Promoting Comprehension of Health Information among Older Adults

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Abstract

Understanding and acting on online health information is increasingly a pre-requisite for patient self-care. Therefore, inadequate health literacy is a barrier to self-care among older adults with chronic illness. The goal of our study was to improve older adults' comprehension of online health information. We extracted typical health texts from multiple credible health websites, and systematically improved the texts in terms of, content, language, organization and design. Results showed that older adults better understood the revised passages than the typical ones, in terms of their reading efficiency (time per unit of information uptake). Intervention benefits were greater for older adults with more domain-specific health knowledge, suggesting that knowledge facilitated the comprehension of health information in the revised texts. Implications for promoting older adults' comprehension of health information are discussed.

Keywords: cognitive aging; health literacy; comprehension; domain knowledge; healthcare

Introduction

Health literacy is often defined as the ability to access, obtain and understand health information in order to support self-care decisions (U.S. Department of Health Services, 2000). In addition to the fact that older adults were likely to have inadequate health literacy compared to younger ones (Baker, Gazmararian, Sudano & Patternson, 2000), there is mounting evidence showing that health literacy (such as measured by STOFHLA, Short Test of Functional Health Literacy in Adults; Baker, Williams, Parker, Gazmararian & Nurss, 1999) is associated with health behaviors, such as medication adherence, utilization of health services and health outcomes (DeWalt, Berkman, Sheridan, Lohr & Pignone, 2004; Wolf, Gazmararian & Baker, 2005). The link between inadequate health literacy and poor health behaviors and outcomes may be due to the fact that older adults with lower levels of health literacy have more difficulty understanding health information (e.g., Chin et al., 2015). As self-care information proliferates on the web, comprehension of this information is increasingly important for self-care and inadequate comprehension among older adults with low health literacy is a concern.

The Process-Knowledge Model of Health Literacy suggests there are different cognitive components that are related to the development of health literacy, including processing capacity, general knowledge, and health knowledge (Chin et al., 2011). These components have different trajectories across the lifespan, with processing capacity declining, while knowledge tends to sustain with age (Beier & Ackerman, 2005; Baltes, 1997). These age-related changes in component abilities may influence the development of health literacy of older adults. However, knowledge can compensate for the effect of the declining processing capacity on health literacy (Chin et al., 2011). Therefore, links between health literacy and comprehension would depend on the interaction between processing capacity and knowledge (Chin et al., under review).

Theories of comprehension suggest that knowledge can offset the effects of processing capacity limits on comprehension among older adults through different reading strategies (e.g., Miller, Stine-Morrow, Kirkorian & Conroy, 2004). Processing capacity and knowledge jointly shape comprehension across lifespan. There are three levels of comprehension (Kintsch, 1998), including surface-level (recognizing words), textbase level (semantic integration, binding concepts) and situation model level of representations (having a mental model of the situation described by the text). Decline in processing capacity may impair surface-level and textbase level processing for example by reducing ability to integrate concepts to create textbase (e.g., Stine-Morrow, Miller, Gagne & Hertzog, 2008). However, knowledge can promote conceptual integration and the use of situation model in reading (e.g., Chin et al., 2015; Miller et al., 2004). According to this view, comprehension of health information can be improved by designing health texts to reduce demands of comprehension on processing capacity and build on patients' knowledge relevant to the texts.

In this study we used a systematic, multi-leveled approach to revising patient education passages about hypertension self-care in order to improve older adults' comprehension of this information. We examined the following two questions. First, do participants perform better in the revised texts than the typical ones? Second, while the intervention was broadly tapping into multiple patients' resources, such as processing capacity and knowledge, we would like to explore whether some participants benefit more than others from the revised passages?

Method

Participants

One hundred and twenty eight older participants were recruited in the study (Age: Mean=70.84 years old, SD=7.73). Seventy-nine participants were females (61.7%). Ninety-five participants were patients with hypertension (74.2%). Most participants had completed high school (N=109, 85.2%), and the rest completed some high school (N=11, 8.6%) or did not enter high school (N=8, 6.3%).

Health literacy was measured by a commonly used standardized test, STOFHLA (Short Test of Functional Health Literacy in Adults; Baker, Williams, Parker, Gazmararian, & Nurss, 1999). Although most participants had adequate health literacy, 12% had marginal health literacy (N=12), and 5.5% had inadequate health literacy (N=7).

Measures

We measured processing speed with Letter and Pattern Comparison (Salthouse, 1991), working memory with Reading Span (Stine & Hindman, 1994), and general knowledge with Advanced Vocabulary Task (Ekstrom et al., 1976). We measured hypertension knowledge with a questionnaire used in the previous studies (e.g., Chin et al., 2011; 2015), which consisted of 33 true/false and 4 multiple-choice questions and was modified from Gazmararian et al. (2003) (Cronbach α=.90; Chin et al., 2009).

We also measured the psychomotor speed of using the mouse given that participants would read the passages on a computer. Participants were told to scroll down five webpages at their own pace. We used the average time (in seconds) participants took to scroll down the webpages to estimate their basic scrolling time without reading activities.

Passages

Nine 4-5 page passages about hypertension were used in the study. Four passages were 'typical' in the sense that they were representative of information about hypertension found on credible websites. To develop these passages, we identified websites that provided high quality information for patients, including National Institute of Aging, American Heart Association, National Heart, Lung, and Blood Institute and Mayo Clinic (HON, Health On the Net, certified).

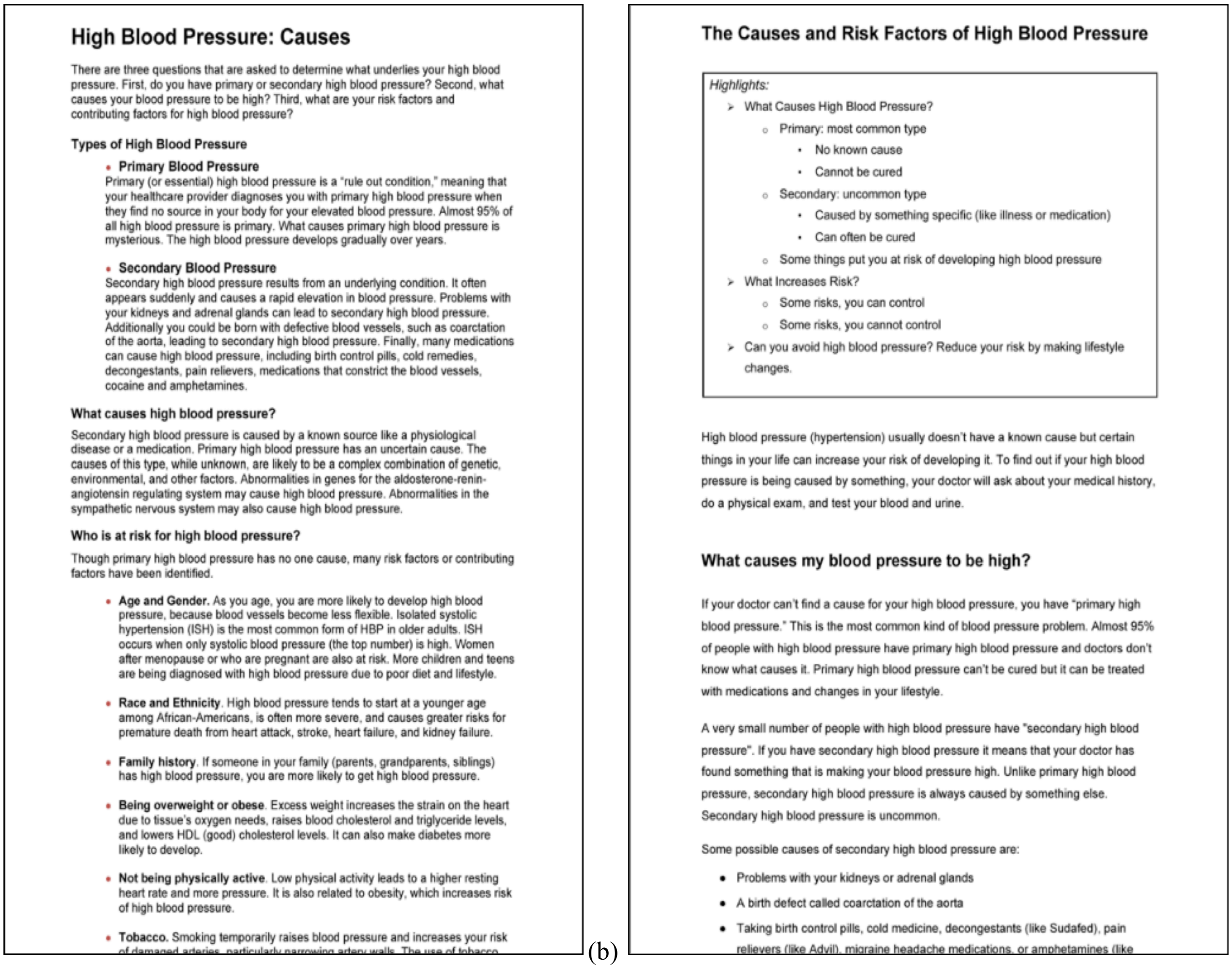
Source passages were extracted from the websites, on the following five hypertension-related topics: an introduction to high blood pressure, the causes of high blood pressure, the complications of high blood pressure, lifestyle changes to improve blood pressure, and the pharmaceutical treatment of high blood pressure. We then created a typical passage for each topic was created from the source passages. The typical passage did not differ from the corresponding source passages in terms of the number of words, number of paragraphs, Flesch-Kincaid readability grade level and Flesch-Kincaid reading ease. A pilot study involving older adults with similar background to those in the primary study found that these passages did not statistically differ from their corresponding sources in terms of rated difficulty.

Four revised passages were then created from these typical passages. To do this, each typical passage was revised in terms of its content, organization, language and design, following guidelines from the literature on patient education (e.g., Doak, Doak & Root, 1996) and discourse processing (Hill-Briggs, Schumann & Dike, 2012, Lorch, Lemari & Gant, 2011), as well as the Process-Knowledge model of health literacy (Chin et al. 2011). In addition, revision of the content and organization of the passages was guided by recommendations of three medical experts (two internal medicine physicians and one pharmacist) on content relevancy and completeness, as well as appropriateness of headers and the order of information. For the organization, paragraph breaks, titles and headers, and bullet lists were determined by the use of a consensus process from five trained students. For language, we made edits on word choice and sentence structures with multiple reviews from both trained students and medical experts. For passage design, we first modified the font size and styles of the passages, and then included an, a concept outline that served to signal the important concepts in the passage and the relations among these concepts (advanced organizer).

Table 1. Text characteristics of the typical and revised passages.

	Typical Mean (SD)	Revised Mean (SD)	*t*
Number of words	742.25 (73.78)	1008.25 (150.83)	-3.34*
Number of syllables	1236.25 (252.04)	1254.5 (244.52)	-2.39
Number of sentences	49 (10.95)	62.25 (10.65)	-1.43
Flesh-Kincaid grade level	9.98 (2.18)	8.63 (1.61)	2.53

Note. * $p<.05$



(a)

High Blood Pressure: Causes

There are three questions that are asked to determine what underlies your high blood pressure. First, do you have primary or secondary high blood pressure? Second, what causes your blood pressure to be high? Third, what are your risk factors and contributing factors for high blood pressure?

Types of High Blood Pressure

- **Primary Blood Pressure**
Primary (or essential) high blood pressure is a "rule out condition," meaning that your healthcare provider diagnoses you with primary high blood pressure when they find no source in your body for your elevated blood pressure. Almost 95% of all high blood pressure is primary. What causes primary high blood pressure is mysterious. The high blood pressure develops gradually over years.
- **Secondary Blood Pressure**
Secondary high blood pressure results from an underlying condition. It often appears suddenly and causes a rapid elevation in blood pressure. Problems with your kidneys and adrenal glands can lead to secondary high blood pressure. Additionally you could be born with defective blood vessels, such as coarctation of the aorta, leading to secondary high blood pressure. Finally, many medications can cause high blood pressure, including birth control pills, cold remedies, decongestants, pain relievers, medications that constrict the blood vessels, cocaine and amphetamines.

What causes high blood pressure?

Secondary high blood pressure is caused by a known source like a physiological disease or a medication. Primary high blood pressure has an uncertain cause. The causes of this type, while unknown, are likely to be a complex combination of genetic, environmental, and other factors. Abnormalities in genes for the aldosterone-renin-angiotensin regulating system may cause high blood pressure. Abnormalities in the sympathetic nervous system may also cause high blood pressure.

Who is at risk for high blood pressure?

Though primary high blood pressure has no one cause, many risk factors or contributing factors have been identified.

- **Age and Gender.** As you age, you are more likely to develop high blood pressure, because blood vessels become less flexible. Isolated systolic hypertension (ISH) is the most common form of HBP in older adults. ISH occurs when only systolic blood pressure (the top number) is high. Women after menopause or who are pregnant are also at risk. More children and teens are being diagnosed with high blood pressure due to poor diet and lifestyle.
- **Race and Ethnicity**. High blood pressure tends to start at a younger age among African-Americans, is often more severe, and causes greater risks for premature death from heart attack, stroke, heart failure, and kidney failure.
- **Family history**. If someone in your family (parents, grandparents, siblings) has high blood pressure, you are more likely to get high blood pressure.
- **Being overweight or obese**. Excess weight increases the strain on the heart due to tissue's oxygen needs, raises blood cholesterol and triglyceride levels, and lowers HDL (good) cholesterol levels. It can also make diabetes more likely to develop.
- **Not being physically active**. Low physical activity leads to a higher resting heart rate and more pressure. It is also related to obesity, which increases risk of high blood pressure.
- **Tobacco.** Smoking temporarily raises blood pressure and increases your risk

(b)

The Causes and Risk Factors of High Blood Pressure

Highlights:
- What Causes High Blood Pressure?
  - Primary: most common type
    - No known cause
    - Cannot be cured
  - Secondary: uncommon type
    - Caused by something specific (like illness or medication)
    - Can often be cured
  - Some things put you at risk of developing high blood pressure
- What Increases Risk?
  - Some risks, you can control
  - Some risks, you cannot control
- Can you avoid high blood pressure? Reduce your risk by making lifestyle changes.

High blood pressure (hypertension) usually doesn't have a known cause but certain things in your life can increase your risk of developing it. To find out if your high blood pressure is being caused by something, your doctor will ask about your medical history, do a physical exam, and test your blood and urine.

What causes my blood pressure to be high?

If your doctor can't find a cause for your high blood pressure, you have "primary high blood pressure." This is the most common kind of blood pressure problem. Almost 95% of people with high blood pressure have primary high blood pressure and doctors don't know what causes it. Primary high blood pressure can't be cured but it can be treated with medications and changes in your lifestyle.

A very small number of people with high blood pressure have "secondary high blood pressure". If you have secondary high blood pressure it means that your doctor has found something that is making your blood pressure high. Unlike primary high blood pressure, secondary high blood pressure is always caused by something else. Secondary high blood pressure is uncommon.

Some possible causes of secondary high blood pressure are:

- Problems with your kidneys or adrenal glands
- A birth defect called coarctation of the aorta
- Taking birth control pills, cold medicine, decongestants (like Sudafed), pain

Figure 1. Example passages: (a) typical passage, (b) revised passage

In the study, participants read 5 out of the 9 passages (one for each topic): a practice passage, two typical passages, and two revised passages. The practice passage was about the introduction of hypertension, which was formatted as a revised passage with the concept outline. The typical and revised passages were blocked and block order counterbalanced across all participants. Below showed the text characteristics of the typical and improved passages respectively. There were no differences in font size, number of syllables, number of sentences and grade level between typical and revised passages. Revised texts were a little longer than the typical ones in terms of the number of words.

After reading each passage, participants answered 13 multiple-choice questions to test their understanding about the passage. For example, "ACE inhibitors and ARBs both block a hormone that (a) widen your blood vessels, (b) constrict your blood vessels, (c) decrease the amount of fluid in your blood, (d) allow calcium to enter the cells of your arteries", where (b) was the correct answer. Although the presentation of information varied in the typical and revised passages, the main messages and key concepts remained the same across two types of passages. Only information that was in both versions of the passages was tested.

Experimental Design

The within-subject variable is Passage type, typical and revised. Participants read two passages under each condition. The order of passages was counterbalanced.

Procedure

Upon arrival to the study, after the consent process, participants first completed the demographic questionnaire and the hypertension knowledge questionnaire. Then they completed a battery of cognitive measures, including Pattern and Letter Comparison, Reading Span and Advanced Vocabulary test, and the health literacy measure (STOFHLA).

Participants were then given the reading task on a computer. Text was displayed in black Arial 12-point font on a white background (See task layout in Figure 1). They read five passages in total: the practice introduction passage, two typical passages and two revised passages. Participants would see one passage at a time on a computer screen, and they could scroll up and down the screen at their own pace. The maximum time allotted for each typical and revised passage was 9 minutes. All participants finished reading the passage before the time limit. Participants were instructed to read the passages for understanding. After reading each passage, participants first verbally summarized the information they learned from this passage, and then answered 13 multiple-choice questions testing their understanding the key points in the passage. (The data for summary task will be presented in a later paper)

Results

Linear mixed effects models were used to analyze the effects of passage type (typical and revised) as well as individual difference variables, including age, processing capacity (PC), general knowledge (GK) and health knowledge (HK), on reading efficiency. We used the function lmer in package lme4 (Bates, 2005; Bates & Sarkar, 2007) to run the models and Baayens MCMC function to estimate significance intervals for the parameter estimates (Baayen, et al., 2008) in R software.

The processing capacity variable was constructed by averaging the standardized scores of the letter comparison, pattern comparison and reading span tasks. General knowledge and health knowledge were the standardized scores of advanced vocabulary task and hypertension knowledge questionnaire, respectively.

Reading time was measured for each passage. , Reading time data from six participants were missing due to technical problems. To control for differences in passage length, we first divided overall passage reading time by the number of words in the corresponding passage. We used reading time per word in order to create the reading efficiency measure. Reading efficiency was operationalized as the unit reading time divided by the proportion of information uptake (Miller, 2009), which was defined by accuracy of responses to the passage comprehension questions. Therefore, reading efficiency scores were computed as the reading time per word divided by the accuracy scores for each passage; that is, the amount of time readers needed to take to uptake one unit of information. This reading efficiency measure was the dependent variable for the mixed effects analysis.

Correlates of Reading Efficiency

Following the process-knowledge model of health literacy, we examined the fixed effects of health knowledge in addition to general knowledge and processing capacity on reading efficiency. In addition, we entered age and the basic

Table 2. Estimated parameters (with standard error of estimates) of mixed-effects modeling

	Model 1		Model 2		Model 3		Model 4	
	B	t	B	t	B	t	B	t
Intercept	235.75 (17.19)	13.71*	252.92 (17.61)	14.36*	252.92 (18.32)	13.80*	248.87 (84.46)	2.95*
Item Predictors								
Pass	-53.70 (7.01)	-7.66*	-59.31 (7.33)	-8.10*	-59.31 (7.26)	-8.17*	-53.52 (6.99)	-7.66*
Subject Predictors								
Age							-0.12 (1.17)	-0.10
PC	-52.27 (13.33)	-3.92*					-36.71 (12.90)	-2.85*
GK			-53.38 (9.49)	-5.63*			-40.91 (10.85)	-3.77*
HK					-26.59 (10.33)	-2.57*	-8.30 (9.49)	-0.87
Cross-level Interaction								
PC x Pass	-17.79 (9.79)	-1.82						
GK x Pass			3.89 (7.36)	0.53				
HK x Pass					-19.96 (7.30)	-2.74*	-16.86 (7.06)	-2.39*

Note: (1) Pass = types of passages; PC = processing capacity; GK = general knowledge, HK= health knowledge.
(2) *p<.05

scrolling time as covariates in the model. Given the random effects of subjects and passages, we found significant fixed effects of general knowledge, processing capacity and scrolling time on reading efficiency. Participants with better processing capacity, general knowledge, and quicker scrolling speed, required less time to uptake one unit of information (processing capacity: B=-26.80, SE=13.22, t=-2.03; general knowledge: B=-39.65, SE=10.60, t=-3.74; scrolling speed: B=2.48, SE=1.02, t=2.44, all *p*'s <.05). Thus, general knowledge and processing capacity facilitated the uptake of health information among older adults.

In addition, given that health knowledge was moderately associated with general knowledge (r=0.31, *p*<.01), we examined the effect of health knowledge on reading efficiency when only age and health knowledge were used in the analysis. Participants with more health knowledge needed less time to uptake one unit of health information than ones with less health knowledge (B=-25.75, SE=10.31, t=-2.50, *p*<.05). Age was not associated with reading efficiency (B=-1.48, SE=1.33, t=-1.11).

Effects of Passage Revision on Comprehension

First, a paired-t test showed that participants had better comprehension (accuracy scores) of the revised (Mean=0.74, SD=0.14) compared to the typical passages (Mean=0.70, SD=0.11) (t(127)=-3.08, p<.01). Participants also read the revised passages more efficiently (Mean=0.50, SD=0.23) than the typical passages (Mean=0.60, SD=0.25) (t(121)=-3.08, p<.01). In other words, they took about 0.1 second less to uptake a unit of information in the revised passage than the typical ones.

Who Benefits More from the Revised Passages

To identify whether some kinds of participants benefited from than others from redesigning the passages, we examined the effects of processing capacity, general knowledge, health knowledge and their interactions with the type of passage on reading efficiency using the mixed effects models (See Table 2).

We first examined the fixed effects of passage type, processing capacity, and their interaction on reading efficiency (Model 1 in Table 2). There was no interaction of processing capacity and passage type, showing that participants better understood the revised texts than the typical ones regardless of their level of processing capacity (B=-17.79, SE=9.79, t=-1.82). A similar analysis of general knowledge, passage type, and their interaction on reading efficiency (Model 2 in Table 2) showed that passage type did not interact with general knowledge, suggesting that participants better understood the revised texts than the typical ones regardless of their general knowledge.

However, a similar analysis with health knowledge (Model 3 in Table 2) revealed a significant interaction of health knowledge and passage type (B=-19.96, SE=7.30, t=-2.74, p<.05). Participants with more health knowledge benefited more from the revised texts than participants with less health knowledge. Moreover, the interaction remained significant after the effects of age, processing capacity and general knowledge were controlled; (B=-16.86, SE=7.06, t=-2.39, p<.05; see Model 4 in Table 2). Processing capacity and general knowledge facilitated the uptake of health information. In addition, health knowledge further exaggerated the beneficial effects of revised texts relative to the typical ones. We plotted the time needed to uptake one unit of information from the typical and revised texts for participants who had one standard deviation below and above the mean health knowledge performance in Figure 2.

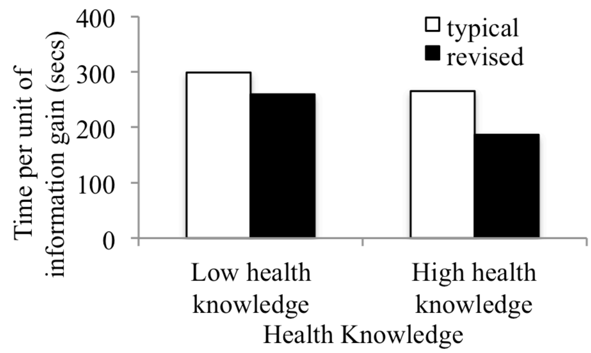


Figure 2. Interaction of health knowledge and types of passages on reading efficiency (time per unit of information uptake)

Discussion

Our findings suggest that older adults' comprehension of hypertension self-care information that is readily available on the internet can be improved by using a systematic multi-leveled approach to revising the information. Better comprehension of self-care information should translate into better health-related decisions, behaviors and outcomes, because previous research has found that comprehension of self-care information predicts health behaviors (Dewalt et al., 2004). Of course this link needs to be demonstrated for the present passages in future research.

The Process-Knowledge model suggests that processing capacity and knowledge interact to influence comprehension of self-care information because these abilities have different age-related trajectories. Interestingly, we found that older adults with higher domain-specific health knowledge benefit more than those with less knowledge from the revised passages in terms of obtaining information more quickly. However, there was limitation in the current study in terms of differentiating the benefits of multiple levels of text revision on comprehension. Therefore, we need to be cautious to make arguments about what made older adults with more health knowledge benefit more from those with less health knowledge. Theoretically, the intervention was to reduce the demands on processing capacity by simplifying the language and streamlining the organization as well as to promote integrating concepts with prior knowledge using structural features (such as headers) and the advanced concept organizer. Hence, the differential benefits of revised texts on people with more health knowledge may suggest that having structural features and advanced concept organizers facilitated reading by building a situation model representation with prior knowledge.

Although we did find differential accumulative advantages of older adults with more domain-specific knowledge gaining more from our intervention, it did not mean that people with fewer resources (such as lower processing capacity, lower general or lower health knowledge) were not able to benefit from the revised health texts. Though parts of the "Matthew effects", that people with better resources gaining more, were observed in our study, it is not discouraging given that people with poorer resources, at whom we aimed, were able to take advantages of the intervention and showed improvement in their comprehension. Thus, future research will investigate the effects of different levels of intervention on promoting comprehension for people varying in cognitive resources.

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