Variability among older adults in Internet health information-seeking performance

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S.J. Czaja, J. Sharit, M.A. Hernandez, S.N. Nair, D. Loewenstein. Variability among older adults in Internet health information-seeking performance. Gerontechnology 2010; 9(1):46-55; doi:10.4017/gt.2010.09.01.004.00 Understanding sources of performance variability in technology-based tasks among older adults is important to the development of design interventions. This study compared older adults (60-83 yrs) with high levels of performance on Internet health information-seeking tasks to older adults with lower levels of Internet performance on measures of: domain knowledge, cognitive abilities, Internet experience, and computer attitudes. The older adults were also compared on these factors to a sample of younger adults (20-38 yrs). In addition, we examined if factors that predicted performance varied between younger-old and older-old adults. Results indicated that the high performing older adults had higher reasoning skills and Internet knowledge than the low performers. They also had higher reasoning skills than the younger adults and the same level of Internet knowledge. Predictors of performance varied within the older age cohort such that among the younger-old adults knowledge about the Internet was the strongest predictor of performance whereas among the older-old adults cognitive abilities were the strongest predictors of performance. The implications of these results for training and interface design are discussed.

Keywords: Internet search, variability, cognitive profiles

Over the past several decades, a wide variety of studies have examined the nature of age-related changes in cognitive processes. The findings from most of these studies indicate that, on average, cognitive abilities such as processing speed, working memory, and reasoning show decline over the course of adulthood[1-3]. Studies that have focused on practical or everyday tasks such as tasks of daily living[4], comprehension of medical instructions[5], medication adherence[6,7], computer-based work tasks[8], and use of interactive telephone menu systems[9] have also reported age-related performance declines.

However, one important finding that emerges is the wide variability in the performance of older adults with some older adults performing at relatively high levels and others at lower levels[10-12]. For example, in a study examining performance on a complex information search and retrieval task in a sample of adults ranging in age from 20 to 75 years, a large number of older people were found to perform at the same level as the younger people, and in fact, some performed even better than some younger people[8]. These findings suggest that not all older adults are at risk for decline in cognitive abilities or performance on everyday tasks. Understanding the sources of variability in the performance of everyday tasks is important as it helps identify individuals who are at risk for decline and loss of independence and also aids in the development of intervention strategies to offset decline.

Recently, we examined[13] the relative impacts of age, Internet-related knowledge, and cognitive abilities on web-based health information-seeking performance among a sample of 40 older adults ranging in age from 60-83 years. The sample also included a comparison group of 10 younger adults 20-38 years of age. Overall, the results showed that the younger adults outperformed the older adults on the information-seeking tasks and that both cognitive abilities and Internet knowledge were significant predictors of performance. However, we also noted significant performance variability in our older adult sample such that some older adults were 'highly' successful in their information-seeking performance and performed at comparable levels to the younger adults.

In this paper we extend the analyses of that study and examine the profiles of the older adults who exhibited high performance on the information-seeking tasks. Specifically, we are interested in identifying the characteristics that differentiated older adults who performed well on the tasks from older adults who performed at lower levels on the tasks. We also compare the performance of the high and low performing older adults with the younger comparison group. Knowledge of this type is important to understanding differences in cognitive aging and also to the development of empirically-based interventions that can enhance the performance of older individuals who perform tasks at lower levels.

Given the wide age range of our older adult sample, we also examine what happens across the older adult age-span. Do factors that predict successful performance vary between younger-old and older-old adults? This is an important question as age-related changes in cognition become more evident in the later decades and our interest is in determining if these differences have implications for performance.

Given that Internet-based information-seeking places a high demand on cognitive abilities[13,14] our primary focus is on cognitive abilities. In addition, we examine a variety of other factors likely to influence task performance including prior Internet experience, attitudes towards computers, and knowledge about the Internet and information search.

Exploring the issues addressed in this paper is of paramount importance given the increased reliance on the Internet as a vehicle for the delivery of information and services. The Internet has assumed a central role in communication, education, commerce and healthcare. For example, the number of Internet sites geared towards helping consumers find information about health issues and health care is rapidly growing. Patients are also using the Internet for peer support, to communicate with healthcare professionals, and to obtain medical supplies and prescription medications. In 2006, about 8 million Americans searched for health information on-line on a typical day[15]. As noted by Powell, Darvell, and Gray[16], the Internet is altering the knowledge-based balance of power between healthcare professionals and consumers, thereby providing an opportunity for more efficient and effective collaborations between older adult patients and their physicians.

However, the potential benefits of the Internet for older adults are predicated on the assumption that they will be able to successfully engage in Internet information-seeking activities. Currently, despite the increase in Internet adoption among older adults there is still an age-related digital divide, especially among those who are less educated or of lower socio-economic status. Further, older adults who use the Internet typically encounter more user problems than younger adults[13,17]. It is important to understand the sources of variability in Internet information-seeking activities in order to more effectively design tools and training programs to enhance meaningful access to Internet health applications for all user groups.

To date, most studies examining Internet search and age have primarily focused on age differences in performance, or have considered older adults as a single user group. This study examined individual characteristics that affect the performance of Internet search tasks and how the influence of these factors varies within age subgroups of older adults.

Methodology

Sample description

The sample consisted of 40 community dwelling adults ranging in age from 60-83 years (M=70.9; SD=6.9; 15 males and 25 females) and a comparison group of 10 younger adults (18-39 years of age; M=27.9, SD=6.4; 2 males and 8 females). For some analyses we also divided the older adult sample into younger-old (60-70 years of age; n=20) and older-old (70+ years; n=20) adults. The sample was ethnically diverse and consisted of 5 Black/African-Americans, 31 White/Caucasians, 11 Hispanic/Latino, and 3 reporting other ethnicities. Education was categorized into high school or beyond high school. There was no significant difference between the younger adults and the older adults in level of education ($\chi^2(1)=3.40$; $p>0.05$). All of the younger adults and 95% of the older adults had at least some college or a college degree. All participants were non-cognitively impaired (Mini Mental Status Examination score ≥ 27[18]), had at least 20/40 near and far vision with or without correction, and spoke English. All participants also had at least minimal Internet experience. They were asked to rate how frequently they used the Internet on a six point scale ranging from never to very often and 90% of the older adults and all of the younger adults reported using the Internet to search for information at least some of the time. Given that this variable was not normally distributed we analyzed age group differences in amount of Internet use using the Mann-Whitney U test. The results indicated that there was no significant difference in amount of Internet use between the young adults and older adults ($Z=-1.88$; $p>0.05$).

Participants were compensated $75.00 for their participation. The study was approved by the University's Institutional Review Board.

Setting

Participants performed their Internet search tasks in an office equipped with a computer system that had a 19″ flat panel display monitor. The system was configured with Microsoft Internet Explorer 6.0 and the Hypercam 2.10 screen capture utility[19]. The screen capture utility enabled each participant's onscreen task to be recorded in the form of a Windows-based digital movie.

Measurements taken

Cognitive abilities

Three measures of cognitive abilities were included: (i) the Digit Symbol Substitution Test[20], a measure of attention and response speed which requires individuals to match a set of number/symbol pairs within a time limit of 90 seconds; (ii) the Computation Span Test[21], a measure of working memory which requires individuals to solve a series of arithmetic problems and also remember the last digit from the previous problem; and (iii) the Inference Test[22], a measure of reasoning which requires individuals to draw inferences from statements of facts. These measures were selected as they represented the abilities that were the most predictive of performance on the search tasks[13].

Internet knowledge
Each participant completed a structured interview that consisted of 74 questions that assessed general knowledge of the Internet, and knowledge of web browsers and of simple and advanced Internet search. The questions were read aloud to the participant who verbalized a response or demonstrated (using the computer) aspects of information-seeking. Scoring varied according to the nature and complexity of the question. Simple questions were scored correct or incorrect; more complex questions (for instance, multiple-part questions) were scored correct, partially correct, or incorrect; and some questions were scored based on the number of items correctly identified by the participant. Responses were audiotaped. Scores could range from: 0 to 300 with higher scores indicating higher knowledge[13].

Other measurements
Additional measures included a demographic questionnaire and a technology and computer experience questionnaire[17]. Participants also completed the Attitudes Toward Computers Questionnaire (ATCQ)[23], a 35-item multidimensional scale assessing seven dimensions of attitudes towards computers: comfort, efficacy, gender equality, control

Table 1. Search task problems

Problem and difficulty rating		Problem Description
Rating	Evaluation	
1a	Easy	The US Government has a department that deals with Aging and issues which concern older adults. Find a web site for one of these departments, the Administration on Aging.
1b	Moderate	In the Administration on Aging website, find a web page containing information on ways to remodel a home or apartment that make it more senior-friendly or more comfortable for older adults.
2	Easy	Suppose you have a friend and suspect he or she is overweight. You remember something called the BMI that might help determine whether your friend is overweight or not. You know two (2) facts about your friend: (a) Their height is 5 feet 2 inches (or 62″) (b) Their weight is 175 pounds Use the Internet to find out whether your friend is overweight or not. Also, what does BMI mean?
3	Difficult	Flu season is coming around and you're interested in getting a flu shot. However, you want to be sure you don't belong to the group of people who should not receive this shot. Find information on at least 3 types of people who should not get a flu shot.
4	Moderately difficult	You've decided that you want to get back in shape. Using the Internet, find information on 5 things you can do to get back into shape. Remember that these recommendations must be appropriate for your age.
5	Moderately difficult	A friend of yours uses a wheelchair. They want to get a new one and have asked you to help them find information on the Internet regarding new models and prices. Wheelchairs are also known as mobility solutions and you can recommend new designs that don't look like traditional wheelchairs but are still recommended for older adults. Find three mobility solutions and corresponding prices for your friend. They cannot all be wheelchairs.

(the belief that people control computers), interest, dehumanization (the belief that computers are dehumanizing); and utility. Each dimension is assessed by 5 or 6 items and scored using a 5-point Likert-type scale.

Procedure

The study was conducted over two days. On day one, after providing informed consent, participants completed the demographic questionnaire, computer and Internet experience questionnaire, and ATCQ. Following a break they were tested on the cognitive abilities. On day two, they completed the vision tests (Snellen Near and Far),were provided with a break and then proceeded to complete six Internet information search problems that varied in complexity (problem 1 had two related parts that were scored as two separate problems). The problems addressed health and wellness issues[13] (*Table 1*). The questions were presented on separate laminated cards.

Participants were free to use any search engine and any approach to solving the problem (for example, they could proceed directly to a website or web page by using its URL). In almost all cases the participants chose the Google search engine. Participants were handed the problems, one at a time, and had up to 15 minutes to solve each problem. In a few cases where it was judged that the participant was close to a solution, the time limit was relaxed by a few minutes. The experimenter monitored the participant's search process.

Following completion of the problems they were provided with a rest break. The structured interview regarding Internet knowledge was then administered.

Results

Task Performance

For each problem, a composite score was computed that was based on correctness (incorrect/no answer, partially correct, correct), completion time (how long it took to complete the problem), and problem difficulty[13]. A task performance score for each participant was then computed by aggregating these problem scores across all six problems (as noted, problem 1 had two parts). We used a composite measure of performance in our primary analyses because both efficiency and effectiveness of search are important in determining the success of a search. A searcher may be slow but eventually find the answer whereas another could find the answer very quickly or a searcher can complete a task quickly but with less accuracy than someone who was slower[24].

Correctness was determined through examination of the final screen outputs and guided by a scoring sheet that scored each problem as incorrect, partially correct, or correct. Given that search success is also influenced by the difficulty of the search task we also included a rating of problem difficulty in the composite measure. Problem difficulty was rated by consensus agreement and the weights that were assigned were: 1 for problems 1a and 2; 2 for problem 1b; 4 for problem 3; and 3 for problems 4 and 5 (*Table 1*). The assignment of these weights was based on the number of answers the problem required and whether initial conditions or expected outcomes were well-defined. To further elucidate the differences between the three groups (high and low performing older adults and younger adults), we also examined accuracy. The accuracy score is a proportion computed to reflect the weighted average correctness across all six problems (weighted by problem difficulty).

Analyses

To establish high and low performance comparison groups for the older adults, the average overall score (M=169.43, SD=68.82) was computed and those individuals whose scores were higher than 0.5 SD above the mean were considered the high performing group (n=10) and those individuals whose scores were lower than 0.5 SD below the mean were considered the low performing group (n=12). The average performance scores for these groups were, 257.90

Table 2. Individuals (%) within the groups who answered the problem completely correct

Question	Adult groups		
	Young n=10	Older: High performance n=10	Older: Low performance n=12
1a	60	100	83
1b	80	100	58
2	90	100	75
3	80	100	8
4	90	100	75
5	80	100	58

(SD=46.29) for the high performing older group and 92.32 (SD=25.85) for the low performing older group. It should be noted that there were no differences between these two groups in education or use of the Internet (all p's >0.01). The average performance score for the younger group was 222.38 (SD=107.87). The younger group performed significantly better on the Internet search problems than the low performing older group (t (20)=4.23; p<0.001) but not the high performing older group (t (18)=-.80; p>0.05).

The average weighted accuracy scores for the high and low performing older adults and the younger adults were; 1.0, 0.64 (SD=0.16), and 0.89 (SD=0.13), respectively. These group differences are consistent with the results for the composite performance measure. The percentage of people in each group whose answers to the problem were completely correct (*Table 2*) showed that performance differences among the low and high performing older adults tended to be greater for the more difficult problems.

We compared the older high performers, older low performers and the younger subjects on the cognitive ability measures, Internet knowledge, and the computer attitude dimensions using a series of one-way analysis of variance procedures (ANOVA). Because of multiple contrasts, the test-wise α was set at a more conservative p<0.01. Post-hoc tests between means were examined using the Scheffe's procedure at p<0.05.

We then conducted hierarchical regression analyses for the younger-old group and the older-old group to determine if the factors that predicted performance varied within these subgroups. We entered Internet knowledge scores in the first step and the cognitive ability scores in the second step. We conducted separate analyses for each of the two older age groups to determine the relative roles of Internet knowledge and cognitive abilities in predicting the performance of age groups. We restricted the cognitive ability measures to the Inference Test and the Digit Symbol Substitution Test as we found differences among the groups (see below) on these measures and our sample sizes were relatively small. We did not find differences among the older age groups on the Computation Span test so we did not include this measure in the regression analyses (*Table 3*).

Table 3. Differences in cognitive abilities, Internet knowledge and computer attitudes between the younger-old (n=20) and the older-old adults (n=20); M=mean; SD=standard deviation

Variable	Younger-old M	Younger-old SD	Older-old M	Older-old SD
Cognitive abilities				
Digit symbol	48.25	8.14	45.50	9.82
Inference test	12.25	5.20	12.35	3.82
Computation span	30.47	23.83	18.60	13.62
Internet knowledge	111.15	47.82	89.85	35.22
Attitudes towards computers				
Control	17.47	3.03	18.50	2.63
Comfort	19.42	3.19	16.80	4.83
Efficacy	20.95	2.30	20.45	2.50
Interest	21.89	1.76	21.20	3.21
Utility	24.89	2.74	23.05	3.17

Table 4. Differences in cognitive abilities, Internet knowledge and computer attitudes between the high and low performing older adults and the young adults; M=mean; SD=standard deviation

Variables	Adult groups					
	Older-old				Young	
	Low performance		High performance			
	M	SD	M	SD	M	SD
Cognitive abilities						
Digit symbol	41.00	10.97	46.90	7.65	62.20	17.70
Inference test	8.92	2.23	16.00	2.16	10.40	3.84
Computation span	22.42	20.47	30.10	22.37	27.70	14.67
Internet knowledge	71.58	27.94	134.60	38.51	133.80	62.25
Attitudes towards computers						
Control	17.27	3.52	18.90	2.69	18.70	3.53
Comfort	17.42	4.29	17.90	5.22	21.10	3.25
Efficacy	20.17	2.41	21.00	2.40	21.20	2.66
Interest	21.08	3.06	21.80	2.39	21.60	1.96
Utility	22.91	2.26	24.20	3.12	22.70	1.42

Comparisons

There was a significant difference among the three groups for the Inference Test ($F(2,29)=18.61$; $p<0.001$); the older higher performers scored significantly higher than both the older low performers and the younger adults. There was also a significant difference among the groups for the Digit Symbol Substitution test ($F(2,29)=7.91$; $p<0.01$). The younger adults scored significantly higher on this test than both of the older age groups. There was no difference among the two older groups on this measure. There was no difference among the groups for the Computation Span test ($p>0.01$). With respect to Internet knowledge, the results indicated that the high performing older adults had significantly better knowledge about the Internet than the low performing older adults ($F(2,29)=5.20$; $p<0.01$). There were no other group differences for Internet knowledge. Finally there were no significant group differences in computer attitudes (*Table 4*).

Regression Analyses

There were differences between the younger-old adults and the older-old adults in factors that predicted performance on the search tasks (*Table 5*). For the younger-old adults, Internet knowledge was the significant predictor of performance and accounted for about 35% of the variance in performance. However, for the older-old adults, variability in cognitive abilities predicted differences in performance, accounting for about 51% of the variance. Importantly, after taking cognitive abilities into account Internet knowledge was not a significant predictor of performance for this age group. An examination of the semi-partial correlations for the cognitive ability variables in the final model indicated that reasoning ability as measured by the Inference Test was the most important predictor of performance for this age group.

*Table 5. Summary of final regression model for younger-old (n=20) and older-old (n=20); *=p<0.05; ***=p<0.001*

	β	Adj. R^2	R^2	F
Younger-old		0.417	0.126	5.526
Total knowledge	0.547*			
Inference test correct	0.126			
Digit symbol	0.313			
Older-old		0.609	0.525	10.875***
Total knowledge	-0.157			
Inference test correct	0.815*			
Digit symbol	0.282			

Discussion

The Internet is emerging as a vital knowledge resource for consumers and has assumed a central role in communication, education, commerce and healthcare. In this study we examined characteristics that differentiated older adults who performed at high levels versus those who performed at low levels on Internet health information-seeking tasks. We also examined if factors that predicted performance on these tasks are the same for age subgroups of older adults.

Overall, the findings indicated that within the older adults there was a subgroup of 'high performers' whose performance on the tasks was comparable to a comparison sample of younger adults. When comparing the high and low performers within the older adult sample, the data indicated that the high performing older adults had better reasoning skills than the low performing older adults. In addition, despite having comparable levels of Internet experience the high performers also had more Internet knowledge than the low performers. This is likely due to the fact that they had higher cognitive abilities which may have influenced their ability to learn and retain concepts related to Internet search. Although the difference between the two groups in working memory was not statistically significant, the data indicates that the high performers also had higher working memory skills than the low performers.

When examining age cohorts within the older adult sample the data indicated that among the younger-old adults Internet knowledge was the strongest predictor of performance. Cognitive abilities did not predict performance for this group after accounting for differences in knowledge. However, for the older-old adults cognitive abilities, specifically attention/response speed and reasoning, were the strongest predictors of performance with reasoning being the most important predictor. These findings confirm the importance of cognition to everyday task performance.

The importance of cognitive skills, such as reasoning, to performance was underscored when comparing the older adults, to the younger adults. The younger adults had better abilities on cognitive tests tapping cognitive processing and psychomotor speed than both groups of older adults which was not surprising. Interestingly, however, the high performing older people had better reasoning skills than the younger people. This may have in part, represented higher levels of cognitive reserve,[25] which may have allowed them to compensate for declines in processing and psychomotor speed. The combination of Internet knowledge (for instance, knowing where to search, how to navigate within a website) and the ability to understand concepts and draw inferences among terms and concepts may allow for a high level of Internet search proficiency despite declines in speed.

Clearly, this study also has some limitations. First, the sample size was small. Second, the sample of older adults was fairly well educated and had computer and Internet experience; thus the results may not generalize to other groups. Also, we only have markers of cognitive abilities at one time point and acknowledge that one source of variability in cognition is intra-individual variability, and that scores on ability tests can vary across measurement points[10].

However, despite these limitations, the findings from this study have important implications. One is that among older adults the support for Internet information-seeking, whether in instruction, interface design, or training may need to be tailored differently according to individual needs. To enable people with lower cognitive abilities to successfully engage in Internet information-seeking, emphasis should be directed at design interventions or training that help compensate for cognitive declines. This could include making website information less technical and easier to read; minimizing the demands on memory; and providing search aids and history markers. Provision of basic training about the Internet and how to search is also important.

Overall, our findings reinforce those of others[2,4] and demonstrate that individual differences in cognition are important determinants of age differences in the performance of complex tasks and underscore the importance of cognition to 'successful aging' and functional independence. The data also confirm findings regarding the wide variability in the performance of older people and the hypothesis that aging is associated with multiple trajectories of change[26]. Our data also suggest that for some tasks, high levels of some cognitive abilities such as reasoning can compensate for age-related declines in other abilities such as processing speed. Finally, these results underscore the importance of limiting conclusions regarding age group differences in abilities that are drawn on the basis of comparisons of average performance.

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