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Abstract: Health information is increasingly conveyed to patients in digital formats, such as through health websites, patient portals, and electronic health records. However, for people to be able to process information effectively, information must be presented in a suitable format. This study examines the effectiveness of different strategies for tailoring the mode of presentation (i.e., using textual, visual, and/or audio-visual formats) on information processing outcomes among different audiences (i.e., lower vs. higher health literates; younger [25-45 years] vs. older adults [?65 years]). In an online experiment participants viewed either a customized, personalized, or non-tailored (mismatched) website based on individual preferences for presentation mode. We analysed a 3 (condition) × 2 (health literacy level) × 2 (age group) between-subjects design, examining effects on: time spent online, attention, perceived relevance, website involvement, website satisfaction, and information recall. Results (N = 490) showed that mode tailoring, by both customization and personalisation, is more effective than no tailoring. However, contingent on the outcome variable (i.e., attention, website satisfaction, information recall), or health literacy level, and age group, different tailoring strategies show different effects. Designers of digital health information should strategically consider employing personalized information modes or to have people to customize their own information materials.

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Article

Customisation versus Personalisation of Digital Health Information

Effects of Mode Tailoring on Information Processing Outcomes

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Abstract

Health information is increasingly conveyed to patients in digital formats, such as through health websites, patient portals and electronic health records. However, for people to be able to process information effectively, the information must be presented in a suitable format. This study examines the effectiveness of different strategies for tailoring the mode of information presentation (i.e., using textual, visual and/or audiovisual formats) on information processing outcomes among different at-risk audiences (i.e., low health literacy levels or older adults [≥65 years]). We conducted an online experiment where participants viewed either a customised, personalised or non-tailored (mismatched) health website based on individual preferences for presentation mode. We analysed a 3 (tailored condition) × 2 (health literacy level) × 2 (age group) between-subjects design, examining the effects on time spent online, attention, perceived relevance, website involvement, website satisfaction and information recall. The results

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effective than a non-tailored online health information presentation. However, contingent on the specific outcome variable (i.e., attention, website satisfaction, information recall), level of health literacy and age group, particular tailoring strategies show different effects. Designers of digital health information should consider the strategic deployment of personalised information modes or having people to customise their own information materials.

Keywords

Health information conveyed to patients via health websites, patient portals and electronic health records can benefit patients by facilitating information provision, information exchange and promoting self-management (Bolle et al., 2015). Meta-analytical reviews have shown that tailored online health information tools, typically providing people with content adapted to their unique characteristics, needs and/or preferences, are more effective than non-tailored tools (Krebs et al., 2010; Lustria et al., 2013; Noar et al., 2007; Sohl & Moyer, 2007). Despite the effectiveness of tailoring, the effect sizes of content tailoring often remain small, suggesting that innovations in the conceptualisation and delivery of online health information could improve effectiveness. As such, researchers and practitioners continue to look for novel ways to tailor information to patients and the public (Smit et al., 2015).

Tailoring the mode of information presentation, or providing information based on individuals' preferences for the delivery format (e.g., textual, visual and/or audiovisual information), is one novel tailoring approach for health communication researchers (Jensen et al., 2012; Nguyen et al., 2017; Smit et al., 2015). Extant research suggests the way in which health information is presented affects *how* information is evaluated and processed (Kreuter et al., 2000; Lang, 2006; Ritterband et al., 2009). Moreover, research has shown that individuals vary in their information mode preferences (e.g., textual vs. audiovisual information; Heo & Cho, 2009; Mayer & Massa, 2003) and processing styles (e.g., verbal vs. visual learners; Childers et al., 1985; Mayer & Massa, 2003). In contexts where the aim is to convey health information (e.g., patient education materials, communication of diagnostic results) to audiences that may experience difficulties with processing such information, such as low-health-literate people or older adults, *mode tailoring* could be a relevant strategy to make information more accessible. This is especially important because health information is often complex, with studies indicating that many health websites are not optimally designed for audiences at risk of poor information processing (e.g., Meppelink et al., 2017; Tian et al., 2014). This study examines the effectiveness of different mode-tailoring strategies, namely customisation and personalisation of information, to match individual preferences for the delivery mode of online health information on information processing outcomes among different audiences, specifically for people with varying health literacy levels and of different age groups.

What Does Tailored Health Communication Entail?

The rise of computer technology has made tailoring an attractive strategy to optimise online health communication interventions (Lustria et al., 2013). Tailored health information refers to communication intended to reach one specific person, and thus involves adjusting information in such a way as to match unique individual characteristics and preferences related to outcomes of interest (Kreuter et al., 2000; Rimer & Kreuter, 2006). The goal of tailored health information is to increase the personal relevance of this information and, by doing so, motivate and enable people to process information better, and consequently elicit the desired changes in the outcome of interest in response to the information (e.g., knowledge, attitudes, behaviour; Hawkins et al., 2008; Kreuter & Wray, 2003). Because tailored information materials facilitate deeper processing of information (Lustria et al., 2016), tailoring offers an evidence-based strategy to optimise online information provision to audiences who are more likely to experience difficulties with processing information, such as for lower health literates and older adults.

Over the past decades, tailoring has been applied as a communication strategy to address a wide range of health topics, ranging from health promotion and disease prevention behaviours (e.g., smoking, physical activity; Oenema et al., 2008) to screening and detection behaviours (e.g., STDs, cancer; Lustria et al., 2016; Vernon et al., 2011) and patient education materials (e.g., based on information needs; Albada et al., 2012). Tailoring can be operationalised by adapting the *content* to individual information needs and preferences, framing information in a *context* that is meaningful for the targeted person or providing information in a *format* or *delivery mode* that fits with individual preferences and processing abilities (Rimer & Kreuter, 2006; Smit et al., 2015). The large body of scholarship devoted to tailoring has, however, mainly focused on adapting health information content. More recently, scholars have explored tailoring the delivery mode as a strategy to enhance the effects of health communication efforts (Smit et al., 2015). One of the relative advantages of digital health information is the possibility to integrate and tailor different modes of information presentation to individual preferences and processing abilities. Mode tailoring – in this study operationalised as providing information based on individuals' preferences for the delivery format using textual, visual and/or audiovisual information – is thus a particularly relevant strategy to employ in digital tailored health communication efforts (e.g., health websites, patient portals, Web-based interventions). To this end, our aim is not to compare different information presentation modes (e.g., for textual, visual and/or audiovisual information) in their effectiveness, but rather to understand how different forms of tailoring these presentation modes to individual preferences (i.e., customisation or personalisation) influences outcomes compared to non-tailored information.

State of the Art: Mode Tailoring of Health Information

Previous scholarship has conceptualised 'tailoring' through different approaches and distinguished between customisation and personalisation of digital information (Sundar & Marathe, 2010). Customisation refers to a user-driven approach to information tailoring and asks individuals to actively self-tailor content presented to them. Personalisation, on the other hand, refers to a system-driven way of delivering information in a pre-planned format based on an assessment of individual characteristics or preferences.

Previous mode-tailoring studies that have examined user-driven customisation or system-driven personalisation approaches have shown mixed results. Two studies looking at system-driven personalisation found positive effects on cancer screening intentions after adapting information to visual preference (i.e., charts/graphs vs. illustrated visuals; text vs. text with images vs. video; Jensen et al., 2012; Linn et al., 2015), although one of the studies found no effect on information recall (Linn et al., 2015). In two other studies, the benefits of a personalised information mode were less convincing (i.e., print brochures vs. phone; text vs. video vs. both), as they found no effects on message acceptance (Vandelanotte et al., 2012) or physical activity behaviours (Lewis et al., 2006; Vandelanotte et al., 2012). A potential drawback of such personalisation approaches to mode tailoring is that participants were asked questions about how they wanted to receive the information *beforehand* (e.g., text vs. video), on the basis of which it may have been difficult for them to make a decision about which information format they would prefer without having seen the information topic first. In a study where participants were able to change their mode preference (text, video or both) after the intervention period, 20% of those receiving tailored information and 34% of those receiving mismatched information changed their mode of delivery (Vandelanotte et al., 2012). Two recent studies applying a user-driven customisation approach to mode tailoring found that allowing participants to self-select textual, visual and audiovisual elements on a health website while viewing the information benefited website evaluations and information recall (Nguyen et al., 2017, 2018). Furthermore, a different study showed that a preparatory website where cancer patients could customise the mode of information presentation decreased anxiety, whereas non-tailored versions of the website did not (Nguyen et al., 2019). Altogether, the current scholarship on mode tailoring has examined different tailoring strategies (i.e., customisation and personalisation) separately and operationalised them in different ways. As such, current investigations may be unintentionally providing ambiguous perspectives on how mode tailoring benefits online health information processing.

Mode Tailoring for Audiences at Risk

Audiences at risk of experiencing difficulties processing health information can especially benefit from mode-tailored online health materials. At-risk groups may include people with lower health literacy and older adults. Health literacy refers to 'the degree to which individuals can obtain, process, understand, and communicate about health-related information needed to make informed health decisions' (Berkman et al., 2010, p. 16). People with lower health literacy generally tend to have lower reading skills and less health-related knowledge, which poses challenges for their understanding of health information (Chin et al., 2011; Sørensen et al., 2012). As a result, people with lower health literacy more likely experience information overload when presented with online health information, negatively affecting their satisfaction with health websites and information recall (Meppelink et al., 2016). Similarly, older adults are more likely to experience overload when presented with health information due to age-related declines in sensory (e.g., visual, auditory) and cognitive functioning (e.g., working memory, processing; Becker, 2004; Echt, 2002). However, many available health websites do not consider age-related needs and preferences in their design (Bolle et al., 2016), which could partly explain why many older adults are not satisfied with the information they encounter (Rideout et al., 2005). For both people with lower health literacy and

older adults, designing health information that facilitates processing is of vital importance, and mode tailoring could be a path to facilitating information processing across the lifespan.

The cognitive theory of multimedia learning (CTML; Mayer, 2005) proposes that multimodal information combining verbal (i.e., written or spoken text) and visual modes (i.e., static or animated pictures) is more effective at improving learning than unimodal information. CTML is based on dual coding theory (Paivio, 1991), which posits that people have separate processing systems for verbal and visual information and that each system has limited processing capacity. Thus, combining different information modes can effectively expand one's processing capacity, thereby improving motivation and learning outcomes (Mayer, 2014). Multimodal information is especially relevant for older adults, as the cognitive ageing principle posits that older adults have a reduced working memory capacity that can be expanded by using multimodal information (Paas et al., 2005). Similar arguments have been given for the design of health information for those with lower health literacy (Wilson & Wolf, 2009).

While considerable research has compared different textual, visual and audiovisual information formats based on CTML for different audiences, including younger versus older adults and people with varying health literacy levels (for extensive work on this, see Bol, 2015; Meppelink, 2016), the results have not always shown convincing evidence for a specific combination of modalities for each of these target groups. This suggests that there are limits to the potential of static one-size-fits-all multimodal health information, even if based on theory-driven design principles such as CTML. A potential explanation is that people vary in their mode preferences as well as processing abilities. For instance, older adults are a highly heterogeneous group when it comes to their preferences for digital information presentation (Soroka et al., 2006), and age-related factors, such as cognitive ability, influence their mode preferences as well (Wright et al., 2008). One study that considered health literacy and learning styles showed that tailoring health information to these factors can improve learning outcomes (Giuse et al., 2012). Overall, these findings suggest a benefit of more tailored approaches when designing online health information for audiences at risk (e.g., older adults and people with lower health literacy). In the current study, we aim to advance applications of CTML by tailoring information modality to increase the effectiveness of online health information presentations.

We note that preferences are distinctly different from abilities, although research has shown that cognitive ability (e.g., high vs. low spatial ability), cognitive style (e.g., thinking with words or pictures) and learning preference (e.g., preferring textual or visual information) are central to learning-style distinctions (Mayer & Massa, 2003). As such, in this paper we focus on people's preference for the mode of information delivery to aid with differences in the information processing abilities of people with varying levels of health literacy and of different ages.

The Current Study

The aim of the present study is twofold. First, we examine the differential effects of customised and personalised (vs. non-tailored and mismatched) modes of information delivery (i.e., using textual, visual, audiovisual information) on online health information processing outcomes. These information processing outcomes, identified as important mechanisms for understanding the effects of tailored health information by earlier scholarship (e.g., Jensen et al., 2012; Lustria et al.,

2016; Nguyen et al., 2020), include time spent online, attention, perceived relevance, website involvement, website satisfaction and information recall. Second, we examine whether certain groups of individuals – low versus high health literacy and younger versus older – are more likely to benefit from customised versus personalised mode tailoring of online health information. Specifically, we hypothesise that:

H1: A customised and personalised (versus non-tailored and mismatched) mode of delivery will lead to (a) more time spent on the website, (b) higher attention, (c) higher perceived personal relevance, (d) higher website involvement, (e) higher website satisfaction and (f) better recall of information.

Furthermore, we explore the following three research questions:

RQ1: To what extent are there differential effects of a customised and personalised (vs. non-tailored and mismatched) mode of delivery on the aforementioned outcome variables?

RQ2: To what extent are there differential effects of a customised and personalised (versus non-tailored and mismatched) mode of delivery for younger (25–45 years) versus older adults (≥ 65 years)?

RQ3: To what extent are there differential effects of a customised and personalised (versus non-tailored and mismatched) mode of delivery for people with lower versus higher health literacy levels?

Method

Design and Materials

This study is a secondary analysis of data from a study with a different research aim (Nguyen et al., 2017; Nguyen et al., 2018). The original study examined the effects of user-driven mode tailoring, compared to four non-tailored static conditions (i.e., text only, text and illustrations, text and video, and a combination of all modes) on website satisfaction and information recall for different age groups. Based on collected information on people's mode preferences, we recoded the original data to analyse a 3 (condition: customisation vs. personalisation vs. mismatched based on mode preference) by 2 (low vs. high health literacy level) by 2 (age group: younger [25–45 years] vs. older [≥65 years] adults) between-subjects design in the current study. A detailed description of this process and justifications for categorising participants in the personalised or non-tailored, mismatched condition is given under 'Participants and Conditions'. Ethical approval was given by the ethics committee at the Amsterdam School of Communication Research.

Stimulus Materials

We developed five different versions of a health website based on an existing webpage of a multidisciplinary outpatient clinic in Europe (the Gastro-Intestinal Oncological Centre Amsterdam; GIOCA). The clinic is a specialised centre that provides fast diagnostics for prospective colorectal cancer patients within one day. The website content included general information about the clinic (e.g., their usual procedure, what fast diagnostics entails) as well as

Figure 1a. Customisable website (text, illustration and video mode selected), male patient.
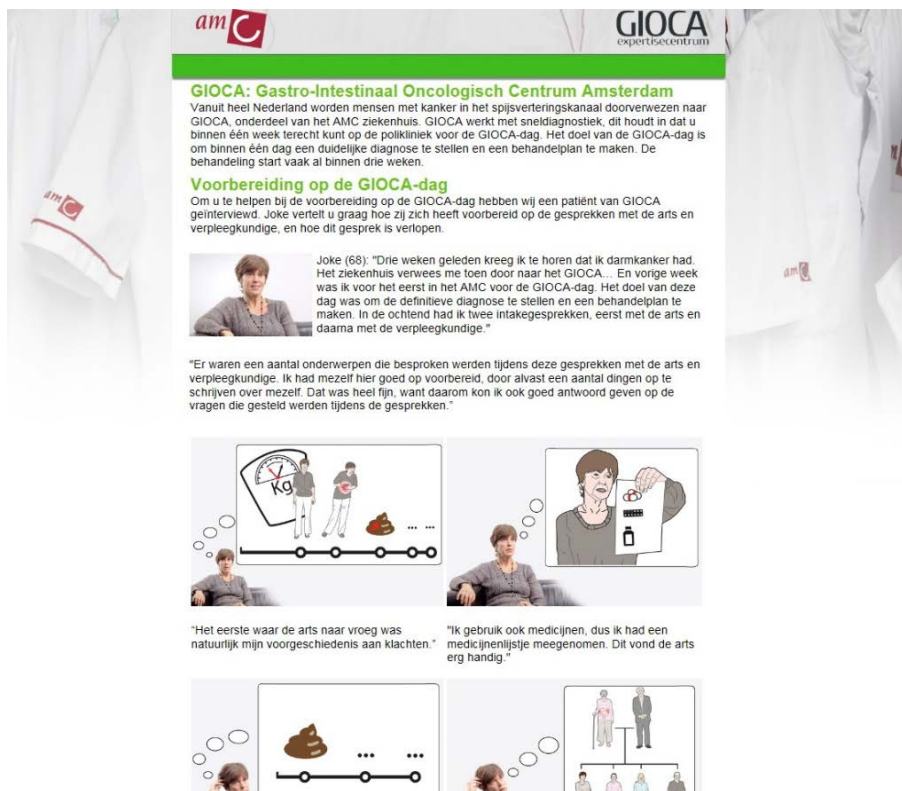

Figure 1b. Standard website with text and illustrations shown in the personalised or non-tailored condition, female patient.

specific topics of discussion patients should prepare for when dealing with a colorectal cancer diagnosis (e.g., physical symptoms, genetics, medical history). The information was conveyed through a patient narrative, as this informal narration style can yield greater effects on information processing than a formal narration style in the cancer context (Bol, van Weert, et al., 2015). We developed a male and female patient version for all websites and randomly exposed participants to a male or female version of the website to control for gender effects.

The text-only website included a written patient narrative about the information topics listed above. The text-with-visuals version featured the same written patient narrative, but was supported with illustrations containing the patient. The video version included a video of the patient in which the spoken narration was the same as the written testimonial on the text and text-with-visuals version. The combined version contained all the aforementioned information modalities (i.e., text, visuals and video). Similar to the combined version, the customisable website version also contained all modes, but this website included the option for participants to choose and toggle between different modes of presentation (e.g., showing, for instance, only text and video, or video and illustrations). All websites contained a short introductory section with written information about the clinic. Figure 1 shows examples of the website versions.

Procedure

The online questionnaire was distributed to participants by the ISO-certified[1] market research company PanelClix (for other scholarly examples using this research panel, see Bol, van Weert, et al., 2015 and Meppelink et al., 2015). Participants could participate in the survey on their own computer. After briefing instructions and informed consent, participants' gender, age and education level were recorded for stratification. We collected a stratified quota sample in which gender, age groups (younger [25–45 years] and older [≥ 65 years]) and low and high education levels (to ensure equal distribution of low vs. high health-literate participants across the experimental conditions; a similar procedure has been applied by Meppelink et al., 2015) were equally represented.[2] Middle-aged participants (46–64 years) were screened out, in order to create two clearly distinguished age groups. Similarly, middle-educated people were screened out to increase the chances of being able to create two clearly distinguished groups based on health literacy level. The low education level included those who had no education and those who finished primary education, lower vocational education and preparatory or intermediate secondary vocational education. The high education level was specified by having a higher vocational education or university degree.

Participants were instructed to imagine that they had just received a possible diagnosis of colorectal cancer and that they would have to visit the clinic in the near future. Next, participants were randomised to view one of the five website versions. All participants were instructed that they could take as long as they wanted to view the website and that they would receive questions afterwards. At the opening of the customisable website, all modes were deselected by default to ensure that participants would select their preferred mode(s). The other website versions contained the same information in different modes, but in a fixed manner. Next, we assessed the outcome measures, participants' mode preferences (for text, visuals and/or video – including the option to

have no preference) and remaining background variables. Participants received a reward worth approximately 1.50 euros upon study completion.

Participants and Conditions

In total, 559 respondents successfully completed the online questionnaire. Participants in the customisation condition ($n = 102$) received the website on which they could self-select their preferred mode(s) of presentation. The remaining participants randomly viewed one of four standard website versions and were classified into either the personalised condition or non-tailored (mismatched) condition, based on (1) the website version they were exposed to and (2) their individual mode preferences. Mode preferences were assessed by asking: 'What is your information preference when consulting websites? You can check multiple options. When I consult a website and need to remember information, the website should contain the following elements: text; photos and illustrations; videos; no preference'. Participants who were assigned to the personalised condition ($n = 171$) either had perfect matches between their preferences and the viewed website version (e.g., those who preferred text, visuals and video and viewed the combined website version) or nearly perfect matches based on their preferences for video (e.g., those who preferred text and video and viewed the combined version). Participants categorised into the non-tailored (mismatched) condition ($n = 217$) had clear mismatches between their reported preferences for the mode of information presentation and the website version they viewed (e.g., those who preferred text-only but received the website with video). Participants who indicated no mode preference ($n = 69$) could not be classified into study conditions and were thus excluded from the analyses. In total, 490 participants were included in the reported analyses.

To summarise, participants in the customisation condition could self-select on the website which information modes they wanted to receive while viewing the website. Participants in the personalisation condition received information that matched with their modality preferences assessed after viewing the website. Participants in the non-tailored condition received information that mismatched with their assessed preferences. Unlike in the customisation condition, in both the personalisation and non-tailored conditions, participants were not able to self-select their preferred information modes while viewing the website.

Measures

Outcome Variables. A built-in website tracker captured *time spent on the website* in minutes (M = 2m 35s, SD = 3m 37s). We assessed other outcomes with 7-point scales with answer options ranging from 1 (*totally disagree*) to 7 (*totally agree*), unless indicated otherwise. Self-reported *attention* was measured with three items (Visser et al., 2016), such as 'While viewing the website, I was fully concentrated on the story' (M = 4.6, SD = 1.3, Cronbach's α = .85). We measured *perceived relevance* of the website content with two items derived from earlier studies on tailored health communication (Jensen et al., 2012; Lustria et al., 2016), such as 'The website seemed personally made for me' (M = 4.5, SD = 1.5, Pearson's r = .69). *Website involvement* was measured with four items (Dutta-Bergman, 2004), such as 'I put a lot of effort into evaluating the website' (M = 5.0, SD = 1.0, Cronbach's α = .81). *Website satisfaction* was measured with the three-dimensional Website Satisfaction Scale (Bol, Smets, et al., 2015; Nguyen et al., 2018) and

included satisfaction with the *attractiveness* (three items, e.g., 'The website looks nice', $M = 4.7$, $SD = 1.3$, Cronbach's $\alpha = .89$), *comprehensibility* (three items, e.g., 'The website is understandable', $M = 5.9$, $SD = 0.9$, Cronbach's $\alpha = .91$) and *emotional support* (four items, e.g., 'The website increases my self-confidence', $M = 4.7$, $SD = 1.2$, Cronbach's $\alpha = .85$). Finally, we measured *information recall* with seven open-ended questions about website content, such as 'What does fast diagnostics entail?' and 'Which topics will be discussed with the physician?' We developed a codebook beforehand to score the answers (Nguyen et al., 2017). For five questions, participants could receive a maximum of two points ($0 = incorrect$, $1 = partially\ correct$, and $2 = correct$). For the two remaining questions, participants could receive a maximum of 3 and 5 points. As such, participants could obtain a sum score ranging between 0 and 18, which we then converted into the percentage correctly recalled ($M = 30.3$, $SD = 21.7$). We calculated inter-coder reliability over 26% of the recall answers ($n = 143$), which was shown to be good (mean $\kappa = .87$, $p < .001$).

Moderating Variables. We asked for participants' age and divided them into a group of younger adults (aged 25–45 years) and older adults (aged 65 years and older). We measured health literacy with the Short Assessment of Health Literacy in Dutch, which consists of 22 health-related words (e.g., biopsy, ventricle, palliative; Pander Maat et al., 2014). For each word, participants were asked to select the correct meaning out of three multiple choice options or an 'I don't know' option. The sum score of correct answers reflected their health literacy level and could range between 0 and 22 ($M = 15.5$, $SD = 4.3$, $Mdn = 16$). In line with earlier research (Meppelink et al., 2015), we distinguished lower and higher health-literate participants based on a median split.

Background Variables. Besides age, we asked about participants' sex (male/female) and level of education. We measured Internet use in hours/week with one question: 'How many hours per week do you make use of the Internet, including surfing and emailing?'

Statistical Analyses

We conducted chi-square tests and *t*-tests to check whether participants' background characteristics were equally distributed over the conditions. We conducted analyses of variance (ANOVAs; no covariates) to test main (i.e., condition) and interaction effects (i.e., health literacy, age group) on outcome variables, with Bonferroni corrections for post-hoc tests. We additionally explored within-group differences for age group and health literacy level with simple effects analyses.

Results

Sample Characteristics

The final sample ($N = 490$) for analysis consisted of 235 younger adults ($M_{age} = 35.5$, $SD_{age} = 6.5$, range 25–45 years, 46.4% male) and 255 older adults ($M_{age} = 72.9$, $SD_{age} = 5.7$, range 65–88 years, 51.4% male). About half of the participants had a lower education level (49.2%, $n = 241$), while the other half was considered higher educated (50.8%, $n = 249$). Less than half of participants were

considered lower health literates (43.3%; $n = 212$) versus 56.7% higher health literates ($n = 278$). The average Internet use was 20.3 hours per week ($SD = 15.0$). The three study conditions did not differ in age group, χ^2 (2, $N = 490$) = 2.32, $p = .313$, sex, χ^2 (2, $N = 490$) = 0.27, $p = .872$, education level, χ^2 (2, $N = 490$) = 0.97, $p = .614$, and internet use, $F(2, 487) = 2.17$, $p = .115$, $\eta p^2 = .01$. While participants with higher health literacy were overrepresented across the conditions overall, χ^2 (2, $N = 490$) = 7.54, $p = .023$, we controlled for this in the analyses, as health literacy was included as a factor in the ANOVA. Age group and health literacy level were unrelated overall, χ^2 (2, $N = 490$) = 1.79, $p = .181$, and their combinations were equally distributed in the non-tailored condition, χ^2 (1, $N = 217$) = 0.00, $p = .979$, and personalised condition, χ^2 (1, $N = 171$) = 0.24, $p = .628$. In the customised condition, higher health literates were slightly overrepresented, but this was not related to age group, and so combinations of age group and health literacy were equally distributed, χ^2 (2, $N = 102$) = 5.01, $p = .025$.

Table 1. Customised Website Use Characteristics

	Age		Health Literacy		Total
	Younger	Older	Low	High	
	$n = 43$	$n = 54$	$n = 31$	$n = 66$	$n = 97$
	M (SD)	*M (SD)*	*M (SD)*	*M (SD)*	*M (SD)*
Number of mode actions[a]	4.9 (3.6)	3.5 (2.0)	4.0 (2.1)	4.2 (3.2)	4.2 (2.9)
Time until 1st mode (s)	25.9 (56.3)	25.4 (29.2)	16.8 (14.0)	29.7 (51.0)	25.6 (43.1)
Time 1st > 2nd mode (s)[b]	14.0 (21.4)	16.2 (29.8)	7.7 (10.2)	18.6 (30.3)	15.2 (26.2)
	n (%)	*n (%)*	*n (%)*	*n (%)*	*n (%)*
First mode ≤ 10 (s)	23 (53.5)	19 (35.2)	15 (48.4)	27 (40.9)	42 (43.3)
First mode 11-20 (s)	10 (23.3)	18 (33.3)	10 (32.3)	18 (27.3)	28 (28.9)
First mode > 20 (s)	10 (23.3)	17 (31.5)	6 (19.4)	21 (31.8)	27 (27.8)
First mode chosen					
Text	33 (76.7)	33 (61.1)	21 (67.7)	45 (68.2)	66 (68.0)
Illustrations	7 (16.3)	15 (27.8)	5 (16.1)	17 (25.8)	22 (22.7)
Video	3 (7.0)	6 (11.1)	5 (16.1)	4 (6.1)	9 (9.3)
Mode combinations					
All three modes	32 (74.4)	39 (72.2)	23 (74.2)	48 (72.7)	71 (73.2)
Text and illustrations	9 (20.9)	8 (14.8)	5 (16.1)	12 (18.2)	17 (17.5)
Text and video	-	-	-	-	-
Illustrations and video	-	1 (1.9)	-	1 (1.5)	1 (1.0)
Text-only	-	4 (7.4)	-	4 (6.1)	4 (4.1)
Illustrations-only	1 (2.3)	-	1 (3.2)	-	1 (1.0)
Video-only	1 (2.3)	2 (3.7)	2 (6.5)	1 (1.5)	3 (3.1)

Note. Web analytics were available for 97 participants in the mode-tailored condition, as some disabled us to track their online actions (n = 5). Variables measured in seconds are rounded to one decimal. [a]Mean differs between younger and older adults (p = .024). [b]Mean differs between low and high health literates (p = .013).

Website Use in the Customised Condition

The website-use characteristics for those viewing a customised website are shown in Table 1. People mostly selected all three modes or text and visuals, with a few participants choosing only single-mode information. Participants made 4.2 (SD = 2.9) mode selections on average, with older adults making significantly fewer mode selections than younger adults. The average time until the first mode selection was 26 seconds (SD = 43s), with no mean differences between subgroups. However, 35% (n = 19) of older adults made a mode selection within the first 10 seconds on the website, against 54% (n = 23) of younger adults. This difference was less pronounced between low (48%, n = 15) and high (41%, n = 27) health literates.

Mode Tailoring Effects on Information Processing Outcomes

We first report the results of the main and interaction effects for the outcome variables. Table 2 displays the ANOVAs, and Table 3 displays the means and standard deviations by condition. Regarding *time spent on the website*, we observed no significant main effects of condition nor

Table 2.   Analyses of Variance

		F	p	ηp^2
Time spent on the website	C	0.67	.513	.00
	C × HL	2.79	.062	.01
	C × AG	0.26	.768	.00
Attention	C	5.60	.004	.02
	C × HL	1.39	.251	.01
	C × AG	0.19	.830	.00
Perceived relevance	C	8.49	.000	.03
	C × HL	0.12	.887	.00
	C × AG	1.87	.156	.01
Website involvement	C	4.73	.009	.02
	C × HL	0.01	.987	.00
	C × AG	0.04	.958	.00
WSS: Attractiveness	C	9.47	.000	.04
	C × HL	0.41	.663	.00
	C × AG	2.19	.114	.01
WSS: Comprehensibility	C	12.03	.000	.05
	C × HL	0.53	.588	.00
	C × AG	0.35	.703	.00
WSS: Emotional support	C	9.03	.000	.04
	C × HL	0.67	.514	.00
	C × AG	1.59	.206	.01
Information recall	C	5.82	.003	.02
	C × HL	0.57	.567	.00
	C × AG	4.80	.009	.02

Note. C = condition, HL = health literacy, AG = age group. WSS = Website Satisfaction Scale.
Total N = 490, df = 2, 478.

Table 3. Descriptives of Outcome Variables by Condition

	Customisation		Personalisation	
	M	SD	M	SD
Time on website (min)	03:29*[a]	06:03	02:45	02:04
Attention	4.7	1.3	4.8**[a]	1.3
Perceived relevance	4.8**[a]	1.4	4.8***[a]	1.4
Website involvement	4.9	1.1	5.2*[ab]	0.9
WSS: Attractiveness	5.1***[a]	1.1	4.9***[a]	1.4
WSS: Comprehensibility	6.1**[a]	0.9	6.1***[a]	0.7
WSS: Emotional support	4.8*[a]	1.1	5.0***[a]	1.1
Information recall	29.9	22.5	33.8*[a]	21.2
	Non-Tailored		Total	
	M	SD	M	SD
Time on website (min)	02:24	02:58	02:45	03:37
Attention	4.4	1.3	4.6	1.3
Perceived relevance	4.2	1.5	4.6	1.5
Website involvement	4.9	0.9	5.0	1.0
WSS: Attractiveness	4.4	1.4	4.7	1.4
WSS: Comprehensibility	5.7	1.0	5.9	0.9
WSS: Emotional support	4.4	1.2	4.7	1.2
Information recall	28.1	21.6	30.5	21.7

Note. WSS = Website Satisfaction Scale. Total N = 490.
[a]*Differs from non-tailored condition.* [b]*Differs from customisation condition.* *** $p < .001$, ** $p < .01$, * $p < .05$.

interaction effects with health literacy and age group. With respect to *attention* to the information, there was a significant main effect of condition, with post-hoc analyses showing that participants in the personalised condition reported higher attention than those in the non-tailored condition. As for *perceived personal relevance*, there was a significant main effect of condition, with post-hoc analyses showing that participants receiving the customised or personalised website found the website to be more relevant to them than those viewing a non-tailored website. With respect to *website involvement*, we found a significant main effect of condition, with post-hoc analyses showing that participants in the personalisation condition reported greater website involvement than those in the non-tailored and customisation conditions.

We also found significant main effects for all three *website satisfaction* subscales. First, post-hoc analyses showed that participants viewing a customised or personalised website were more satisfied with its *attractiveness* than those receiving a non-tailored website. For satisfaction with the website *comprehensibility*, both the customisation and personalisation websites were favoured over the non-tailored website. Third, participants viewing a customised or personalised website were more satisfied with the *emotional support* from the website than those viewing a non-tailored version.

With respect to *information recall*, we found a significant main effect of condition as well as a significant interaction effect between condition and age group. Overall, participants in the

personalisation condition recalled more information than those in the non-tailored condition. However, when breaking it down by age group, younger participants in the personalised condition recalled more than those in the customised and non-tailored conditions. Lower health literates in the personalised condition had higher recall than those in the non-tailored condition, with no differences among higher health literates.

Exploring Mode-Tailoring Effects by Health Literacy and Age Group

Overall, we found no significant interaction effects for the above-reported analyses, except for information recall. However, to explore whether personalisation and customisation affect age groups and health literacy levels differently, we report simple effects analyses. The simple effects analyses yielded significant patterns, of which some deviated from the main effects. Here, we will only describe the patterns by health literacy and age group that deviate from the main effects. Tables 4 and 5 show the means and standard deviations of the outcome variables broken down by

Table 4.   Descriptives of Outcome Variables: Condition by Health Literacy Level

	Customisation				Personalisation			
	Low HL		High HL		Low HL		High HL	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Time on website	01:51*[a]	01:11	04:14**[bc]	07:10	02:43	02:02	02:47	02:06
Attention	5.0*[b]	1.2	4.6	1.4	4.8	1.3	4.9*[b]	1.3
Perc. relevance	4.9*[b]	1.6	4.8*[b]	1.3	4.8*[b]	1.3	4.9**[b]	1.4
WS involvement	4.7	1.3	5.0*[c]	1.0	5.0	1.0	5.3	0.9
WSS: Attract.	5.1*[b]	1.1	5.1***b	1.1	4.9	1.5	4.9**[b]	1.3
WSS: Comp.	5.8*[b]	1.1	6.2*[b]	0.8	6.0***[b]	0.7	6.2**[b]	0.7
WSS: Emo. supp.	4.8	1.2	4.8*[b]	1.1	5.0*[b]	1.1	5.0***[b]	1.2
Info. recall	21.0	22.0	33.9	21.6	28.3**[b]	20.4	38.8	20.8
	Non-Tailored				Total			
	Low HL		High HL		Low HL		High HL	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Time on website	02:26	03:42	02:21	02:11	02:27	02:52	02:58	04:06
Attention	4.4	1.3	4.4	1.3	4.7	1.3	4.6	1.3
Perc. relevance	4.2	1.4	4.3	1.6	4.5	1.4	4.6	1.5
WS involvement	4.8	0.9	5.0	0.9	4.9*[a]	1.0	5.1	0.9
WSS: Attract.	4.6	1.4	4.3	1.4	4.8	1.4	4.7	1.4
WSS: Comp.	5.5**[a]	1.0	5.9	1.0	5.7**[a]	1.0	6.1	0.9
WSS: Emo. supp.	4.6	1.2	4.3	1.2	4.8	1.2	4.7	1.2
Info. recall	19.8	18.0	35.1	22.0	23.2***[a]	19.9	36.0	21.5

Note. HL = Health literacy; Perc. relevance = Perceived relevance; WSS = Website Satisfaction Scale; Attract = Attractiveness; Comp. = Comprehensibility; Emo. supp. = Emotional support; Info. recall = Information recall. Total N = 490.
[a]*Differs from High HL within the same condition.* [b]*Differs from non-tailored condition within the same HL category.* [c]*Differs from personalised condition within the same HL category. *** p < .001, ** p < .01, * p < .05.*

Table 5.   Descriptives of Outcome Variables: Condition by Age Group

	Customisation				Personalisation			
	Younger		Older		Younger		Older	
	M	SD	M	SD	M	SD	M	SD
Time on website	02:17	02:08	04:24	07:43	02:24**[b]	01:46	03:03	02:15
Attention	4.5	1.5	4.9	1.2	4.7	1.3	5.0	1.2
Perc. relevance	4.7**[b]	1.3	4.9	1.5	4.7**[b]	1.4	5.0	1.4
WS involvement	4.7*[c]	1.3	5.0*[c]	0.9	5.0	1.0	5.3	0.9
WSS: Attract.	4.8***[b]	1.2	5.3	1.0	4.3***[a]*[b]	1.5	5.4*[b]	1.0
WSS: Comp.	6.0**[b]	0.9	6.1	0.9	6.0***[b]	0.8	6.2**[b]	0.6
WSS: Emo. supp.	4.4	1.2	5.1	1.0	4.8***[b]	1.2	5.1	1.1
Info. recall	26.6**[c]	24.5	32.3	20.6	39.3***[a]***[b]	23.8	29.1	17.5

	Non-Tailored				Total			
	Younger		Older		Younger		Older	
	M	SD	M	SD	M	SD	M	SD
Time on website	01:57	02:22	02:52	03:27	02:10**[a]	02:09	03:17	04:31
Attention	4.2*[a]	1.3	4.6	1.3	4.4**[a]	1.4	4.8	1.3
Perc. relevance	3.9**[a]	1.6	4.6	1.4	4.3*[a]	1.5	4.8	1.4
WS involvement	4.8**[a]	0.9	5.1	0.8	4.8***[a]	1.0	5.2	0.9
WSS: Attract.	3.9***[a]	1.4	5.0	1.1	4.2***[a]	1.5	5.2	1.1
WSS: Comp.	5.5**[a]	1.1	5.9	0.9	5.8**[a]	1.0	6.1	0.8
WSS: Emo. supp.	4.1***[a]	1.3	4.8	1.1	4.4***[a]	1.2	5.0	1.1
Info. recall	27.0	21.2	29.3	22.0	31.1	23.4	29.9	20.2

Note. Perc. relevance = Perceived relevance; WSS = Website Satisfaction Scale; Attract = Attractiveness;
Comp. = Comprehensibility; Emo. supp. = Emotional support; Info. recall = Information recall. Total N = 490.
[a]Differs from older adults within the same condition. [b]Differs from non-tailored condition within the same age
*category. [c]Differs from personalised condition within the same age category. *** p < .001, ** p < .01, * p < .05.*

age group and health literacy level and indicate the significant results. These simple effects should be considered cautiously, as they are exploratory and the interaction effects were not significant.

First, the data showed that high health literates *spent more time* on the customised website than the non-tailored website, but not on the personalised website. Second, compared to the non-tailored website, lower health literates reported *greater attention* to the customised website, while higher health literates reported more attention to the personalised website. Furthermore, lower health literates were more *satisfied with the attractiveness* of the customized than the non-tailored website, while high health literates evaluated both the customised and personalised websites more positively than the non-tailored version. Finally, younger adults were *more satisfied with the attractiveness* of the customised website than those viewing the personalised or non-tailored website, with the personalised website in turn outperforming the non-tailored version. Among older adults, those in the personalised condition evaluated the website's *attractiveness* more positively than those in the non-tailored condition.

Discussion

For people to be able to process digital health information effectively (e.g., from online patient portals, health websites, electronic health records), information should be presented in a format corresponding to people's preferences. The current study examined whether tailoring the mode of presentation (using text, visual and audiovisual information) to individuals' mode preferences benefits online health information processing by comparing different tailoring strategies (i.e., personalisation vs. customisation). Specifically, it explores the differential effects of mode-tailoring strategies for people with varying health literacy levels and of different ages. Below, we first give a summary of the results and follow with a discussion of the findings and the theoretical and practical implications.

We hypothesised that tailoring the mode of information delivery (i.e., using textual, visual or audiovisual information) via both customisation and personalisation would lead to improved information processing as compared to non-tailored information (H1). Taken together, the data showed that mode-tailored online health information – both in personalised and customised forms – is more effective than non-tailored material for increasing perceived personal relevance (H1c) and satisfaction with the attractiveness and comprehensibility of, and emotional support from, the website (H1e). For increasing attention (H1b) and website involvement (H1d), a personalised approach to mode tailoring was more effective than non-tailored information. There were no differences between conditions regarding time spent on the website (H1a). We additionally asked whether there were differential effects of the different tailoring strategies (RQ1). Here, we found that personalisation outperformed customisation in terms of website involvement, although there were no differences for the other outcomes. Next, we asked if there were differential effects of the tailoring strategies for people with varying levels of health literacy (RQ2) and ages (RQ3). We found that lower health literates and younger adults recalled the most from personalised information (vs. non-tailored/customised information). Although no other significant interaction patterns emerged, additional exploratory analyses revealed some interesting deviations from the main patterns. Addressing RQ2, we found that higher health literates spent most time on the customised website, reported greater attention for the personalised website, and were more satisfied with the attractiveness of both the customised and personalised websites compared to the non-tailored version. Lower health literates paid greater attention to the customised website and were also most satisfied with the attractiveness of this version. Answering RQ3, we found that younger adults were most satisfied with the attractiveness of the customised website, while older adults evaluated the personalised version most favourably.

Overall, our findings show that both tailoring strategies, namely system-driven tailoring (here: personalisation) and user-driven tailoring (here: customisation), increase the effectiveness of online health information on information processing outcomes compared to non-tailored information (confirming H1), with slightly more favourable results for personalisation overall (RQ1). For instance, personalisation increased both attention and website involvement (vs. non-tailored information), while customisation did not. A potential explanation is that personalised mode tailoring required less cognitive effort from the user as opposed to mode customisation, which was a novel task that required action on the user side (e.g., in our study, people toggled between modes about four times). However, a more recent study has shown that customisation and

perceived active control over online health information can decrease the cognitive load and facilitate information processing (Nguyen et al., 2020). It could be that with repeated use of the customisable website, the cognitive effort is reduced as users become familiar with the interface, and thus the customisation becomes more effective. Since reducing cognitive load is especially important when designing online health information for audiences that may experience difficulties in processing information (e.g., older adults, people with lower health literacy levels), future research could explore the role of cognitive load when employing different tailoring strategies (i.e., personalisation and customisation).

While both tailoring strategies showed favourable effects contingent on the specific outcome variable as well as the target audience, different tailoring strategies could lead to different effects (RQ2–3; see summary of results). For instance, lower health literates and younger adults recalled more information from the personalised website. Thus, our results show that considering people's preferences for the mode of information presentation can benefit various audiences, including those who are at risk for poor processing of online health information. Our results are in line with previous work indicating that tailoring health information materials to both health literacy level and verbal/visual learning preference can improve learning outcomes (Giuse et al., 2012). We note that these results should be considered exploratory, and future research is necessary to corroborate these findings. Still, our analyses yield some interesting preliminary insights. Depending on the desired outcome goal and target audience, designers of digital health information should strategically consider which strategy to employ when tailoring the mode of information presentation.

Although we find positive effects of mode tailoring on information processing outcomes, it is important to note that these effects remained small. While this may seem disappointing, these effects are meaningful in advancing the scholarship on tailored communication and digital health. Previous studies focusing on *content* tailoring have mostly reported small effect sizes as well (Krebs et al., 2010; Lustria et al., 2013; Noar et al., 2007; Sohl & Moyer, 2007). A question that arises is whether the combination of different tailoring strategies, such as content tailoring and mode tailoring, may yield greater effects combined than their individual effects alone. A fruitful avenue for future research is to explore such synergy effects of these tailoring strategies, as well as other strategies, such as cultural tailoring (Huang & Shen, 2016) or message frame tailoring (Altendorf et al., 2019). Moreover, future research could employ study designs that compare content tailoring and mode tailoring to gain insight into their relative effectiveness, as well as whether they induce similar or different information processing mechanisms and impact similar or different health behaviour outcomes. Such studies are valuable, as it is important to know how tailored health communication interventions can yield greater effects on health-related outcomes than have been found to date.

Our work also calls for novel research directions on how to fine-tune tailoring processes. In this study, we operationalised system-driven personalisation by straightforwardly asking participants to indicate their preference for text, visuals and/or video. Alternatively, we may be able to tailor our communication with more precision by assessing more complex constructs, such as learning styles or cognitive abilities (Mayer & Massa, 2003) as input for personalisation algorithms. However, such sophisticated tailoring strategies may also pose practical challenges. While in an

ideal world we would provide each individual with unique information tailored to their preferences and needs, digital information is often designed to reach broader audiences. Our study showed that under specific conditions, user-driven customisation of health information is favourable (over personalisation). Moreover, a recent study showed that individuals with a high need for autonomy prefer to exert some control over how to reach their health-related goals and suggests that such individuals may benefit more from customisable health information (Smit & Bol, 2019). Moreover, information mode preferences may not only vary between individuals but also within individuals across different contexts (e.g., different types of health information, such as the communication of test results, prescription information or appointment details; or different information goals, e.g., knowledge acquisition or emotional support), arguably making it even more important to refrain from developing one-size-fits-all tailored information delivery systems. This raises the question of whether one tailoring approach is more desirable over the other (i.e., customisation vs. personalisation), or if we should rather develop hybrid information systems that personalise information upon first-time use and additionally provide options for customisation if people desire or need this. Such hybrid information systems may be able to cater to a wider audience and could therefore be a promising practical application of tailored health communication. Studies examining hybrid tailoring methods in which both system-driven personalisation and user-driven customisation approaches are combined could shed new light on how mode tailoring, but also content tailoring, can best be operationalised.

The current study has some limitations that need to be addressed. First, we used a hypothetical scenario about a colorectal cancer diagnosis and asked participants to use the health website with this scenario in mind. The inclusion of 'analogue patients' is an often-used method in experimental studies to disburden clinical patients, and previous work has shown that the responses of analogue and clinical patients in health communication research are largely comparable (van Vliet et al., 2012; Visser et al., 2016). Nevertheless, it may be that clinical patients respond differently to different types of tailored online health information, for instance because they have higher information needs when they face a health threat than analogue patients. As such, future research is warranted to confirm if our results can be extended to clinical settings.

Second, we opted for online health information in the form of a patient narrative. While previous research has shown that narrative information in particular may be easier to process by, for example, older patients, this may have attenuated the effects and led to less pronounced differences between the mode-tailored and non-tailored conditions in the present study. In other contexts where informal language is used to convey information, mode tailoring may lead to more pronounced effects. It is important to note that the specific type of information used in this study (i.e., patient narrative) presents limitations to the generalisability of the results, and thus the transferability of claims for future research that uses different ways of information portrayal should be done with careful consideration.

The final limitation pertains to the secondary analysis of existing data with implications for the study design and sample. In the original study, participants were randomly allocated to either a tailored condition (i.e., those who made up the customised condition in the present study) or one of four non-tailored conditions (i.e., those who made up the personalised and mismatched/non-tailored condition in the present study). For this paper, we re-categorised participants into a

personalised and mismatched condition and left out participants for whom a match or a mismatch could not be determined (see our explanation under 'Participants and Conditions' in the Method section). As a result, the sample sizes of the personalised and mismatched (non-tailored) condition were larger than that of the customisation condition. Future research could replicate this study and apply a research design that randomises participants to a customised versus personalised condition from the start. Finally, given the research design of our study (i.e., an online experiment), we only included self-report measurements. Future research can extend our work by employing other research methods, such as eye-tracking, to measure attention and engagement beyond time spent on the website and self-reported attention. This can give us deeper insight into the effects of tailored online health information on information processing.

Conclusion

Our work contributes to and extends current tailoring literature by showing that tailoring the mode of online health information delivery can improve message effectiveness. Furthermore, we are the first to give insight into the relative effectiveness of personalisation and customisation in mode tailoring, and to disentangle how these effects play out for audience groups that are at greater risk to have difficulties with processing online health information (e.g., lower health literates and older adults). Although mode-tailored online health information – both by means of personalisation or customisation approaches – is more effective than non-tailored information, we find that depending on the outcome (e.g., attention, website satisfaction, information recall) and target audience (i.e., low vs. high health literates; younger vs. older adults), either personalisation or customisation can be a more favourable strategy to employ. Given the increasing digitisation of the health care sector, insights from this study are valuable for scholars and designers of online health communication tools and interventions.

Notes

1. International quality certification for market, opinion and social research panels: https://www.iso.org/standard/43521.html.
2. The aim of the original study was to examine the added value of tailored health information for older adults. As such, a younger group of participants aged 25 to 45 years was included as comparison to create two clearly distinct age groups. Thus, participants aged between 46 and 64 years were not represented in the current nor the original study. We did the same for middle education level, which was also not represented in the original study.

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