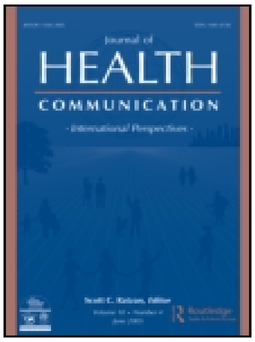

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How Are Online Health Messages Processed? Using Eye Tracking to Predict Recall of Information in Younger and Older Adults

NADINE BOL[1], JULIA C. M. VAN WEERT[1], EUGÈNE F. LOOS[1], JENNIFER C. ROMANO BERGSTROM[2], SIFRA BOLLE[1], and ELLEN M. A. SMETS[3]

[1]*Amsterdam School of Communication Research, University of Amsterdam, Amsterdam, The Netherlands*
[2]*Facebook, Palo Alto, California, USA*
[3]*Department of Medical Psychology, University of Amsterdam, Amsterdam, The Netherlands*

Little research has focused on what precedes the processing of health messages to predict recall of information and whether age matters in this regard. To address this gap, this study investigates the relationship between attention and recall among younger (<65 years) and older (≥65 years) adults. Using eye tracking, we exposed participants to a webpage consisting of text-only information, text with cognitive illustrations, or text with affective illustrations. When attention to text increased, older adults recalled more information, whereas younger adults did not. However, younger adults paid more attention to cognitive illustrations than older adults and recalled more information. These results reveal conditions under which health messages are effectively recalled by younger and older adults.

Attention to information is a critical first step in information processing and eventual recall of information (Wedel & Pieters, 2000). Recall of information is the ability to remember and reproduce information correctly, and it plays an important role in predicting many health-related behaviors, such as successful disease management (Kravitz et al., 1993) and adherence to medical regimes (Ley, 1988; Linn, Van Dijk, Smit, Jansen, & Van Weert, 2013). Unfortunately, approximately 40% to 80% of medical information is immediately forgotten after exposure (Kessels, 2003), especially by older adults (Jansen et al., 2008). Older adults have more problems seeking, finding, and understanding health information than younger ones, particularly when information is presented online (Xie, 2008). Even though increasingly more older adults are using the Internet (Hart, Chaparro, & Halcomb, 2008; U.S. Census Bureau, 2010), this does not necessarily mean that they are able to understand and recall online health information. To optimize recall of information among older adults, information should be provided in such a way that older adults' cognitive abilities are taken into account (Van Gerven, Paas, Van Merriënboer, & Schmidt, 2000). One way to accomplish this is by using illustrations that complement online health texts. Illustrations can serve as cues that enable one to make connections between words and pictures in building mental images, thereby reducing working memory demands (Paivio, 1990). Numerous studies have revealed positive effects on recall of information when illustrations are added to information (e.g., Houts, Doak, Doak, & Loscalzo, 2006; Levie & Lentz, 1982).

Although much research has focused on the effects of using illustrations in health messages (e.g., on recall of information), none to date has considered the process that precedes these effects. Even though three major subprocesses (encoding, storage, and retrieval) have been acknowledged (Lang, 2000), little is known about the association between encoding information (i.e., attention to text and illustrations) and retrieval (i.e., recall of such text and illustrations), whether the encoding process can predict retrieval, and whether age matters in this regard. This study evaluates the relationship between attention to and recall of online health information among younger and older adults. We use eye tracking to gain novel insights into *how* individuals attend to online health texts and illustrations and *under what conditions* this attention leads to accurate recall of information.

Attention to Online Health Information

Attention is important not only for processing information and eventually recalling it (Wedel & Pieters, 2000) but also for a message to register. In their functional approach to the effects of illustrations, Levie and Lentz (1982) proposed that illustrations serve an attentional function—that is, attracting and directing attention. In addition, illustrations purportedly serve cognitive and affective functions as well. Cognitive illustrations are those that mainly complement textual information and help people to understand text, whereas affective illustrations are irrelevant to

Address correspondence to Nadine Bol, Amsterdam School of Communication Research, University of Amsterdam, Nieuwe Achtergracht 166, P.O. Box 15793, 1001 NG Amsterdam, The Netherlands. E-mail: n.bol@uva.nl

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the text but aim to evoke positive feelings and elicit positive emotions (Park & Lim, 2004). Research has shown that attention to information increases when messages include cognitive illustrations (Delp & Jones, 1996) or affective illustrations (Park & Lim, 2007).

Even though a large number of studies have focused on the effects of adding illustrations, especially cognitive ones, to improve recall (e.g., Levie & Lentz, 1982; Mayer, 2003), research has not yet focused on which parts of information are attended to when illustrations are added to texts. Whether cognitive and affective illustrations arouse interest in the full text or only in the illustrations is unclear (Levie & Lentz, 1982). Traditional measures of attention, such as simply asking whether people read the instructions (Delp & Jones, 1996) or assessing perceived attention to the information (Park & Lim, 2007), do not provide detailed insights into which parts of information (i.e., text and/or illustrations) are focused on. Such measures may fail to capture attention at all accurately, as it is difficult to remember whether one paid attention and, if so, to what extent. Eye tracking could offer greater insight into which specific parts of a health webpage attract attention. This raised the following research question:

> Research Question 1a: How is attention to text and cognitive and affective illustrations divided on a health webpage?

Some research has focused on how younger and older adults attend to online information; however, findings have not been consistent. Several studies have indicated that older adults spend in general more time looking at information because their pace of processing information is slower than that of younger adults (John & Cole, 1986; Liu, Kemper, & McDowd, 2009). However, other studies have found evidence to the contrary (Bol, Romano Bergstrom, et al., 2014) or found no age differences in attention to information when, for instance, videos were added to online information (Bol et al., 2013). Moreover, it is unknown which parts of online information (i.e., text and/or illustrations) are focused on specifically by younger and older adults. It might be that some parts of online information need more processing time than others, and this might differ across age. We therefore explore the following research question:

> Research Question 1b: How do younger and older adults attend to text and illustrations on a health webpage?

Does Attention to Online Health Information Predict Recall?

Illustrations also influence how information is recalled. From the perspective of cognitive theory of multimedia learning, information is more deeply embedded in memory when text is combined with illustrations than when text is the exclusive format (Mayer, 1999). The theory is based on the idea that people have two separate processing systems for verbal (i.e., text) and visual (i.e., illustrations) information. As these systems are individually limited, combining text with illustrations will expand cognitive capacity, which results in better recall of information (Paivio, 1971). This multimedia effect is expected to occur when complementary illustrations (i.e., cognitive illustrations) are added to text (Mayer, 1999).

As this theory assumes that people actively use both text and illustrations (during the encoding process) to create mental images that they store in working memory for retrieval in recalling information (Mayer, 1999), it is vital to know to what extent text and illustrations are attended to. Because previous studies have mainly focused on the retrieval process (i.e., recall of information), the individual effects of attention to text and illustrations on recall of information are presently unknown. We therefore pose the following research question:

> Research Question 2a: Is greater attention to text and/or illustrations on a health webpage related to better recall of health information?

Whereas previous research has provided evidence for the multimedia effect among younger learners (see Mayer, 2003), studies regarding the multimedia effect in older adults have been scarce and have provided mixed results. Some studies have shown that older adults recall more information when cognitive illustrations are added to text (e.g., Cherry, Dokey, Reese, & Brigman, 2003), whereas other research has failed to find evidence for the multimedia effect in older adults (e.g., Bol, Van Weert, et al., 2014). Moreover, an eye-tracking study indicated that although older adults spend more time looking at text and illustrations, they have more difficulties integrating illustrations with text (Liu et al., 2009). Exploring whether attention is predictive of recall of information is therefore of special interest for those of older age. As attention to and recall of information are expected to be related (Wedel & Pieters, 2000), an explanation for age-related differences in the retrieval process (i.e., recall of information) could be that older adults enact a different encoding process (i.e., attention to information) from younger adults. Eye tracking enables researchers to discern how older adults attend to information (i.e., text and/or illustrations) as well as to examine how predictive this is of their recall of information. We therefore address the following research question:

> Research Question 2b: Is the relationship between attention to text and/or illustrations on a health webpage and recall of health information different for older and younger adults?

Methods

Design

We investigated the effect of attention to cognitive and affective illustrations and text on recall of information by exposing participants to one of three conditions (condition: text-only information vs. text and two cognitive illustrations vs. text and two affective illustrations) stratified by age (age: younger [<65 years] vs. older [≥65 years]). These two age groups are generally considered worthy of separate analysis when studying aging effects in health (Jorgensen, Young, Harrison, & Solomon, 2012; Silliman, Troyan, Guadagnoli, Kaplan, & Greenfield, 1997). To reach a statistical power level of 0.80 to detect large effect sizes (effect size $f = .40$) with an alpha level of .05, a total sample size of at least 86 participants was required (Cohen, 1988). Permission for this study was granted by the institutional review board of the research institute (reference number: 2012-CW-48).

Participants

Participants (n = 129) were recruited via mailings and flyers, the senior panel database of the Dutch Senior Citizens' Association, and a snowball technique. We combined these several recruitment techniques to create a heterogeneous sample. Adults were eligible to take part if they (a) were 18 years or older, (b) had no prior knowledge concerning radiofrequency ablation (RFA), (c) had normal to corrected-normal vision, and (d) had no severe cognitive decline according to the Mini-Mental State Examination (Kok & Verhey, 2002). No prior knowledge of RFA was required because participants were exposed to information about RFA treatment. Although we chose RFA because it is a relatively unknown treatment and we expected our participants to have little prior knowledge of it, we measured participants' prior knowledge and excluded those who reported having knowledge of RFA (i.e., scored >4 on a 7-point Likert scale). Table 1 presents background characteristics of the sample stratified by younger (<65 years) and older (≥65 years) adults.

Table 1. Background characteristics (n = 97)

	Younger adults (<65 years; n = 55)		Older adults (≥65 years; n = 42)		
Variable	n	(%)	n	(%)	p
Gender					.351
Male	21	38.2	20	47.6	
Female	34	61.8	22	52.4	
Age					<.001
M (*SD*)	44.02 (12.03)		73.48 (5.90)		
Range	21–64		65–88		
Education					.019
Low	7	12.7	14	33.3	
Middle	16	29.1	14	33.3	
High	32	58.2	14	33.3	
Internet experience (hours per week)					.085
M (*SD*)	15.81 (9.90)		12.27 (9.95)		
Range	0–40		1–50		
Medical knowledge of lung cancer (1–7 scale)[a]					.135
M (*SD*)	2.09 (0.97)		1.81 (0.83)		
Range	1–5		1–4		
Medical knowledge of RFA (1–7 scale)[a]					.462
M (*SD*)	1.15 (0.36)		1.10 (0.30)		
Range	1–2		1–2		
Cognitive status (MMSE)[b]					.397
M (*SD*)	28.84 (1.17)		28.62 (1.34)		
Range	25–30		24–30		

Note. Conditions stratified by age differed significantly only on age and education. RFA = radiofrequency ablation; MMSE = Mini-Mental State Examination. [a]A higher score indicates more knowledge. [b]A score of 24 or higher indicates no cognitive impairment according to the MMSE.

Stimulus Material

All participants were exposed to one of three versions of a webpage of The Netherlands Cancer Institute on which information concerning RFA appeared: (a) text-only information, (b) text and two cognitive illustrations, and (c) text and two affective illustrations. The text information was constant across conditions. Stimulus material from a previous study was used in which cognitive and affective illustrations were extensively pretested (for a detailed description, see Bol, Van Weert, et al., 2014). One cognitive illustration reflected the RFA treatment using a needle to destruct the tumor and the other visualized a pneumothorax, which was one of the complications described in the text. To make the illustrated webpages comparable for eye-tracking purposes, the webpage with affective illustrations required a second illustration. In a pretest, we combined the affective illustration that was already on the webpage in the previous study with three others that were ranked highly in the study's pretest. Students (n = 49) indicated on a 7-point Likert scale to what extent they felt these illustrations would be compatible on a webpage. One combination scored highest (M = 4.02, SD = 1.64) compared to the other two combinations (M = 3.92, SD = 1.54; and M = 2.51, SD = 1.47) and was therefore chosen for the affective illustrations webpage. The affective illustrations were a photo of a female doctor bending over a female patient and a photo of a male doctor with an anatomical model of the lungs and a patient (see Figures 1 and 2 for the webpages with cognitive and affective illustrations).

Procedure

The participants were invited and informed about the experiment via e-mail and were asked to complete an online screening questionnaire concerning age, gender, education, Internet experience, vision, and prior RFA knowledge. Using this information, we stratified our sample on age (<65, ≥65), gender, level of education, and Internet experience. This stratified sample was equally distributed across the three experimental conditions. When the participants arrived for the study, a researcher explained the study procedure, answered questions they had, and asked them to sign an informed consent form. They were to sit behind a 22-in monitor at a distance of 60 to 80 cm. The SMI RED 120 (SensoMotoric Instruments, 2012) eye tracker was attached to the bottom of the monitor. The average angular distance from the actual gaze point to the one measured by the eye tracker was 0.4°. Eye-tracking data were collected with a gaze sample rate of 120 Hz per second, and gaze samples were recorded for eye fixations of 80 ms or more. Participants were to follow a moving black dot with their eyes for calibration purposes. After calibration, they read instructions that explained that they could look at the webpage as long as they wanted, and when they were finished they were to press the space bar to record the data. On completion (after participants pressed the space bar), participants completed an online questionnaire to assess recall of the information they had just been exposed to. Finally, a researcher assessed participants' cognitive status. At the very end, participants were thanked and were compensated €20 for their participation.

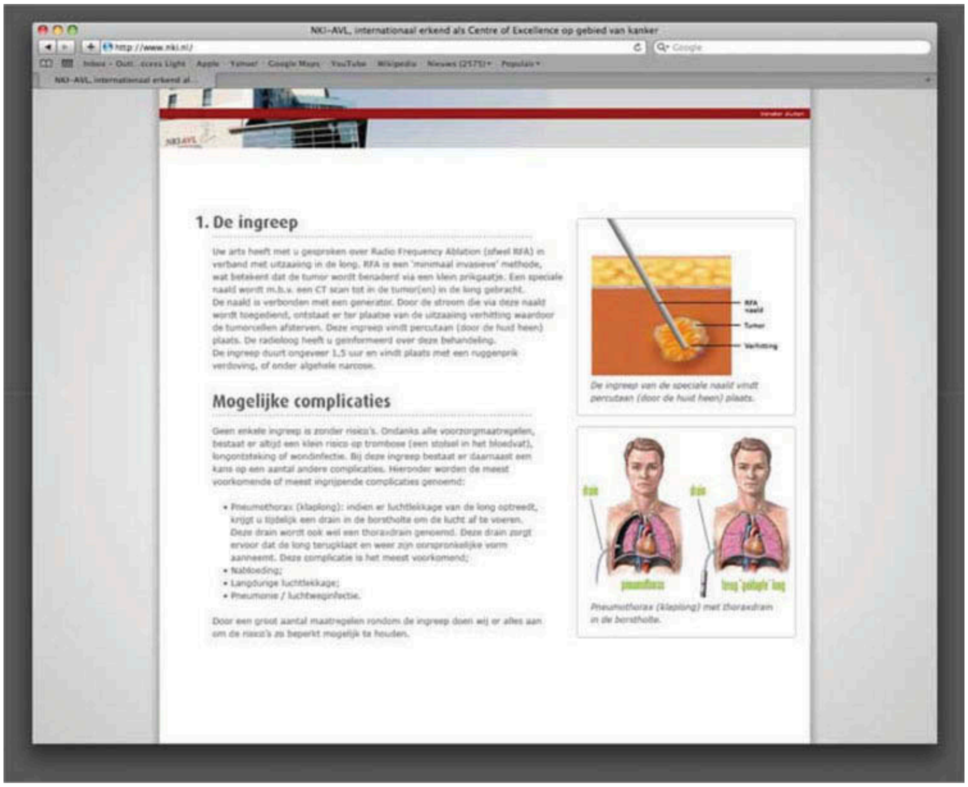

Fig. 1. Webpage containing radiofrequency ablation text information and cognitive illustrations.

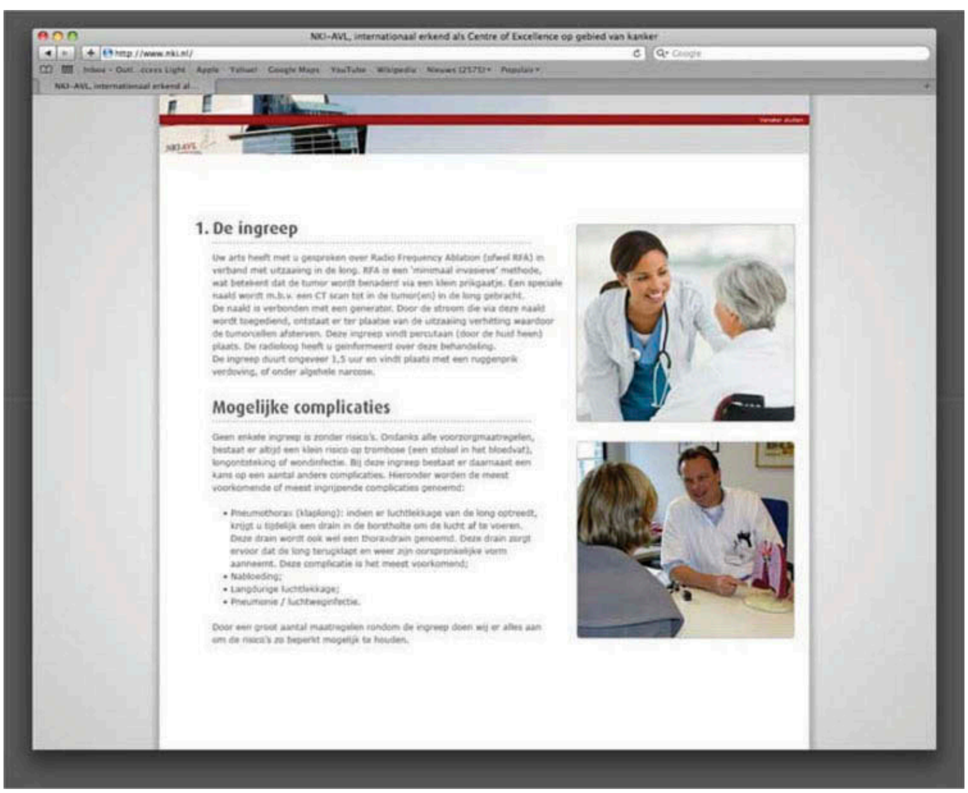

Fig. 2. Webpage containing radiofrequency ablation text information and affective illustrations.

Measures

Recall of Health Information

Recall was assessed based on The Netherlands Patient Information Recall Questionnaire (Jansen et al., 2008). Questions were produced from the RFA information text, which resulted in 11 free-recall questions, such as "What is the most common complication that can occur during RFA treatment?" (Bol et al., 2013; Bol, Van Weert, et al., 2014). Corresponding answer options were "not discussed," "discussed, but I can't remember the details," and "discussed, namely …" Scoring entailed the use of a codebook and ranged from 0 (not recalled), to 1 (recalled partially), to 2 (recalled correctly). Recall scores in 21 cases (21.6%) were double coded by two independent coders to establish interrater reliability (mean $\kappa = .91$, range = .67–1.00). Scores for the 11 questions were summed and yielded scores within a maximum range from 0 to 22 ($M = 7.09$, $SD = 3.63$). The raw scores were converted to percentages of correctly recalled information. Recall scores and percentages stratified by condition and age group are presented in Table 2.

Attention to the Webpage

Participants' attention to the webpage was recorded via the eye tracker in terms of total fixation duration on the webpage (in seconds; $M = 83.10$, $SD = 41.06$; Djamasbi, Siegel, & Tullis, 2010). In addition, two areas of interest were created for independent determination of the time the participants spent fixating on the text versus the illustrations. Attention was measured in terms of total fixation duration inside the areas of interest (in seconds). Heat maps and gaze opacities were created using the cumulative fixation duration data for all participants. In a fixation duration heat map, red indicates a longer time fixating on the area, whereas yellow and green indicate less time fixating on the area, with green indicating the least duration of fixation. In a gaze opacity map, areas that receive attention are visible, and areas that do not are blacked out.

Table 2. Percentage of information recalled correctly stratified by condition and younger (<65 years) and older (≥65 years) adults ($n = 97$)

		Recall of health information		
Condition	*n*	% recall	*M*	*SD*
Text only	32	34.1	7.50	3.54
Younger adults	18	35.9	7.89	3.66
Older adults	14	31.8	7.00	3.44
Cognitive illustrations	35	32.6	7.17	3.72
Younger adults	20	38.6	8.50	3.53
Older adults	15	24.5	5.40[a]*	3.29
Affective illustrations	30	29.9	6.57	3.69
Younger adults	17	31.0	6.82	3.54
Older adults	13	28.3	6.23	4.00
Total	97	32.2	7.09	3.63
Younger adults	55	35.4	7.78	3.58
Older adults	42	28.1	6.19[b]*	3.55

Note. Recall of information ranged from 0 to 22. The higher the score, the more information was recalled correctly. [a]Mean differs significantly compared to younger adults in the cognitive illustrations condition. [b]Mean differs significantly compared to younger adults. *$p < .05$.

Background Variables

Background measures included age, gender, level of education, Internet experience, prior medical knowledge (of lung cancer and RFA treatment), and cognitive status. The age variable (which was continuous) was dichotomized: younger than 65 for the younger age group and 65 and older for the older age group (Jorgensen et al., 2012; Silliman et al., 1997). Level of education was divided into 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). Internet experience was assessed by the average number of hours the participants reported spending per week using the Internet. Prior medical knowledge of lung cancer and RFA was measured via two items using 7-point Likert scales relating to the participants' amount of knowledge of lung cancer and RFA. Cognitive status was assessed using the Mini-Mental State Examination, which is a widely used scale that assesses the severity of cognitive decline (Kok & Verhey, 2002). None of the participants in our sample were excluded based on the Mini-Mental State Examination, as they all scored below the threshold of 24, indicating no severe cognitive decline such as dementia (Folstein, Folstein, McHugh, & Fanjiang, 2001).

Statistical Analyses

The eye-tracking data were prepared and exported to SPSS using the SMI BeGaze software. To test the effects of condition and age on attention (Research Question 1a, Research Question 1b), we conducted three 3 (condition) × 2 (age) analyses of variance with attention (fixation duration) to the entire webpage, to the text, and to the illustrations as the dependent variables. Whether attention predicts recall of information (Research Question 2a) and how this relationship is moderated by age (Research Question 2b) were investigated using moderation analyses using Hayes's (2012) PROCESS macro. All effects were subjected to bootstrap analyses with 5,000 bootstrap samples and a 95% confidence interval. Recall of information was the dependent variable, attention to the information on the webpage was the independent variable, and age was a moderator. The independent and moderating variables were centered at the mean.

Results

Eye-Tracking Data and Participants

Prior to analysis, the eye-tracking scan paths of all 129 participants were examined. Participants with poor eye-tracking data were removed from the data set. Poor data included abnormal scan paths due to technical issues (e.g., the eye tracker misidentifying the participant's eyes) and bad tracking ratios (i.e., when less than 75% of the eye movements were recorded by the eye tracker; Romano Bergstrom, Olmsted-Hawala, & Bergstrom, 2014). This was the case for data from 32 participants (mean tracking ratio = 68.64%). Thus, data from 97 participants were included (mean tracking ratio = 94.37%), which exceeded the minimum number

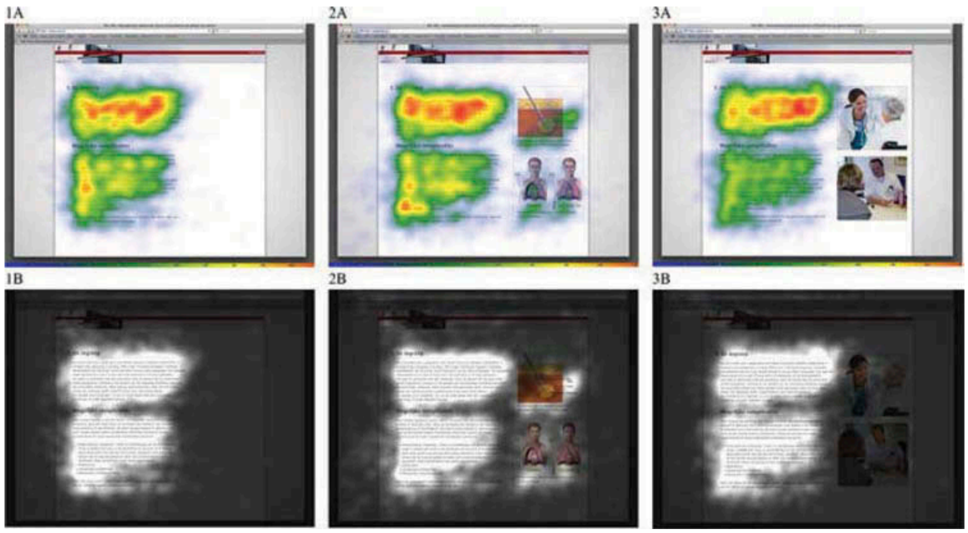

Fig. 3. (A) Heat maps (in color) and (B) gaze opacities (in black and white) of the average fixation time of all participants in the text-only condition (1), text with cognitive illustrations condition (2), and text with affective illustrations condition (3).

of participants (n = 86) that was needed according to the power analysis. Excluded participants were more likely to be older than included participants (see the Discussion), $\chi^2 = 4.80$, $p = .028$ (n = 21, 65.6%). However, the excluded older participants did not differ in recall of information compared to the included older participants, $F(1, 126) = 2.33$, $p = .130$. The remaining 97 participants did not differ across the three experimental conditions stratified by age on gender, education level, Internet experience, prior medical knowledge of lung cancer, or prior RFA knowledge: gender, $\chi^2 = 2.02$, $p = .847$; education level, $\chi^2 = 9.93$, $p = .447$; Internet experience, $F(5, 91) = 1.79$, $p = .123$, $\eta_p^2 = .09$; prior medical knowledge of lung cancer, $F(5, 91) = 1.28$, $p = .278$, $\eta_p^2 = .07$; prior RFA knowledge, $F(5, 91) = 0.45$, $p = .811$, $\eta_p^2 = .02$. Of the 97 participants, 57.7% were female. Participants had a mean age of 56.77 years old (SD = 17.65).

Age and Attention to Health Information

In answering the question on how attention to text and illustrations is divided on a health webpage (Research Question 1a), we found that most of the time spent on the webpage was dedicated to reading the text information. In the text-only condition, the younger and older adults spent on average 98.1% of their time fixating on the text information on the webpage (M = 77.60 s, SD = 35.46). In the cognitive and affective illustration conditions, respectively, 82.8% and 95.9% of the total fixation duration was related to text information (M = 71.90, SD = 42.87; and M = 79.61, SD = 39.53, respectively) and another 14.9% and 2.3% was related to the illustrations (M = 12.90, SD = 9.78; and M = 1.94, SD = 2.20, respectively). Attention to the entire webpage did not differ across conditions, $F(2, 91) = 0.24$, $p = .786$, $\eta_p^2 = .01$. This indicates that despite the addition of visual elements (i.e., cognitive or affective illustrations), participants spent similar amounts of time fixating on the webpage. Cognitive illustrations received significantly more attention than the affective illustrations from both younger and older adults, $F(1, 61) = 35.19$, $p < .001$, $\eta_p^2 = .37$. Heat maps and gaze opacities for the three experimental conditions are presented in Figure 3, and descriptive statistics for the attention measures stratified by condition and age group appear in Table 3. When exploring age differences in how online health information is attended to (Research Question 1b), we found that younger adults (M = 15.39, SD = 11.01) spent about 60.8% more time fixating on the cognitive illustrations than older adults (M = 9.59, SD = 6.85), $F(1, 61) = 5.69$, $p = .020$, $\eta_p^2 = .09$ (see Figure 4).

Relationships Between Age, Attention, and Recall

When examining whether attention to text and/or attention to illustrations is related to recall of information (Research Question 2a), we found that attention to text information (in seconds) was predictive of recall of information (b = 0.02, SE = 0.01, p = .022), whereas attention to cognitive or affective illustrations (in seconds) did not contribute to more accurate recall of information (b = 0.04, SE = 0.07, p = .619; and b = 0.27, SE = 0.38, p = .489, respectively). When we explored age-related differences in the relationship between attention and recall of information (Research Question 2b), moderation analysis revealed that the predictive power of attention to text was greatest for the older adults. Whereas simple effects analysis revealed that younger adults recalled equal amounts of information regardless of the time they spent on the text (b = 0.01, SE = 0.01, p = .210), older adults' accurate recall of information was related to increased time spent on the text. With higher fixation time on the text, older adults recalled the same amount of information as younger adults (e.g., plus 1 SD higher on fixation time: b = –0.33, SE = 1.18, p = .783). However, when fixation time on the text was low (e.g., minus 1 SD), older adults scored significantly lower on recall of information than older adults with a higher fixation time (b = –0.04, SE = 0.02, p = .052) and younger adults (b = –2.16, SE = 1.05, p = .042). The scatterplot

Table 3. Attention to the information on the webpage (in seconds) stratified by condition and younger (<65 years) and older (≥65 years) adults (n = 97)

		Attention to the webpage		Attention to the text		Attention to the illustrations	
Condition	*n*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Text only	32	79.13	36.04	77.60	35.46		
Younger adults	18	83.39	34.49	82.08	34.42		
Older adults	14	73.66	38.53	71.84	37.22		
Cognitive illustrations	35	86.81	46.44	71.90	42.87	12.90	9.78
Younger adults	20	94.23	56.41	76.92	52.22	15.39	11.01
Older adults	15	76.91	27.11	65.20	26.04	9.59[a]*	6.85
Affective illustrations	30	83.00	40.36	79.61	39.53	1.94[b]***	2.20
Younger adults	17	91.65	47.95	87.26	47.20	2.38	2.58
Older adults	13	71.70	25.05	69.60	24.79	1.36	1.50
Total	97	83.10	41.06	76.16	39.24	7.84	9.13
Younger adults	55	89.88	46.88	81.81	44.84	9.41	10.49
Older adults	42	74.22	30.17	68.77	29.30	5.77	6.54

Note. Attention to the webpage ranged from 27.42 to 264.17 s, attention to the text ranged from 9.59 to 242.31 s, and attention to the illustrations ranged from 0 to 42.05 s. The higher the score, the higher the fixation time on (elements of) the webpage. The sum of attention to the text and attention to the illustrations does not equal attention to the webpage, as participants also spent time outside the areas of interest. [a]Mean differs significantly compared to younger adults in the cognitive illustrations condition. [b]Mean differs significantly compared to the cognitive illustrations condition. *p < .05. ***p < .001.

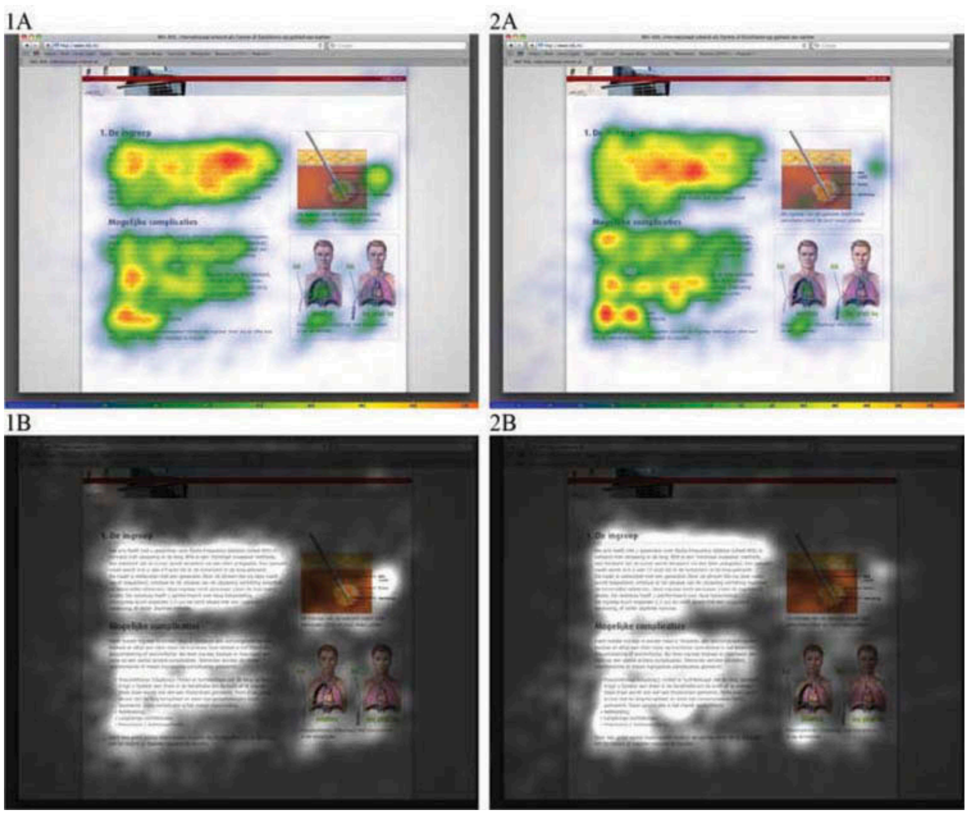

Fig. 4. (A) Heat maps (in color) and (B) gaze opacities (in black and white) of average fixation time on the text with cognitive illustrations among younger (1) and older (2) participants.

in Figure 5 illustrates the interaction between attention to the text on the webpage and age on recall of information.

Furthermore, in addition to finding that younger adults spent more time fixating on the cognitive illustrations (see above), we found a main effect of age on recall within the cognitive illustrations condition, $F(1, 91) = 6.44$, $p = .013$, $\eta_p^2 = .07$ (see also Table 2), indicating that younger adults recalled more information compared to older adults when cognitive illustrations were

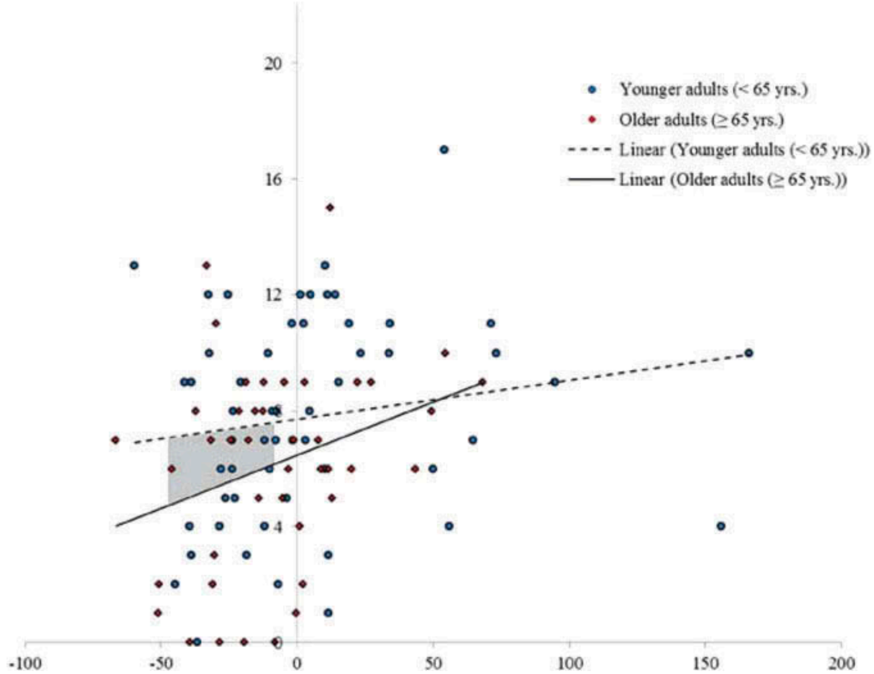

Fig. 5. Scatterplot showing the effect of attention to the text on the webpage (x axis: total fixation time in seconds, centered at the mean) on recall of health information (y axis: range = 0–22) for younger and older adults. The Johnson-Neyman significance region lay between −9.31 and −48.32, meaning that age differences in the attention–recall relationship were significant between 27.84 and 66.85 s of fixation time. yrs = years.

presented. Yet moderation analysis did not reveal an interaction effect between age and attention to the cognitive illustrations on recall of information (b = 0.03, SE = 0.16, p = .863). This finding suggests that recall of information among younger adults was not fully explained by mere attention to cognitive illustrations. The relationship between attention to affective illustrations and recall of information was also not moderated by age (b = 0.30, SE = 0.83, p = .725).

Discussion

This study evaluated the relationship between attention to and recall of online health messages among younger and older adults. Eye-tracking data enabled us to gain greater insight into the association between encoding information (i.e., attention to text and illustrations) and retrieval (i.e., recall of such text and illustrations) and whether the encoding process is predictive of retrieval. The results yield novel insights into the role of text and cognitive and affective illustrations as determinants of the effectiveness of online health information by exploring how attention to such parts of information predicts recall of information. Greater attention to text information on a health webpage appears to increase recall in older adults but not in younger ones. This result shows that older adults recall as much information as younger adults when they spend more time reading text. Earlier studies have shown that older adults generally need more time to process online information than younger adults (for overview studies, see Romano Bergstrom, Olmsted-Hawala, & Jans, 2013). Nevertheless, previous research has also demonstrated that when older adults are given sufficient time to process information, age differences begin to disappear (John & Cole, 1986). Our results add to these conclusions by revealing that taking time to process text information on a health webpage helps older adults to adequately recall information. Taken together, these findings underscore the importance for older adults of being able to self-pace in processing information.

We found that younger adults spent significantly more time on the cognitive illustrations than older adults as well as recalled more information correctly in the cognitive illustrations condition than in the other two conditions. This difference in recall was not evident among older adults. These findings indicate that the proposed learning effect of cognitive illustrations is more pronounced among younger adults than older adults. Yet our moderation analysis revealed that this effect was not explained by the extent to which attention was paid to cognitive illustrations, suggesting that mere attention to cognitive illustrations does not predict recall of information. Further research would benefit from exploring differences in how illustrations are used (e.g., the ability to integrate illustrations with text) by younger and older adults to unravel what makes attention to cognitive illustrations predictive of recall of information. As cognitive and affective illustrations increase satisfaction with the attractiveness of a website (Bol, Van Weert, et al., 2014), and satisfaction might be related to recall, illustrations may also indirectly improve recall of information.

Adding illustrations to the webpage did not significantly increase the total time younger and older adults spent on the webpage; participants tended to give priority to the text information (more than 88% of the time spent). Similarly, an advertising study showed that the majority of fixations on an advertisement involved text information rather than the illustrations (Rayner, Rotello, Stewart, Keir, & Duffy, 2001). This may be attributable to the fact that people can encode much more information per fixation from illustrations than from text. In other words, people do not need to spend as much time looking at illustrations as at text to recall information. We also determined that cognitive illustrations received in general more attention than affective ones. Cognitive illustrations seemingly serve a learning function, whereas affective illustrations have no clear pedagogic purpose (Harp & Mayer, 1997). Cognitive illustrations therefore generally command more attention than affective illustrations because of the relevance of the information. Prior research has also shown that cognitive illustrations contain more information to encode (e.g., labels of illustrations) than affective illustrations (Rayner et al., 2001). Moreover, cognitive illustrations play a facilitating role in recall of information (Levie & Lentz, 1982) and might therefore receive more attention while one is reading text than affective illustrations. Nevertheless, future research should explore whether these results are generalizable to other cognitive and affective illustrations.

This study has several limitations. We used duration of fixation as a proxy for attention. Even though this index reliably relates to attention (Djamasbi et al., 2010), it can be interpreted in many ways. For instance, longer fixation to information might indicate confusion, as people tend to reread confusing information (Olmsted-Hawala, Holland, & Quach, 2014). Future research should combine eye-tracking techniques with think-aloud methods to gain more insight into the reasons why people fixate on specific parts of information. Furthermore, we did not include the target group of the study—that is, cancer patients who will be treated with RFA. Our results might have been different if cancer patients had participated because of their ego involvement with the information on the webpage. Such involvement reportedly affects the way people process information (Petty & Cacioppo, 1990).

The participants excluded from our sample because of poor eye-tracking data were more likely to be older than the participants whose data were retained. This could be due to the fact that older adults tend to wear corrective eye glasses with bi- and trifocal lenses, which affect the success of eye tracking. Hence, the excluded group of older adults might have had poorer eye health. Nevertheless, a post hoc analysis showed that the excluded older adults were not more likely to wear multifocal glasses than the included older adults, $\chi^2 = 1.73$, $p = .189$. Moreover, this specific group of older adults did not differ in recall of information compared to the older adults who were included in the sample, suggesting that our conclusions might be generalized to this population as well.

This study specifically focused on explaining the relationship between attention to online health information (i.e., text and illustrations) and recall of information and whether age matters in this regard. Considering the great variability within attention and recall, we expect that other factors might also have played a role in how people process information, such as people's mode preference (i.e., the preference for type of format, such as text only or text with illustrations). Our results might have been different if participants had been able to choose a preferred mode of presented information. Previous research has shown the importance of recognizing the diversity among older adults and providing them with choices of mode (Soroka et al., 2006). In addition, there may be differences in people's ability to integrate illustrations with text information (Liu et al., 2009), level of education, and level of health literacy. Older adults' inability to integrate illustrations with text appropriately might be one explanation for their paying less attention to the cognitive illustrations than the younger adults in this study. Moreover, older adults are more likely to be less educated and to have lower levels of health literacy in general (Baker, Gazmararian, Sudano, & Patterson, 2000), which have also been associated with information processing (Von Wagner, Semmler, Good, & Wardle, 2009). Future research should focus on such factors to gain more insight into other predictors of online information processing and to better prepare online information for older adults. Nevertheless, this study provides expanded insight into effective online communication for older adults. Specifically, it suggests that effectively communicating online health information to older adults and aiding them in recalling information involves consideration of webpages that include effective text and cues that enhance older adults' motivation to spend time consuming it.

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