Designing digital health information in a health literacy context

Meppelink, C.S.

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Health literacy and online health information processing: Unraveling the underlying mechanisms

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ABSTRACT

The usefulness of the Internet as a health information source largely depends on the receiver's health literacy. This study investigates the mechanisms through which health literacy affects information recall and website attitudes. Using two independent surveys addressing different Dutch health websites (N = 423 and N = 395), the mediating role of cognitive load, imagination ease, and website involvement was tested. Results showed that the influence of health literacy on information recall and website attitudes was mediated by cognitive load and imagination ease, but hardly by website involvement. Thus, in order to improve recall and attitudes among people with limited health literacy, online health communication should consist of information that is not cognitively demanding and easy to imagine.

INTRODUCTION

The Internet is a powerful information source, which makes an unlimited amount of information available to everyone with an Internet connection. In the United States, 84% of the adults use the Internet (Perrin & Duggan, 2015) and in the Netherlands even 97% of the adult population has Internet access (Statistics Netherlands, 2014). Moreover, over two-thirds of the US adults population currently own a smartphone (Smith, 2015). Because nearly anything can be found online, these statistics suggest that people's access to information does not divide groups in society anymore. Especially smartphones are expected to decrease the digital divide that was caused by the Internet as they offer opportunities to reach parts of the population that were difficult to reach before (Fiordelli, Diviani, & Schulz, 2013). Equal physical access to the Internet, however, does necessarily correspond to equal ability to understand and use online information. For some population groups, finding, evaluating, and understanding information is harder than it is for others.

Information is a valuable asset in many domains, especially in health. The extent to which people are able to benefit from online information largely depends on one's level of health literacy. Health literacy is defined as peoples' ability to "obtain, process, understand, and communicate about health-related information needed to make informed health decisions." (Berkman, Davis, & McCormack, 2010, p.16). Without adequate health literacy, people are unable to understand and use health information in their daily lives. Limited health literacy is quite prevalent in Western societies (HLS-EU Consortium, 2012; Kutner, Greenberg, Jin, & Paulsen, 2006). Therefore, although people with limited health literacy have equal access to technology as people with adequate heath literacy (Jensen, King, Davis, & Guntzviller, 2010), limited health literacy might jeopardize the potential of the Internet as a health information source. Research has shown that online health information is often complex and written on a reading level that is difficult to understand (Lachance, Erby, Ford, Allen, & Kaphingst, 2010; McInnes & Haglund, 2011). If only people with adequate health literacy are able to process and understand online information and people with limited literacy do not, the knowledge gap between these groups will only increase.

Although the concept of health literacy is still evolving and multiple perspectives exist, health information processing is a key element of several health literacy frameworks (Sørensen et al., 2012). However, information processing is often a black box (Geiger & Newhagen, 1993). In order to develop effective design strategies for online health information that suit people of all health literacy levels we need to know how health literacy facilitates information processing, and subsequently, message effects. According to Von Wagner, Steptoe, Wolf, and Wardle (2009), health literacy has both cognitive (e.g., knowledge, understanding) and affective effects (e.g., attitudes and beliefs). Both types of outcomes are important, because they are related to access and use of health care, patient provider interactions, self-management, and ability to make informed health decisions (Marteau, Dormandy, & Michie, 2001; Paasche-Orlow & Wolf, 2007). In this study, we investigate the mechanisms that underlie the effect of health literacy on cognitive and affective message effects (i.e., information recall and website attitudes). Three mechanisms are tested, namely the mediating role of cognitive load, imagination ease, and involvement with the information. These mechanisms have been suggested in the literature (Meppelink, Smit, Buurman, & van Weert, 2015; von Wagner, Semmler, Good, & Wardle, 2009; Wilson & Wolf, 2009), but were, to the best of our knowledge, never tested empirically or in conjunction. By doing this, our paper also responds to the call for theory driven studies on health literacy and e-health (Mackert, Champlin, Holton, Muñoz, & Damásio, 2014) and aims to fill the lack of European health literacy studies (Barry, D'Eath, & Sixsmith, 2013).

Cognitive load, imagination ease, and website involvement

The first tested mechanism is the mediating role of the cognitive load that is required for information processing. According to Lang's limited capacity model of motivated mediated message processing (LC4MP), full message processing comprises three sub processes: message encoding, storage, and retrieval (Lang, 2000). Each sub process requires cognitive capacity to be completed. However, human cognitive capacity is limited. This means that if reading a message and deriving meaning from its content (information encoding) requires much cognitive capacity, there will be less capacity left for message storage and, ultimately, retrieval. Encoding health information is particularly difficult, and cognitively demanding, for people with limited health literacy (von Wagner et al., 2009). This makes them at risk of experiencing cognitive overload when they try to process health information (Wilson & Wolf, 2009). For people with adequate health literacy, in contrast, processing health information requires relatively less cognitive capacity (Chin et al., 2011). This difference in relative cognitive load that information processing takes can influence recall of information (Lang, 2006), which is in line with cognitive load theory (Sweller, Van Merrienboer, & Paas, 1998). Next to its positive influence on recall, the cognitive load that is associated with information processing may also affect peoples' attitudes towards the information. Research in cognitive psychology has shown that pictures that are easy to process results in more positive affect (Winkielman & Cacioppo, 2001). The subjective experience of ease associated with processing information, also known as processing fluency, has shown to be a general metacognitive cue that positively influences peoples' evaluations in various domains (Alter & Oppenheimer, 2009). It must be noted, however, that most studies related to processing fluency were conducted with relatively simple stimuli such as photo's or words. Nevertheless, the mechanism might also apply to more difficult materials such as health websites. When this is the case, the relative difference in cognitive load that is required for information processing, caused by health literacy, will not only influence information recall, but attitudes as well.

The second mechanism is the mediating role of imagination ease. Successful information processing incorporates the creation of mental models in which new information is connected to existing knowledge (Lang, 2000; Mayer, 2002). People with limited health literacy often have a lack of health-related background knowledge (Chin et al., 2011), which undermines the creation of a correct mental model. According to the cognitive theory of multimedia learning, people have separate channels to process verbal and visual information (Mayer, 2002), and both channels have their own, limited, capacity. This theory has been supported by different studies that showed that information presented as both text and pictures was better understood and remembered compared to text-only information (e,g. Bol et al., 2015; Mayer, 2002). However, research has shown that especially people with limited health literacy benefit from illustrations added to complex health information whereas illustrations made no difference for people with adequate levels of health literacy (Meppelink et al., 2015). Therefore, it could be argued that for people with adequate health literacy illustrations do not improve information recall because it is easy for them to imagine the information and 'make the picture mentally'. Furthermore, research in health communication has shown that the subjective ease with which symptoms information can be imagined influences peoples' attitudes towards the recommended behavior (Broemer, 2004). Therefore, we expect that online health information will be less well processed, recalled, and evaluated compared to people with adequate health literacy, for whom the creation of a mental model with respect to health information is relatively easy.

The third mechanism is the mediating role of involvement with the website. It has been shown that people with health literacy less often search for health information than people with adequate health literacy (Kutner et al., 2006). One possible explanation is the fact that people with limited health literacy are less likely to engage with health information or experience motivational barriers when they are confronted with health information (von Wagner et al., 2009; von Wagner et al., 2009). Due to a lack of engagement, people with limited health literacy may put less effort in health information processing which reduces the likelihood that the information is fully processed and remembered (Lang, 2000). Besides influencing recall, peoples' involvement with a website is also assumed to induce positive attitudes. When receivers are involved, this is expected to positively influence message elaboration which subsequently produces more positive attitudes (Liu & Shrum, 2009). Research on the customization on webportals has shown that website involvement induced by customization positively influences people's attitudes towards the portal (Kalyanaraman & Sundar, 2006). Also in health communication, it has been suggested that website involvement, induced by website interactivity, generated positive attitudes towards the health website (Lustria, 2007). Taking the three potential mechanisms together, this leads to the following hypotheses: *Health literacy positively influences recall of online health information. This relationship is mediated by cognitive load, perceived imagination ease, and website involvement (H1). Health literacy positively influences people's attitude towards online health information. This relationship is mediated by cognitive load, perceived imagination ease, and website involvement (H2).*

METHOD

Survey procedure

To rigorously test the influence of perceived cognitive load, perceived imagination ease, and website involvement, our hypotheses were independently tested on two different websites using online surveys. Ethical approval for this study was provided by the research institute. Data were collected between 27 February and 5 March 2015. The survey started with questions about gender, age, and education level. Furthermore, health-related internet use and self-reported knowledge about the topic of the website, fibromyalgia, were assessed. Then, respondents visited a real, existing website about fibromyalgia. People were instructed to imagine that they were searching for information about fibromyalgia online and found this website. After visiting the website, the survey continued measuring information recall, attitude towards the website, website involvement, perceived cognitive load, and perceived imagination ease. Health literacy was measured at the end of the questionnaire.

Website selection

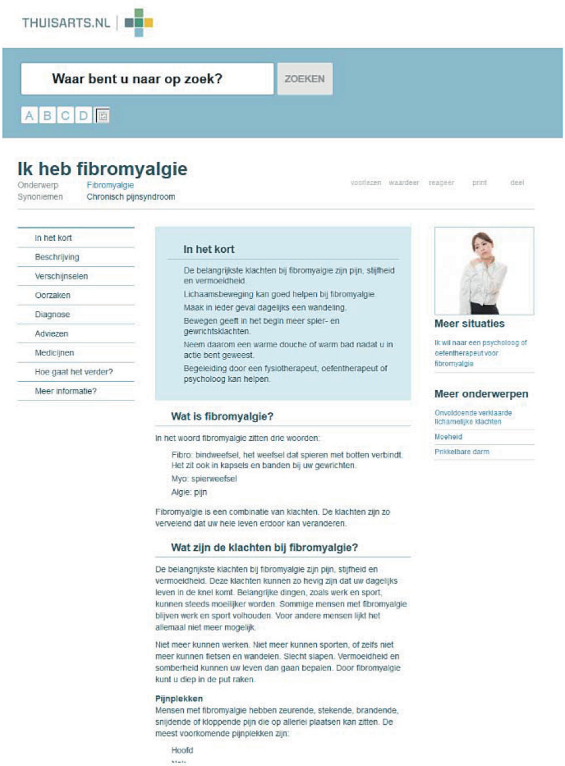
The two websites that were used in this study were selected after an extensive procedure. First, the topic of fibromyalgia was chosen because it was the second most often health-related topic searched for in the Netherlands in the search engine Google.nl over the last 24 months (November 2012 - November 2014), indicated by the tool Google AdWords. Google AdWords gives an indication of the popularity of search terms per country over a specific period of time. We analyzed a list of 850 health-related search terms in AdWords which showed that only Ebola was more often Googled than fibromyalgia. This was probably due to the Ebola epidemic that was going on in Western Africa in the summer of 2014. As we preferred a topic that was less hype-related and more representative of general health information, we chose fibromyalgia.

Subsequently, the search term fibromyalgia was entered in the search engine Google.nl on a cookie-free computer. Google is often used by people who are looking for health information (Diviani, Van den Putte, Meppelink, & Van Weert, 2015). The websites were selected using the following exclusion criteria: 1. multiple links to the same website, 2. news results, 3. live feeds, 4. advertisements, 5. other search engine related material such as definitions, 6. websites on which the information about fibromyalgia was more than five clicks away, 7. webpages targeting health care professionals, 8. webpages that only provided a list of links to other content providers. These criteria were also applied in other content analyses (McInnes & Haglund, 2011; Tian, Champlin, Mackert, Lazard, & Agrawal, 2014). The first website was the fibromyalgia page of Thuisarts.nl (i.e. Home doctor). This website provides information on numerous health topics to a general audience and is hosted by the Dutch society of general practitioners (Nederlands Huisartsen Genootschap, NHG). Consequently, the information on the site is consistent with the medical guidelines for general practitioners. The second website was the fibromyalgia page of Gezondheidsplein.nl (i.e. Health square), which is a leading commercial health website in the Netherlands. The content of this website is approved by a medical professional, but does not necessarily reflect specific medical guidelines.

Although both websites were about fibromyalgia, some differences were observed. Besides being different in length (Thuisarts consisted of 1267 words, and Gezondheidsplein of 601 words), Thuisarts had no images whereas Gezondheidsplein included an image and an animation. Overall, the contents of the websites were comparable, as both discussed commonly experienced problems of fibromyalgia patients, the unknown cause of the disease, the criteria for diagnosis, and tips how to relief the pain caused by fibromyalgia. The websites also differed on some aspects: for example Gezondheidsplein stated that fibromyalgia is a rheumatic disease, whereas Thuisarts did not. Screenshots of the websites are presented in Figures 5.1 and 5.2, the corresponding author will provide pdf files of the websites upon request.

Participants

Data collection was conducted by the research company PanelClix (ISO certified) which randomly selected participants aged 18 or older from their large participant pool. A stratified sample was used, with strata corresponding to the Dutch population in terms of gender, age, and education level. Before the survey was sent to the participants, it was pre-tested several times on people who were not part of the final sample. During these pretests, the duration and usability of the questionnaire was tested. Of the 1784 people who viewed the first page of the survey, 1091 participants (61.15%) were eligible to participate. 693 individuals (38.85%) were excluded because the stratum to which they belonged was already full. To determine the uniqueness of the participants,



Figures 5.1 and 5.2 Fibromyalgia page of Thuisarts.nl and Gezondheidsplein.nl

the pid-code was used. This is an anonymous code that PanelClix assigns to individual participants. Identical pid-codes in the dataset showed that thirteen participants (1.19%) were exposed to the survey twice. In these cases, the second entry was excluded from the analysis. Eighteen cases (1.65%) were excluded because participation took place on a smartphone, whereas the introduction text clearly mentioned that the questionnaire was not suitable for a smartphone (as the screen would be too small to see the desktop version of the website). Of the 1002 people who continued after the informed consent page, 821 (81.93%) completed the questionnaire. Finally, three cases were removed because one respondent reported that he had not seen a website at all, another one directly copy-pasted the answers from the website, and a third respondent answered all open-ended questions by writing down 'not applicable'. As the independent variable health literacy was measured at the end of the questionnaire, only fully completed questionnaires could be used in the analysis.

Measures

Health literacy

To assess peoples' level of health literacy, we used the comprehension test of the 22-item version of the Short Assessment of Health Literacy in Dutch (Pander Maat, Essink-Bot, Leenaars, & Fransen, 2014). Participants were exposed to 22 multiple choice questions in which participants had to select the accurate meaning of an health-related word. Item examples are: 'pancreas', 'biopsy' and 'psoriasis'. For each correct answer, one point was awarded. An incorrect answer received no points, just as the answer 'I don't know'. SAHL-D scores therefore range from 0 to 22 (Thuisarts: M = 15.08, SD = 4.84; Gezondheidsplein: M = 15.14, SD = 4.70).

Information recall

Recall of information was measured with 13 open-ended questions, using an adapted version of the Netherlands Patient Information Recall Questionnaire (Jansen et al., 2008). Seven questions were identical for both the websites and six were different, due to the differences in content of the existing webpages. The recall questions were pretested for clarity and understandability. A predefined codebook was used to score each answer, ranging from zero (false), one (partly good), or two (good). As a result, recall-scores ranged between 0 and 26 (Thuisarts: M = 8.50, SD = 6.97; Gezondheidsplein: M = 9.65, SD = 6.44). In both samples, 15% of the cases (n = 68) were coded by a second coder who was not part of the research team. Intercoder reliability appeared to be good for both websites: Cohen's Kappa Thuisarts = 0.93 (range 0.70 – 1.00); Gezondheidsplein = 0.85 (range 0.75 – 1.00).

Attitude towards the website

Attitude towards the site was measured with 9 items, on a seven-point Likert scale. The items were based on the Website Satisfaction Scale (Bol et al., 2014) and a measure for attitudes towards information (Chang & Thorson, 2004) and included items as such as "The website is pleasant", "The website is appealing", and "The website is informative". Answer options ranged from 1 (totally disagree) to 7 (totally agree). For both sites, the scale was reliable Thuisarts: α = .92, *M* = 4.93, *SD* = .94; Gezondheidsplein: α = .93, *M* = 4.87, *SD* = 1.01.

Perceived cognitive load

Perceived cognitive load was measured with four items on a 7-point Likert scale (Eveland & Dunwoody, 2001; Van Cauwenberge, Schaap, & van Roy, 2014). Statements included "Sometimes I felt "lost" when reading the website" (reversed) and "The main points of the story were clear and coherent". Scores ranged from 1 (much cognitive load) to 7 (little cognitive load). In both samples, the scale was reliable: Thuisarts: α = .81, *M* = 5.19, *SD* = 1.04; Gezondheidsplein: α = .80, *M* = 5.23, *SD* = 1.07.

Perceived imagination ease

Three items were used to measure the ease with which the message could be imagined (Keller & Block, 1997). The semantic differential scale had the following endpoints: The information on the website is "very difficult to imagine" (1) "very easy to imagine (7), "very difficult to picture" (1) "very easy to picture" (7), "does not appeal to the imagination at all" (1) "appeals to the imagination very much" (7). The scale was reliable for both samples: Thuisarts: α = .88, *M* = 5.08, *SD* = 1.14; Gezondheidsplein: α = .88, *M* = 5,18, *SD* = 1.05.

Website involvement

Website involvement was measured with four items using the website involvement scale (Dutta-Bergman, 2004). Items included for example: "I tried hard to evaluate the information on the website" and "I was highly involved in evaluating the website". Answer options ranged from ranging from totally disagree (1) to totally agree (7). For Gezondheidsplein, the involvement measure was extended with two items that addressed involvement with the pictures and animations on the website, which were absent on Thuisarts. In both samples, the scale was reliable (Thuisarts: α = .81, *M* = 4.50, *SD* = 1.03; Gezondheidsplein: α = .84, *M* = 4.56, *SD* = 1,07).

Control variables

In addition to gender and age, we measured several variables to control for their potential influence. Highest obtained education level consisted of nine response categories, which were coded into three categorical variables, identifying respondents who had a low (primary education, lower vocational education, preparatory secondary vocational education, and intermediate secondary vocational education), middle (senior secondary vocational education and university preparatory vocational education), and high (higher vocational education and university) level of education. Furthermore, we asked the respondents how often they used the Internet to find health-related information, if they had a medical profession, how much they knew about fibromyalgia, if they had fibromyalgia themselves, if they had previously searched for information about fibromyalgia online, and if they had visited the specific webpage before.

Statistical analysis

We first ran a correlational analysis using SPSS 22 to examine the relationships among the variables. The correlation matrices for both samples are presented in Table 5.1 and 5.2. Subsequently, we used PROCESS (model 4, 10,000 bootstrapped samples) to test our hypotheses. PROCESS is a macro for SPSS which estimates 95% bias corrected confidence intervals for total and specific indirect effects by means of bootstrapping. Model 4 in PROCESS provides the opportunity to test multiple mediators in parallel, in order to test different mechanisms against each other (Hayes, 2013). PROCESS specifies specific indirect effects for each mediator, while keeping the other mediators constant. Significant effects are indicated by 95% confidence intervals that do not include zero. Two mediation models were tested, with information recall and website attitudes as dependent variables. Health literacy was the independent variable in both models.

Table 5.1 Correlation matrix survey 1, Thuisarts

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Gender (1 = woman)	1														
2. Age	-,06	1													
3. Education	-,01	-,15**													
4. Health literacy	,25***	,21***	,25***	1											
5. Recall	,20***	,05	,20***	,49***	1										
6. Attitude website	-,04	,13**	,01	,16**	,21***	1									
7. Involvement	,09	,15**	,01	,13**	,22***	,41***	1								
8. Cognitive load	,04	,12*	,12*	,41***	,51***	,44***	,28***	1							
9. Imagination ease	-,03	,16**	,09	,35***	,39***	,45***	,26***	,58***	1						
10. Self-reported knowledge about fibromyalgia	,16**	-,06	,10*	,21***	,11*	,07	,22***	,09	,05	1					
11. Online health information seeking	,12*	-,04	,10*	,13**	,02	,12*	,20***	,06	,07	,30**	1				
12. Fibromyalgia patient (1 = yes)	,06	,07	-,02	,08	,07	-,01	,01	-,03	,04	,29***	,06	1			
13. Online information seeking for fibromyalgia (1 = yes)	,06	,04	,09	,16**	,09	,12*	,19***	,13**	,11*	,63***	,21***	,28***	1		
14. Previously visited the website (1 = yes)	,03	-,16**	-,01	-,03	,11*	,14**	,16**	,16**	,11*	,18***	,19***	,07	,23***	1	
15. Medical professional (1 = yes)	,23***	-,13**	,13**	,16**	,04	,05	,13**	-,01	,04	,40***	,11*	,04	,28***	,071	1

Note. N = 423.
*p <.05, **p <.01, ***p <.001

Table 5.2 Correlation matrix survey 2, Gezondheidsplein

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Gender (1 = woman)	1														
2. Age	-,02	1													
3. Education	,00	-,09	1												
4. Health literacy	,21***	,22***	,31***	1											
5. Recall	,19***	,03	,11*	,44***	1										
6. Attitude website	,02	,11*	,11*	,13**	,22***	1									
7. Website involvement	,07	,08	,08	,14**	,26***	,47***	1								
8. Cognitive load	,12*	,14**	,09	,38***	,42***	,35***	,30***	1							
9. Imagination ease	,13*	,12*	,14**	,35***	,38***	,38***	,34***	,62***	1						
10. Self-reported knowledge about fibromy-algia	,21***	-,01	,12*	,18***	,08	,16**	,21***	,04	,20***	1					
11. Online health information seeking	,11*	-,08	,07	,12*	,00	,10*	,22**	,04	,06	,30***	1				
12. Fibromyalgia patient (1 = yes)	,16**	,13*	-,08	,04	,08	,05	,16**	,07	,19***	,43***	,13*	1			
13. Online information seeking for fibromyalgia (1 = yes)	,15**	,10	,07	,16**	,08	,12*	,14**	,07	,18***	,55***	,21***	,35***	1		
14. Previously vis-ited the website (1 = yes)	,15**	-,12*	,05	,07	,09	,16**	,14**	,14**	,14**	,23***	,19***	,20***	,27***	1	
15. Medical professional (1 = yes)	,15**	-,14**	,03	,05	-,01	,01	-,02	,02	,02	,24***	,21***	,06	,17**	,10	1

Note. $N = 395$.
*p <.05, **p <.01, ***p <.001

RESULTS

Table 5.3 provides an overview of both samples. It shows that the groups are comparable in terms of gender, age, and education level. The respondents are also representative for the Dutch population based on the strata used by the research company. Most people consulted the Internet for health purposes a few times per year, although almost ten percent of the individuals used the Internet a few times per week to find health information. In both samples, 14 percent of the people were a medical professional and 25% had previously searched for information about fibromyalgia online.

Survey 1: Thuisarts

To test our first hypothesis, mediation analysis was conducted using PROCESS (model 4, 10000 bootstrapped samples), with health literacy as independent variable, recall as dependent variable and cognitive load, imagination ease and website involvement as three parallel mediators. Although the website automatically closed when people continued with the questionnaire, 43 respondents reported that they had consulted the website for a second time when they answered the recall questions. This was possible as we used a real website. Because we aimed to measure recall of information and not people's ability to find information, these people were excluded from the model in which recall was the dependent variable. Results showed a significant indirect effect of health literacy on information recall through cognitive load (b = 0.18, 95% CI = 0.11, 0.27). Imagination ease (b = 0.03, 95% CI = -0.03, 0.10) and involvement (b = 0.01, 95% CI = -0.00, 0.04) did not mediate the relationship.

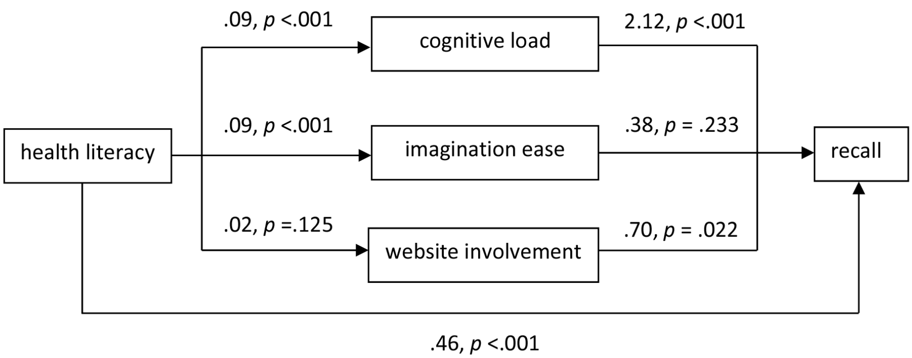


Figure 5.3 Relationship between health literacy and recall for Thuisarts. N = 380. Unstandardized coefficients are reported. In the model, self-reported knowledge of fibromyalgia is kept constant.

Table 5.3 Participant characteristics

		Survey 1, Thuisarts (*N*= 423)		Survey 2, Gezond-heidsplein (*N*=395)	
Variable		*n*	%	*n*	%
Gender	Male	221	52.2	203	51.4
	Female	202	47.8	192	48.6
Age (years)	Mean (SD)	45.11	(16.07)	45.12	(15.8)
	Range	18-78		18-75	
Education level	Low	99	23.4	94	23.8
	Middle	213	50.4	187	47.3
	High	111	26.2	114	28.9
Internet use for health purposes	Never	18	4.3	16	4.1
	Once per year	22	5.2	31	7.8
	Few times per year	130	30.7	111	28.1
	Once per month	84	19.9	78	19.7
	Few times per month	92	21.7	75	19.0
	Once per week	41	9.7	46	11.6
	Few times per week	36	8.5	38	9.6
Professional medical background	Yes	61	14.4	57	14.4
	No	362	85.6	338	85.6
Perceived knowledge of fibromyalgia (range 1-7)	Mean (SD)	2.66	(1.72)	2.71	(1.70)
Fibromyalgia patient	Yes	37	(8.7)	45	(11.4)
	No	386	(91.3)	350	(88.6)
Previously searched for information about fibromyalgia online	Yes	106	(25.1)	103	(26.1)
	No	317	(74.9)	292	(73.9)
Previously visited the specific website	Yes	76	(18.0)	99	(25.1)
	No	347	(82.0)	296	(74.9)

In addition to the indirect effects, health literacy also influenced recall directly (b = 0.46, 95% CI = 0.33, 0.59). To eliminate the influence of prior knowledge on the mediators as well as recall, self-reported knowledge about fibromyalgia was included as a control variable in the analysis and was therefore kept constant[5.1]. The direct and indirect paths are presented in Figure 5.3.

Similarly, PROCESS (model 4, 10000 bootstrapped samples) was used to test the indirect effects of health literacy on attitude towards the website through cognitive load, imagination ease, and website involvement. To be consistent with respect to the control variable, self-reported knowledge about fibromyalgia was also included as a control variable in this analysis[5.2].We found a significant indirect effect of health literacy on attitudes towards the site through cognitive load (b = 0.02, 95% CI = 0.01, 0.03) as well as through imagination ease (b = 0.02, 95% CI = 0.01, 0.03). No indirect effect was found through involvement (b = 0.01, 95% CI = -0.00, 0.01). There was no significant difference in effect size between cognitive load and imagination ease, meaning that both mediators explained the relationship between health literacy and website attitudes to an equal extent. Also, health literacy did not influence website attitude directly (b = -0.01, 95% CI = -0.03, 0.00). The direct and indirect paths are presented in Figure 5.4.

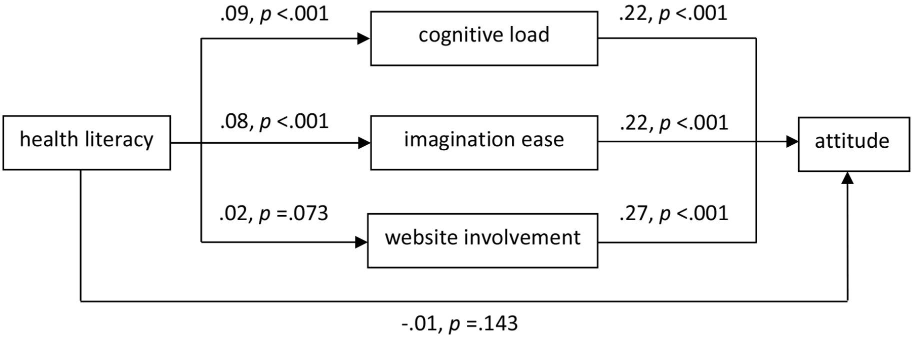


Figure 5.4 Relationship between health literacy and attitude for Thuisarts. N = 423. Unstandardized coefficients are reported. In the model, self-reported knowledge of fibromyalgia is kept constant.

[5.1] We also tested the model with other variables that are associated with the dependent variable recall and at least one of the mediators (i.e., gender, education level, and having previously visited the website). When we included each of these variables as a control variable, this did not change the outcomes.
[5.2] We also tested the model with other variables that are associated with the dependent variable attitudes and at least one of the mediators (i.e., age, frequency of online health information seeking, online information seeking for fibromyalgia, and having previously visited the website). When we included each of these variables as a control variable, this did not change the outcomes.

Survey 2: Gezondheidsplein

In order to rigorously test the hypotheses, the same analyses were done on a different sample of participants who had been exposed to a different website: the fibromyalgia page of Gezondheidsplein. First, the indirect effect of health literacy on information recall was tested, through cognitive load, imagination ease, and website involvement. Again, PROCESS model 4 was used (10000 bootstrapped samples). In order to be consistent with the analyses conducted for Thuisarts, self-reported knowledge of fibromyalgia was added as a control variable and kept constant in the analysis, in order to prevent it from influencing recall of information[5.3]. Results showed that for this website, health literacy not only significantly influenced information recall through cognitive load (b = 0.11, 95% CI = 0.05, 0.19), but also through imagination ease (b = 0.07, 95% CI = 0.01, 0.14) and involvement (b = 0.02, 95% CI = 0.00, 0.05). Although all mediators were found to play a role in explaining the relationship between health literacy and information recall, the effect of involvement was significantly smaller than the effect of cognitive load (b = -0.09, 95% CI = -0.18, -0.02). No other differences in effect sizes were observed between the three mediators. Furthermore, health literacy did also influence recall directly (b = 0.39, 95% CI = 0.26, 0.52). The direct and indirect paths are presented in Figure 5.5.

Finally, we also tested the hypothesis in which attitude towards the website was the dependent variable for the second website, Gezondheidsplein. Similar to the previous analyses, self-reported knowledge on fibromyalgia was added as a control variable to the analysis in PROCESS (model 4, 10000 bootstrapped samples)[5.4]. Results showed that health literacy indirectly influenced attitude towards the website through cognitive load (b = .01, 95% CI = 0.00, 0.02), imagination ease (b = 0.01, 95% CI = 0.00, 0.02), as well as website involvement (b = .01, 95% CI = 0.00, 0.02). The mediators did not significantly differ in terms of effect size. Furthermore, health literacy did not directly influence people's attitude to the website (b = -0.01, 95% CI = -0.03, 0.11). The direct and indirect paths are presented in Figure 5.6, whereas Table 5.4 provides an overview of all indirect effects.

[5.3] We also tested the model with the other variables that are associated with the dependent variable recall and at least one of the mediators (i.e., gender and education level). When we included each of these variables as a control variable, this did not change the outcomes.

[5.4] We also tested the model with other variables that are associated with the dependent variable attitudes and at least of the mediators (i.e., age, education level, online health information seeking, online information seeking for fibromyalgia, and having previously visited the website). When we included each of these variables as a control variable, this did not change the outcomes.

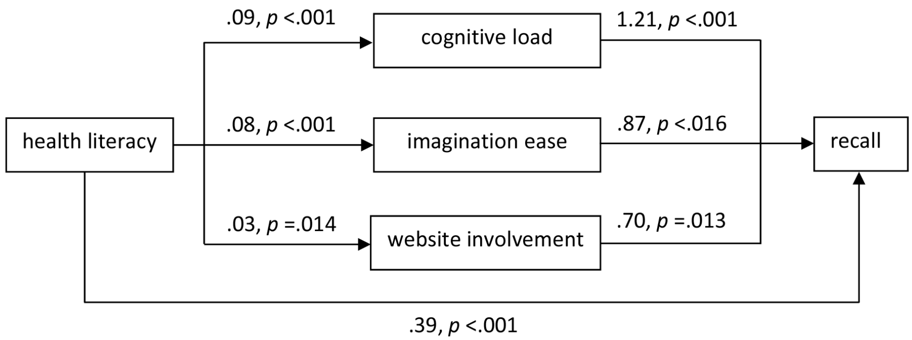


Figure 5.5 Relationship between health literacy and recall for Gezondheidsplein. *N* = 367. Unstandardized coefficients are reported. In the model, self-reported knowledge of fibromyalgia is kept constant.

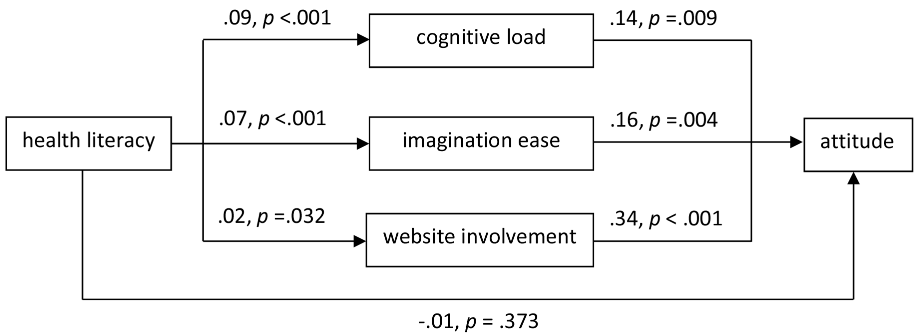


Figure 5.6 Relationship between health literacy and attitude for Gezondheidsplein. *N* = 395. Unstandardized coefficients are reported. In the model, self-reported knowledge of fibromyalgia is kept constant.

Table 5.4 Specific indirect effects for both health websites

Dependent variable	Mediator	Survey 1, Thuisarts		Survey 2, Gezondheidsplein	
		b	(95% CI)	*b*	(95% CI)
Recall					
	Cognitive load	0.18	(0.11, 0.27)	0.11	(0.05, 0.19)
	Imagination ease	0.03	(-0.03, 0.10)	0.07	(0.01, 0.14)
	Website involvement	0.01	(-0.00, 0.04)	0.02	(0.00, 0.05)
Attitude					
	Cognitive load	0.02	(0.01, 0.03)	0.01	(0.00, 0.02)
	Imagination ease	0.02	(0.01, 0.03)	0.01	(0.00, 0.02)
	Website involvement	0.01	(-0.00, 0.01)	0.01	(0.00, 0.07)

Note. Unstandardized coefficients (*b*) are reported. CI = confidence interval.

DISCUSSION

In this study, we investigated how health literacy influences recall of and attitude towards online health information. This was done by testing three potential underlying mechanisms simultaneously. Results showed that the relationship between health literacy and information recall was partly mediated by the relative cognitive capacity that is demanded during message processing. For people with adequate levels of health literacy, processing health information requires less cognitive capacity, which subsequently positively influences information recall. For people with limited health literacy, however, processing the same online information requires more cognitive capacity, resulting in less recall of information. This mechanism was found on both websites that were tested in this study. The underlying role of cognitive load has been suggested by multiple scholars (von Wagner et al., 2009; Wilson & Wolf, 2009) but, to our knowledge, this is the first time that its influence has been empirically tested. This finding supports the applicability of the LC4MP (Lang, 2006) and cognitive load theory (Sweller et al., 1998) to the domain of health literacy and information processing. In addition to information recall, the mediating role of cognitive load with respect to attitudes towards the website was also found in both samples. Thus, the relative ease with which health information can be processed positively influences peoples' evaluation of this information, supporting the concept of processing fluency (Alter & Oppenheimer, 2009).

The second mechanism, the mediating role of perceived imagination ease, appeared to explain the relationship between health literacy and information recall as well, but only for one website (Gezondheidsplein). Probably, this inconsistency across websites can be explained by the different design characteristics of the sites. It was our aim to test our hypotheses on different types of health websites, and we therefore selected two websites that were different in terms of design features. Gezondheidsplein incorporated images and an animation about fibromyalgia, whereas Thuisarts did not present any illustrational material to clarify the text. Moreover, the text on Thuisarts was substantially longer than the text on Gezondheidsplein. It is therefore possible that these design characteristics have influenced the ease with which people were able to imagine the information, irrespective of one's level of health literacy. However, imagination ease did influence the relationship between health literacy and website attitudes as well, and this result was found for both websites. Thus, for people with adequate health literacy levels it is easier to imagine the content of a health website, which subsequently positively influences attitudes towards the site.

The third mechanism that was tested was the mediating role of involvement with the information on the website. For this mediator we found least evidence. On the website Thuisarts, involvement did neither explain the influence of health literacy on recall, nor on attitudes towards the website. For the other website, Gezondheidsplein, significant indirect effects through involvement were found for both outcomes, but these effects were very small. Especially the influence of health literacy on website involvement was limited, although involvement did positively influence attitudes. This result is encouraging as it indicates that people with limited health literacy are just as engaged with health information as people with adequate health literacy. However, different explanations may apply to this result. First, the respondents in this study were explicitly asked to pay close attention to the website and its text. Therefore, the level of website involvement of the people in our study might have been different from involvement levels in a more natural setting. For example, when people read information on websites, they are more likely to skip information compared to readers of print materials (Lustria, 2007). Furthermore, the scales we used are all self-reported. It could therefore be that people did overestimate their personal involvement level, which might also have impacted our findings. Future research should therefore examine to what extent people with different health literacy levels are involved with health websites when they search for health information voluntarily, in a natural setting.

This study has some limitations. First the indirect effects that were found in our study are relatively small, especially with respect to website attitudes. Therefore, it must be concluded that variables other than health literacy influence on peoples' attitudes towards health information as well. Nevertheless, the effects that we found were consistent over different websites, contributing to the generalizability of our findings. Furthermore, in order to investigate how information processing works for real online websites we purposely used real, existing websites in our study. Consequently, we did neither control the content of the websites, nor the design characteristics. As the quality of information processing is influenced by both the receiver and the message, the message characteristics might have had an impact on our findings. However, the fact that most findings were consistent over the two real, but completely different websites, strongly contributes to the external validity of our study. Finally, it must be noted that we only tested one health condition, namely fibromyalgia. It is unclear whether the mechanisms that were found in this study also apply to information about other health conditions. Nevertheless, fibromyalgia is a health condition that is often searched for in the Netherlands, and therefore representative for a significant part of the health-related Internet use.

Our study has some implications for health communication practitioners. In order to improve recall of and attitudes towards online health information, it is important to improve health literacy among the population. Not only because health literacy facilitates information processing, which was shown in this study, but also to reduce health inequalities and improve health outcomes (Nutbeam, 2008; Zarcadoolas, 2011). However, increasing a population's health literacy level is difficult and time consuming. A more easy, and short term solution for improving information processing is therefore to reduce the cognitive demands of health messages among people with limited health literacy by for example using non-complex texts (Meppelink et al., 2015; Wilson & Wolf, 2009). Moreover, this study also emphasizes the importance of creating health messages that are easy to imagine, especially by people who are less able to create the mental picture themselves, such as people with limited health literacy. There are several ways to do this, for example by using images, animations, or concrete language (Mayer, 2002; Meppelink, van Weert, Haven, & Smit, 2015). The finding that involvement did only marginally explain the relationship between health literacy, recall and attitudes is promising, as it suggests that people with limited health literacy do not experience a lack of engagement with the information when it comes to health information processing. Therefore, it would be useful to create messages that are easy to process and imagine, but it is not necessary to create different messages in order to engage limited health literacy groups.

Conclusion

To the best of our knowledge, this study is the first to empirically test the mechanisms by which health literacy influences recall of health information as well as people's attitudes towards online health information. We found that particularly cognitive load plays a significant role in both recall as well as attitude formation. Imagination ease explained the influence of health literacy on attitudes. In order to have more people in Western societies benefit from the Internet as a health information source, health communicators should be aware of these mechanisms and create health messages that are easy to process and appeal to the imagination. When this is done, we might be able to decrease the gap between health literacy levels with respect to health information processing and, ultimately, decrease inequalities in society with respect to the usefulness of online health information is peoples' daily lives.

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