Effects of Cognitive Aging on Credibility Assessment of Online Health Information

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Abstract
Results from a study comparing how different Web contents and features influence younger and older adults' credibility assessment are reported. Results were in general consistent with the *Elaboration Likelihood Model (ELM)* of persuasive communication. It was found that cognitive aging differentially influences the processing of central arguments and peripheral cues (web features such as layouts, third-party endorsement). Specifically, older adults were in general worse at distinguishing between strong and weak arguments, and this effect was moderated by cognitive abilities and motivation for cognition. Results will be useful for informing designs that facilitate credibility assessment of health information for older adults.

Keywords
Web credibility, cognitive aging, Design for the elderly

ACM Classification Keywords
H5.4. Hytertext/Hypermidia : User issues

General Terms
Human Factors, Experimentation

Introduction
The concern for Web credibility is especially important for people who search for health information on

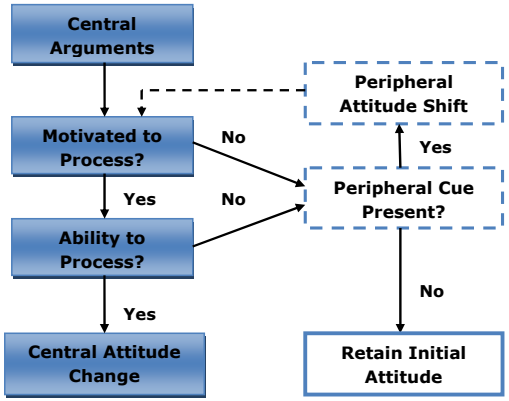

Figure 1 Elaboration Likelihood Model (ELM)

Internet, since unreliable health information can be a matter of life and death [3], and older adults constitute a notable group. This is not only because of their naturally higher need for health information, but also because there has been research showing that information search and performance [2], text comprehension [6], and decision making [8] are subject to effects of cognitive aging in many different perspectives. Despite these findings, there has been little research focusing on the various cognitive aging factors related to Web credibility assessment. An empirical study that compares how different contents and Web page features influence younger and older adults' credibility assessment of health information websites was therefore conducted.

Related Work

Several theoretical frameworks have been proposed to understand the process of credibility assessment. Fogg's Prominence-Interpretation Theory [4] considers credibility assessment to be a two-stage process: user first notices something prominent, then makes judgment by interpreting it. Rieh's model views credibility assessment as an iterative process and begins earlier at the point at which users make predictive judgment based on their previous knowledge [12]. Sundar presents a MAIN model [15] to point out four factors afforded by the media that are capable of cueing cognitive heuristics pertinent to credibility assessments: Modality, Agency, Interactivity and Navigability. Similarly, Metzger proposes a three-phase model of Web site credibility [9], which states that when either motivation or ability is low, subject enters the evaluation phase with the peripheral evaluation by relying on simple heuristics such as Web page's design. Previous models seem to more or less converge to the idea that there are dual processes in credibility assessments. This idea can be traced back to the Elaboration Likelihood Model, which is one of the widely accepted dual processing models for persuasive communications [10]. ELM (Fig.1) assumes that there are two distinct routes of persuasion. The first type of persuasion follows an objective processing of the central cues by careful and thoughtful consideration of merits in the arguments in support of advocacy. Objective processing of central cues are found to be influenced by motivational factors such as personal involvement or motivation for cognition. The second type of persuasion follows the peripheral route that induces change by simple cues in the persuasion context. Because the former is more effortful, it is also subject to differences in individual cognitive abilities to process the central arguments. In addition, people who lack either motivation and/or ability to analyze message content will resort to the peripheral route.

Based on the ELM model, we hypothesize that aging influences the processing of the central and peripheral cues differentially. Specifically, ELM model suggests that people who have a stronger general motivation for cognition or higher cognitive ability will be more sensitive to the central cues, otherwise they will be more influenced by the peripheral cues. Because older adults tend to have declining cognitive abilities, we hypothesize that they will be less sensitive to the central cues than younger adults. We also hypothesize that older adults with declining cognitive abilities and lower motivation for cognition may adopt different strategies to process the central and peripheral cues. The different processes and strategies may imply that we need different designs to better accommodate older adults' processing of Web information.

	Design look	Structural features
Examples of weak peripheral cues	Bad layout Bad image/color Typoraphy Too many white space Text font/size problem Lack of information organizaiton	No privicy statement No contact information Skeptical ownership Many ads No third-party endorsement No reference

Table 1. Examples of weak peripheral cues used in the experiment material

Method

Participants and Design

Twenty-four participants were recruited from a university community in this study. Of this twelve were younger adults (range from 19 to 28, Mean=21.8, SD=3.36; female=8), and twelve were older adults (range from 63 to 78, Mean=73.3, SD=4.68; female=5). Most participants (91.7%) had completed at least some years of college, and there is no significant difference of education level, health literacy, and self reported experience with healthcare websites between the two age groups.

A 2×2×2 mixed factor experimental design was used in this study. There were two within-subject variables: central cue and peripheral cue, and one between-subject variable: age (young/old). Participants in each age group were given 8 sets of medicine information web pages, each of them consisted of all four combinations of central and peripheral cues(strong central-strong peripheral, strong central-weak peripheral, weak central-strong peripheral, weak central-weak peripheral). Paper-based interface was used to present the materials to reduce the fatigue, as well as to control for influence of worse manual motor skill (in using mouse and keyboard) for older adults.

Material

For the central cue manipulation, we followed the empirical method used by Petty and Cacioppo [10]. We selected material from a well-known public healthcare website revolutionhealth (www.revolutinhealth.com), which provides lists of alternative medicines by disease conditions with user and clinical ratings. Based on these ratings we selected "strong" and "weak" documents, and modified their argument strength to manipulate their credibility [11]. We validated the manipulation by a group of 7 participants. We then selected 8 sets of documents based on these results. The disease and medicine names were modified to avoid identification.

For the peripheral cue manipulation, we added or removed features that were known to be peripheral cues for web credibility. For each web page, we randomly chose to control several features from one of the two categories of peripheral cues: design look and structural features (Table 1). Design look, including layout, typography, white space, images and color schemes, was found to be the greatest concern in website credibility evaluation [5]. Structural features was defined to be features that constitute elements fundamental to the composition of web sites, including privacy policy statement, third-party endorsements, site ownership, etc.[7].

Pre-tests and Credibility Assessment Tasks

All participants were given the same eight sets of tasks, but their order was randomized. For each task, they were asked to evaluate four alternative medicines as treatments of a certain disease by visiting and comparing four different web pages. Participants rated their preference for each medicine based on a 7-point scale. To ensure that the information processing happened in an unbiased manner [9], credibility was not explicitly mentioned during the task. Instead, the evaluation task instruction (Fig.4) was designed to implicitly strengthen the importance of credibility assessment in the evaluation process by highlighting the concern of discriminating "fake medicines".

To understand how objective elaboration variables influence credibility cue processing, we gave two pre-

Jason is taking a healthcare class, and is assigned for a presentation about alternative medicine. He was asked to research across the Internet and find one alternative medicine for each of 8 disease. The solution should be something new, but also highly effective and reliable. He has found 4 candidate medicines for each condition from different websites. He printed out the screenshots and asked you to rate your preference. He wanted you to help him decide which medicine is most likely to benefit the patients. At the same time he also had much concern about whether it is "fake medicine" so that he would not be humiliated in front of class.

Figure 2. Instruction of experiment task

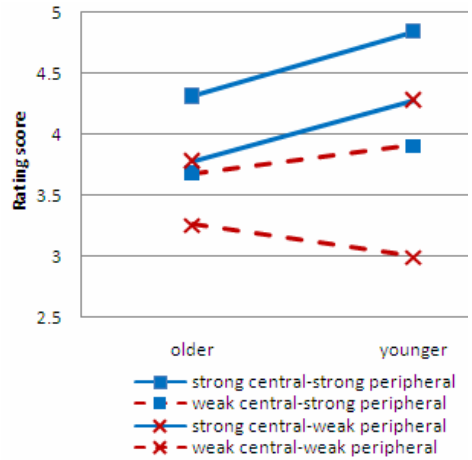

Figure 3 Rating score of all subjects

tests to all participants to measure the individual differences in cognitive ability and motivation for cognition. Processing speed was measured by the average score of the letter comparison task and the pattern comparison task [14]. We measured the motivation for cognition by a 45 item 7-point scale developed by Cacioppo and Petty [1]. It was designed to distinguish individuals who dispositionally tend to engage in and enjoy effortful analytic activity from those who do not, and was proved to be a variable that influences the general extent of objective processing.

Results

A three-way ANOVA with the strength of central and peripheral cue as within-subject variables and age as between-subject variable showed significant main effects of central ($F(1,188)=79.10$, $p<.001$) and peripheral cue($F(1,188)=35.33$, $p<.001$) on credibility ratings. The interaction between central and age was significant ($F(1,188)=7.98$,$p=0.005$), but that between peripheral and age was not significant ($p=0.24$). The three-way interaction was also not significant ($p=0.28$). Therefore, consistent with our hypothesis, cognitive aging had differential effects on the processing of the central and peripheral cues.

Figure 3 shows the significant centralxage interaction was caused by the closer ratings given to strong/weak central cues by older than younger adults. This suggests that older adults were less sensitive to differences in central cues to differentiate the credibility of the web pages. The lack of a significant interaction between peripheral and age implies that there was in general no age difference in the processing pattern of the peripheral cues (although older adults were biased to give lower credibility ratings equally in all levels).

We found a significantly lower processing speed for older adults ($F(1,22)=8.34$, $p=0.009$),but there was no significant age difference in motivation for cognition ($F(1,22)=1.27$, $p=0.271$).A medium split on these variables was performed to divide participants into a high and low group for each variable, which were used as between subject variables. The same ANOVA was then performed with low/high processing speed added as an between-subject variable. Results still showed significant main effects of central cue ($F(1,186)=70.17$, $p<.001$) and peripheral cue ($F(1,186)=23.35$, $p<.001$), and a marginally significant two-way interaction of central cue and age ($F(1,186)=3.35$, $p=0.069$). There was also a significant three-way interaction between central cue, age and processing speed ($F(1,186)=4.03$, $p=0.046$).

To understand the three-way interaction, we performed a separate ANOVA on the high and low processing speed group. For the high processing speed group, none of the interactions was significant. However, for the low processing speed group, a two-way interaction between central cue and age was significant ($F(1,100)=8.43$, $p=0.005$). Figure 4 shows that older adults whose processing speed is high could perform as good as younger adults in differentiating the central cues, although they generally gave lower score to all of them. However, Figure 5 shows that older adults whose processing speed is low were less able to differentiate strong and weak central cues than younger adults. *In other words, for those older individuals whose processing ability does not significantly decline, they could differentiate the central cue just as good as younger adults; and processing speed seemed to be able to only partially explain why they were worse at differentiating central cue strength.*

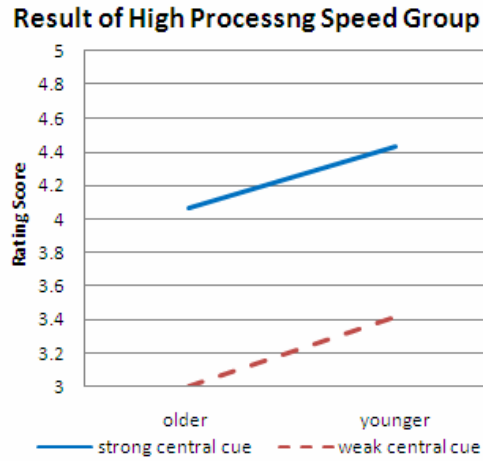

Figure 4 Result of high processing speed group

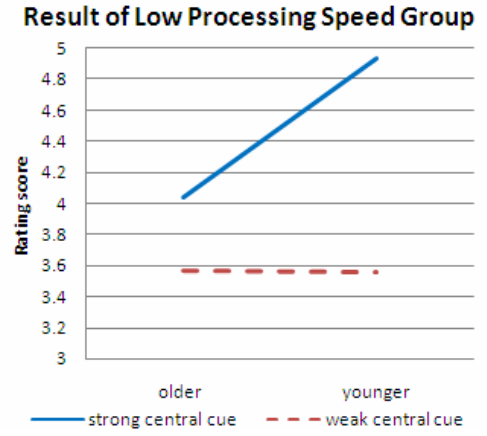

Figure 5 Result of low processing speed group

We then performed the same ANOVA with low/high motivation for cognition as a between-subject variable. There was significant main effects of central ($F(1,186)=78.17$, $p<.001$) and peripheral cues ($F(1,186)=32.26$, $p<.001$), two-way interaction of central cue and age ($F(1,186)=10.97$, $p=.001$), and two-way interaction of central cue and motivation for cognition ($F(1,186)=7.55$, $p=0.007$). There was also a significant three-way interaction between central, peripheral and motivation for cognition ($F(1,186)=4.041$, $p=0.046$) and a marginally significant three-way interaction between peripheral cue, central cue and age ($F(1,186)=2.387$, $p=0.124$).

To understand the three-way interaction, we separated the participants by low and high motivation for cognition and performed a separate ANOVA for each group. We found that the interaction of central cue x age was significant in the low motivation for cognition group ($F(1,68)=4.808$, $p=0.032$), and marginally significant for the high motivation for cognition group ($F(1,118)=3.076$, $p=0.082$). However, there was a significant three-way interaction of peripheral cue, central cue and age in the low motivation for cognition group ($F(1,68)=3.651$, $p=0.06$), but not in the high motivation group ($p=0.97$).Figure 6 shows that older adults with high motivation were as sensitive to the central and peripheral cues as younger adults, although they gave a marginally significant closer rating between weak/strong central cues.

For older adults with low motivation for cognition, Figure 7 shows that older adults gave a high rating only when both central and peripheral cues were strong, and deemed all the other three combinations to be equally less credible; but younger adults seemed to be able to differentiate the cues as in the high motivation group. It was possible that older adults in this group adopted a much simplified "satisficing" strategy: As long as they perceived a negative cue they gave up further processing and gave an overall low credibility rating.

Conclusion and Discussion

The results of this study are consistent with ELM model in general, but we also found some interesting effects of cognitive aging on credibility assessment that deserves further investigation. To summarize, we found three major effects that are worth noting: 1) cognitive aging lowers the depth of arguments scrutiny, which obscures the boundaries between strong and weak central cues in older adults' assessment of credibility, 2) cognitive aging does not show significant effects on peripheral cue processing, which may imply that the lower fluid abilities of older adults lead to an adaptive shift from systematic to heuristic processing, which requires less cognitive resources that allow older adults to effectively process the peripheral cues [8],and 3) elder adults' Web credibility assessments interact with individual variables regarding cognitive ability and motivation. The interaction with processing speed implies that the generally lower cognitive ability contributes to the age difference in central route processing, and the interaction with motivation for cognition suggests that older adults who are less motivated to engage in effortful cognitive work will *even more* likely choose a less cognitively demanding heuristic processing strategy. Future research will focus on testing design features that will help older adults to utilize less cognitively demanding strategies to more accurately assess the credibility of health information through both the central and peripheral cues.

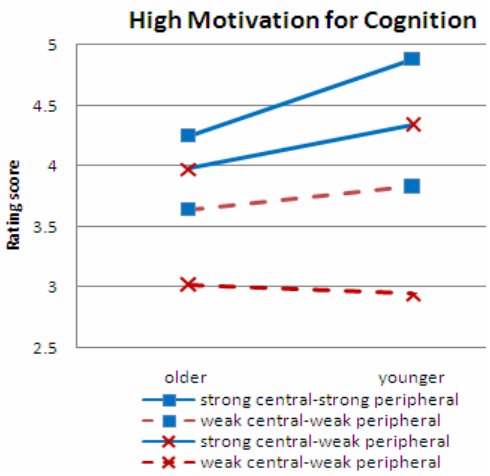

Figure 6 Result of high motivation for cognition group

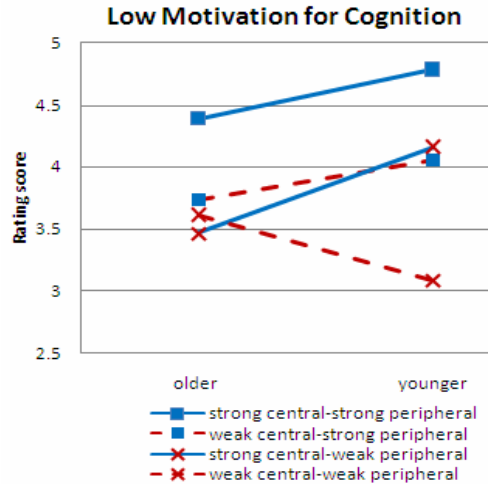

Figure 7 Result of low motivation for cognition group

Another important implication of this study is the "multidimensional" nature of the effects of aging in Web credibility assessment. It seems that there are multiple factors influencing the dual processing of different cues on a Web page, and these factors could also induce a change of strategies or processes that interact with these cues. It suggests that besides the declined fluid ability, there are more factors contributing to the age difference in Web credibility assessment, which we will study in future research. It seems that more research are needed to help older adults to better utilize health information online.

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