table 15 below. There is no statistical difference between the older and younger groups on the mean scores on any of these demographic variables except life satisfaction, where older participants are more satisfied than younger ones (significance 0.001 using One-Way ANOVA test).

		All Participants		Younger		Older	
Item	**Categories**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**
Gender	Female	56	57.7	30	60.0	26	55.3
	Male	41	42.3	20	40.0	21	44.7
Feeling (compared to an avg. day)	Much Worse	0	0.0	0	0.0	0	0.0
	Worse	7	7.2	6	12.0	1	2.1
	Same	66	68.0	29	58.0	37	78.7
	Better	20	20.6	14	28.0	6	12.8
	Much Better	4	4.1	1	2.0	3	6.4
	Mean	3.22		3.20		3.23	
Satisfied (with life in general)	Very Dissatisfied	0	0.0	0	0.0	0	0.0
	Dissatisfied	2	2.1	1	2.0	1	2.1
	Neutral	7	7.2	6	12.0	1	2.1
	Satisfied	44	45.4	29	58.0	15	31.9
	Very Satisfied	44	45.4	14	28.0	30	63.8
	Mean	4.34		4.12		4.57	
Education	No High School	3	3.1	0	0.0	3	6.4
	High School	9	9.3	6	12.0	3	6.4
	Some Post Sec	41	42.3	26	52.0	15	31.9
	Post Secondary	29	29.9	10	20.0	19	40.4
	Graduate Degree	15	15.5	8	16.0	7	14.9
	Mean	3.48		3.40		3.57	
Health	Poor	0	0.0	0	0.0	0	0.0
	Fair	5	5.2	2	4.0	3	6.4
	Good	16	16.5	7	14.0	9	19.1
	Very Good	53	54.6	30	60.0	23	48.9
	Excellent	23	23.7	11	22.0	12	25.5
	Mean	3.97		4.00		3.94	

Table 15: Frequencies for demographic items

Further items were collected concerning the participants' Internet and subject matter experience. As Table 16 illustrates, older participants have more years of experience using the Internet, yet younger participants use the Internet more hours per week. The statistical significance of the difference between groups was determined using One-Way ANOVA tests.

	Younger	Older	Significance
Years of Internet use	Mean = 11.10 Std. Dev. = 2.53345	Mean = 13.9574 Std. Dev. = 5.49291	0.001
Hours per week	Mean = 21.73 Std. Dev. = 10.2595	Mean = 8.9787 Std. Dev. = 7.88915	0.000

Table 16: Descriptive statistics for years and hours per week of Internet use

To assess their subject matter expertise, participants were asked their level of familiarity with healthy living topics, as well as how often they visited web sites on the topic. Here, older participants are statistically more familiar with healthy living topics (significance 0.006 using One-Way ANOVA test), but there is no significant difference in frequency of web site visits.

		All Participants		Younger		Older	
Item	**Categories**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**
Familiarity	1 Not at all familiar	0	0.0	0	0.0	0	0.0
	2	0	0.0	0	0.0	0	0.0
	3	0	0.0	0	0.0	0	0.0
	4	5	5.2	4	8.0	1	2.1
	5	26	26.8	18	36.0	8	17.0
	6	36	37.1	17	34.0	19	40.4
	7 Very familiar	30	30.9	11	22.0	19	40.0
	Mean	5.94		5.70		6.19	
Frequency	Never	26	26.8	13	26.0	13	27.7
	Rare	16	16.5	8	16.0	8	17.0
	Occasional	45	46.4	21	42.0	24	51.1
	Frequent	10	10.3	8	16.0	2	4.3
	Mean	2.51		2.48		2.53	

Table 17: Frequencies for subject matter expertise

One-Way ANOVA tests were also conducted to determine whether the participants in each web site condition (Tree vs. Menu layout) differed significantly on any of the above mentioned measures. No statistical differences between the conditions were found.

5.4 Evaluation of Research Model

The research model was evaluated in a number of steps. First, the validity of the measurement model was assessed. Next, common method bias was examined to ensure the validity of the measurement method. And finally, the structural model was examined.

As discussed earlier, the research model in this study contains both reflective and formative constructs. Each of the two categories of constructs was evaluated separately since their underlying assumptions are different. For example, reflective constructs are said to be the effect of their latent construct and thus the items are expected to correlate highly. Formative indicators, on the other hand, are said to cause the latent variable through a linear composite of indicators, which do not necessarily correlate to the other indicators. Thus the techniques necessary to evaluate the two types of indicators are different (Diamantopoulos & Winklhofer, 2001).

5.4.1 Evaluation of Reflective Constructs

The reflective constructs of the model (disorientation, engagement, and satisfaction) were evaluated in terms of content validity, construct (convergent and divergent) validity, and internal consistency.

Content validity is concerned with how accurately and completely latent constructs are represented by the items chosen to measure them (Straub, Boudreau, & Gefen, 2004). As mentioned in the methodology section, each of the measures chosen

for this study have been used and validated in previous studies, demonstrating that the content of these constructs are valid.

Construct validity is concerned with the distinctiveness of a construct. In other words, the items of a construct should have high correlation with items in the same construct (convergent validity) and low correlations with items in different constructs (divergent validity)(Straub et al., 2004).

According to Fornell & Larcker (1981), convergent validity is sufficient if three criteria are met: 1) all item factor loadings should be significant and greater than 0.70; 2) average variance extracted (AVE) should be greater than 0.50 (or square root of AVE > 0.707); and 3) composite reliability index for each construct should be greater than 0.80. As illustrated in Tables 18 and 19, each of these criteria was met. Further, as described in Gefen & Straub (2005) and illustrated in Table 18, each of the items loads on its own latent construct more strongly than on any other latent construct with a difference of at least 0.10. Thus, the reflective constructs demonstrate sufficient convergent validity. It should also be noted that the table of overview statistics illustrates that Cronbach's Alpha statistic exceeded the recommended value of 0.70 for each construct (Cronbach, 1951), indicating that the constructs demonstrated high internal consistency and were sufficiently reliable.

	Disorientation	Engagement	Satisfaction
dis1	**0.771**	-0.365	-0.488
dis2	**0.747**	-0.263	-0.405
dis3	**0.845**	-0.397	-0.542
dis4	**0.823**	-0.399	-0.488
dis5	**0.882**	-0.436	-0.549
dis6	**0.906**	-0.467	-0.592
dis7	**0.718**	-0.316	-0.428
eng1	-0.407	**0.839**	0.661
eng2	-0.434	**0.865**	0.673
eng3	-0.403	**0.886**	0.726
eng4	-0.355	**0.840**	0.706
eng5	-0.384	**0.890**	0.744
eng6	-0.448	**0.884**	0.768
eng7	-0.441	**0.913**	0.802
sat1	-0.612	0.785	**0.945**
sat2	-0.566	0.802	**0.951**
sat3	-0.653	0.774	**0.924**
sat4	-0.446	0.725	**0.893**

Table 18:
Item factor loadings for reflective constructs

	AVE	Composite Reliability	Cronbach's Alpha
Disorientation	0.665	0.933	0.915
Engagement	0.764	0.958	0.948
Satisfaction	0.862	0.961	0.946

Table 19: Overview statistics for reflective constructs

Fornell & Larcker (1981) also provide a guideline for assessing discriminant validity: the square root of AVE of a construct should be greater than its correlations with all other constructs. As Table 20 demonstrates, this guideline was met for each of the constructs indicating sufficient discriminant validity.

	Disorientation	Engagement	Satisfaction
Disorientation	0.816		
Engagement	-0.469	0.874	
Satisfaction	-0.617	0.832	0.928

Table 20: Construct correlations with square root of AVE in diagonal

Finally, as shown in Table 21, all of the item loadings exceeded the recommended value of 0.7 (Nunnally, 1978) and are significant. Overall, the reflective constructs of the research model exhibit sufficient reliability and validity.

Construct	Item	Mean	Std. Dev.	Loading	t-stat	Sig.
Disorientation	dis1	1.89	1.030	0.771	13.742	0.000
	dis2	1.86	1.109	0.747	9.934	0.000
	dis3	2.07	1.260	0.845	24.423	0.000
	dis4	1.76	1.153	0.823	15.533	0.000
	dis5	2.18	1.407	0.882	24.964	0.000
	dis6	1.91	1.331	0.906	29.427	0.000
	dis7	1.84	1.296	0.718	10.543	0.000
Engagement	eng1	5.05	1.642	0.839	19.969	0.000
	eng2	5.28	1.546	0.865	27.500	0.000
	eng3	4.90	1.496	0.886	37.596	0.000
	eng4	4.29	1.436	0.840	21.652	0.000
	eng5	4.52	1.727	0.890	39.632	0.000
	eng6	5.06	1.580	0.884	38.145	0.000
	eng7	4.94	1.485	0.913	49.228	0.000
Satisfaction	sat1	5.44	1.241	0.945	101.612	0.000
	sat2	5.25	1.208	0.951	82.269	0.000
	sat3	5.24	1.345	0.924	62.575	0.000
	sat4	4.68	1.271	0.893	34.774	0.000

Table 21: Descriptive statistics and indicators for reflective constructs

5.4.2 Evaluation of Formative Constructs

As discussed earlier, the research model has four formative constructs: age, spatial ability, mental model accuracy, and performance. Diamantopoulos and Winklhofer (2001) recommend that formative model constructs be evaluated for indicator collinearity and external validity.

Indicator collinearity is assessed by examining the Variance Inflation Factors (VIFs) and inter-item correlations when conducting a linear regression with the formative items as the independent variables and an average of the items from the respective endogenous construct as the dependent variable. Since age and MMA have only one indicator each, this indicator collinearity analysis is not applicable to them. The

items from the Performance construct were regressed onto average Satisfaction and the items from the Spatial construct were regressed onto MMA. As Tables 22 and 23 illustrate, the VIFs are well below the cutoff of 3.3 as recommended by Petter, Straub, & Rai (2007). Further, the inter-item correlations are all below the limit of 0.8 suggested by Stevens (1996). Therefore, multicollinearity is not an issue with the formative constructs in the model.

	Satisfaction	Time	Correct	VIF
Satisfaction	1.000	0.019	-0.049	
Time		1.000	0.399	1.189
Correct			1.000	1.189

Table 22: Performance – Satisfaction correlation matrix and VIFs

	MMA	Spatial1	Spatial2	VIF
MMA	1.000	0.469	0.452	
Spatial1		1.000	0.624	1.638
Spatial2			1.000	1.638

Table 23: Spatial – MMA correlation matrix and VIFs

Next, the external validity of each of the four formative constructs was assessed via a two construct Multiple Indicators, Multiple Causes (MIMIC) model in PLS. This assessment involved creating a two construct model and examining the path betas and their significance for each case. External validity is concluded when the path between the two constructs is non-zero and statistically significant (Diamantopoulos & Winklhofer, 2001). As Table 24 shows, these criteria were met for each of the formative constructs except performance (performance → satisfaction is not significant). While this brings to question the external validity of the performance construct, performance

did serve as the endogenous variable in the statistically significant results for the MMA construct, lending it some credibility. Thus, the issue may be a weak relationship between performance and satisfaction rather than an issue with the performance construct itself.

	Path Beta	t-stat	Significance	R-Squared
Age --> Spatial Ability	-0.622	9.710	0.000	0.387
Spatial Ability --> MMA	0.511	6.130	0.000	0.261
MMA --> Performance	0.464	6.942	0.000	0.215
Performance --> Satisfaction	-0.113	0.567	n.s.	0.013

Table 24: Results of MIMIC analysis

The item weights for the multi-item formative constructs are shown in the table below along with their level of significance. These weights reflect the extent to which the items relate to their underlying construct. Overall, the formative constructs of the research model have met the validation requirements set out by Diamantopoulos & Winklhofer (2001).

Construct	Item	Mean	Std. Dev.	Weight	t-stat	Sig.
Spatial	Spatial1	0.541	0.223	0.691	5.295	0.000
	Spatial2	0.619	0.195	0.410	2.818	0.005
Performance	Time	227.794	113.294	0.877	13.096	0.000
	Score	4.897	0.860	0.244	2.130	0.034

Table 25: Descriptive statistics and indices for formative constructs

5.4.3 Common Method Bias

Common method bias was an important consideration in assessing the validity of this study since the three reflective constructs in the research model are self-assessed

measures. To ensure that the variance observed was in fact due to the constructs and not the measurement method itself, two statistical procedures were implemented.

First, Harman's one-factor test was conducted by entering each of the multi-item variables of interest into an exploratory factor analysis (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). Using principal component analysis and eigenvalues greater than one, a three factor solution emerged in the unrotated solution. The first factor accounted for 44.5% of variance and the three factors together accounted for 69.0%. Additionally, the solution was rotated using varimax rotation in principal component analysis. The first factor in the rotated solution accounted for 33.9% of variance. Therefore, there is evidence that the variables in the research model do not load on a single factor, which implies that the risk of common method bias is minimal.

Second, a common method bias assessment using PLS was conducted as in Liang, Saraf, Hu, & Xue (2007). As a first step, a PLS analysis of the research model was run with age, spatial ability, MMA, and performance modeled as formative and again with those constructs as reflective. There were no qualitative differences in the statistical results: no paths gained or lost significance and no paths changed signs. Thus, as described in Liang et al. (2007), it was feasible to use the method with all constructs modeled as reflective. Next, a common method factor was added to the PLS model, indicated by each of the measurement items in the model. Also, each of the measurement items of the model was converted to a single-indicator construct. Thus, in the path model, each item had a path into it from the common method factor as well

as its substantive factor. The variance explained by each source is equivalent to the item's loading on each factor. As illustrated in Table 26, substantially more variance in the indicators was explained by their substantive constructs (0.724) than the method construct (0.010). The ratio of substantive variance to method variance is roughly 83:1, and only one of the method factor loadings is significant, supporting the notion that method variance is not contaminating the results of this study.

		Method Factor Loadings			Substantive Factor Loadings		
Construct	**Indicator**	**Loading**	**Sig.**	**(Loading)^2**	**Loading**	**Sig.**	**(Loading)^2**
Disorientation	dis1	-0.006	0.055	0.000	0.769	7.133 ***	0.591
	dis2	0.142	1.549	0.020	0.866	7.965 ***	0.749
	dis3	-0.013	0.157	0.000	0.836	11.087 ***	0.698
	dis4	-0.019	0.230	0.000	0.806	9.166 ***	0.649
	dis5	-0.036	0.478	0.001	0.855	11.936 ***	0.730
	dis6	-0.090	1.176	0.008	0.834	14.027 ***	0.695
	dis7	0.052	0.483	0.003	0.754	7.995 ***	0.569
Engagement	eng1	0.015	0.098	0.000	0.827	5.588 ***	0.684
	eng2	-0.011	0.066	0.000	0.876	5.700 ***	0.767
	eng3	-0.101	0.812	0.010	0.980	8.760 ***	0.960
	eng4	-0.063	0.407	0.004	0.899	5.596 ***	0.807
	eng5	-0.048	0.354	0.002	0.933	7.576 ***	0.871
	eng6	0.067	0.480	0.004	0.821	6.068 ***	0.674
	eng7	0.133	1.095	0.018	0.788	7.036 ***	0.621
Performance	correct	-0.018	0.308	0.000	0.809	20.812 ***	0.654
	time	0.016	0.309	0.000	0.862	42.980 ***	0.743
Satisfaction	sat1	0.071	0.648	0.005	0.878	8.479 ***	0.771
	sat2	0.034	0.314	0.001	0.920	9.374 ***	0.846
	sat3	0.189	1.470	0.036	0.746	6.017 ***	0.557
	sat4	-0.310	2.317 *	0.096	1.183	10.393 ***	1.399
Spatial Ability	spatial1	0.036	0.710	0.001	0.914	46.320 ***	0.835
	spatial2	-0.037	0.708	0.001	0.888	37.681 ***	0.788
Average				**0.010**			**0.724**

Table 26: PLS Common Method Bias assessment results

5.4.4 The Structural Model

While the previous sections established the validity and reliability of the measurement model, this section discusses the validity and reliability of the structural

model. The structural model was evaluated using SmartPLS (Ringle, Wende, & Will, 2005) and result is depicted in Figure 21. The level of significance of the parameter estimates (indicated by asterisks) were calculated based on the t-statistics from a Bootstrapping process (with 500 resamples).

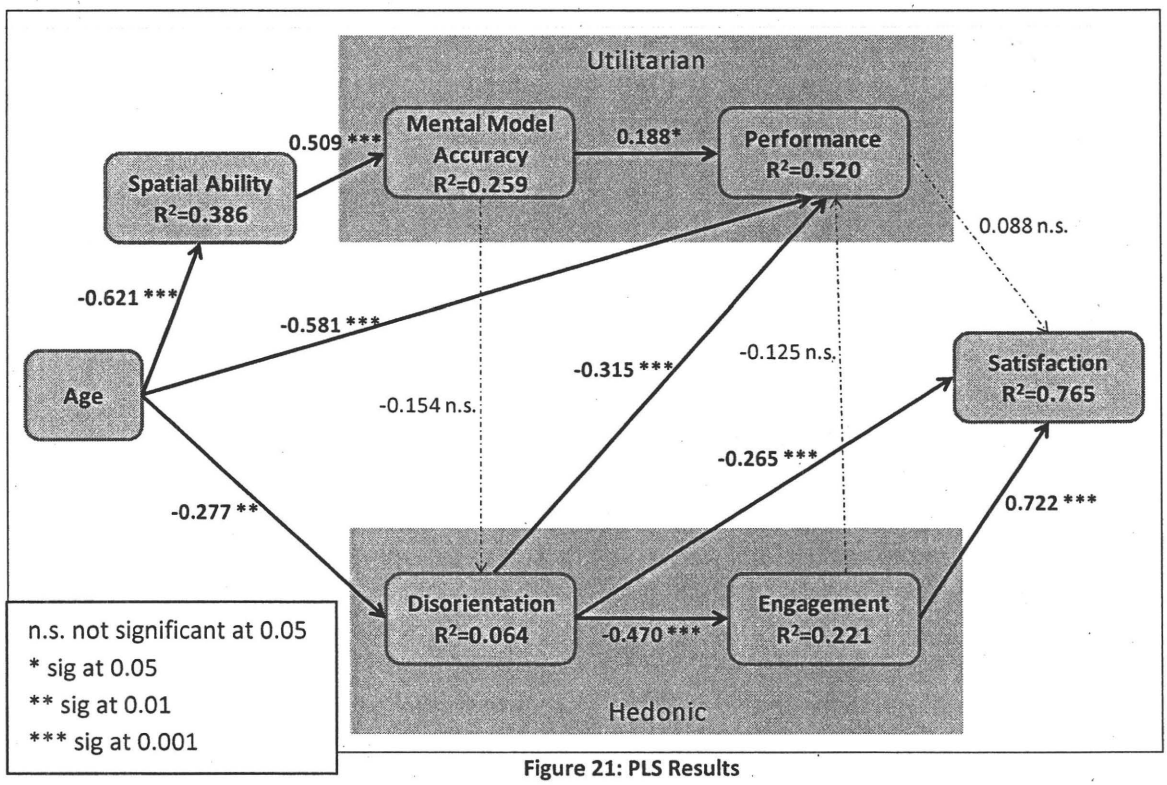


Figure 21: PLS Results

Nine out of twelve paths in the model are significant (at $p<0.05$ or better) indicating that the model is reliable overall (see Table 27 for further details). The variance explanation of the endogenous variable Satisfaction is substantial at $R^2 = 0.765$ (Chin, 1998), supporting the validity of the model. Further, most of the other endogenous variables in the model have variance explanation greater than 10% as

recommended by Falk & Miller (1992), with the exception of disorientation at $R^2 = 6.4\%$. However, the relatively low variance explanation of disorientation is not a threat to the model's overall validity. In general, low R^2 values are relatively common in behavioral research. For example, some of the most renowned studies in the IS field observed R^2 values below 10% (e.g. Davis, Bagozzi, & Warshaw, 1989). Further, age was the only predictor of disorientation in this study, indicating that substantial predictors of disorientation were not considered here.

	Model Path	Path Beta	Expected +/-	t-stat	p-value	Validation
H1	Performance → Satisfaction	0.088	Y	1.757	0.079	Rejected
H2	MMA → Performance	0.188	Y	2.140	< 0.05	Supported
H3	MMA → Disorientation	-0.154	Y	1.406	0.160	Rejected
H4	Spatial Ability → MMA	0.509	Y	6.165	< 0.001	Supported
H5	Engagement → Satisfaction	0.722	Y	13.889	< 0.001	Supported
H6	Engagement → Performance	-0.125	N	1.492	0.136	Rejected
H7	Disorientation → Satisfaction	-0.265	Y	3.982	< 0.001	Supported
H8	Disorientation → Performance	-0.315	Y	3.670	< 0.001	Supported
H9	Disorientation → Engagement	-0.470	Y	5.532	< 0.001	Supported
H10	Age →Spatial Ability	-0.621	Y	10.265	< 0.001	Supported
H11	Age → Performance	-0.581	Y	7.446	< 0.001	Supported
H12	Age → Disorientation	-0.277	N	2.580	< 0.01	Supported

Table 27: Summary of Findings of Support for Hypotheses

Although the PLS approach to SEM does not provide overall model fit indices equivalent to those available to covariance-based approaches (Chin, 1998; Gefen et al., 2000), a global fit measure has been suggested by Tenenhaus, Vinzi, Chatelin, & Lauro (2005). In this measure, goodness of fit (GoF) is defined as the geometric mean of the average AVE and average R^2 for endogenous constructs in the model, or GoF =

$\sqrt{(\text{Average (AVE)} * \text{Average } (R^2))}$. The result is a number between zero and one such that $0.10<\text{GoF}\leq 0.25$ is small, $0.25<\text{GoF}\leq 0.36$ is medium, and $\text{GoF}\geq 0.36$ is large (Wetzels, Odekerken-Schröder, & Van Oppen, 2009). Using this measure, the GoF for the current study is 0.531, or the effect size is large, indicating that the research model performed well.

5.4.4.1 Effect Sizes

The predictive power of the model can be evaluated further by examining the impact of individual constructs on the variance explained by dependent variables throughout the model. This is done by calculating the effect size (f^2) of the independent variables (Chin, 1998), which is calculated as follows:

$$f^2 = \frac{R^2_{included} - R^2_{excluded}}{1 - R^2_{excluded}}$$

We can then assess the magnitude of the effect size according to Cohen (1988) such that $0.02<f^2\leq 0.15$ is small, $0.15<f^2\leq 0.35$ is medium, and $f^2\geq 0.35$ is large. Table 28 illustrates the effect size of each of the independent variables, as well as the F-Test value to determine its level of significance. The F-Test value is equal to $F = f^2 \times (n - k - 1)$ where n is the sample size, k is the number of independent variables, and the degrees of freedom are 1 and $(n - k)$ (Mathieson, Peacock, & Chin, 2001).

Independent Variable	Dependent Variable	R^2 Included	R^2 Excluded	ΔR^2	f^2	Effect	F Test	P
Performance	Satisfaction	*0.765*	*0.758*	*0.007*	*0.030*	*n.s.*	*2.770*	*0.099*
Engagement		0.765	0.393	0.372	1.583	large	147.217	0.000
Disorientation		0.765	0.714	0.051	0.217	medium	20.183	0.000
MMA	Performance	0.520	0.492	0.028	0.058	small	5.367	0.023
Engagement		*0.520*	*0.509*	*0.011*	*0.023*	*n.s.*	*2.108*	*0.150*
Disorientation		0.520	0.445	0.075	0.156	medium	14.375	0.000
Age		0.520	0.275	0.245	0.510	large	46.958	0.000
Spatial Ability	MMA	0.259	0.000	0.259	0.350	large	33.205	0.000
Age	Spatial Ability	0.386	0.000	0.386	0.629	large	59.723	0.000
Disorientation	Engagement	0.221	0.000	0.221	0.284	medium	26.951	0.000
Age	Disorientation	0.064	0.001	0.063	0.067	small	6.327	0.014
MMA		*0.064*	*0.044*	*0.020*	*0.021*	*n.s.*	*2.009*	*0.160*

Table 28: Summary of Findings of Effect Sizes

Each of the paths that is significant in the PLS model has significant effect size (at least $p<0.05$). Figure 22 illustrates the magnitude of the effect sizes in the model.

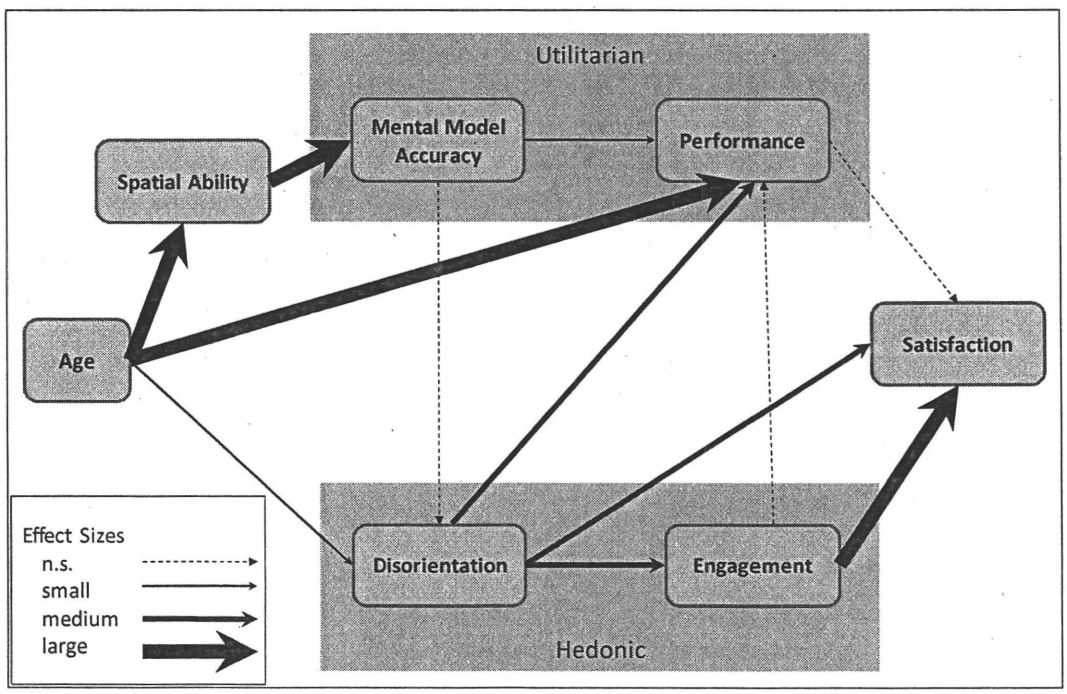


Figure 22: Effect sizes in PLS model

5.4.4.2 Saturated Model

To investigate the possibility that some significant paths were not included in the model, a saturated model was tested (as demonstrated in Hassanein & Head, 2007; Karahanna & Straub, 1999). This involved adding paths in the PLS model as indicated in Table 29. Using a Bootstrapping process (with 500 resamples) it was determined that none of these new paths were statistically significant. Further, the R^2 of satisfaction in the saturated model increased only slightly to 0.781 (from 0.765). Thus the research model encompasses all of the key relationships between the constructs.

From	To
Age	MMA
	Satisfaction
	Engagement
Spatial Ability	Performance
	Satisfaction
	Engagement
	Disorientation
MMA	Satisfaction
	Engagement

Table 29: Paths added to PLS for saturated model

5.4.4.3 Impact of Control Variables

As mentioned earlier, a number of items were collected from participants in order to assess their impact as control variables. These items include:

1. condition: the navigation condition assigned
2. gender: male or female

3. feeling: how the participant was feeling on the day of the session in comparison to an average day
4. satisfied: how satisfied with life the participant is
5. years: the number of years experience using the Internet
6. hours: average hours per week spent using the Internet
7. PIIT: Personal Innovativeness in the domain of Information Technology
8. education: highest level of education completed
9. familiar: level of familiarity with subject matter
10. frequency: with which participant visits web sites of similar content
11. similar: similarity between the experimental web site and previously visited web sites of similar content
12. nav familiar: level of familiarity with the navigation layout

The impact of these control variables was assessed by adding them (one at a time) to the PLS model, with a path from the control variable to each of the dependent variables in the model, and assessing the changes caused in the model. In particular, the change in R^2 of each of the dependent variables was noted, in addition to any paths from the control variable that were significant. The results are summarized in the Table 30.

	MMA	Performance	Disorientation	Engagement	Satisfaction
no controls	0.259	0.520	0.064	0.221	0.765
condition	0.273	0.537	**0.103**	0.232	0.765
gender	0.263	0.521	0.068	**0.292**	0.764
feeling	0.273	0.528	0.080	0.221	0.770
satisfied	0.259	0.524	0.070	0.221	0.766
years	0.287	0.524	0.074	0.223	0.766
hours	0.260	**0.541**	0.093	0.243	0.767
PIIT	0.284	0.523	0.070	0.248	0.768
education	0.277	0.521	0.064	0.221	0.766
familiar	0.268	0.521	0.087	0.234	0.767
frequency	0.263	0.521	0.074	0.223	0.770
similar	**0.290**	0.520	0.084	0.227	0.770
nav familiar	0.260	0.523	**0.274**	0.221	0.767

Table 30: R2 values without control variables and each control individually included
(significant paths bolded, $p<0.05$)

While the variance explained in the endogenous construct Satisfaction shows very little increase in R^2 with the inclusion of any of the control variables, some did create statistically significant paths. From these results we can conclude that:

- Participants in the menu condition experienced higher levels of perceived disorientation ($p<0.001$). This is likely because the collapsible tree in the tree condition provided participants with a visual representation of the web site, which the participants in the menu condition did not have. Similar results were found in Webster & Ahuja (2006).
- Female participants experienced higher levels of engagement ($p<0.001$). This is likely because female participants were more familiar with the topic ($p<0.05$) which suggests that they may be more interested in it.

- Participants who spend more hours per week online had better performance ($p<0.001$), implying that experience (as measured by current use level rather than length of use) has a positive impact on performance.
- Participants who had visited similar web sites in the past had higher MMA ($p<0.001$), indicating that some participants' preexisting mental models of the subject matter assisted them with the exercise.
- Participants who were more familiar with the navigation layout of the web site had lower levels of Disorientation ($p<0.001$). In other words, participants who have experience using web sites with similar navigation layouts were less likely to feel lost.

5.4.4.4 Post Hoc Analysis

Some post hoc analyses were run in order to further explore the collected data. First, one-way ANOVAs were run, testing for significant mean differences between the age groups on each of the model constructs. As is evident in the table below, older adults have lower levels of spatial ability, less mental model accuracy, and lower levels of performance, as expected. Interestingly, older adults reported less perceived disorientation than younger ones, which is counter to expectation. Finally, older adults were more engaged and equally satisfied with the web site.

Construct	Older Avg.	Younger Avg.	Mean Difference Significance
Spatial Ability	0.4588	0.6934	p<0.000
MMA	-0.4444	0.4177	p<0.000
Disorientation	1.6991	2.1429	p<0.029
Performance	-0.6124	0.5757	P<0.000
Engagement	5.2948	4.4543	p<0.002
Satisfaction	5.3351	4.9800	n.s.

Table 31: Mean differences between older and younger on model constructs

To further explore the unexpected findings between age and disorientation, a histogram was compiled as shown in Figure 23. Interestingly, the highest level of disorientation is reported by the youngest participants. In fact, within the group of younger participants, disorientation declines with age. This decline continues well into the older group, without an increase until the 70-74 age block of participants. Examining the responses to the open-ended questions implies that this may be a result of the design of the experimental web site: the youngest, most experienced users were missing navigation items not included such as breadcrumbs and search function, which may have led them to feel disoriented. Further discussion around this finding is located in Chapter 6.

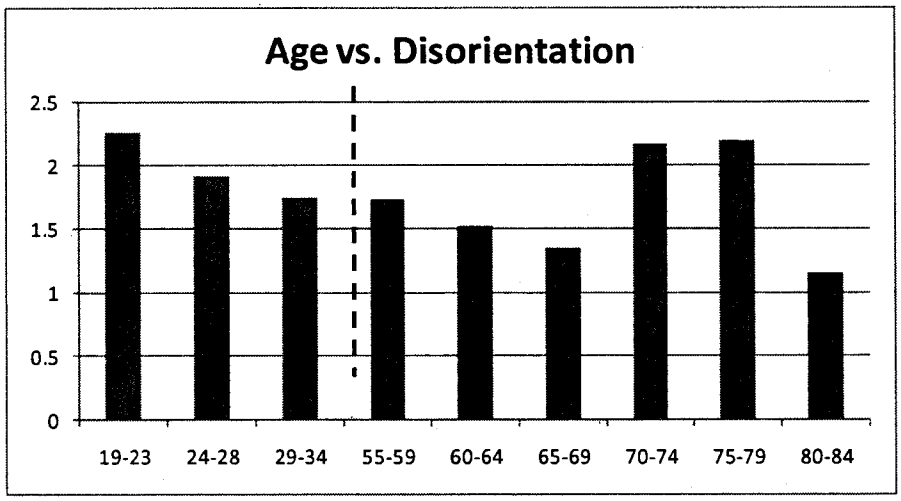


Figure 23: Participant age vs. reported disorientation

In order to explore the impact of different conceptualizations of age, correlations were run between each of the conceptualizations collected and each of the model constructs. Although some of the correlations are insignificant, as shown in Table 32, their directionality and relative magnitudes may provide some indications for future exploration of utilitarian and hedonic outcomes.

Construct	Correlation with age conceptualization		
	Chronological	Subjective	Functional
Hours/week	-0.537**	-0.560**	0.045
Familiarity	0.241*	0.147	0.207*
Spatial Ability	-0.615**	-0.561**	0.008
MMA	-0.432**	-0.387**	0.103
Performance	-0.633**	-0.494**	-0.085
Disorientation	-0.212*	-0.208*	-0.037
Engagement	0.298**	0.195	0.059
Satisfaction	0.138	0.058	0.118

Table 32: Correlations between conceptualizations and constructs (*p<0.05)

While the utilitarian outcomes (spatial ability, MMA, and performance) all correlate more strongly with chronological age than the other age conceptualizations, the correlations with other constructs are less clear. Hours of Internet use per week correlated more strongly with subjective age, implying that older adults that feel younger may behave younger in terms of their Internet use. Although engagement correlated more strongly with chronological age, this may be because chronological age correlated with topic familiarity (and thus interest in the topic) and may not be a result of age on its own. Disorientation correlates fairly equally with the chronological and subjective conceptualizations and satisfaction does not correlate significantly with any of the conceptualizations. This may imply that chronological age is a strong predictor of utilitarian outcomes, whereas other conceptualizations could add insight to the more complex study of hedonic outcomes. As discussed in section 5.3, older adults' subjective age had greater variance from their actual age than that of younger adults. Thus, these conceptualizations may have greater importance when studying older adults.

In the past, a number of studies have examined the relative contributions of age, experience, and cognitive abilities on performance. To assess the same in this study, a hierarchical regression was run, as was the case in previous studies (Charness et al., 2001; Czaja & Sharit, 1993; Sharit, Hernandez, Czaja, & Pirolli, 2008). In this case, MMA, spatial ability, hours (experience) and age were each entered into a linear regression on performance in separate blocks. Each step produced a significant improvement in R^2,

which indicates that each contributes to performance, as shown in Table 33. While one previous study found that age and experience contributed roughly equally to performance (Charness et al., 2001), that was not the case here. As shown in the table, age improved R^2 (0.087) more than twice as much as experience (0.033). Thus the findings are also different from Czaja & Sharit (1993) and Sharit et al. (2008) who found that experience had a greater effect than age.

Predictors	Predictor added	R^2 Change	Significance
MMA		0.214	p<0.000
MMA, spatial	spatial (cognitive ability)	0.137	p<0.000
MMA, spatial, hours	hours (experience)	0.033	p<0.029
MMA, spatial, hours, age	age	0.087	p<0.000

Table 33: R^2 improvement in hierarchical regression predicting performance

Chapter 6: Discussion & Conclusion

As older adults increasingly make use of computers and the Internet to enhance their daily lives, the study of web site usability for older adults is becoming increasingly relevant. The needs and concerns of older adults as computer users differ from those of younger users as a result of the natural changes associated with the aging process. Much research has been conducted in a variety of disciplines in order to understand how these changes experienced by older adults impact their use of computers and the Internet. Chapter 2 presented an overview of this research and identified gaps in the literature. The study conducted in this dissertation addresses some of these gaps by exploring hedonic (disorientation and engagement) and utilitarian (MMA) constructs that have not previously been studied in the context of web usability for older adults. This chapter answers each of the research questions guiding the research, discusses theoretical and practical contributions, acknowledges limitations, and suggests future research directions.

6.1 Research Questions Answered

What utilitarian and hedonic usability factors influence user satisfaction?

This study examined two utilitarian (MMA and performance) and two hedonic (disorientation and engagement) antecedents of satisfaction. The results indicate that hedonic factors had more of an impact on user satisfaction than utilitarian factors. While performance did not have a significant impact on satisfaction (H1 not supported),

disorientation and engagement did both have a significant impact (H5 and H7 supported). Specifically, the less disorientated and more engaged a user was, the more satisfied. This is a significant finding since neither engagement nor disorientation has been studied in direct relation to satisfaction in prior research. Despite the insignificant influence of utilitarian constructs, 76.5% of variance in satisfaction was explained.

What relationships exist between utilitarian and hedonic usability antecedents to satisfaction?

Of the three relationships hypothesized between the utilitarian and hedonic constructs, only one was found to be significant. Specifically, disorientation was found to have a negative impact on user performance (H8 supported) as was found in previous research by Otter & Johnson (2000) and Webster & Ahuja (2006). MMA was expected to impact disorientation, but this was not found to be the case (H3 not supported). This is the result of the unexpected findings within the disorientation construct, as discussed in Chapter 5. Although younger adults' perceptions of disorientation were higher, this was not reflected in their utilitarian outcomes (mental models or performance). The unexpected results of the disorientation construct may stem from two separate issues:

1. Younger adults over-reported their feelings of disorientation since the site did not provide the additional navigation cues that they may be accustomed to, such as breadcrumbs or search functionality, which may have caused them to feel unsupported. Their performance, however, was not impacted.

2. Older adults under-reported their feelings of disorientation since older participants have a tendency to focus on the positive aspects of their experience and report feelings more positive than observed by the experimenter (Sayers, 2004), and have more of a desire to be polite and socially desirable (Dickinson et al., 2007).

In all likelihood, it is probably a combination of these two issues. In support of the notion that younger adults over-reported their disorientation is the lack of statistically significant correlation between disorientation and both MMA and performance within the younger subgroup. On the other hand, it is plausible that older adults under-reported since they report lower levels than younger adults, and were also observed to be more disoriented by the experimenter.

It should be noted that the variance observed in disorientation was relatively low. The average disorientation reported was 1.93 on a five point scale (1.699 for older and 2.143 for younger). So although the discussion above concerns the most disoriented in this experiment, their level of disorientation was not severe.

It may be reasonable to consider MMA as an objective measure of disorientation. In that sense, this study has similar results to Otter & Johnson (2000) in that both objective and perceived disorientation influence performance, yet perceived disorientation has a stronger impact. Further, in that interpretation, the younger participants were less disoriented than older participants.

The second insignificant relationship between the utilitarian and hedonic sides of the model was that between engagement and performance (H6 not supported). While more engaged users were expected to have superior performance, this was not the case. This may be a result of the attention element of engagement: "the experience of total engagement where all other attention demands are ignored" (Agarwal & Karahanna, 2000). It may be that engaged users lost focus on the tasks because of their engagement with the web site, and as a result their performance suffered.

How does age influence the hedonic and utilitarian usability antecedents to satisfaction?

Age had a significant influence on both the hedonic and utilitarian constructs in the model. On the utilitarian side, as age increased, spatial ability decreased (H10 supported) as described in Salthouse (1982). Spatial ability subsequently was an important determinant in participants' ability to form an accurate mental model (H4 supported), which is a novel finding. Age also had a significant impact on performance directly (H11 supported) as expected based on the literature reviewed in Chapter 2. This direct age effect would be the result of age related changes such as manual dexterity and processing speed. It is interesting to note that there was not a significant correlation between age and performance within the younger subgroup, yet there was within the older group (-0.346, $p<0.05$). This supports the notion that older adults are a heterogeneous group, and that there is a distinction between young-old and old-old in

terms of performance. Another interesting difference between the older and younger groups in terms of performance is the impact of navigation condition. The condition had no significant impact on older adults, yet younger adults had better performance in the tree condition (correlation -0.302, $p<0.05$). This may imply that variations in navigation elements have more impact for younger adults than older, supporting the discussion above that younger users felt relatively unsupported by the navigation in the experimental web site.

On the hedonic side, the influence of age was unexpected. Where it was hypothesized that increased age would result in increased disorientation, the opposite was found: older participants reported lower perceptions of disorientation (H12 not supported). The histogram of disorientation by age group (Figure 23) indicates that in fact the youngest participants reported the most disorientation.

As the histograms in Figures 24 and 25 illustrate, where four older adults reported disorientation higher than 3, eleven younger adults did. The open-ended comments of these most disoriented participants were examined to explore this peculiarity. Interestingly, most of the comments made by the most disoriented older adults were positive, including that the web site was "simple to use", "clear", and "straight forward". Further, the negative comments made by older adults were not related to navigation, and as such did not provide insight as to why they felt disoriented. In fact, there were very few negative comments made by any of the older adults. This

may be related to older participants' desire to be polite and socially desirable (Dickinson et al., 2007).

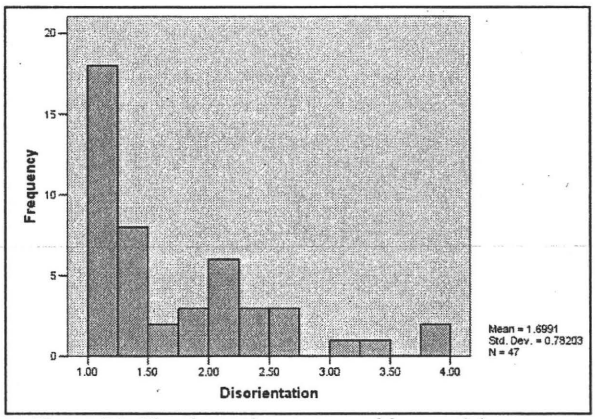


Figure 24: Disorientation among older participants

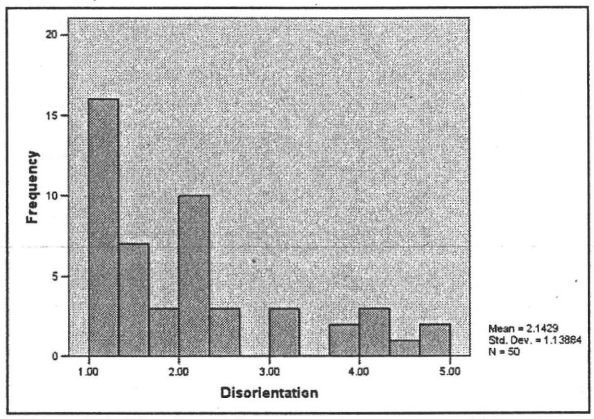


Figure 25: Disorientation among younger participants

The most disoriented younger participants, on the other hand, provided plenty of detailed feedback. Their comments centred on both navigation and aesthetic elements. Illustrative samples of these comments include:

- It wasn't intuitive
- I felt "lost" easily
- Bolded text does not link to other sections
- No access to previous page once in sections
- Hard to go back to find information previously viewed
- Loss of navigation as you progress through site
- Too many subheadings
- No back button on the site itself
- No search capability
- Everything looked the same, hard to find distinct info
- Boring
- Not interactive
- No pictures

These comments indicate that younger participants may have been negatively impacted by the simple layout and navigation of the web site. Perhaps their greater volume of web use creates expectations about what a web site "should" include: network-type links between sections, search capabilities, and other visual indicators. While the web site was kept simple in order to not disadvantage older adults, it may have been less supportive for experienced younger adults.

Hypotheses were not made about the impact of age on engagement and satisfaction since theoretical basis was not discovered in the literature review in Chapter 2. When exploring the relationships via the saturated model, however, no statistically significant relationship was observed. In terms of bivariate correlations, there was no significant correlation between age and satisfaction suggesting that the relationship between age and satisfaction is fully mediated by other factors, as proposed in the research model. Age did, however, positively correlate with engagement. Older adults were found to be more engaged with the site (0.298, $p<0.01$), but also more interested in the topic, as assessed by their familiarity with it (0.241, $p<0.05$). The same was observed among female participants who were more engaged and familiar ($p<0.05$). This supports the notion that engagement is triggered when the subject matter is personally interesting (O'Brien & Toms, 2008), but does not indicate whether there is an age effect on engagement.

It may be plausible that younger adults were less able to engage with the web site because of the nature of the experiment. Researchers are beginning to explore

whether or not young adults' tendency to frequently multitask has any impact on their ability to remain focused in a single task. Some suspect that individuals that multitask consistently may reduce their capacity to fully focus on a single task, referred to as attention deficit trait (Tugend, 2008). The youngest participants in the experiment are the most likely to be persistent multitaskers, and thus may have had the most difficulty engaging in the use of one web site without distraction.

It is also plausible that younger adults were less engaged with the web site as a result of the design issues noted above. This brings to question the causality between engagement and disorientation: were younger adults less able to engage with the site because they were disoriented, or were they disoriented because they were unable to engage with web site? Since experienced younger adults are less likely to feel disoriented, there is reason to believe that the causality between these two constructs may be the reverse of previous findings where disorientation leads to engagement.

How can mental model accuracy be measured and what role does it play in influencing the user experience?

Here the MMA of the participants was assessed by having them recreate the hierarchy of the web site as they understood it using a set of cards (with each card representing one page in the site). Although having participants create a mental model in this fashion is not a new concept, the scoring method implemented here is novel in a usability experiment context. Each participant's hierarchy was compared to the correct

hierarchy using a tree distance algorithm, previously used in the computer science and biomedical computing disciplines, resulting in a score for the exercise. This scoring method was more sophisticated than that used in previous mental model studies (which only allotted one point for each node connected to the correct parent node) and the resulting scores performed well on the utilitarian side of the PLS model, being positively influenced by spatial ability (H4 supported) and having a positive influence on performance (H2 supported).

MMA did not impact disorientation on the hedonic side as expected (H3 not supported). This is related to the discussion of disorientation above since older participants did have less accurate mental models, but reported lower perceived disorientation than younger participants. Thus, MMA assisted participants in performing from a utilitarian perspective, but did not have significant influence on their hedonic perceptions.

Participants' MMA was also positively influenced by previous experience with similar sites. As described in Lee & Boling (2008), users make sense of incoming information by assimilating it into their existing knowledge framework. Thus, participants who were experienced in the knowledge domain had an existing knowledge structure that they were able to use as a foundation when exploring the experimental web site.

Summary

So, what is the impact of age on web site usability? The results of this study indicate that the answer to this question from the performance (utilitarian) aspect of usability is quite clear: age has a negative impact on performance in this context. The answer from the satisfaction (hedonic) aspect of usability is less apparent. This study found the relationship between age and user satisfaction to be fully mediated by other hedonic constructs (disorientation and engagement), and the relationship between age and these other hedonic constructs is uncertain.

It is apparent from the PLS results that there is a disconnect between the utilitarian and hedonic elements in the research model. Although three relationships were hypothesized based on previous studies, the only statistically significant relationship is between disorientation and performance. It is possible that this results from characteristics that have been observed in the past in studies with older adults. According to Dickinson et al. (2007), older adults may find the experimental process stressful and also have a greater concern with being socially desirable. These two tendencies can impact the reliability of self-report responses of older adults. So perhaps older adults under-reported disorientation and over-reported engagement in an effort to be socially desirable, leading to insignificant relationships between the utilitarian and hedonic sides of the PLS model.

Another possible source of this disconnect is the experimental web site itself. Designed with the concerns of older adults in mind, the site design was intended to

create a level playing field for all of the participants. It seems that creating a web site simple enough to avoid distractions for older adults may make it unappealing for younger adults. So although younger adults were able to perform well from a utilitarian standpoint, they did not enjoy the site from a hedonic perspective. Conversely, the older adults had more hedonic appreciation for the web site, but their utilitarian performance suffered from the effects of age.

This raises the question of whether it is reasonable to hope that a web site will appeal equally to both older and younger adults. In reality, it is unlikely that older and younger adults would be making use of the same web site for hedonic purposes since these groups have different interests. Thus the concern over appeal may be more relevant in the context of a utilitarian web site. Past studies have found that younger adults are more concerned with perceived usefulness (which is a utilitarian outcome) in a utilitarian context (Morris & Venkatesh, 2000). Thus, the apparent lack of appeal to younger users in a web site designed to be user friendly to older adults may be inconsequential in practice.

6.2 Contributions

This research makes a number of contributions to theory and practice. From a theoretical perspective, there are contributions to four areas of literature.

Usability theory: this study contributes to the usability literature by exploring some novel hedonic and utilitarian indicators of satisfaction with a web site. In the

utilitarian category, mental model accuracy was explored as an antecedent of performance. This new operationalization of MMA performed well in the research model as a strong indicator of performance with the web site. In the hedonic category, disorientation and engagement were studied as indicators of performance and satisfaction. Although hedonic constructs are studied less often in usability research, these constructs had a more significant impact on user satisfaction than the utilitarian indicators, supporting the notion that there is great opportunity to explore the impact of hedonic constructs in usability research.

Usability for older adults: this study contributes to literature concerning web site usability for older adults by examining the impact of age and its associated changes in spatial abilities on utilitarian and hedonic usability outcomes. On the utilitarian side, the consideration of spatial ability's relationship with MMA is a novel addition to the literature, and creates a new antecedent for the often studied performance construct. On the hedonic side, disorientation had not been discussed in the literature reviewed for Chapter 2, and the results surrounding it were unexpected, indicating that further research concerning this important construct is warranted. Also, the exploratory investigation of the impact of age on engagement raised some interesting questions about the engagement construct, and the causal relationship between engagement and disorientation. And finally, the results suggest the full mediation of the relationship between age and user satisfaction, offering some insight into previous studies' findings of an insignificant relationship between the two constructs.

Computer use by older adults: the extensive, multi-disciplinary literature review presented in Chapter 2 is a significant contribution to the literature concerning computer use by older adults. The holistic overview of the literature examined through the lens of Social Cognitive Theory provides a thorough survey of the field and a clear framework for future research in this growing and important field. While some of the literature gaps are addressed in this research, a great number of gaps remain for future research.

Measuring Mental Model Accuracy and its impacts: this study presents a new methodology for examining the mental model accuracy of web site users, which is more sophisticated than previously implemented methodologies, and performed well in the utilitarian path of the research model. Although Nielsen recommends that system learnability be considered as an element of usability, Hornbaek (2006) noted that usability studies do not make attempts to measure the learnability of systems. The MMA methodology developed and used here can be viewed as a measure of the learnability of web sites and an indicator of usability, adding a tool to the existing toolkit available for usability testing.

From a practical perspective, the findings of this research highlight the distinction between utilitarian and hedonic aspects of usability. On the utilitarian side, web site developers can assist users with lower levels of spatial ability by encouraging the development of the user's mental model through their design, thereby improving the users' performance with the web site. It is important to note, however, that

ultimate user satisfaction is not solely dependent on users' ability to perform well within a web site. In fact, hedonic aspects such as disorientation and engagement have a stronger influence on user satisfaction.

The results also reveal some intricacies with respect to designing web sites for users of different age groups. In this experiment, the web site design was simple in an effort to not disadvantage older users. This simplicity seemed to create issues for the younger group, since some of the navigation clues that they may have expected were absent. This raises the question of whether a web site can be designed to appeal to both older and younger age groups. When developing a utilitarian web site to be used by both age groups, developers should provide the navigation cues that experienced users have come to expect, while bearing in mind the simplicity that older users prefer. Although the simplicity may not appeal to younger users, they will be more concerned with utilitarian outcomes in this context, and this study indicates that their performance will not be hampered by this lack of appeal. It is unlikely that a developer would be faced with the task of designing a utilitarian web site for use by both older and younger users. Should this situation arise, the findings indicate here that it may be difficult to please both age groups with a single web site.

6.3 Limitations

One limitation of this study is the population of older adult participants. Although this experiment goes beyond the typical recruitment of a limited range of

ages, the sample of older adults here is not likely representative of older adults in general. For example, older adults are generally less educated than younger ones (Dickinson et al., 2007), but that was not observed here. It appeared that the older adults who were willing to participate were more educated and experienced than general and thus likely had better performance than the typical older adult. The implication of this limitation on hedonic outcomes is less clear, although it is expected that less experienced older adults would have more negative attitudes.

Another limitation is the experimental web site. For one, it was designed for the purpose of the experiment and may not be representative of actual web sites. For example, the navigation of the site was limited to links in the navigation system with no network-type links between pages and the site was simple in that it excluded some aspects of navigation (such as breadcrumbs and search functionality) to facilitate the MMA exercise.

Finally, MMA was assessed after fairly limited exposure to the web site. Although the web site was designed to be simple enough for this to be sufficient, the study does not consider how a mental model develops over time or how that development influences disorientation.

6.4 Future Research

Although this research answered a number of research questions, it also raised several new questions. The measurement of hedonic constructs with older and younger

adults appears to be more complex than anticipated. In particular, the variance explained in disorientation was only 6.4%, the causality between disorientation and engagement is uncertain, and the reason for the variance in engagement between the age groups is uncertain. These questions raise the issue of whether or not the existing measures are appropriate for use with older adults, since they were devised and validated using younger samples. As discussed in Chapter 2, some researchers have developed new scales specifically for use with older adults (e.g. Lagana (2008), and Lin (2003b)), which may prove to be relevant in this case also.

Another area that may be appropriate for new measure development is conceptualizations of age. Although the single item measures are commonly used in other disciplines, there may be more appropriate measures for subjective and functional age for measurement in the IS context. For example, functional age could account for some of the unexplained variance in performance, and subjective age could help to explain hedonic measures more accurately if IS-specific measures were developed.

As discussed in Chapter 2, there is a plethora of opportunity for future research concerning older adults and computer use in general, including in the area of web site usability. Figure 4 provides an overview of existing research in this field which researchers can use to deduce opportunities for future research. Three ways to use Figure 4 to identify research opportunities are described in detail in section 2.3.

6.5 Conclusion

The objective of this dissertation research was to explore the impact of age on utilitarian and hedonic measures of web site usability. As the world's population ages and makes increasing use of the Internet, web usability for older adults is an increasingly important topic, which has been under-studied to date. The rigorous laboratory experiment conducted here offers a number of insights to this topic. For one, the study of users' spatial abilities and resulting mental models provides a new means of examining the impact of age on performance. Also, the often-neglected hedonic usability constructs measured here had a more significant impact on user satisfaction than the utilitarian constructs did. At the same time, these hedonic constructs proved to be unexpectedly complex in terms of their relationship to age. Although this research sheds some light on web site usability for older adults, there is much more to discover in this increasingly relevant field.

References

Agarwal, R., & Karahanna, E. 2000. Time Flies When You're Having Fun: Cognitive Absorption and Beliefs About Information Technology Usage. ***MIS Quarterly***, 24(4): 665-694.

Agarwal, R., & Venkatesh, V. 2002. Assessing a firm's web presence: A heuristic evaluation procedure for the measurement of usability. ***Information Systems Research***, 13(2): 168-186.

Ahuja, J. S., & Webster, J. 2001. Perceived Disorientation: An Examination of a New Measure to Assess Web Design Effectiveness. ***Interacting with Computers***, 14(1): 15-29.

Alemagno, S. A., Niles, S. A., & Treiber, E. A. 2004. Using computers to reduce medication misuses of community-based seniors: results of a pilot intervention program. ***Geriatric Nursing***, 25(5): 281-285.

Alexy, E. M. 2000. Computers and caregiving: Reaching out and redesigning interventions for homebound older adults and caregivers. ***Holistic Nursing Practice***, 14(4): 60-66.

Alphonso, C., & Bonoguore, T. 2007. Aging population set to alter landscape, ***The Globe and Mail***. Toronto.

Aula, A. 2005. User study on older adults' use of the web and search engines. ***Universal Access in the Information Society***, 4(1): 67-81.

Baack, S. A., & Brown, T. S. 1991. Attitudes toward computers: Views of older adults compared with those of young adults. ***Journal of Research on Computing in Education***, 23(3): 422-433.

Baldi, R. 1997. Training older adults to use the computer: issues related to the workplace, attitudes, and training. ***Educational Gerontology***, 23(5): 453-465.

Bandura, A. 1986. ***Social Foundations of Thought and Action***. Englewood Cliffs, NJ: Prentice Hall.

Bandura, A. 1997. ***Self-efficacy: The exercise of control***. New York: Freeman.

Becker, S. A. 2004a. E-government visual accessibility for older adult users. ***Social Science Computer Review***, 22(1): 11-23.

Becker, S. A. 2004b. A study of web usability for older adults seeking online health resources. ***ACM Transactions on Computer-Human Interaction***, 11(4): 387-403.

Becker, S. A. 2005. E-Government Usability for Older Adults. ***Communications of the ACM***, 48(2): 102-104.

Benyon, D., & Murray, D. 1993. ***Developing adaptive systems to fit individual aptitudes***. Paper presented at the 1st International Conference on Intelligent User Interfaces, Orlando, Florida, USA.

Bhattacherjee, A. 2001. Understanding Information Systems Continuance: An Expectation-Confirmation Model. ***MIS Quarterly***, 25(3): 351-370.

Bickmore, T. W., Caruso, L., Clough-Gorr, K., & Heeren, T. 2005. 'It's just like you talk to a friend' relational agents for older adults. ***Interacting with Computers***, 17(6): 711-735.

Bille, P. 2005. A survey on tree edit distance and related problems. ***Theoretical Computer Science***, 337: 217-239.

Birdi, K., Pennington, J., & Zapf, D. 1997. Ageing and errors in computer-based work: An observational field study. ***Journal of Occupational & Organizational Psychology***, 70(1): 35-47.

Birdi, K. S., & Zapf, D. 1997. Age differences in reactions to errors in computer-based work. ***Behaviour & Information Technology***, 16(6): 309-319.

Bitterman, N., & Shalev, I. 2004. The silver surfer: Making the internet usable for seniors. ***Ergonomics in Design***, 12(1): 24-28.

Blake, M. 1998. Libraries, the Internet and older people. ***New Review of Information Networking***, 4: 23-38.

Blit-Cohen, E., & Litwin, H. 2004. Elder participation in cyberspace: A qualitative analysis of Israeli retirees. ***Journal of Aging Studies***, 18(4): 385-398.

Blythe, M., Reid, J., Wright, P., & Geelhoed, E. 2006. Interdisciplinary criticism: analysing the experience of *riot!* a location-sensitive digital narrative. ***Behaviour & Information Technology***, 25(2): 127-139.

Bolt, M. A., Killough, L. N., & Koh, H. C. 2001. Testing the interaction effects of task complexity in computer training using the social cognitive model. ***Decision Sciences***, 32(1): 1-20.

Bucur, A., Renold, C., & Henke, M. 1999. How do older netcitizens compare with their younger counterparts? ***CyberPsychology & Behavior***, 2(6): 505-513.

Campbell, R. J. 2008. Meeting seniors' information needs: using computer technology. ***Home Health Care Management & Practice***, 20(4): 328-335.

Carpenter, B. D., & Buday, S. 2007. Computer use among older adults in a naturally occurring retirement community. ***Computers in Human Behavior***, 23(6): 3012-3024.

Chadwick-Dias, A., McNulty, M., & Tullis, T. 2003. ***Web usability and age: How design changes can improve performance***. Paper presented at the Conference on Universal Usability, Vancouver, British Columbia, Canada.

Chaffin, A. J., & Harlow, S. D. 2005. Cognitive Learning Applied to Older Adult Learners and Technology. ***Educational Gerontology***, 31(4): 301-329.

Chan, S.-c., & Lu, M.-t. 2004. Understanding Internet Banking Adoption and Use Behavior: A Hong Kong Perspective. ***Journal of Global Information Management***, 12(3): 21-43.

Charness, N., & Holley, P. 2004. The New Media and Older Adults: Usable and Useful? ***American Behavioral Scientist***, 48(4): 416-433.

Charness, N., Kelley, C. L., Bosman, E. A., & Mottram, M. 2001. Word-Processing Training and Retraining: Effects of Adult Age, Experience, and Interface. ***Psychology and Aging***, 16(1): 110-127.

Chen, Y., & Persson, A. 2002. Internet use among young and older adults: relation to psychological well-being. ***Educational Gerontology***, 28(9): 731-744.

Chevalier, A., & Rossetti, M. 2010. Searching for information on the worlds wide web with a search engine: A pilot study on cognitive flexibility in younger and older users. ***Psychological Reports***, 106(2): 490-498.

Childers, T. L., Carr, C. L., Peck, J., & Carson, S. 2001. Hedonic and utiitarian motivations for online retail shopping behavior. ***Journal of Retailing and Consumer Services***, 77(4): 511-535.

Chin, W. 1998. The Partial Least Squares Approach to Structural Equation Modeling. In G. A. Marcoulides (Ed.), ***Modern Methods for Business Research***: 295-336. Mahwah, NJ: Lawrence Erlbaum Associates.

Chung, J., & Tan, F. 2004. Antecedents of perceived playfulness: and exploratory study on user acceptance of general information-searching websites. ***Information & Management***, 41: 869-881.

Cody, M. J., Dunn, D., Hoppin, S., & Wendt, P. 1999. Silver surfers: Training and evaluating Internet use among older adult learners. ***Communication Education***, 48(4): 269-286.

Cohen, J. 1988. ***Statistical Power Analysis for the Behavioral Sciences*** (2nd ed.). Hillsdale, N.J.: Lawrence Erlbaum Associates.

Compeau, D., Higgins, C. A., & Huff, S. 1999. Social cognitive theory and individual reactions to computing technology: A longitudinal study. ***MIS Quarterly***, 23(2): 145-159.

Compeau, D. R., & Higgins, C. A. 1995. Computer Self-Efficacy: Development of a Measure and Initial Test. ***MIS Quarterly***, 19(2): 189-211.

Conklin, J. 1987. Hypertext: An Introduction and Survey. ***IEEE Computer***, 20(9): 17-41.

Cowan, T. 2007. A picture of the future in 2017; how will Canadian society look after the bulk of the baby boom has shifted from the work force to retirement?, ***The Globe and Mail***. Toronto.

Coyne, K., & Nielsen, J. 2002. Web Usability for Senior Citizens: 46 Design Guidelines Based on Usabiity Studies with People Age 65 and Older: Nielsen Norman Group.

Cronbach, L. J. 1951. Coefficient alpha and the internal structure of tests. ***Psychometrika***, 16(3): 297-334.

Curzon, P., Wilson, J., & Whitney, G. 2005. Successful strategies of older people for finding information. ***Interacting with Computers***, 17(6): 660-671.

Cutler, S. J., Hendricks, J., & Guyer, A. 2003. Age Differences in Home Computer Availability and Use. ***The Journals of Gerontology***, 58B(5): S271-S280.

Czaja, S. J. 1997. Computer Technology and the Older Adult. In M. Helander, T. K. Landauer, & P. Prabhu (Eds.), ***Handbook of Human-Computer Interaction***, Second ed.: 797-812: Elsevier Science.

Czaja, S. J., Charness, N., Fisk, A. D., Hertzog, C., Nair, S. N., Rogers, W. A., & Sharit, J. 2006. Factors Predicting the Use of Technology: Findings From the Center for Research and Education on Aging and Technology Enhancement (CREATE). ***Psychology and Aging***, 21(2): 333-352.

Czaja, S. J., & Hiltz, S. R. 2005. Digital Aids for an Aging Society. ***Communications of the ACM***, 48(10): 43-44.

Czaja, S. J., & Lee, C. C. 2001. The Internet and Older Adults: Design Challenges and Opportunities. In N. Charness, D. Parks, & B. Sabel (Eds.), ***Communication, Technology and Aging: Opportunities and Challenges for the Future***. New York, NY: Springer Publishing Co.

Czaja, S. J., & Sharit, J. 1993. Age differences in the performance of computer-based work. ***Psychology and Aging***, 8(1): 59-67.

Czaja, S. J., & Sharit, J. 1998. Age differences in attitudes toward computers. ***The Journals of Gerontology***, 53B(5): 329-340.

Czaja, S. J., Sharit, J., Ownby, R., Roth, D. L., & Nair, S. 2001. Examining age differences in performance of a complex information search and retrieval task. ***Psychology and Aging***, 16(4): 564-579.

Danielson, D. R. 2003. Transitional Volatility in Web Navigation. ***IT & Society***, 1(3): 131-158.

Davis, F. D. 1989. Perceived usefulness, perceived ease of use, and user acceptance of information technology. ***MIS Quarterly***, 13(3): 319-339.

Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. 1989. User acceptance of computer technology: A comparison of two theoretical models. ***Management Science***, 35(8): 982-1003.

Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. 1992. Extrinsic and intrinsic motivation to use computers in the workplace. ***Journal of Applied Social Psychology***, 22(14): 1111-1132.

Deatrick, D. 1997. Senior-Med: Creating a network to help manage medication. ***Generations***, 21(3): 59-60.

DeGraves, D., & Denesiuk, R. 2000. The seniors computer information program: a pioneer website for seniors. ***Educational Gerontology***, 26(4): 345-355.

Diamantopoulos, A., & Winklhofer, H. 2001. Index Construction with Formative Indicators: An Alternaive to Scale Development. ***Journal of Marketing Research***, 38(May): 239-277.

Dickinson, A., Arnott, J., & Prior, S. 2007. Methods for human-computer interaction research with older people. ***Behaviour & Information Technology***, 26(4): 343-352.

Dickinson, A., Eisma, R., Gregor, P., Syme, A., & Milne, S. 2005. Strategies for teaching older people to use the world wide web. ***Universal Access in the Information Society***, 4(1): 3-15.

Dickinson, A., & Gregor, P. 2006. Computer use has no demonstrated impact on the well-being of older adults. ***International Journal of Human-Computer Studies***, 64(8): 744-753.

Dillon, A., Richardson, J., & McKnight, C. 1990. ***Navigation in Hypertext: a critical review of the concept***. Paper presented at the Human-Computer Interaction-INTERACT'90, North Holland: Amsterdam.

Doll, W. J., & Torkzadeh, G. 1988. The Measurement of End-User Computing Satisfaction. ***MIS Quarterly***, 12(2): 259-274.

Dorin, M. 2007. Online education of older adults and its relation to life satisfaction. ***Educational Gerontology***, 33(2): 127-143.

Dyck, J. L., Gee, N. R., & Smither, J. A.-A. 1998. The changing construct of computer anxiety for younger and older adults. ***Computers in Human Behavior***, 14(1): 61-77.

Dyck, J. L., & Smither, J. A.-A. 1996. Older adults' acquisition of word processing: the contribution of cognitive abilities and computer anxiety. ***Computers in Human Behavior***, 12(1): 107-119.

Eastman, J. K., & Iyer, R. 2005. The impact of cognitive age on Internet use of the elderly: an introduction to the public policy implications. ***International Journal of Consumer Studies***, 29 (2): 125-136.

Echt, K. V., Morrell, R. W., & Park, D. C. 1998. Effects of age and training formats on basic computer skill acquisition in older adults. ***Educational Gerontology***, 24(1): 3-25.

Edwards, D., & Hardman, L. 1989. 'Lost in Hyperspace': Cognitive Mapping and Navigation in a Hypertext Environment. In R. McAleese (Ed.), ***Hypertext: theory into practice***. Norwood, N.J.: Ablex Pub. Co.

Egan, D. E., & Gomez, L. M. 1985. Assaying, isolating, and accommodating individual differences in learning complex skill, ***Individual Differences in Cognition***, Vol. 2: 174-217.

Ekstrom, R. B., French, J. W., Harmon, H. H., & Dermen, E. 1976. ***Kit of Factor-Referenced Cognitive Tests***. Princeton, NJ: Educational Testing Service.

Eliot, J., & Smith, I. M. 1983. ***An International Directory of Spatial Tests***. Windsor, Berks: NFER-NELSON.

Ellis, R. D., & Kurnlawan, S. H. 2000. Increasing the Usability of Online Information for Older Users: A Case Study in Participatory Design. ***International Journal of Human-Computer Interaction***, 12(2): 263-276.

Falk, R. F., & Miller, N. B. 1992. ***A Primer for Soft Modeling*** (first ed.). Akron, Ohio: The University of Akron Press.

Festervand, T. A., & Meinert, D. B. 1994. Older adults' attitudes toward and adoption of personal computers and computer-based lifestyle assistance. ***Journal of Applied Business Research***, 10(2): 13-22.

Flynn, K. E., Smith, M. A., & Freese, J. 2006. When do older adults turn to the internet for health information? Findings from the Wisconsin longitudinal study. ***Journal of General Internal Medicine***, 21(12): 1295-1301.

Foot, D. K. 1996. ***Boom, Bust & Echo: how to profit from the coming demographic shift***. Toronto: Macfarlane Walter & Ross.

Fornell, C., & Larcker, D. F. 1981. Evaluating Structural Equation Models with Unobservable Variables and Measurement Error. ***Journal of Marketing Research***, 18(1): 39-50.

Freese, J., Rivas, S., & Hargittai, E. 2006. Cognitive ability and Internet use among older adults. ***Poetics***, 34(4-5): 236-249.

Freudenthal, D. 2001. Age differences in the performance of information retrieval tasks. ***Behaviour & Information Technology***, 20(1): 9-22.

Friedberg, L. 2003. The impact of technological change on older workers: Evidence from data on computer usage. ***Industrial and Labor Relations Review***, 56(3): 511-529.

Fukuda, R., & Bubb, H. 2003. Eye tracking study on web-use: comparison between younger and elderly users in case of search task with electronic timetable service. ***PsychNology Journal***, 1(3): 202-228.

Furlong, M. 1997. Creating online community for older adults. ***Generations***, 21(3): 33-35.

Gagliardi, C., Mazzarini, G., Papa, R., Giuli, C., & Marcellini, F. 2008. Designing a learning program to link old and disabled people to computers. ***Educational Gerontology***, 34(1): 15-29.

Galletta, D. F., Henry, R. M., McCoy, S., & Polak, P. 2006. When the Wait Isn't So Bad: The Interacting Effects of Website Delay, Familiarity, and Breadth. ***Information Systems Research***, 17(1): 20-37.

Gefen, D., & Straub, D. 2005. A practical guide to factorial validity using PLS-Graph: tutorial and annotated example. ***Communications of the AIS***, 16(25): 91-109.

Gefen, D., Straub, D. W., & Boudreau, M.-C. 2000. Structural Equation Modeling and Regression: Guidelines for Research Practice. ***Communications of the AIS***, 4(7): 1-77.

Given, L. M., Ruecker, S., Simpson, H., Sadler, E., & Ruskin, A. 2007. Inclusive interface design for seniors: image-browsing for a health information context. ***Journal of the American Society for Information Science and Technology***, 58(11): 1610-1617.

Goodman, J., & Lundell, J. 2005. HCI and the older population. ***Interacting with Computers***, 17(6): 612-620.

Graff, M. 2005. Individual differences in hypertext browsing strategies. ***Behaviour & Information Technology***, 24(2): 93-99.

Grahame, M., Laberge, J., & Scialfa, C. T. 2004. Age Differences in Search of Web Pages: The Effects of Link Size, Link Number, and Clutter. ***Human Factors***, 46(3): 385-398.

Gunther, V., Schafer, P., Holzner, B., & Kemmler, G. 2003. Long-term improvements in cognitive performance through computer-assisted cognitive training: a pilot study in a residential home for older people. ***Aging & Mental Health***, 7(3): 200-206.

Hanson, V. L., & Crayne, S. 2005. Personalization of web browsing: adaptations to meet the needs of older people. ***Universal Access in the Information Society***, 4(1): 46-58.

Hart, T., Chaparro, B., & Halcomb, C. 2008. Evaluating websites for older adults: adherence to senior-friendly guidelines and end-user performance. ***Behaviour & Information Technology***, 27(3): 191-199.

Hassanein, K., & Head, M. 2007. Manipulating perceived social presence through the web interface and its impact on attitude towards online shopping. ***International Journal of Human-Computer Studies***, 65: 689-708.

Hawthorn, D. 2000. Possible implications of aging for interface designers. ***Interacting with Computers***, 12(5): 507-528.

Hawthorn, D. 2007. Interface design and engagement with older people. ***Behaviour & Information Technology***, 26(4): 333-341.

Ho, G., Wheatley, D., & Scialfa, C. 2005. Age differences in trust and reliance of a medication management system ***Interacting with Computers***, 17(6): 690-710.

Hogan, M. 2005. Technophobia Amongst Older Adults in Ireland. ***Irish Journal of Management***(Special Issue): 57-77.

Hollis-Sawyer, L. A., & Sterns, H. L. 1999. A novel goal-oriented approach for training older adult computer novices: beyond the effects of individual difference factors. ***Educational Gerontology***, 25: 661-684.

Höök, K., Dahlbäck, N., & Sjölinder, M. 1996. Individual Differences and Navigation in Hypermedia: European Research Consortium for Informatics and Mathematics at SIC.

Hornbaek, K. 2006. Current practice in measuring usability: challenges to usability studies and research. ***International Journal of Human-Computer Studies***, 64: 79-102.

Hough, M., & Kobylanski, A. 2009. Increasing elder consumer interactions with information technology. ***Journal of Consumer Marketing***, 26(1): 39-48.

Huang, C. D., & Hu, Q. 2004. Integrating web services with competitive strategies: the balanced scorecard approach. ***Communications of the AIS***, 2004(13): 57-80.

Hutchison, D., Eastman, C., & Tirrito, T. 1997. Designing user interfaces for older adults. ***Educational Gerontology***, 23(6): 497-513.

ISO. 1998. Ergonomic requirements for office work with visual display terminals (VDTs)- Part II: guidance on usability, Vol. 9241-11.

Jacko, J., Emery, V. K., Edwards, P. J., Ashok, M., Barnard, L., Kongnakorn, T., Moloney, K. P., & Sainfort, F. 2004. The effects of multimodal feedback on older adults' task performance given varying levels of computer experience. ***Behaviour & Information Technology***, 23(4): 247-264.

Jacques, R., Preece, J., & Carey, T. 1995. Engagement as a Design Concept for Multimedia. ***Canadian Journal of Educational Communication***, 24(1): 49-59.

Jansen, B. J. 2006. Search log analysis: What is it; what's been done; how to do it. ***Library and Information Science Research***, 28(3): 407-432.

Jimison, H., Pavel, M., McKanna, J., & Pavel, J. 2004. Unobtrusive monitoring of computer interactions to detect cognitive status in elders. ***IEEE Transactions on Information Technology in Biomedicine***, 8(3): 248-252.

Jones, B. D., & Bayen, U. J. 1998. Teaching older adults to use computers: Recommendations based on cognitive aging research. ***Educational Gerontology***, 24(7): 675-689.

Juznic, P., Blazic, M., Mercun, T., & Plestenjak, B. 2006. Who says that old dogs cannot learn new tricks? ***New Library World***, 107(7-8): 332-345.

Karahanna, E., & Straub, D. 1999. The psychological origins of perceived usefulness and ease-of-use. ***Information & Management***, 35(4): 237-250.

Karavidas, M., Lim, N. K., & Katsikas, S. L. 2005. The effects of computers on older adult users. ***Computers in Human Behavior***, 21(5): 697-711.

Kelley, C. L., & Charness, N. 1995. Issues in training older adults to use computers. ***Behaviour & Information Technology***, 14(2): 107-120.

Kelley, C. L., Morrell, R. W., Park, D. C., & Mayhorn, C. B. 1999. Predictors of electronic bulletin board system use in older adults. ***Educational Gerontology***, 25(1): 19-35.

Kim, H., & Hirtle, S. 1995. Spatial metaphors and disorientation in hypertext browsing. ***Behaviour & Information Technology***, 14: 239-250.

Knight, M. B., & Pearson, J. M. 2005. The Changing Demographics: The Diminishing Role of Age and Gender in Computer Usage. ***Journal of Organizational and End User Computing***, 17(4): 49-65.

Kooij, D., deLange, A., Jansen, P., & Dikkers, J. 2008. Older workers' motivation to continue to work: five meanings of age, A conceptual review. ***Journal of Managerial Psychology***, 23(4): 364-394.

Korthauer, R. D., & Koubek, R. J. 1994. An empirical evaluation of knowledge, cognitive style, and structure upon the performance of a hypertext task. ***International Journal of Human-Computer Interaction***, 6(4): 373-390.

Koufaris, M. 2002. Applying the Technology Acceptance Model and Flow Theory to Online Consumer Behavior. ***Information Systems Research***, 13(2): 205-223.

Kovacs, D., & Robinson, K. 2004. ***The Kovacs Guide to Electronic Library Collection Development***. New York: Neal-Schuman Publishers.

Kressig, R., & Echt, K. 2002. Exercise prescribing: Computer application in older adults. ***Gerontologist***, 42(2): 273-277.

Kubeck, J. E., Miller-Albrecht, S. A., & Murphy, M. D. 1999. Finding information on the World Wide Web: Exploring older adults' exploration ***Educational Gerontology***, 25(2): 167-183.

Kurniawan, S. H., King, A., Evans, D. G., & Blenkhorn, P. L. 2006. Personalising web page presentation for older people. ***Interacting with Computers***, 18(3): 457-477.

Laberge, J. C., & Scialfa, C. T. 2005. Predictors of web navigation performance in a life span sample of adults. ***Human Factors***, 47(2): 289-302.

Lagana, L. 2008. Enhancing the attitudes and self-efficacy of older adults toward computers and the internet: results of a pilot study. ***Educational Gerontology***, 34: 831-843.

Laguna, K., & Babcock, R. L. 1997. Computer anxiety in young and older adults: Implications for human-computer interactions in older populations. ***Computers in Human Behavior***, 13(3): 317-326.

Lam, J. C. Y., & Lee, M. K. O. 2006. Digital Inclusiveness--Longitudinal Study of Internet Adoption by Older Adults. ***Journal of Management Information Systems***, 22(4): 177-206.

Lazar, J., Bessiere, K., Ceaparu, I., Robinson, J., & Shneiderman, B. 2003. Help! I'm Lost: User Frustration in Web Navigation. ***IT & Society***, 1(3): 18-26.

Lee, J., & Boling, E. 2008. Information-Conveying Approaches and Cognitive Styles of Mental Modeling in a Hypermedia-Based Learning Environment. ***Journal of the American Society for Information Science and Technology***, 59(4): 644-661.

Lee, Y., & Kozar, K. A. 2009. Designing usable online stores: A landscape preference perspective. ***Information & Management***, 46: 31-41.

Legris, P., Ingham, J., & Collerette, P. 2003. Why do people use information technology? A critical review of the technology acceptance model. ***Information & Management***, 40: 191-204.

Leung, A., Ko, P., Chan, K., Chi, I., & Chow, N. 2007. Searching health information via the web: Hong Kong Chinese older adults' experience. ***Public Health Nursing***, 24(2): 169-175.

Li, X., Hsieh, J. J. P.-A., & Rai, A. 2009. ***A Motivational Account for Post-Acceptance Routine and Innovative Use: Introducing the Concept of Tri-Dimensional Intrinsic Motivation***. Paper presented at the International Conference for Information Systems, Phoenix, Arizona.

Liang, H., Saraf, N., Hu, Q., & Xue, Y. 2007. Assimilation of Enterprise Systems: The Effect of Institutional Pressures and the Mediating Role of Top Management. ***MIS Quarterly***, 31(1): 59-87.

Lin, C. S., Wu, S., & Tsai, R. J. 2005. Integrating perceived playfulness into expectation-confirmation model for web portal context. ***Information & Management***, 42: 683-693.

Lin, D.-Y. M. 2003a. Age differences in the performance of hypertext perusal as a function of text typology. ***Behaviour & Information Technology***, 22(4): 219-226.

Lin, D.-Y. M. 2003b. Hypertext for the aged: effects of text topologies. ***Computers in Human Behavior***, 19(2): 201-209.

Lin, D.-Y. M. 2004. ***A comparison of navigation performances between older and younger adults in hypermedia e-mall shopping***. Paper presented at the The 8th ERCIM Workshop "User Interfaces for All", Vienna, Austria.

Lindberg, T., Nasanen, R., & Muller, K. 2006. How age affects the speed of perception of computer icons. ***Displays***, 27(4-5): 170-177.

Lippincott, G. 2004. Gray matters: Where are the technical communicators in research and design for aging audiences? . ***IEEE Transactions on Professional Communication***, 47(3): 157-170.

Loges, W. E., & Jung, J.-Y. 2001. Exploring the digital divide: Internet connectedness and age. ***Communication Research***, 28(4): 536-562.

Lustbader, W. 1997. On bringing older people into the computer age. ***Generations***, 21(3): 30-31.

Macias, W., & McMillan, S. 2008. The return of the house call: the role of internet-based interactivity in bringing health information home to older adults. ***Health Communications***, 23(1): 34-44.

Mahmood, M. A., Burn, J. M., Gemoets, L. A., & Jacquez, C. 2000. Variables affecting information technology end-user satisfaction: a meta-analysis of the empirical literature. ***International Journal of Human-Computer Studies***, 52: 751-771.

Malta, S. 2007. Love Actually! Older adults and their romantic internet relationships. ***Australian Journal of Emerging Technologies and Society***, 5(2): 84-102.

Mann, W. C., Belchior, P., Tomita, M. R., & Kemp, B. J. 2005. Computer use by middle-aged and older adults with disabilities. ***Technology and Disability***, 17(1): 1-9.

Marchant, T. D., Tiernan, T. M., & Mann, W. C. 2005. Computer accessibility issues for older adults with disabilities: a pilot study. ***OTJR Occupation, Participation and Health***, 25(2): 55-65.

Marquié, J. C., Jourdan-Boddaert, L., & Huet, N. 2002. Do older adults underestimate their actual computer knowledge? . ***Behaviour & Information Technology***, 21(4): 273-280.

Mathieson, K., Peacock, E., & Chin, W. 2001. Extending the Technology Acceptance Model: The Influence of Perceived User Resources. ***The DATA BASE for Advances in Information Systems***, 32(3): 86-112.

Mayhorn, C. B. 2004. Older adults, computer training, and the systems approach: a formula for success. ***Educational Gerontology***, 30(3): 185-203.

McCloskey, D. W. 2006. The importance of ease of use, usefulness, and trust to online consumers: an examination of the technology acceptance model with older consumers. ***Journal of Organizational and End User Computing***, 19(3): 47-65.

McCloskey, D. W., & Leppel, K. 2010. The impact of age on electronic commerce participation: and exploratory model. ***Journal of Electronic Commerce in Organizations***, 8(1): 41-60.

McDonald, S., & Stevenson, J. R. 1996. Disorientation in hypertext: the effects of three text structures on navigation performance. ***Applied Ergonomics***, 27(1): 61-68.

McDonald, S., & Stevenson, R. J. 1998. Effects of Text Structure and Prior Knowledge of the Learner on Navigation in Hypertext. ***Human Factors***, 40(1): 18-27.

McMellon, C. A., & Schiffman, L. G. 2000. Cybersenior Mobility: Why Some Older Consumers May Be Adopting the Internet. ***Advances in Consumer Research***, 27(1): 139-144.

Mead, S. E., Batsakes, P., Fisk, A. D., & Mykityshyn, A. 1999. Application of Cognitive Theory to Training and Design Solutions for Age-related Computer Use. ***International Journal of Behavioral Development***, 23(3): 553-573.

Mead, S. E., Sit, R. A., Rogers, W. A., Jamieson, B. A., & Rousseau, G. K. 2000. Influences of general computer experience and age on library database search performance. ***Behaviour & Information Technology***, 19(2): 107-123.

Melenhorst, A.-S., Rogers, W. A., & Bouwhuis, D. G. 2006. Older Adults' Motivated Choice for Technological Innovation: Evidence for Benefit-Driven Selectivity. ***Psychology and Aging***, 21(1): 190-195.

Merzenich, M. 2007. Neuroscience via computer: brain exercise for older adults. ***Interactions***, 14(4): 42-45.

Meyer, B., Sit, R. A., Spaulding, V. A., Mead, S. E., & Walker, N. 1997. ***Age Group Differences in World Wide Web Navigation***. Paper presented at the CHI '97 Human Factors in Computing Systems.

Moon, J., & Kim, Y. 2001. Extending the TAM for a World Wide Web Context. ***Information & Management***, 38: 217-230.

Morrell, R. W. 2005. http://www.nihseniorhealth.gov: the process of construction and revision in the development of a model web site for use by older adults. ***Universal Access in the Information Society***, 4(1): 24-38.

Morrell, R. W., Dailey, S. R., Feldman, C., Mayhorn, C. B., Echt, K. V., Holt, B. J., & Podany, K. I. 2003. Older Adults and Information Technology: A Compendium of Scientific Research and Web Site Accessibility Guidelines: National Institute on Aging,.

Morrell, R. W., Mayhorn, C. B., & Bennett, J. 2000. A survey of World Wide Web use in middle-aged and older adults. ***Human Factors***, 42(2): 175-182.

Morris, A., Goodman, J., & Brading, H. 2007. Internet use and non-use: views of older users. ***Universal Access in the Information Society***, 6(1): 43-57.

Morris, J. M. 1994. User interface design for older adults. ***Interacting with Computers***, 6(4): 373-393.

Morris, M. G., & Venkatesh, V. 2000. Age Differences in Technology Adoption Decisions: Implications for a Changing Work Force. ***Personnel Psychology***, 53: 375-403.

Morris, M. G., Venkatesh, V., & Ackerman, P. L. 2005. Gender and Age Differences in Employee Decisions About New Technology: An Extension to the Theory of Planned Behavior. ***IEEE Transactions on Engineering Management***, 52(1): 69-84.

Muylle, S., Moenaert, R., & Despontin, M. 2004. The conceptualization and empirical validation of web site user satisfaction. ***Information & Management***, 41: 543-560.

Naditz, A. 2005. At one with the web. Is your site senior-friendly? ***Contemporary Longterm Care***, 28(8): 10, 12-13, 21.

Nahm, E.-S., Resnick, B., & Gaines, J. 2004. Testing the reliability and validity of computer-mediated social support measures among older adults. ***CIN: Computers, Informatics, Nursing***, 22(4): 211-219.

Ng, C.-h. 2008. Motivation among older adults in learning computer technologies: a grounded model. ***Educational Gerontology***, 34(1): 1-14.

Nielsen, J. 1995. ***Multimedia and hypertext, the Internet and beyond***. Cambridge, MA: Academic Press.

Nord, G. D., McCubbins, T. F., & Nord, J. H. 2006. E-Monitoring in the Workplace: Privacy, Legislation, and Surveillance Software. ***Communications of the ACM***, 49(8): 73-77.

Nunnally, J. C. 1978. ***Psychometric Theory*** (Second ed.). New York: McGraw Hill.

O'Brien, H. L. 2010. The influence of hedonic and utilitarian motivations on user engagement: The case of online shopping experiences. ***Interacting with Computers***, 22: 344-352.

O'Brien, H. L., & Toms, E. G. 2008. What is User Engagement? A Conceptual Framework for Defining User Engagement with Technology. ***Journal of the American Society for Information Science and Technology***, 59(6): 938-955.

O'Brien, H. L., & Toms, E. G. 2010. The Development and Evaluation of a Survey to Measure User Engagement. ***Journal of the American Society for Information Science and Technology***, 61(1): 50-69.

O'Hara, K. 2004. "Curb Cuts" on the Information Highway: Older Adults and the Internet. ***Technical Communication Quarterly***, 13(4): 423-445.

OECD. 2006. Ageing and Employment Policies. Live Longer, Work Longer. In OECD (Ed.): The Netherlands,.

Oermann, M. H., Hamilton, J., & Shook, M. L. 2003. Using the web to improve seniors' awareness of their role in preventing medical errors. ***Journal of Nursing Care Quality***, 18(2): 122-128.

Oliver, R. L. 1981. Measurement and Evaluation of Satisfaction Processes in Retail Settings. ***Journal of Retailing***, 57: 25-48.

Opalinski, L. 2001. Older adults and the digital divide: assessing results of a web-based survey. ***Journal of Technology in Human Services***, 18(3): 203-221.

Osman, Z., Poulson, D., & Nicolle, C. 2005. Introducing computers and the Internet to older users: findings from the Care OnLine project. ***Universal Access in the Information Society***, 4(1): 16-23.

Otter, M., & Johnson, H. 2000. Lost in hyperspace: metrics and mental models. ***Interacting with Computers***, 13: 1-40.

Pak, R., Czaja, S., Sharit, J., Rogers, W., & Fisk, A. 2008. The role of spatial ability and age in performance in an auditory computer navigation task. ***Computers in Human Behavior***, 24: 3045-3051.

Parton, D., Huffman, K., Pridgen, P., Norman, K., & Shneiderman, B. 1985. Learning a menu selection tree: training methods compared. ***Behaviour & Information Technology***, 4(2): 81-91.

Patwardhan, P. 2004. Exposure, Involvement and Satisfaction with Online Activities. ***Gazette: The International Journal for Communication Studies***, 66(5): 411-436.

Peacock, S. E., & Kunemund, H. 2007. Senior citizens and internet technology: reasons and correlates of access versus non-access in a European comparative perspective. ***European Journal of Ageing***, 4(4): 191-200.

Pernice, K., & Nielsen, J. 2005. Web Usability for Senior Citizens. In N. N. Group (Ed.). Fremont, California.

Petter, S., & McLean, E. 2009. A meta-analytic assessment of the DeLone and McLean IS success model: An examination of IS success at the individual level. ***Information & Management***, 46: 159-166.

Petter, S., Straub, D., & Rai, A. 2007. Specifying Formative Constructs in Information Systems Research. ***MIS Quarterly***, 31(4): 623-656.

Podsakoff, P. M., MacKenzie, S. B., Lee, J. Y., & Podsakoff, N. P. 2003. Common method biases in behavioral research: A critical review of the literature and recommended remedies. ***Journal of Applied Psychology***, 88(5): 879-903.

Priest, L., Nayak, L., & Stuart-Hamilton, I. 2007. Website task performance by older adults. ***Behaviour & Information Technology***, 26(3): 189-195.

Purcell, P. J. 2006. Older Workers: Employment and Retirement Trends. ***Journal of Pension Planning & Compliance***, 32(1): 1-18.

Reed, K., Doty, H., & May, D. 2005. The Impact of Aging on Self-efficacy and Computer Skill Acquisition. ***Journal of Managerial Issues***, 17(2): 212-228.

Reisenwitz, T., Iyer, R., Kuhlmeier, D., & Eastman, J. 2007. The elderly's internet usage: an updated look. ***Journal of Consumer Marketing***, 24(7): 406-418.

Renaud, K., & Ramsay, J. 2007. Now what was that password again? A more flexible way of identifying and authenticating our seniors. ***Behaviour & Information Technology***, 26(4): 309-322.

Ringle, C. M., Wende, S., & Will, S. 2005. SmartPLS 2.0 (M3) Beta, http://www.smartpls.de ed. Hamburg.

Roca, J. C., Chiu, C.-M., & Martinez, F. J. 2006. Understanding e-learning continuance intention: An extension of the Technology Acceptance Model. ***International Journal of Human-Computer Studies***, 64: 683-696.

Rosenthal, R. L. 2008. Older computer-literate women: their motivations, obstacles, and paths to success. ***Educational Gerontology***, 34(7): 610-626.

Salthouse, T. 1982. ***Adult cognition: An experimental psychology of human aging***. New York: Springer-Verlag.

Saunders, E. J. 2004. Maximizing Computer Use Among the Elderly in Rural Senior Centers. ***Educational Gerontology***, 30(7): 573-585.

Sayers, H. 2004. Desktop virtual environments: A study of navigation and age. ***Interacting with Computers***, 16(5): 939-956.

Schleife, K. 2006. Computer Use and Employment Status of Older Workers — An Analysis Based on Individual Data. ***Labour***, 20(2): 325-348.

Scott, J. E., & Walczak, S. 2009. Cognitive engagement with a multimedia ERP training tool: Assessing computer self-efficacy and technology acceptance. ***Information & Management***, 46: 221-232.

Segrist, K. 2004. Attitudes of older adults toward a computer training program. ***Educational Gerontology***, 30(7): 563-571.

Selwyn, N., Gorard, S., Furlong, J., & Madden, L. 2003. Older adults' use of information and communications technology in everyday life. ***Ageing & Society***, 23(5): 561-582.

Shapira, N., Barak, A., & Gal, I. 2007. Promoting older adults' well-being through internet training and use. ***Aging & Mental Health***, 11(5): 477-484.

Sharit, J., Hernandez, M., Czaja, S., & Pirolli, P. 2008. Investigating the roles of knowledge and cognitive abilities in older adult information seeking on the web. ***ACM Transactions on Human-Computer Interaction***, 15(1): Article 3.

Shneiderman, B. 1998. ***Designing the User Interface***. Boston, MA: Addison-Wesley.

Shoemaker, S. 2003. Acquisition of computer skills by older users: a mixed methods study. ***Research Strategies***, 19: 165-180.

Simon, S. J., Grover, V., Teng, J. T. C., & Whitcomb, K. 1996. The relationship of information system training methods and cognitive ability to end-user satisfaction, comprehension, and skill transfer: A longitudinal field study. ***Information Systems Research***, 7(4).

Simpson, A., & McKnight, C. 1989. ***Navigation in hypertext: structural cues and mental maps***. Paper presented at the HYPERTEXT II, the Second Annual UK conference on Hypertext, York, UK.

Sjolinder, M. 2006. ***Age-related cognitive decline and navigation in electronic environments***. Stockholm University, Stockholm.

Sjölinder, M. 1998. Spatial Cognition and Environmental Descriptions. In N. Dahlbäck (Ed.), ***Exploring Navigation: Towards a Framework for Design and Evaluation of Navigation in Electronic Spaces***.

Sjolinder, M., Höök, K., & Nilsson, L.-G. 2003. The Effect of Age-Related Cognitive Differences, Task Complexity and Prior Internet Experience in the Use of an On-line Grocery Shop. ***Spatial Cognition & Computation***, 3(1): 61-84.

Sjolinder, M., Höök, K., Nilsson, L.-G., & Andersson, G. 2005. Age differences and the acquisition of spatial knowledge in a three dimensional environment: Evaluating the use of an overview map as a navigation aid. ***International Journal of Human-Computer Studies***, 63: 537-564.

Slone, D. J. 2002. The Influence of Mental Models and Goals on Search Patterns During Web Interaction. ***Journal of the American Society for Information Science and Technology***, 53(13): 1152-1169.

Smith, D. J. 2005. Senior users of the internet: lessons from the cybernun study. ***Universal Access in the Information Society***, 4(1): 59-66.

Smith, P. A. 1996. Towards a practical measure of hypertext usability. ***interacting with Computers***, 4: 365-381.

Stevens, J. 1996. ***Applied Multivariate Statistics for the Social Sciences*** (Third Edition ed.). Mahwah, New Jersey: Lawrence Erlbaum Associates Inc.

Stevens, M. 2010. The ranks of silver surfers are growing, but they aren't mobilising, ***New Media Age***, June 10, 2010 ed.: 7.

Stoltz-Loike, M., Morrell, R. W., & Loike, J. D. 2005. Usability testing of businessthinking™ e-Learning CD-ROMs with older adults. ***Educational Gerontology***, 31(10): 765-786.

Straub, D., Boudreau, M.-C., & Gefen, D. 2004. Validation Guidelines for IS Positivist Research. ***Communications of the AIS***, 13: 380-427.

Stronge, A., Rogers, W., & Fisk, A. 2006. Web-based information search and retrieval: Effects of strategy use and age on search success ***Human Factors***, 48(3): 434-446.

Sum, S., Mathews, R., Hughes, I., & Campbell, A. 2008. Internet use and loneliness in older adults. ***CyberPsychology and Behavior***, 11(2): 208-211.

Tabachnick, B. G., & Fidell, L. S. 2001. ***Using Multivariate Statistics*** (4th ed.). Needham Heights, MA: Allyn & Bacon.

Tak, S. H., & Hong, S. H. 2005. Use of the internet for health information by older adults with arthritis. ***Orthopaedic Nursing***, 24(2): 134-138.

Tenenhaus, M., Vinzi, V. E., Chatelin, Y.-M., & Lauro, C. 2005. PLS Path Modeling. ***Computational Statistics and Data Analysis***, 48(1): 159-205.

Thayer, S. E., & Ray, S. 2006. Online Communication Preferences across Age, Gender, and Duration of Internet Use. ***CyberPsychology & Behavior***, 9(4): 432-440.

Tian, Y., & Robinson, J. D. 2008. Incidental health information use and media complementarity: A comparison of senior and non-senior cancer patients. ***Patient Education and Counselling***, 71(3): 340-344.

Trentin, G. 2004. E-learning and the third age. ***Journal of Computer Assisted Learning***, 20(1): 21-30.

Trevino, L. K., & Webster, J. 1992. Flow in Computer-Mediated Communication: Electronic Mail and Voice Mail Evaluation and Impacts. ***Communication Research***, 19(5): 539-573.

Tugend, A. 2008. Multitasking Can Make You Lose ... Um ... Focus, ***The New York Times***. New York.

Tung, L. L., Xu, Y., & Tan, F. 2009. Attributes of web site usability: a study of web users with the repertory grid technique. ***International Journal of Electronic Commerce***, 13(4): 97-126.

Turel, O., Serenko, A., & Bontis, N. 2010. User acceptance of hedonic digital artifacts: A theory of consumption values perspective. ***Information & Management***, 47: 53-59.

Turner, P., Turner, S., & Van de Walle, G. 2007. How older people account for their experiences with interactive technology. ***Behaviour & Information Technology***, 26(4): 287-296.

Venkatesh, V. 2000. Determinants of perceived ease of use: Integrating control, intrinsic motivation, and emotion into the technology acceptance model. ***Information Systems Research***, 11(4): 342-365.

Venkatesh, V., & Agarwal, R. 2006. Turning Visitors into Customers: A Usability-Centric Perspective on Purchase Behavior in Electronic Channels. ***Management Science***, 52(3): 367-382.

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. 2003. User Acceptance on Information Technology: Toward a Unified View. ***MIS Quarterly***, 27(3): 425-478.

Venkatesh, V., & Ramesh, V. 2006. Web and wireless site usability: Understanding differences and modeling use. ***MIS Quarterly***, 30(1): 181-206.

Vicente, K. J., & Williges, R. C. 1988. Accommodating individual differences in searching a hierarchical file system. ***International Journal of Man-Machine Studies***, 29(647-668).

Vuori, S., & Holmlund-Rytkönen, M. 2005. 55+ people as internet users. ***Marketing Intelligence & Planning***, 23(1): 58-76.

Wagner, N., Hassanein, K., & Head, M. 2007. ***Computer Interaction for Older Users: A Literature Review*** Paper presented at the AMCIS, Keystone, Colorado.

Wagner, N., Hassanein, K., & Head, M. 2010. Computer use by older adults: A multi-disciplinary review. ***Computers in Human Behavior***, 26(5): 870–882.

Webster, J., & Ahuja, J. S. 2006. Enhancing the design of web navigation systems: the influence of user disorientation on engagement and performance. ***MIS Quarterly***, 30(3): 661-378.

Webster, J., & Ho, H. 1997. Audience Engagement in Multimedia Presentations. ***DATA BASE for Advances in Information Systems***, 28(2): 63-77.

Webster, J., & Martocchio, J. 1993. Turning work into play: Implications for microcomputer software training. ***Journal of Management***, 19(1): 127-146.

Webster, J., & Martocchio, J. 1995. The differential effects of software training previews on training outcomes. ***Journal of Management***, 21(4): 757-787.

Westerman, S. J., Davies, D. R., Glendon, A. I., Stammers, R. B., & Matthews, G. 1995. Age and cognitive ability as predictors of computerized information retrieval. ***Behaviour & Information Technology***, 14: 313-326.

Wetzels, M., Odekerken-Schröder, G., & Van Oppen, C. 2009. Using PLS Path Modeling for Assessing Hierarchical Construct Models: Guidelines and Empirical Illustration. ***MIS Quarterly***, 33(1): 177-195.

Whitbourne, S. K. 2002. Cognitive Processes, ***The Aging Individual: Physical & Psychological Perspectives***. New York, NY: Springer Publishing Company.

White, H., McConnell, E., Clipp, E., Branch, L., Sloane, R., Pieper, C., & Box, T. L. 2002. A randomized controlled trial of the psychosocial impact of providing internet training and access to older adults. ***Aging & Mental Health***, 6(3): 213-221.

White, H., McConnell, E., Clipp, E., Bynum, L., Teague, C., Navas, L., Craven, S., & Halbrecht, H. 1999. Surfing the net in later life: A review of the literature and pilot study of computer use and quality of life. ***Journal of Applied Gerontology***, 18(3): 358-379.

White, J., & Weatherall, A. 2000. A grounded theory analysis of older adults and information technology. ***Educational Gerontology***, 26: 371-386.

Woods, D. D. 1984. Visual momentum: a concept to improve the cognitive coupling of person and computer. ***International Journal of Man-Machine Studies***, 21: 229-244.

Wright, K. 2000. Computer-mediated social support, older adults, and coping. ***Journal of Communication***, 50(3): 100-118.

Wu, A., Zhang, W., & Zhang, X. 2009. Evaluation of Wayfinding Aids in Virtual Environment. ***International Journal of Human-Computer Interaction***, 25(1): 1-21.

Xie, B. 2007. Older Chinese, the internet, and well being. ***Care Management Journals***, 8(1): 33-38.

Xie, B. 2008. Multimodal Computer-Mediated Communication and social support among older Chinese internet users. ***Journal of Computer-Mediated Communication***, 13(3): 728-750.

Yi, M. Y., & Hwang, Y. 2003. Predicting the use of web-based information systems: self-efficacy, enjoyment, learning goal orientation, and the technology acceptance model. ***International Journal of Human-Computer Studies***, 59(4): 431-449.

Zajicek, M. 2004. Successful and available: Interface design exemplars for older users. ***Interacting with Computers***, 16(3): 411-430.

Zaphiris, P., Kurniawan, S. H., & Ellis, R. D. 2003. ***Age Related Differences and the Depth vs. Breadth Tradeoff in Hierarchical Online Information Systems***. Paper presented at the User Interfaces for All, Heidelberg, Germany.

Zaphiris, P., Kurniqwan, S., & Ghiawadawala, M. 2007. A systematic approach to the development of research-based web design guidelines for older people. ***Universal Access in the Information Society***, 6: 59-75.

Zhang, K., & Shasha, D. 1989. Simple fast algorithms for the editing distance between trees and related problems. ***SIAM Journal on Computing***, 18: 1245-1262.

Ziefle, M., & Bay, S. 2006. How to Overcome Disorientation in Mobile Phone Menus: A Comparison of Two Different Types of Navigation Aids. ***Human-Computer Interaction***, 21: 393-433.

Appendix A- Definitions

Disorientation- the perception of not knowing where to go next, knowing where to go but not how to get there, or being unaware of location within the structure while using a web site

Effectiveness- the accuracy and completeness with which users achieve specified goals

Efficiency- the resources expended in relation to the accuracy and completeness with which users achieve goals

Engagement- a state of attention focus, intrinsic interest, and curiosity

Hedonic- pleasure-related

Mental model- the users' understanding of the structure of the web site, or how the nodes within the hierarchy of the site relate to one another

Performance- in practice, effectiveness and efficiency are often referred to collectively as performance

Satisfaction- the attitude toward a web site by a hands-on user of the web site

Social Cognitive Theory (SCT)- a widely accepted model of individual behavior

Spatial ability- cognitive functions concerning an individual's ability to conceptualize the spatial relationships between objects in space and awareness of location in space relative to other objects

Usability- the effectiveness, efficiency, and satisfaction with which specified users can achieve goals in particular environments

Utilitarian- functional

Appendix B- Journals and Disciplines of Reviewed Articles

Journal	Discipline	Articles
ACM Transactions on Computer-Human Interaction	HCI	2
Advances in Consumer Research	Business	1
Ageing & Society	Gerontology	1
Aging & Mental Health	Gerontology	3
American Behavioral Scientist	Psychology	1
Australian Journal of Emerging Technologies and Society	IS	1
Behaviour & Information Technology	HCI	13
Care Management Journals	Healthcare	1
CIN: Comupters, Informatics, Nursing	Healthcare	2
Communication Education	Communication	1
Communication Research	Communication	1
Communications of the ACM	IS	2
Computers in Human Behavior	HCI	8
Contemporary Long Term Care	Healthcare	1
CyberPsychology & Behavior	Psychology	3
Displays	HCI	1
Educational Gerontology	Gerontology	21
Ergonomics	HCI	1
Ergonomics in Design	HCI	1
European Journal of Ageing	Gerontology	1
Generations	Gerontology	3
Geriatric Nursing	Healthcare	1
Gerontologist	Gerontology	1
Health Communications	Communication	1
Holistic Nursing Practice	Healthcare	1
Home Health Care Management & Practice	Healthcare	1
Human Factors	HCI	4
IEEE Transactions on Engineering Management	IS	1
IEEE Transactions on Information Technology in Biomedicine	IS	1
IEEE Transactions on Professional Communication	Communication	1
Industrial & Labor Relations Review	Business	1
Interacting with Computers	HCI	10
Interactions	HCI	1
International Journal of Behavioral Development	Psychology	1
International Journal of Consumer Studies	Business	1
International Journal of Human-Computer Interaction	HCI	3
International Journal of Human-Computer Studies	HCI	1
Irish Journal of Management	Business	1
Journal of Aging Studies	Gerontology	1
Journal of Applied Business Research	Business	1
Journal of Applied Gerontology	Gerontology	2
Journal of Communication	Communication	1
Journal of Computer Assisted Learning	Education	1
Journal of Computer-Mediated Communication	Communication	1
Journal of Consumer Marketing	Business	2
Journal of General Internal Medicine	Healthcare	1
Journal of Management	Business	1
Journal of Management Information Systems	IS	1
Journal of Managerial Issues	Business	1
Journal of Nursing Care Quality	Healthcare	1
Journal of Occupational & Organizational Psychology	Psychology	1
Journal of Organizational and End User Computing	HCI	2
Journal of Research on Computing in Education	Education	1
Journal of Technology in Human Services	IS	1
Journal of the American Society for Information Science and Technology	IS	1
Labour	Business	1
Marketing Intelligence & Planning	Business	1
New Library World	Education	1
New Review of Information Networking	IS	1
Orthopaedic Nursing	Healthcare	1
OTJR Occupation, Participation and Health	Healthcare	1
Patient Education and Counseling	Healthcare	1
Personnel Psychology	Psychology	1
Poetics	Psychology	1
PsychNology Journal	HCI	1
Psychology and Aging	Gerontology	5
Public Health Nursing	Healthcare	1
Research Strategies	Education	1
Social Science Computer Review	IS	1
Spatial Cognition and Computation	Psychology	1
Technical Communication Quarterly	Communication	1
Technology and Disability	IS	1
The Journals of Gerontology	Gerontology	2
Universal Access in the Information Society	HCI	8

Appendix C- Demographic Questionnaire

Sex: ☐ Male ☐ Female

Age: _____ (years)

How old do you feel? _____ (years)

How is your health in general? (circle one):

Excellent Very Good Good Fair Poor

How are you feeling today (physically/ mentally/ emotionally) in comparison to an average day? (circle one):

Much Better Better Same Worse Much Worse

How satisfied are you with life in general? (circle one):

Very Satisfied Satisfied Neutral Dissatisfied Very Dissatisfied

Years experience using the Internet: _____

Average number of hours per week spent using web sites: _____

Please indicate your response by placing an X in the appropriate column:

	Strongly Agree 1	2	3	4	5	6	Strongly Disagree 7
If I heard about a new information technology, I would look for ways to experiment with it							
Among my peers, I am usually the first to try out new information technologies							
In general, I am hesitant to try out new information technologies							
I like to experiment with new information technologies							

Highest level of education completed:

- ☐ Did not complete high school
- ☐ High school
- ☐ Some College or University
- ☐ College or University graduate
- ☐ Graduate degree
- ☐ Other

How familiar are you with healthy living information (i.e. nutrition, exercise, etc) in general? (circle one):

Not at all familiar Very familiar

1 2 3 4 5 6 7

In the past, have you made use of healthy living information web sites? ☐ Yes ☐ No

If yes, would you classify your use of these sites as: ☐ Rare
☐ Occasional
☐ Frequent

Appendix D- Post-Experiment Survey

McMaster University DeGROOTE SCHOOL OF BUSINESS

Please indicate your response on by placing an X in the appropriate column.

While I was browsing the experimental web site:

	Never 1	2	3	4	5	6	Always 7
I felt lost							
I felt like I was going around in circles							
It was difficult to find a page that I had previously viewed							
Navigating between pages was a problem							
I didn't know how to get to my desired location							
I felt disoriented							
After browsing for a while I had no idea where to go							

The web site:

	Strongly Agree 1	2	3	4	5	6	Strongly Disagree 7
Kept me totally absorbed in the browsing							
Held my attention							
Excited my curiosity							
Aroused my imagination							
Was fun							
Was intrinsically interesting							
Was engaging							

How do you feel about your overall experience using the web site?

Very Satisfied 1	2	3	4	5	6	Very Dissatisfied 7

Very Pleased 1	2	3	4	5	6	Very Displeased 7

Very Contented 1	2	3	4	5	6	Very Frustrated 7

Absolutely Delighted 1	2	3	4	5	6	Absolutely Terrible 7

	Likely 1	2	3	4	5	6	Unlikely 7
My interaction with the web site is clear and understandable							
I believe that it is easy to get the web site to do what I want it to do							
Overall, I believe that the web site is easy to use							
Learning to operate the web site is easy for me							

For finding healthy living information:

	Strongly Agree 1	2	3	4	5	6	Strongly Disagree 7
Using this web site would be a good idea							
I would intend to use this web site							
Using this web site would be a foolish idea							
I would like the idea of using this web site							
Using this web site would be unpleasant							
I would intend to use this web site very frequently							

If you have used healthy living information web sites in the past, how similar were the web site that you used in this experiment to the ones that you have used in the past?

Not at all similar Very similar

1 2 3 4 5 6 7 N/A

How familiar were you with the type of navigation used in the web site? (Navigation refers to the links that allow you to get to the other pages within the web site.)

Very Familiar Familiar Neutral Unfamiliar Very Unfamiliar

Did you prefer any one section of the web site over others?

Healthy Food Healthy Activity Healthy Nutrition No Preference

Please list 2-3 things that you like about the navigation of the web site:

Please list 2-3 things that you **did not** like about the navigation of the web site:

Appendix E- Measures and Items

Construct	Formative/Reflective	Indicator	Description
Age	Formative	age	age in years
Spatial Ability	Formative	spatial1	% correct on VZ-2
		spatial2	% correct on S-1
Mental Model Accuracy	Formative	MMA	tree distance score
Disorientation	Reflective	dis1	see Appendix B for items
		dis2	
		dis3	
		dis4	
		dis5	
		dis6	
		dis7	
Engagement		eng1	see Appendix B for items
		eng2	
		eng3	
		eng4	
		eng5	
		eng6	
		eng7	
Performance	Formative	correct	number of tasks correct
		time	total time to complete tasks
Satisfaction		sat1	see Appendix B for items
		sat2	
		sat3	
		sat4	

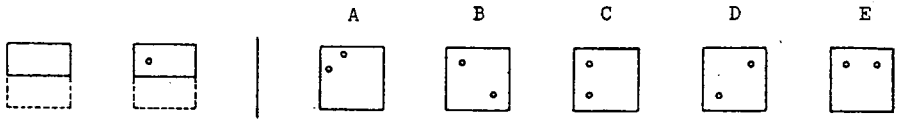
Appendix F- Spatial Ability Tests

Name _____

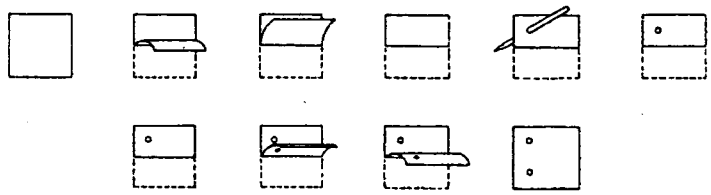
PAPER FOLDING TEST — VZ-2

In this test you are to imagine the folding and unfolding of pieces of paper. In each problem in the test there are some figures drawn at the left of a vertical line and there are others drawn at the right of the line. The figures at the left represent a square piece of paper being folded, and the last of these figures has one or two small circles drawn on it to show where the paper has been punched. Each hole is punched through all the thicknesses of paper at that point. One of the five figures at the right of the vertical line shows where the holes will be when the paper is completely unfolded. You are to decide which one of these figures is correct and draw an X through that figure.

Now try the sample problem below. (In this problem only one hole was punched in the folded paper.)



The correct answer to the sample problem above is C and so it should have been marked with an X. The figures below show how the paper was folded and why C is the correct answer.



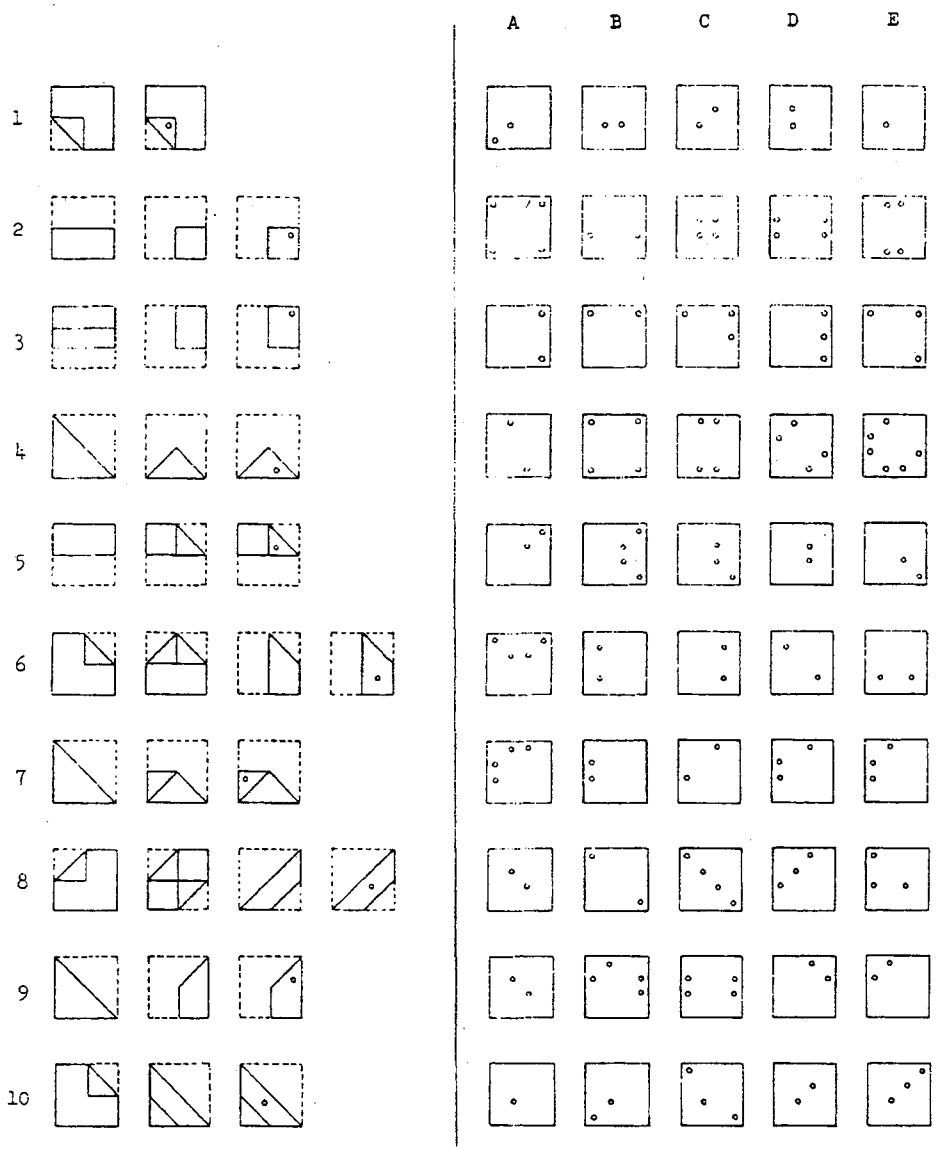
In these problems all of the folds that are made are shown in the figures at the left of the line, and the paper is not turned or moved in any way except to make the folds shown in the figures. Remember, the answer is the figure that shows the positions of the holes when the paper is completely unfolded.

Your score on this test will be the number marked correctly minus a fraction of the number marked incorrectly. Therefore, it will not be to your advantage to guess unless you are able to eliminate one or more of the answer choices as wrong.

You will have 3 minutes for each of the two parts of this test. Each part has 1 page. When you have finished Part 1, STOP. Please do not go on to Part 2 until you are asked to do so.

DO NOT TURN THIS PAGE UNTIL ASKED TO DO SO.

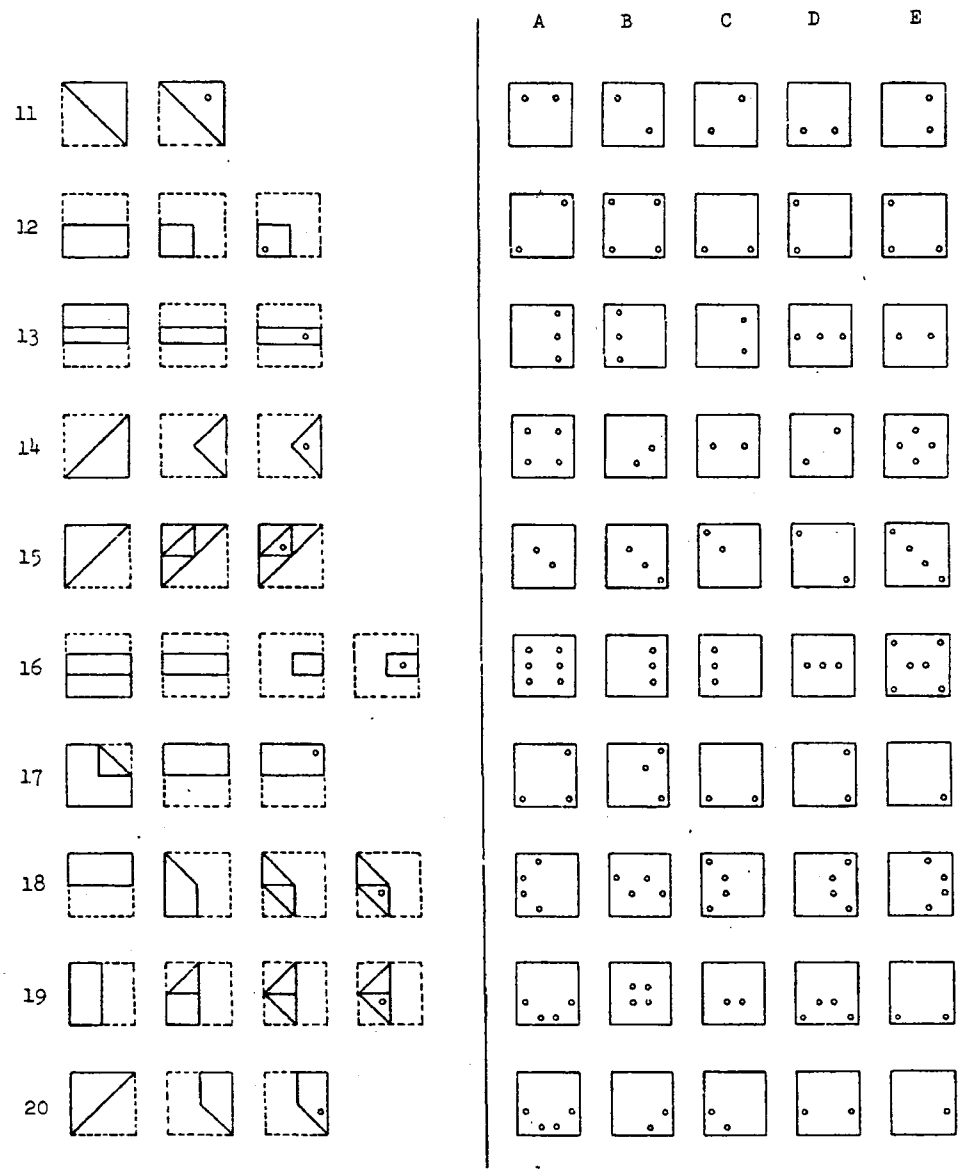
Part 1 (3 minutes)



DO NOT GO ON TO THE NEXT PAGE UNTIL ASKED TO DO SO.

STOP.

Part 2 (3 minutes)



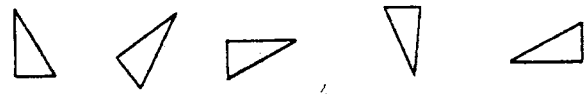
DO NOT GO BACK TO PART 1, AND

DO NOT GO ON TO ANY OTHER TEST UNTIL ASKED TO DO SO. STOP.

Name _____

CARD ROTATIONS TEST — S-1 (Rev.)

This is a test of your ability to see differences in figures. Look at the 5 triangle-shaped cards drawn below.



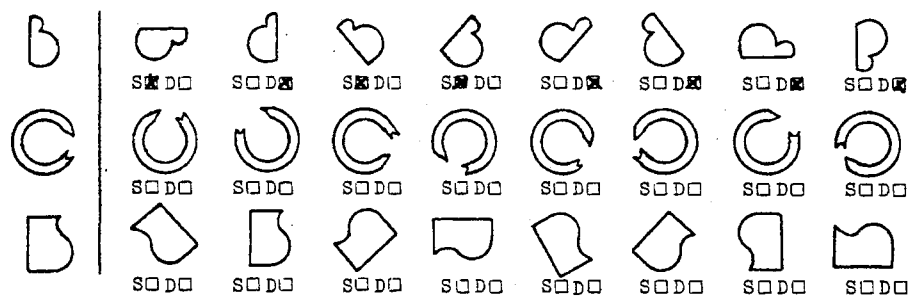
All of these drawings are of the same card, which has been slid around into different positions on the page.

Now look at the 2 cards below:

These two cards are not alike. The first cannot be made to look like the second by sliding it around on the page. It would have to be flipped over or made differently.

Each problem in this test consists of one card on the left of a vertical line and eight cards on the right. You are to decide whether each of the eight cards on the right is the same as or different from the card at the left. Mark the box beside the S if it is the same as the one at the beginning of the row. Mark the box beside the D if it is different from the one at the beginning of the row.

Practice on the following rows. The first row has been correctly marked for you.

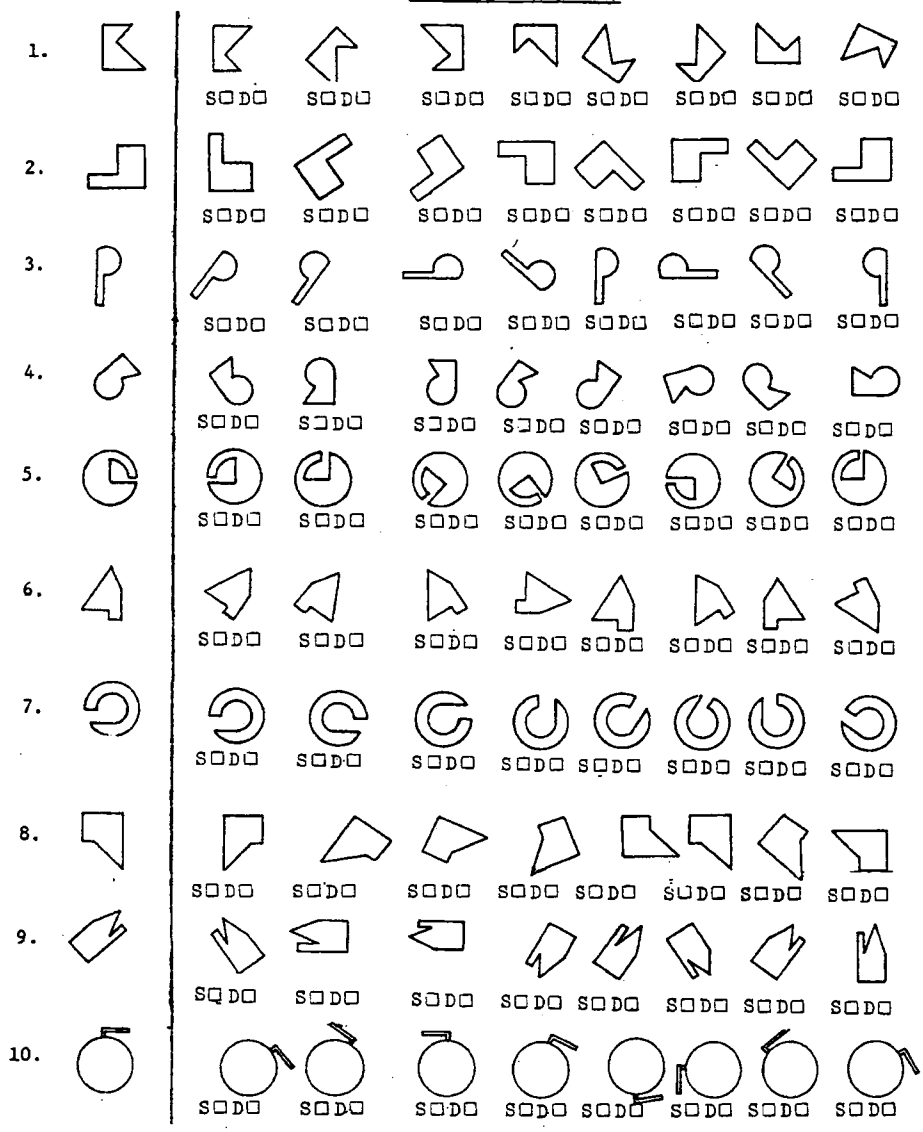


Your score on this test will be the number of items answered correctly minus the number answered incorrectly. Therefore, it will not be to your advantage to guess, unless you have some idea whether the card is the same or different. Work as quickly as you can without sacrificing accuracy.

You will have 3 minutes for each of the two parts of this test. Each part has 1 page. When you have finished Part 1, STOP. Please do not go on to Part 2 until you are asked to do so.

DO NOT TURN THIS PAGE UNTIL ASKED TO DO SO.

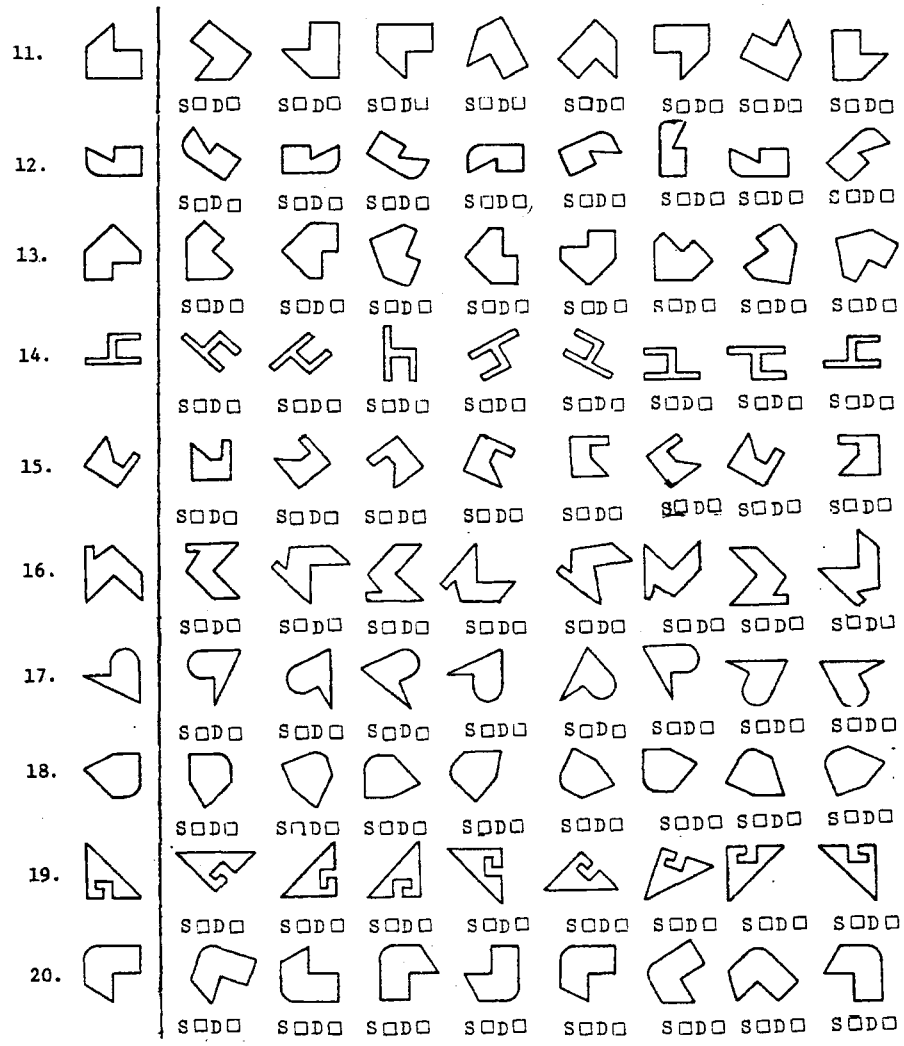
Part 1 (3 minutes)



DO NOT TURN THIS PAGE UNTIL ASKED TO DO SO.

STOP.

Part 2 (3 minutes)



DO NOT GO BACK TO PART 1 AND
DO NOT GO ON TO ANY OTHER TEST UNTIL ASKED TO DO SO. STOP.