Designing for the Wisdom of Elders: Age Related Differences in Online Search Strategies

Robert J. Youmans, Brooke Bellows, Christian A. Gonzalez, Brittany Sarbone, and Ivonne J. Figueroa

George Mason University, Department of Psychology, Fairfax, Virginia, USA
ryouman2@gmu.edu

Abstract. Information search is one of the main reasons that older adults go online, but older adults experience more difficulties than younger adults when interacting with search engines. In this study, 15 younger and 14 older participants completed a battery of cognitive tasks, and then searched for information via a realistic search simulator. Older participants searched using a more methodical strategy that entailed careful word selection and serial processing of search results, while younger participants used a more impulsive strategy whereby they scanned search results quickly and jumped between links more frequently. In keeping with past studies, older adults displayed lower cognitive flexibility, but these deficiencies were apparently offset by their search strategy, and young and old participants ultimately found information in similar amounts of time. We argue that, while age-related cognitive changes certainly exist, their effect on older adults' interactions with search engines may be due to mismatches between older adults' search strategies and the design of current versions of popular search interfaces.

Keywords: Internet Search, Age; Search Strategy, Cognitive Flexibility.

1 Introduction

Of the many comic remarks that have been made about what it means for humans to grow old, many involve observations about tradeoffs between the impulsivity of youth and the wisdom of older age. In his Poor Richard's Almanac, Benjamin Franklin remarked that at 20 years a person's 'will' controls their life, while at 40 it is their 'judgment.' Mark Twain humorously observed that life would be infinitely happier if we could only be born with the wisdom we have at the age of eighty and gradually approach the vitality we enjoy at eighteen. One of the most transformative developments that computers have had on society has been the rapid expansion of access to online information, a development that has necessitated the need for efficient, easy-to-use search engines. Search represents yet another area where age is affecting how people interact with technology. Information search is one of the main reasons that older adults go online [1-4], but research on search suggests that older adults experience more difficulties in interacting with search engines [1, 4], and are slower and less accurate in their search for online information than younger adults [5].

C. Stephanidis and M. Antona (Eds.): UAHCI/HCII 2013, Part II, LNCS 8010, pp. 240–249, 2013.

When it comes to search interface design, understanding why older adults experience more difficulties when it comes to how they find, access, and use online information is paramount. Current search engines (e.g. Google) typically require at least three interrelated steps to complete many types of searches. First, the searcher must draw on their domain knowledge in long-term memory to generate keywords that they believe are relevant to their request and type them into the search engine. Second, the searcher must coordinate a visual scan and motor control of an HCI device (mouse or trackpad) to evaluate the relevance of the large number of results provided by the search engine. Finally, the searcher must select one or more websites to visit, and if the relevant information is not found, they must flexibly reformulate their search, either by navigating to a different search result, or by changing the keywords used in the original request [6, 7].

Importantly, different types of cognitive processing support each of these three steps, and therefore, each step potentially represents an action where age-related cognitive differences could impact the overall effectiveness of an online search engine. In the first step, for example, a searcher is required to type relevant words in to a search engine, a task where older adults' advantages in vocabulary might make them more effective than younger adults [8]. In step two, a searcher must scan the results of their search in order to determine which link to click on, a task that again may favor older users who must draw upon their domain knowledge in order to make a decision about what link to select. Finally, when an initial search does not lead to a successful outcome, searchers must either scan additional links, or reformulate their search entirely. However, in this third step, older adults may find themselves at a disadvantage in comparison to younger adults, who process information more quickly [7], hold more information in working memory [9], and may more flexibly adopt new search strategies [4,6].

In this study, we report the results of a multi-stage research project that required participants to carry out five Internet searches, and complete a battery of cognitive tests. Four of the searches were conducted on a specially designed artificial search engine that we developed to better isolate each step of the search process. We also employed existing measures of motor control, and a new measure of cognitive flexibility. The study had three goals. First, we hoped to isolate any potential age-related differences in performance on the three steps required to find, access, and use information on search engines. Second, we hoped to relate age-related differences in search step performance to underlying differences in cognitive function. Third, we hoped to provide designers with potential design recommendations about future search engine development on the basis of our findings.

2 Methods

2.1 Participants

A sample of 15 younger adults (18-30 years of age, M = 20.27, SD = 4.04) and 14 older adults (57-83 years of age, M = 68.42, SD = 7.60) participated in this study. There were 6 males and 9 females in the younger adult group and 4 males and 10 females in the older adult group. All 15 participants in the younger adult group had completed at least some college credit, while the educational levels in the older adult group included 3 participants with high school diplomas, 2 with some college, 2 with a bachelors degree, and 7 with masters degrees. All participants were non-cognitively impaired as indicated by scores greater than 25 on the Mini Mental State Examination (MMSE) [6].

The younger adult group reported having significantly fewer number of years experience with computers (M = 13.20, SD = 3.69) compared to the older adult group (M = 24.92, SD = 9.80), $t(27) = -4.32$, $p < .05$. However, there was no significant difference between groups with regard to internet expertise, $t(27) = -.49$, *ns*, or frequency of computer use, $t(27) = -.04$, *ns*. All participants reported using a computer at least once a week, and 27 out of the 29 participants reported using a computer at least once a day.

2.2 Materials

Internet Mental Model Questionnaire. The Internet Mental Model Questionnaire (IMMQ) is a ten-question survey, which was adapted from a previously established 74 question general Internet knowledge instrument [6]. It was administered to assess differences in Internet knowledge. Each question was displayed in a fixed order on a computer screen and participants were given an unlimited amount of time to formulate and type a response. Each answer was scored by an evaluator as correct, partially correct, or incorrect. Correct answers were awarded two points, partially correct answers were awarded one point, and incorrect answers receive no points. The possible range of scores was between 0 and 20.

Live Search Task. Participants completed an open-ended search task using a live version of the search engine Google. Google was chosen as the default search engine because of its widespread popularity and accessible interface. None of the participants requested to or attempted to access any alternative search engines throughout the course of the task. We asked participants to use the search engine to find out the date on which a new Star Wars live action television show would be broadcast. We chose this task because the show had been in the planning stages, but then delayed, which made searching for information difficult.

Simulated Search Task. Three interactive search task mockups were manufactured for this study using Axure, a wireframe software tool. The initial page resembled the standard Google keyword entry box, where participants were able to type in keywords for their query. To standardize the search process, participants were only allowed to submit one search query for each task. Regardless of the keywords that were entered, the returned search results were the same for each participant within each task. The uniform results consisted of two pages of links containing a standard number of links per page. Each page contained a mixture of completely irrelevant links, appropriate but incorrect links, and a correct target link. The difficulty of each task was predetermined by the placement of the target link within the search results. For example, the easiest of the three tasks placed the target link near the beginning of the first page, while the most difficult placed it at the bottom of the second page.

Fig. 1. Three representative screens of the simulated search task utilized during the experiment, each of which corresponds to one of three common steps. Users populated the search field with words on the initial screen (left), attempted to search through the results that were generated (middle), and received a warning screen when they clicked on the wrong link (right).

The Impossible Simulated Search Task. A fourth and final search scenario using the simulated search task asked participants to search for a target link that did not exist in the system. This impossible task was therefore a measure of how many links a user might click before deciding that the task was not likely to be solved using the current batch of search results. Times on this task reflect how long it took for a user to verbally 'pass' on this task and move to the next.

Cognitive Flexibility Puzzle. Cognitive flexibility (CF) is an individual's ability to abandon one cognitive strategy in favor of another based on a change in task demands [10]. Cognitive flexibility has been related to task-set switching ability, one of the best indicators of executive control [11]. However, CF is difficult to quantify and a pure measure of CF has yet to be identified [12]. As shown in Figure 2, we utilized a computer-based cognitive flexibility measure based on a paper-and-pencil puzzle task created by Figueroa and Youmans [13]. The paper-based puzzle had previously been shown to correlate with important Wisconsin Card Sorting Task (WCST) variables related to cognitive flexibility [14]. In order to complete the task, participants moved a game marker from the top left of the puzzle to adjacent tiles according to one of three matching rules: the same background color of the adjacent square, the same shape in the adjacent square, or the same shape color in the adjacent square. Sometimes moving forward required participants to use the same strategy that they had used in the prior move, but other times the only way forward was to adopt a different rule. Participants had to frequently switch rules in order to reach the end of the puzzle. Unlike the paper-based puzzle, the computerized version allows the number of switches per puzzle to be manipulated, and the average time to make switch and non-switch moves to be measured.

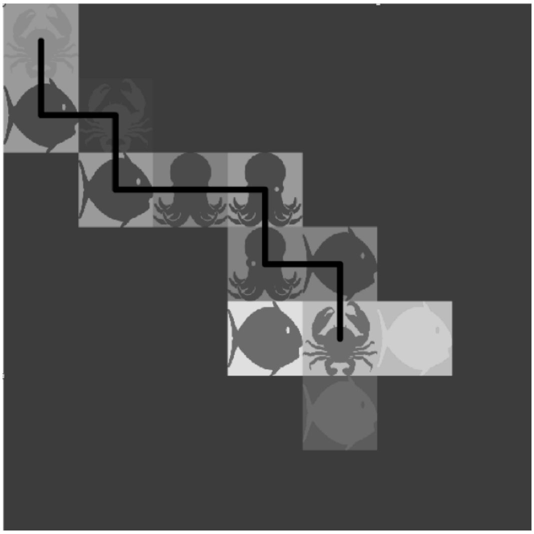

Fig. 2. The computer interface shown to participants during the cognitive flexibility puzzle

2.3 Procedure

Search Tasks. All participants completed one live search task, three simulated search tasks, and the impossible search task in that fixed order. Participants were instructed to complete the search tasks as quickly and accurately as possible but were also advised that they could "pass" and continue on to the next task if they could not find an answer in what they considered a reasonable amount of time. No time constraints were set for any of the search tasks. Throughout all search task trials, Araelium Group's Screenflick screen capture software was enabled to record participants' mouse activity and task completion times for final analysis. Subsequently, participants completed the MMSE, a demographic survey, the IMMQ, the Cognitive Flexibility Puzzle, and then were debriefed.

3 Results

3.1 Internet Mental Model Questionnaire Scores

An independent samples t-test was conducted to test for age-related differences in knowledge about the internet as measured by the IMMQ. Younger participants had slightly higher overall IMMQ scores (M=8.73, SD=3.65) compared to older participants (M=6.50, SD=4.53), but statistical analyses suggests no reliable difference $t(27) = 1.46$, *ns*. These results indicate that younger participants and older participants in our sample had a relatively similar understanding of how the Internet functions.

3.2 Time Entering Search Field Text

Three independent samples t-tests were conducted to test for age-related differences in the time it took for participants to begin typing a query on the search screen, the total time to type in a search, and the overall time spent on the search screen. Time before typing, typing time and overall time were aggregated across the easy, medium, and difficult simulated search tasks for all analyses. There was no reliable difference in the time it took older participants (M=28.24) and younger participants (M=21.07) to begin their search; $t(27) = 1.16$, *ns*. There was a marginally significant difference in the time that older participants took to type information in the search screen (M=77.25, SD=36.23) in comparison with the times of younger adults (M=55.96, SD=21.42), $t(27)=1.94$, $p=.06$. Older adults spent an overall longer time on the search screen (M=105.49) than younger adults (M=77.02); $t(27)=-2.13$, $p<.05$. The results suggest that younger participants were slightly faster at using the search screen.

3.3 Click Rates and Time Spent on Result Screens

A multivariate analysis of variance examined link clicks and time spent on the results screen in relation to age. This analysis revealed there was no main effect of age on time on the search results page for the simulated search tasks between younger adults (M=106.85) and older adults (M=131.32), $F(1,27)=1.55$, *ns.* A significant main effect of age on distracter links clicked on the easy, medium, and hard simulated search tasks was found, $F(1,27)=4.81$, $p < .05$. Participants in the younger adult group clicked on more distracter links (M=2.27) compared to older adults (M=.86). Specifically, a independent samples t-test suggests that younger adults clicked on more irrelevant links (M=1.13) than older adults (M=.29); $t(27)=2.30$, $p < .05$. The results of these analyses seem to suggest that younger adults may have acted more impulsively during the search task. Younger adults were more both more likely to click on links in general, and more likely to click on links that were clearly unrelated to the search task.

3.4 The Impossible Simulated Search Task

The final search task asked participants to search for information that was not included in the simulation. As a result, the task did not end until participants chose to move on to the next task without successfully identifying the correct link by ‘passing’ on the task. A multivariate analysis of variance suggests there was no reliable difference found on time spent on the search results of the impossible task between the younger adult condition (M=105.813) and the older adult condition (M=121.08), $F(1,27)=.66$, *ns.* However, we detected a main effect of age on the number of the total links clicked during the impossible task, $F(1,27)=7.80$, $p < .05$. Participants in the younger adult group clicked on more links (M=3.93) compared to older adults (M=1.21). Put differently, although younger and older adults took about the same amount of time before voluntarily passing on the impossible search task, younger participants did so only after searching through an average of more than two additional distracter links.

3.5 Differences in Underlying Cognitive Flexibility

On average, older adults (M=56.6) were approximately 50% slower than younger adults (M=27.58) across puzzle trials. In order to test the effect of age and number of switches on trial completion time we conducted a multiple regression analysis with age as a dichotomous predictor (young and old) and number of switches as a continuous predictor. Due to data loss, only twelve younger participants were included in the analysis. Univariate plots of raw trial times revealed a heavily positively skewed distribution, not uncommon for reaction time variables. In order to help normalize our dependent variable to meet regression assumptions and reduce the impact of extreme observations, the data were log transformed [15].

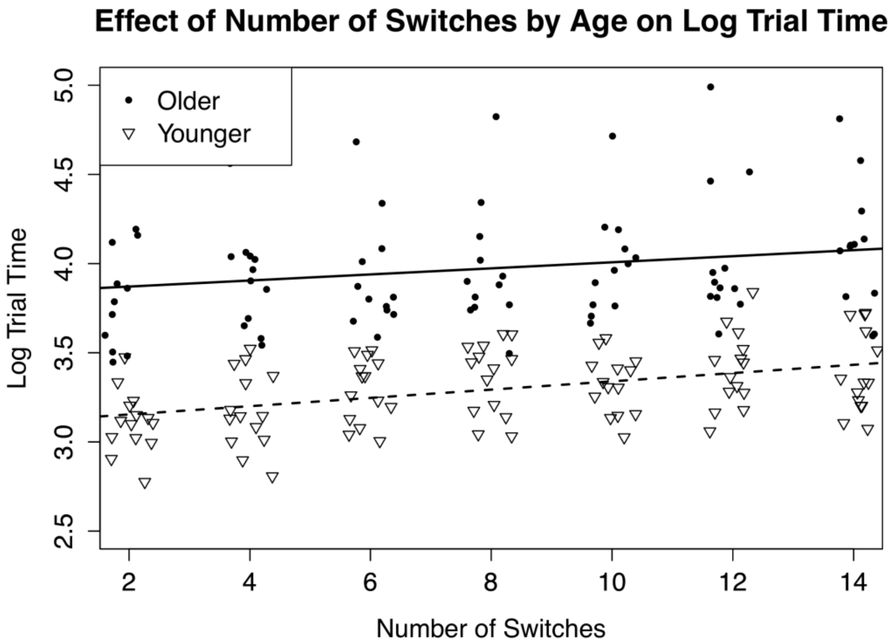

Fig. 3. Switch costs rates for older (solid line) and younger (dashed line) on puzzle completion times as a function of the number of switches those puzzles contained

The following results are based on log transformed trial times. In addition, the switch variable was centered to aid in interpretation of unstandardized regression coefficients in our model. Our overall model was significant ($F(3,178) = 102$, $p < .001$) and explained a considerable amount of the variance in trial completion time (adjusted $R^2 = .63$). The analysis yielded a significant main effect for number of switches ($b = .02$, $t(178) = 3.42$, $p < .001$) and a significant main effect for age ($b = .68$, $t(178) = 16.99$, $p < .001$), but the interaction was not significant ($b = -.006$, $t(178) = -.62$, $p = .60$). These results indicate that increasing the number of switch moves in a puzzle increased the average amount of time it took for participants to complete them. The results also indicate reliable age differences, such that older adults were significantly slower than younger adults in completing the cognitive flexibility puzzle. However, while older adults were slower than younger adults overall, the incremental increase of switches affected all participants, regardless of age, in a similar way.

4 Conclusions and Discussion

When it comes to age-related differences in how younger and older adults interact with technology, it would appear that there are pros and cons for people of different ages. In this study, younger and older participants had a relatively similar understanding of how the Internet functions, but younger participants were slightly faster at using the search screen. However, younger adults were both more likely to click on links in general, and more likely to click on links that were clearly unrelated to the search task. Finally, data from the cognitive flexibility puzzle indicated that older adults were significantly slower than younger adults in completing the cognitive flexibility puzzle, but also that incremental increases of switches affected all participants, regardless of age, in a similar way.

Computers and internet connectivity have been shown to provide older people with a litany of benefits ranging from increased mental stimulation [16-18], to improved intergenerational relations [16, 19], but these technologies are only as good as the interfaces that support them. This study may have implications for search engine designers who want to ensure that website information is made available to both younger and older adults [20]. Given the more methodical and effortful search strategies of older adults, search results could be displayed with extended information about the contents of a particular search results. This would capitalize on the fact that older adults tend to read the details of each individual “hit” more closely, thus saving time on irrelevant pages. Furthermore, our results revealed significant differences in search query styles, with older adults using more vocabulary and structured search terms. Search queries and results could be optimized to conduct targeted searches containing specific phrases, rather than keywords. This functionality is already available in most search engines in the form of quotation marks. While this feature is typically reserved for power users, it could be leveraged to match older adults strategies and mental models of search. Search results could also be structured in such a way to represent parallel keyword and phrase searches from a single query. Results could be clearly labeled as resulting from keyword or phrase search, allowing older users to gain insight on the origin of their search results and increasing the visibility of the systems status. The global profile features offered by search engines like Google create specialized user-experiences online. It seems feasible that the same types of features could account for a user’s age and provide older adult-optimized search features automatically.

Past research has suggested that age-related decline in cognitive flexibility plays a role in the age-related differences observed in searching for information [7], and the implications in these reports has often been that the cognitive decline is responsible for the inferior performance of older adults. Here, we confirmed that the older adults we studied were indeed slower to complete a test of their cognitive flexibility, but we also observed systematic differences in the methods that older and younger adults used to search the Internet. Younger users embodied a fast, inefficient approach to search that led to many dead ends but that eventually found targets by covering a larger search space. Older adults appeared to craft a more targeted search, then methodically read the resulting links more carefully while selecting links more efficiently. Both methods allowed our participants to find target links in roughly the same amount of time. These findings may suggest that older adults have learned to compensate for a loss in cognitive flexibility by becoming more selective in the links they click during Internet search.

References

1. Aula, A.: User study on older adults' use of web and search engines. Universal Access in the Information Society 4, 67–81 (2005)
2. Dinet, J., Brangier, E., Michel, G., Vivian, R., Battisti, S., Doller, R.: Older people as information seekers: Exploratory studies about their needs and strategies. In: Stephanidis, C. (ed.) Universal Access in HCI, Part I, HCII 2007. LNCS, vol. 4554, pp. 877–886. Springer, Heidelberg (2007), doi:10.1007/978-3-540-73279-2_98
3. Hart, T.A., Chaparro, B.S., Halcomb, C.G.: Evaluating websites for older adults: Adherence to 'senior-friendly' guidelines and end-user performance. Behaviour & Information Technology 27, 191–199 (2008), doi:10.1080/01449290600802031
4. Stronge, A.J., Rogers, W.A., Fisk, A.D.: Web-based information search and retrieval: Effects of strategy use and age on search success. Human Factors 48, 434–446 (2006), doi:10.1518/001872006778606804.
5. Pak, R., Price, M.M.: Designing an information search interface for younger and older adults. Human Factors 50, 614–628 (2008), doi:10.1518/001872008X312314
6. Sharit, J., Hernández, M.A., Czaja, S.J., Pirolli, P.: Investigating the roles of knowledge and cognitive abilities in older adult information seeking on the web. ACM Transactions on Computer-Human Interaction (TOCHI) 15(1), 3 (2008)
7. Dommes, A., Chevalier, A., Lia, S.: The role of cognitive flexibility and vocabulary abilities of younger and older users in searching for information on the web. Applied Cognitive Psychology 25, 717–726 (2011)
8. Verhaeghen, P.: Aging and vocabulary scores: A meta-analysis. Psychology and Aging 18, 332–339 (2003), doi:10.1037/0882-7974.18.2.332
9. Chin, J., Fu, W., Kannampallil, T.: Adaptive information search: age-dependent interactions between cognitive profiles and strategies. In: Proceedings of the 27th International Conference on Human Factors in Computing Systems, CHI 2009, Boston, MA, USA, April 4-9, pp. 1683–1692. ACM, New York (2009)
10. Scott, W.A.: Cognitive complexity and cognitive flexibility. Sociometry, 405–414 (1962)
11. Reitan, R.M.: Validity of the Trail Making Test as an indicator of organic brain damage. Perceptual and Motor Skills 8, 271–276 (1958)
12. Youmans, R.J., Figueroa, I.J., Kramarova, O.: Reactive Task-Set Switching Ability, Not Working Memory Capacity, Predicts Change Blindness Sensitivity. Proceedings of the Human Factors and Ergonomics Society Annual Meeting 55, 914–918 (2011)

13. Figueroa, I.J., Youmans, R.J.: Individual differences in cognitive flexibility predict poetry originality. In: Proceedings of the 15th International Conference on Human-Computer Interaction, Las Vegas, Nevada (2013)
14. Grant, D.A., Berg, E.A.: A behavioral analysis of degree of reinforcement and case of shifting to new responses in a Weigl-type card sorting problem. Journal of Experimental Psychology 38, 404–411 (1948)
15. Cohen, J., Cohen, P., West, G., Aiken, L.S.: Applied multiple regression/correlation analysis for the behavioral sciences, 3rd edn. (2003)
16. Eilers, M.L.: Older adults and computer education: "Not to have the world a closed door". International Journal of Technology and Aging 2, 56–76 (1989)
17. Czaja, S.J., Charness, N., Fisk, A.D., Hertzog, C., Nair, S.N., Rogers, W.: Factors predicting the use of technology: findings from the center for research and education on aging and technology enhancement (CREATE). Psychology of Aging 21, 333–352 (2006)
18. Swindell, R.: U3A in Australia: A model for successful ageing. Ageing and Society 13, 245–266 (1993)
19. Furlong, M.: Creating online community for older adults. Generations 21, 33–35 (1997)
20. Loos, E.: In Search of Information on Websites: A Question of Age? In: Stephanidis, C. (ed.) Universal Access in HCI, Part II, HCII 2011. LNCS, vol. 6766, pp. 196–204. Springer, Heidelberg (2011)