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Website interactivity and processing: Menu customization and sense of agency are keys to better interaction design

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ABSTRACT

Particulate matter (PM) pollution is a serious issue in Korea, but people are not actively engaged in preventive actions. Therefore, this study aimed to develop a PM website that includes interactive features where users can easily learn PM information; further, we aimed to explore the effects of website interactivity on behavioral intentions. We conducted an online experiment with four versions of a website with differs regarding the presence/absence of menu customization and highlighter options. Data from 100 participants in South Korea showed that menu customization was effective in increasing the users' sense of agency and their intentions to recommend the website, seek more PM information, and engage in the activities of the website owner. However, a highlighter tool was not a significant prompt for enhancing perceptual bandwidth and behavioral intentions. The findings of this study can contribute to the development of interactivity research and models and better website design.

1. Introduction

Particulate matter (PM) pollution has recently been identified as a serious environmental problem in Korea. The average concentration of PM_{10} (10μm) in the air in Korea increased from 47.7$\mu g/m^3$ in January 2018 to 57.5$\mu g/m^3$ in January 2019 (Hwang et al., 2019). For a better understanding of the figures, the level of PM_{10} concentration is divided into four conditions: 0–15 (good); 16–35 (normal); 36–75 (bad); and over 76 (very bad). In a recent study (Min, 2019), even though 87.2% of respondents felt uncomfortable about PM-induced problems, such as health deterioration and outdoor activity restrictions, only 55% wanted to solve it; more than half of the rest did not realize the seriousness of PM pollution. In order to raise awareness of the PM risk, the Korean government uses digital media for educational purposes (In, 2018; Kim, 2018), reflecting that more than half of Koreans use apps or websites rather than traditional media to obtain PM information (Min, 2019).

Digital media such as apps or websites enhance users' engagement by interacting with the system. For example, users can enter information about their living area or click a region on a map to get customized information. Currently, COVID-19 maps also apply these customizing features and visualize users' preferred information. In addition, users can ask questions and engage with chatbots on websites and choose their preferred mode of information presentation (visual and/or audiovisual) alongside the text. All these interactive features or affordances encourage users to effectively engage in health-related behaviors (Bol et al., 2019), feel autonomy in behaving that way (Sundar et al., 2015b; Ryan and Deci, 2000), and increase their amount of information recall (Nguyen et al., 2020).

Against this background, this study aims to examine the effects of media affordances on informational and behavioral intentions and the underlying mechanism in that process. Based on a theoretical framework regarding media interactivity, we designed an interface of a PM website that is managed by Health and New Media Research Institute in a university in South Korea. The findings with respect to the impacts of interactive website features on users' information processing and outcomes can contribute to developing interactive media theories and understanding users' needs for website design.

2. Theoretical framework

2.1. Theory of interactive media effects

The theory of interactivity media effects (TIME) describes how action possibilities on media (i.e., media affordance) affect knowledge,

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attitudes, and behavior (Sundar et al., 2015b). Media affordance allows users to expect doing certain actions (Norman, 1988), for example, an "X" button on the upper right corner of a website or document will have users expect to click to close the window (Sundar and Limperos, 2013). Also, the affordance (by itself) can work as a cue which directly triggers an action (cue route) or activates considerate processing by using the feature (action route) (Sundar et al., 2015b). Specifically, via the action route, users feel in control and their sensory perception is extended by clicking, dragging, and sliding actions on the website (Sundar et al., 2014), meaning that they go through the mediating process and engage in deeper message processing and behavioral intentions (Sundar et al., 2015b).

In the following sections, we explain different types of interactivity, including examples and effects of each type.

2.2. Source interactivity and its psychological and behavioral impacts

Source interactivity refers to "the degree to which the interface lets the user serve as the source of communication" (Sundar et al., 2015b, p. 56). Website affordances with high source interactivity provide interactive functions for users to control the communication with the system, for example, search boxes, customizable panels, and on/off options; these affordances help users to personalize or customize given information (Yang and Shen, 2018; Zhang and Sundar, 2019).

According to the TIME, customizable functions affect *sense of agency* (Sundar et al., 2015b), which is defined as "the state of being in action or of exerting power" (Nowak and Biocca, 2003, p. 483), as well as "the overall feeling of identity and control in an interface that allows a user to act as a source of information and action" (Sun and Sundar, 2016, p. 189). The more customizing functions or customizable options media have, the more the media user feels the self as a creator or a source (Stavrositu and Sundar, 2012; Sundar et al., 2012a). Indeed, the user's sense of agency increased when a news website has options to choose news topics (Lee and Park, 2007).

This sense of agency has also played a mediating role between media affordances and cognitive and behavioral outcomes (Sundar et al., 2015b). For example, affordances that show high source interactivity, such as likes, comments, and sharing functions on social media, let users sense their agency and, in turn, improve user engagement, positive attitudes, and behavioral intentions in desirable ways (Oh et al., 2018). In addition, a sense of agency increased by self-expressing functions enhanced users' engagement with the content (Zhang, 2015), positive attitudes toward the interface (Sundar et al., 2012b), and intentions to follow and recommend the advice in the message (Kang and Sundar, 2016).

Therefore, we applied the findings of previous studies to our PM context and expected source interactivity to have an effect on sense of agency and on several behavioral intentions through sense of agency as a mediating factor.

H1: Source interactivity on a website will increase sense of agency.

H2: Source interactivity on a website will increase the intentions to recommend the website (H2a), seek PM information (H2b), and get involved in the Institute's activities (H2c) through sense of agency as a mediating factor.

2.3. Modality interactivity and its psychological and behavioral impacts

Modality interactivity refers to the degree of interaction a user feels from a variety of modalities provided to enable the user to experience the website richly (Sundar, 2007; Sundar et al., 2010), for example, icons on smartphone and website screens (Shin et al., 2016) include online interactive actions such as clicking, scrolling, sliding, dragging, zooming in and out, and swiping (Choi et al., 2016; Oh et al., 2019; Sundar et al., 2014). Source interactivity is more focused on ways to tailor content by users' preferences, whereas modality interactivity refers to ways to present or consume the content (information).

Those actions, while using the media, increase the types and numbers of sensory channels, in other words, *perceptual bandwidth* is expanded (Reeves and Nass, 2000; Sundar et al., 2015b). In fact, perceptual bandwidth was enhanced when communicating with media that has a high degree of modality interactivity compared to an environment requiring users' passive actions (Oh and Sundar, 2015).

Enhanced perceptual bandwidth has been found to affect behavioral outcomes, meaning that perceptual bandwidth can act as a mediator between media affordances and outcomes. To be specific, because modality interactivity allows users to improve their perceptual skills such as vision and hearing, affordances with high modality interactivity are likely to make it easier for users to accept information (Sundar, 2007; Kettanurak et al., 2001). For example, the page-flipping feature on a webpage had effects on increasing perceptual bandwidth and, in turn, behavioral intentions to recommend and revisit the website (Oh et al., 2013).

Accordingly, we hypothesize about the effects of modality interactivity on perceptual bandwidth and on behavioral intentions through perceptual bandwidth as a mediating factor.

H3: Modality interactivity on a website will increase perceptual bandwidth.

H4: Modality interactivity on a website will increase the intentions to recommend the website (H4a), seek PM information (H4b), and get involved in the Institute's activities (H4c) through perceptual bandwidth as a mediating factor.

2.4. Interaction effects of source and modality interactivity

A website interface is designed with multiple interactivity functions, for example, saving the history of visits and customizing the searching country (i.e., source interactivity) as well as zooming in and out and switching to satellite view or street view on Google Maps (i.e., modality interactivity). The interactivity literature has also suggested that it would be useful to examine how those features work together on the user experience. Not only the number of interactivity functions (e.g., Sundar et al., 2016) but also a combination of different types of interactivity (e.g., modality and message interactivity in Dou, 2013) have been studied in interactivity research. However, empirical studies on the interaction effects of different interactivity types are nascent.

Therefore, this study inquires how the interaction of source and modality interactivity affects perceptual bandwidth and sense of agency, and in turn, behavioral intentions. Specifically, connecting with the hypotheses above, we ask whether modality interactivity can act as a moderator in the relationship between source interactivity, sense of agency, and intentions; and we also ask whether there is a moderating role of source interactivity between modality interactivity, perceptual bandwidth, and intentions.

RQ1: Will modality interactivity moderate the effect of source interactivity on sense of agency?

RQ2: Will source interactivity moderate the effect of modality interactivity on perceptual bandwidth?

RQ3: Will source interactivity have a conditional indirect effect on intentions to recommend the website (RQ3a), seek PM information (RQ3b), and get involved in the Institute's activities (RQ3c) through sense of agency, moderated by modality interactivity?

RQ4: Will modality interactivity have a conditional indirect effect on intentions to recommend the website (RQ4a), seek PM information (RQ4b), and get involved in the Institute's activities (RQ4c) through perceptual bandwidth, moderated by source interactivity?

The proposed model of this study, including the hypotheses and research questions, is presented in Fig. 1.

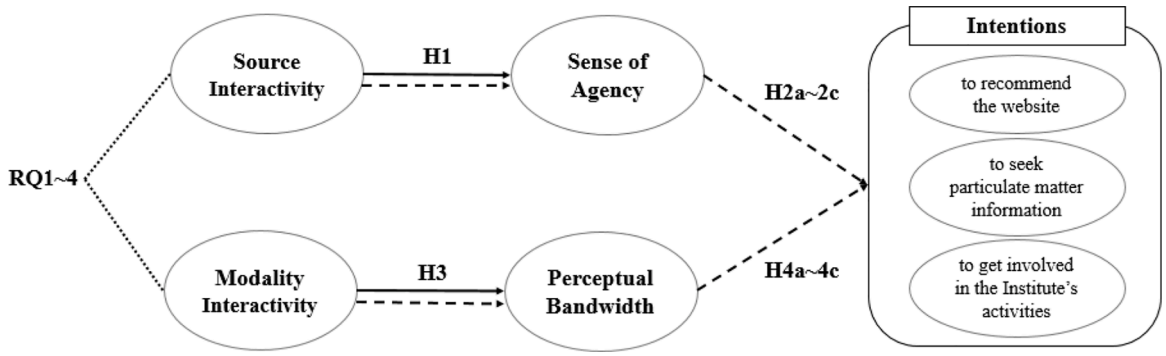

Fig. 1. The proposed model.
Note: Solid lines indicate direct effects, dashed lines indicate indirect effects, and dotted lines indicate interaction effects.

3. Method

3.1. Study design

A 2 (Source interactivity: low vs. high) × 2 (Modality interactivity: low vs. high) between-subject online experiment was conducted to test the hypotheses and research questions. Modality interactivity was operationalized as the absence/presence of a highlighter for marking what participants think is important while they read the given information on the website. Users can choose from a variety of ways of consuming information by adding this interactive tool, which has a similar function to zoom-in/out in terms of focusing on a specific piece of information or message. Source interactivity was operationalized as the absence/presence of menu customization where users can choose the type of information they want. This tool plays a role of customizing information; this process is consistent with the conceptualization of source interactivity (i.e., the possibilities of letting users feel that they are a source of information).

3.2. Participants and procedure

One hundred twenty participants were recruited for this study, which was approved by the intuitional review board at Hallym University (HIRB-2019–087), from a national survey company in Korea (Global Research). The company sent an invitation email to their research panel that included the URLs of the website for this online experiment and the survey questionnaire. Before starting the experiment, participants were asked to use a computer or a laptop to ensure the screen size was similar and to confirm whether the resolution and the screen size were both 100% even though we had already fixed the percentage on the system. The website for the experiment was compatible with all browsers (i.e., Internet Explorer, Google Chrome, Microsoft Edge, Naver Whale, Safari).

Participants signed a consent form and answered the pre-intervention questionnaire and were randomly assigned to one of four conditions. They were asked to browse a PM website, "Clean Air Network," read the given information, and fill out the rest of the survey questionnaire (the details are in the "measurement" section). After completing the 20–25-minute online experiment, participants received credits from the company worth about three dollars. A total of 100 participants (25 in each condition) were used in the analysis; 20 insincere responses (e.g., answering all questions with the same number) were removed. Females made up 52% of the sample, and the average age was 34.9 years (ranging from 19 to 49).

3.3. Stimuli

Four PM websites were constructed for this study, based on the original website of the Health and New Media Research Institute in South Korea. All websites included the same content and page layout.

The differences are the manipulation of source and modality interactivity: the presence of menu customization and the highlighter. In the control condition (i.e., low modality and low source interactivity condition), only scrolling is available for reading the information. In the high source interactivity condition (menu customization), the menu box is at the middle-right side of the website, and the instruction "Once you click on a type of information, you can see the accordant content" is at the top of the box. Participants could choose and click any of menu items that they wanted to read among six categories: 1) the definition of PM, 2) today's air quality index (i.e., PM level), 3) PM preventive actions, 4) information about PM protection masks, 5) PM news, and 6) PM-related campaigns. In the high modality interactivity condition, the highlighter icon and the instruction "When you click the button, you can use the function" were placed at the top right corner. In the beginning of the main text in the left text box, participants could see the instruction and task, "Try to learn about particulate matter as much as possible and use the highlighter to mark where you think it is important. You can scroll down the text."

Fig. 2 shows the four stimuli websites.

3.4. Measurement

All self-reported items except the relevance of PM prevention (Yes/No) and pre-existing attitudes toward PM were measured on a 7-point Likert-scale (1 = Strongly Disagree; 7 = Strongly Agree) (Table 1). The overall means and standard deviations are reported below.

3.4.1. Mediating variables

Perceptual bandwidth refers to users' initial evaluation of the website interface in terms of their perceptual and cognitive abilities in interacting with the website content delivered by the interface (Oh et al., 2018). Perceptual bandwidth was measured with three items that were also used in Oh et al. (2018) measures of interface assessment ("perceptual bandwidth" was renamed as "interface assessment" in the theory of interactive media effects), such as "The way that I used to control the changes on the website seemed natural" ($M = 4.74$, $SD = 1.14$, $\alpha = 0.88$).

Sense of agency is defined as the degree to which users' actions reflect their thoughts and control (Stavrositu and Sundar, 2012), and it was measured with six items from Sundar et al. (2015a). Sundar et al.'s sense of agency items are divided into two factors: sense of agency toward thoughts and life and sense of agency for voice and action. We selected and revised three items in each factor that fit our study such as "By using the website features, I felt I have a distinct voice" ($M = 4.60$, $SD = 1.05$, $\alpha = 0.93$). This measurement focuses on explicit agency judgements (see Haggard, 2017 for the difference between explicit and implicit measures of sense of agency).

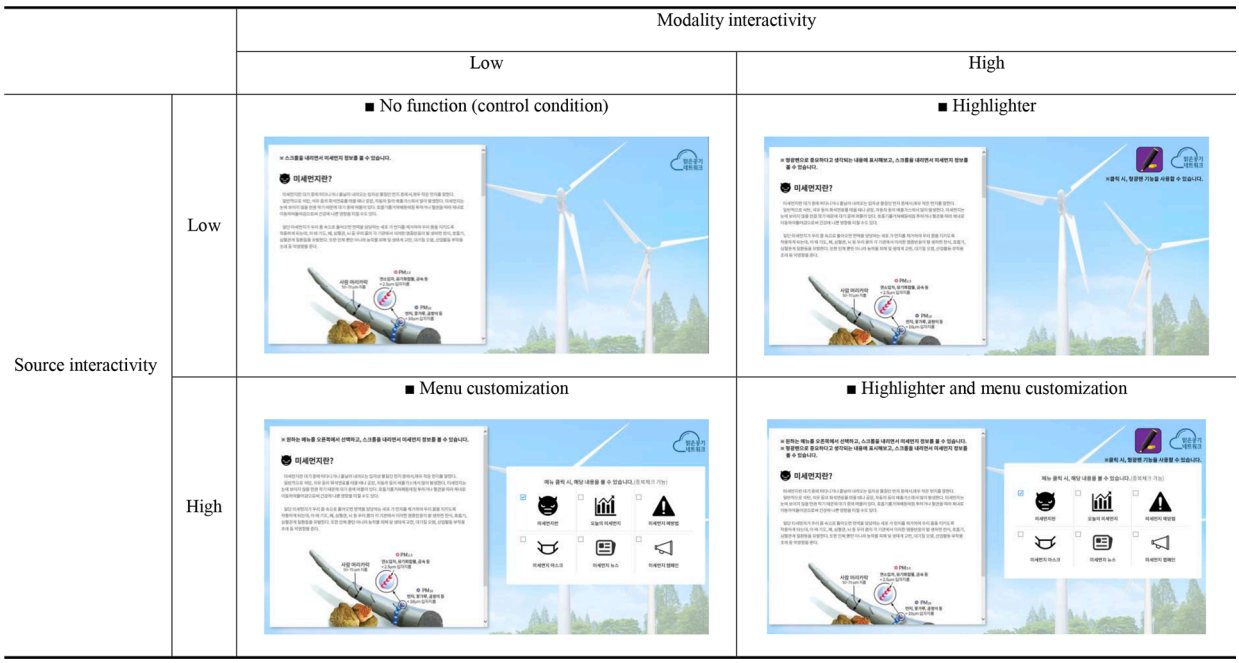

Fig. 2. Four stimuli websites.

3.4.2. Dependent variables

Recommendation intention is defined as the degree to which users want to share the information about the website with others. Therefore, we used the accordant two out of four items in Sundar et al. (2014) *behavioral intention toward the website* measures ($M = 4.52$, $SD = 1.32$, $r = 0.88$).

Seeking intention refers to the participants' intentions to seek more information about PM and was measured with five items from Kim et al. (2017), for example, "I will actively search for particulate matter information to prepare for problems" ($M = 5.05$, $SD = 1.14$, $\alpha = 0.95$).

Participation intention is defined as the willingness to engage in an event, campaign, or community organized by the Institute (Flowerree, 2017). Five items, such as "In the future, I will participate in the events organized by the Health and New Media Research Institute," were created for this study ($M = 4.42$, $SD = 1.25$, $\alpha = 0.95$).

3.4.3. Control variables

Three relevant factors were controlled to prevent confounding effects and examine clearer effects of interactivity.

First, participant's experience of wearing PM protection masks was controlled. From a previous study showing that influenza prevention experiences were related to preventive intentions (Mok et al., 2006), we expected that past PM prevention experiences can affect PM-related prevention intentions besides interactivity effects. Therefore, we asked about experience of PM protection masks (Yes: 91 [91%], No: 9 [9%]).

Second, the relevance of PM prevention to oneself was controlled. Since risk perception or concern of a disease affects positive attitudes toward disease prevention, intentions, and behavior to prevent the disease in the future (Abraham and Sheeran, 2005; Larson et al., 1982), its influential factor needed to be neutralized to explain the pure interactivity effects. The relevance of PM prevention was measured by one item (Haglund et al., 2007), "Particulate matter prevention is important for my health" ($M = 4.32$, $SD = 0.72$, Min = 2.00, Max = 5.00).

Third, pre-existing attitudes toward PM were controlled. A study indicated that AIDS education programs did not overcome nurses' pre-existing attitudes toward AIDS; compared to the nurses with pre-existing positive attitudes toward AIDS, those with pre-existing negative attitudes showed lower positive attitudes toward AIDS patients and care intentions even after the program (Kang, 2010). Therefore, pre-existing attitudes toward PM are expected to affect subsequent outcomes and needed to be controlled. The attitudes were measured with four items by asking participants how much they thought the particulate matter was harmful/harmless, unpleasant/pleasant, negative/positive, and unfavorable/favorable, which were selected from Oh and Sundar (2015) and Swanson et al. (2001). The items were measured on a 7-point bipolar scale ($M = 1.65$, $SD = 1.16$, $\alpha = 0.96$).

3.5. Data analysis

The average of all items was entered as a score of a variable in the analysis. Before the main analysis, we confirmed that the variances of groups for all variables were equal. However, some of the variables of interest, such as seeking intention and pre-attitude toward PM, were not normally distributed. Pre-attitude toward PM showed an extremely positive skewness, which was controlled for in the analysis. The study's limitation with regard to the normality can be found in the Discussion section.

All analyses were conducted by SPSS 22.0. First, an analysis of covariance (ANCOVA) was performed to examine the direct effects and interaction effects of source and modality interactivity on sense of agency and perceptual bandwidth (H1, H3, RQ1, and RQ2) controlling the relevant variables (i.e., PM protection mask experience, relevance of PM prevention, and pre-attitudes toward PM). Second, Model 4 and Model 7 in the PROCESS macro, plugged into SPSS, were employed in the analysis; Model 4 analyzes indirect effects of an independent variable on dependent variables, and Model 7 analyzes conditional indirect effects (Hayes, 2017). Therefore, we analyzed the indirect effect of source interactivity on intentions through sense of agency (H2), that of modality interactivity on intentions through perceptual bandwidth (H4), and conditional indirect effects of source and modality interactivity on intentions through the two mediators (RQ3 and RQ4).

4. Results

4.1. The direct effects of source and modality interactivity (H1 and H3)

H1 predicted that source interactivity would enhance sense of

Table 1
Descriptive data for key variables.

Variable	Measures	M	SD
Perceptual bandwidth	The way that I was able to control the changes on the website seemed natural.	4.52	1.25
	This website is easy to use.	4.91	1.31
	My interaction with the website was intuitive.	4.79	1.27
Sense of agency	By using the website features, ….		
	I felt I had control over my actions.	4.65	1.22
	I felt confident about asserting myself.	4.72	1.26
	I felt I had a distinct voice.	4.71	1.22
	I felt that I was able to cope with my problems.	4.51	1.24
	I felt that I was self-directed.	4.42	1.12
	I felt independent.	4.57	1.28
Recommendation intention	I would recommend this website to others in the future.	4.67	1.32
	I would forward this website to others in the future.	4.37	1.47
Seeking intention	I will actively search for particulate matter information to prepare for problems.	4.96	1.20
	I search for information about what I would have to do to prevent particulate matter.	5.13	1.24
	If particulate matter happens anywhere in my hometown, I am likely to search for information about it.	5.10	1.20
	I will actively act to obtain information on particulate matter.	4.98	1.28
	I will try to get information on particulate matter.	5.06	1.26
Participation intention	In the future, I will use or participate in…		
	services provided by the Health and New Media Research Institute (HNMRI).	4.65	1.29
	events organized by the HNMRI.	4.37	1.43
	campaigns organized by the HNMRI.	4.48	1.31
	the community organized by the HNMRI.	4.48	1.28
	environment-related funding conducted by the HNMRI.	4.14	1.54
Experience of wearing PM protection masks	Have you ever worn a KF80/94 mask to prevent particulate matter? (Yes/No)	1.09	0.29
The relevance of PM prevention	Particulate matter prevention is important for my health.	4.32	0.72
Pre-existing attitudes toward PM	Particulate matter is … to me.		
	harmful/harmless	1.64	1.28
	unpleasant/pleasant	1.73	1.27
	negative/positive	1.56	1.21
	unfavorable/favorable	1.66	1.14

agency. The result showed a significant direct effect of source interactivity on sense of agency, F (1, 93) = 12.67, $p < .01$, $\eta_p^2 = 0.12$. Participants who browsed the website with menu customization felt that they were acting as source ($M = 4.95$, $SD = 0.90$) more than those who browsed the website without the function ($M = 3.87$, $SD = 1.14$). Therefore, H1 was supported.

For H3 predicting that modality interactivity would enhance perceptual bandwidth, there was no significant effect. Thus, H3 was not supported.

4.2. The indirect effects of source and modality interactivity (H2 and H4)

We hypothesized that sense of agency would mediate the effects of source interactivity on recommendation (H2a), information-seeking (H2b), and participation (H2c) intentions. For the analysis, Baron and Kenny's (1986) mediation-analysis steps were used (see Table 2). First, the effect of independent variable on mediating variable should be significant; source interactivity positively affected sense of agency ($a = 0.70$, $p < .001$; Fig. 3). Second, the effect of independent variable on dependent variable should be significant; the effect of source interactivity on the recommendation intention was significant ($c = 0.54$, $p < .05$; Fig. 3). Lastly, the separate effects of independent variable and mediating variable on dependent variable are examined; the effect of sense of agency on the recommendation intention was significant ($b = 0.90$, $p < .001$; Fig. 3). When the mediating variable is included in the analysis, the effect of independent variable on dependent variable should be changed non-significantly (i.e., full mediation) or decrease (i.e., partial mediation); considering the mediating effect, the direct effect of source interactivity on the recommendation intention became non-significant ($c' = -0.09$, ns; Fig. 3). Finally, the bootstrapping results show that the indirect effect of source interactivity on recommendation intention through sense of agency was significant ($B = 0.63$, $SE = 0.21$, 95% CI: 0.25, 1.07), meaning that source interactivity (i.e., menu customization) enhanced sense of agency, which in turn increased the intention to recommend the website. The full mediation result indicates that H2a was supported.

The same approach was used for H2b and H2c (see the results of H2b in Table 3 and Fig. 4; the results of H2c in Table 4 and Fig. 5). Full mediation was found for H2b; the bootstrapping results showed that the mediating effect of source interactivity on information-seeking intention through sense of agency was significant ($B = 0.43$, $SE = 0.16$, 95% CI: 0.17, 0.78). The enhanced sense of agency from source interactivity (i.e., menu customization) had a positive impact on the intention to seek further PM information on the website. H2b was supported.

The results for H2c also show full and significant mediation; the indirect effect of source interactivity on participation intention through sense of agency was significant ($B = 0.65$, $SE = 0.21$, 95% CI: 0.24, 0.82), meaning that the enhanced sense of agency from source interactivity (i.e., menu customization) had a positive impact on the intention to get involved in the Institute's activities. Therefore, H2c was supported.

H4 is about the mediating effects of perceptual bandwidth between modality interactivity and recommendation (H4a), information-seeking (H4b), and participation (H4c) intentions. As a result, the indirect effects of modality interactivity on all three intentions were not significant, meaning that H4a, H4b, and H4c were not supported.

Table 2
Mediating effect of sense of agency between source interactivity and recommendation intention.

Predictor	Mediating variable: sense of agency			Dependent variable: recommendation intention			Dependent variable: recommendation intention		
	B	*SE*	*t*	*B*	*SE*	*t*	*B*	*SE*	*t*
Participant's experience of wearing PM protection masks	−0.05	.40	−0.12	0.02	.52	0.04	0.07	.38	0.18
The relevance of PM prevention to oneself	0.24	.19	1.25	0.18	.25	0.74	−0.03	.18	−0.16
Pre-existing attitudes toward PM	0.03	.11	0.25	0.06	.14	0.40	0.03	.10	0.32
Source interactivity	0.70**	.20	3.45	0.54*	.27	2.02	−0.09	.21	−0.45
Sense of agency							0.90**	.10	9.14

* $p < .05$.
** $p < .001$.

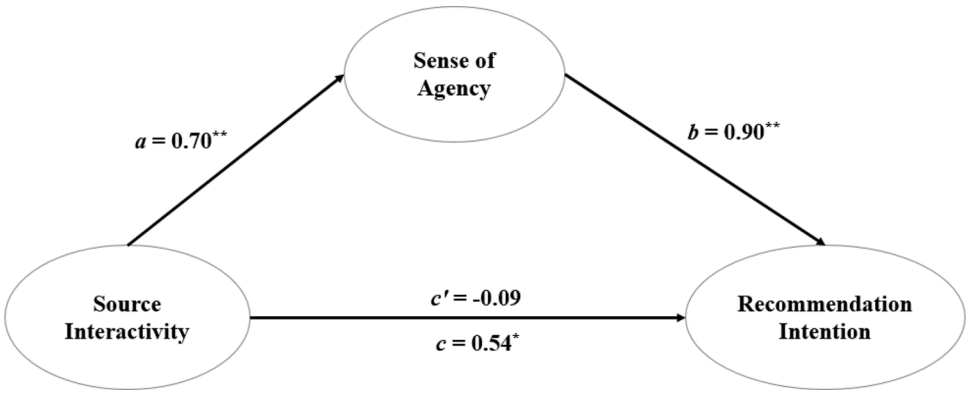

Fig. 3. Relationships between source interactivity, sense of agency, and recommendation intention.
***p* < .05. ****p* < .001.

Table 3
Mediating effect of sense of agency between source interactivity and information-seeking.

Predictor	Mediating variable: sense of agency			Dependent variable: information-seeking intention			Dependent variable: information-seeking intention		
	B	*SE*	*t*	*B*	*SE*	*t*	*B*	*SE*	*t*
Participant's experience of wearing PM protection masks	−0.05	.40	−0.12	−0.22	.42	−0.53	−0.19	.35	−0.56
The relevance of PM prevention to oneself	0.24	.19	1.25	0.30	.20	1.50	0.16	.17	0.94
Pre-existing attitudes toward PM	0.03	.11	0.25	−0.03	.12	−0.30	−0.05	.10	−0.54
Source interactivity	0.70**	.20	3.45	0.71*	.22	3.24	0.27	.19	1.43
Sense of agency							0.62**	.10	6.86

* $p < .05$.
** $p < .001$.

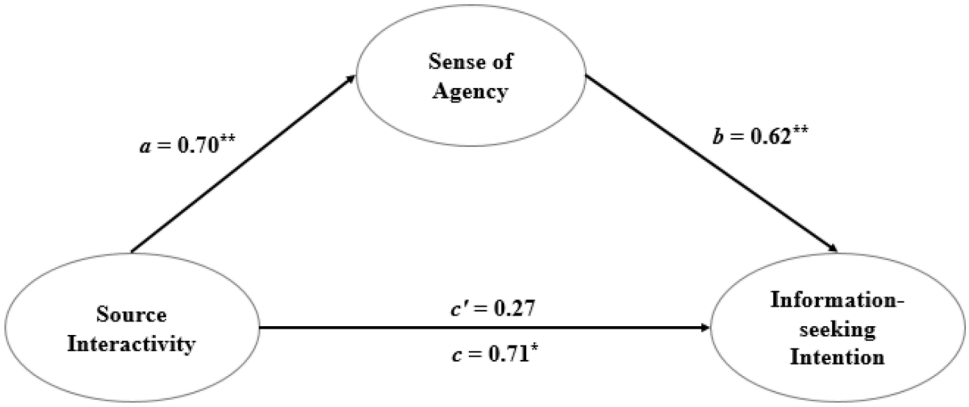

Fig. 4. Relationships between source interactivity, sense of agency, and information-seeking intention.
*$p < .05$. **$p < .001$.

Table 4
Mediating effect of sense of agency between source interactivity and participation intention.

Predictor	Mediating variable: Sense of agency			Dependent variable: Participation intention			Dependent variable: Participation intention		
	B	*SE*	*t*	*B*	*SE*	*t*	*B*	*SE*	*t*
Participant's experience of wearing PM protection masks	−0.05	.40	−0.12	−0.09	.49	−0.19	−0.05	.33	−0.14
The relevance of PM prevention to oneself	0.24	.19	1.25	0.19	.23	0.80	−0.03	.16	−0.19
Pre-existing attitudes toward PM	0.03	.11	0.25	0.09	.13	0.64	0.06	.10	0.68
Source interactivity	0.70**	.20	3.45	0.55*	.25	2.19	−0.10	.18	−0.54
Sense of agency							0.92**	.08	10.83

* $p < .05$.
** $p < .001$.

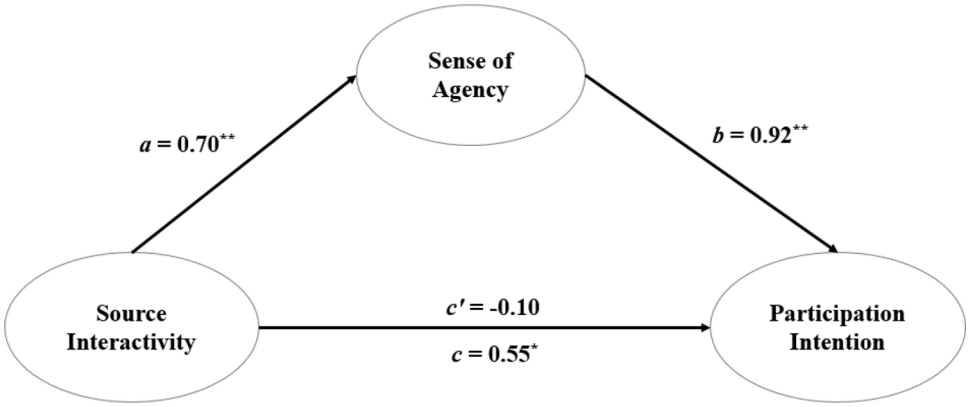

Fig. 5. Relationships between source interactivity, sense of agency, and participation intention.
*$p < .05$. **$p < .001$.

4.3. The interaction effects of source and modality interactivity (RQ1 and RQ2)

We examined the interaction effect of source interactivity and modality interactivity on sense of agency (RQ1), and the effect was significant, $F(1, 93) = 4.22$, $p < .05$, $\eta_p^2 = 0.04$. When source interactivity was low, high modality interactivity brought out a much stronger sense of agency ($M = 4.66$, $SE = 0.20$) compared to low modality interactivity ($M = 3.84$, $SE = 0.20$). However, there was almost no difference in sense of agency between high modality interactivity ($M = 4.96$, $SE = 0.20$) and low modality interactivity ($M = 4.94$, $SE = 0.20$) when source interactivity was high (see Fig. 6).

RQ2 was about the interaction effect of source and modality interactivity on perceptual bandwidth. The results showed that the interaction effect was not significant.

4.4. The conditional indirect effects of source and modality interactivity (RQ3 and RQ4)

We inquired how the combination of source and modality interactivity affects behavioral intentions through sense of agency and perceptual bandwidth respectively. More specifically, RQ3 is to ask whether modality interactivity moderates the indirect effect of source interactivity on intentions through sense of agency. The index of moderated mediation shows that the conditional indirect effects were significant on recommendation ($B = -0.71$, $SE = 0.37$, 95% CI: −1.49, −0.05), information-seeking ($B = -0.49$, $SE = 0.27$, 95% CI: −1.10, −0.03), and participation ($B = -0.73$, $SE = 0.37$, 95% CI: −1.52, −0.05) intentions.

Specifically, for RQ3a, when modality interactivity was low, the indirect effect of source interactivity on recommendation intention was

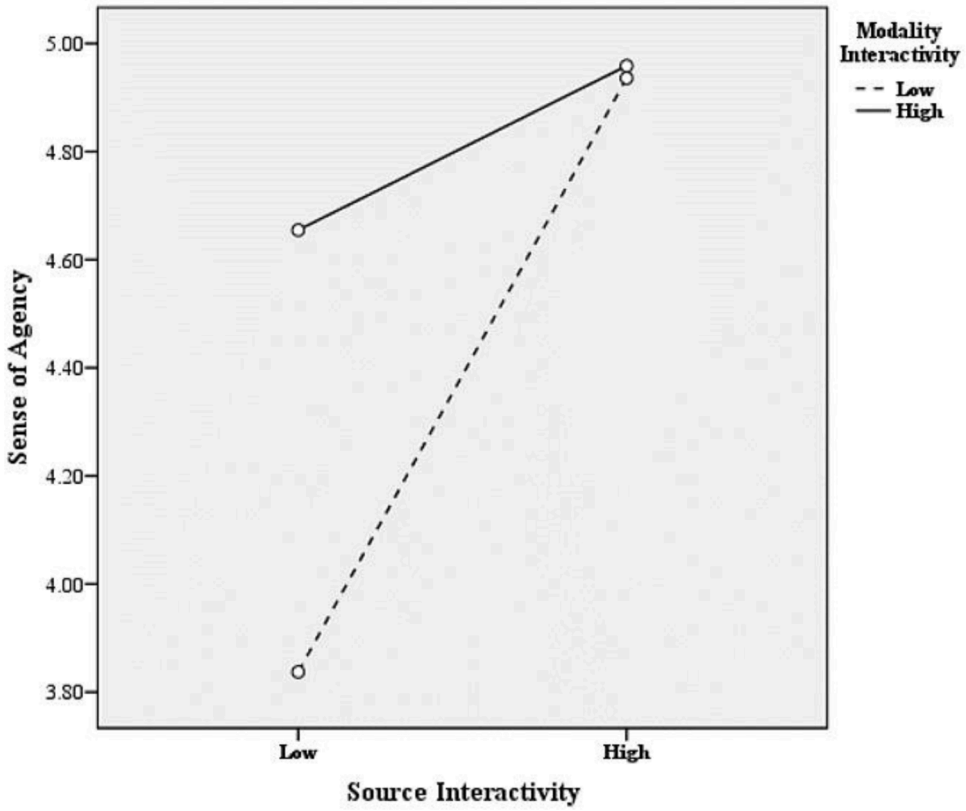

Fig. 6. The interaction effect of source and modality interactivity on sense of agency<Tables>.

significant ($B = 0.99$, $SE = 0.30$, 95% CI: 0.44, 1.62), whereas when modality interactivity was high, the indirect effect was not significant. The same pattern appeared for RQ3b and RQ3c: only when modality interactivity was low, the indirect effects of source interactivity on information-seeking intention ($B = 0.68$, $SE = 0.23$, 95% CI: 0.28, 1.20) and participation intention ($B = 1.01$, $SE = 0.30$, 95% CI: 0.46, 1.63) were significant.

RQ4 is to ask whether source interactivity works as a moderator in the relationship between modality interactivity and intentions through perceptual bandwidth. No significant conditional indirect effects on all intentions were found. In other words, the relationships of modality interactivity → perceptual bandwidth → recommendation (RQ4a), seeking (RQ4b) and participation (RQ4c) intentions were not different by the degree of source interactivity.

5. Discussion

This study designed a website to provide PM information and investigate the effects of different website interactivity types on user psychology and behavioral intentions. Specifically, source interactivity was operationalized as a menu customization, and modality interactivity as a highlighter. The study results can contribute to the development of interactivity research and the design of user-engaging websites regarding environmental risks.

First, the website with a customizable menu enhanced sense of agency and then behavioral intentions. Our finding that customized information or customizable options make users feel as a creator of websites is supported by previous research using the TIME (e.g., Sundar et al., 2015b; Stavrositu and Sundar, 2012). The method of information delivery on a website has been emphasized in terms of influencing user satisfaction and use of the information (Jun and Kang, 2013). For example, when "concise" and "relevant (needed)" information is provided, users are satisfied enough to use the website continuously (Szymanski and Hise, 2000). Likewise, the menu customization functioned to meet participants' informational needs, which was manipulable by themselves, and resulted in positive behavioral intentions. In addition, as stronger feelings of agency cause more engagement in the use of media (Oh et al., 2018), the willingness to display active behaviors, such as recommendation, information seeking, and participation in the website owner's activities, was increased by menu customization.

Contrary to our expectations and previous TIME research, the highlighter was not effective in expanding users' perceptual bandwidth and their subsequent behavioral intentions. The function of the highlighter may be the reason for this result; highlighting could be recognized to be an optional action when participants navigated the website, compared to other actions used for modality interactivity, such as clicking, scrolling, and sliding (e.g., Xu and Sundar, 2014; Wang and Sundar, 2018). As the number and frequency of sensory channels used is related to the degree of interactivity that users experience from the media (Reeves and Nass, 2000), participants might not have a chance to perceive interactivity or their use of sensory channels toward the highlighting function due to its low usage. Our insignificant result regarding the mediating role of perceptual bandwidth can also be explained by the relationship between the awareness of interactions with websites and the positive evaluation of websites (Oh et al., 2019). Participants might find it difficult to engage in follow-up behaviors regarding the website because they did not feel interactivity.

The results of the interaction effects between source interactivity and modality interactivity are interesting. First, this interaction had a significant effect on the sense of agency. Specifically, regardless of the presence of highlighter, sense of agency was enhanced when participants used the website with menu customization. This pattern was expected because functions inducing source interactivity have been known to elevate the sense of agency (Sundar et al., 2012b). However, even when the customizable menu was not present, sense of agency almost reached the highest level (i.e., menu customization and highlighter condition) when the highlighter was available. This finding suggests the possibility that modality interactivity is associated with sense of agency. We assume that the action of skimming the highlighted information could make the participants think that they were gaining the relevant information having agency. The significant interaction effects on sense of agency also helped to increase behavioral intentions, meaning that modality interactivity is a significant moderator in the source interactivity→sense of agency→intentions relationship.

On the other hand, source interactivity did not play a moderating role in either the direct effect of modality interactivity on perceptual bandwidth or its indirect effects on intentions through perceptual bandwidth. Those results are similar to the insignificant relationship between modality interactivity and perceptual bandwidth as mentioned above. If the reason why highlighter did not work as a modality interactivity inducing feature is identified, the relationship can be also explained.

5.1. Theoretical and practical implications

First, we used new examples of source and modality interactivity and added empirical evidence in interactivity research (especially using the TIME). Although our results show the insignificant effects of the highlighter as well as the significant effects of menu customization, both findings would be useful for guiding further research.

Second, we confirmed that a psychological variable, sense of agency, is important in the processing of user actions on website interactivity features. Our findings not only validate that sense of agency is a link between affordances and outcomes, suggested by the TIME, but also emphasize that the website features, which let users feel their control of the interface and information, should be considered when designing environmental and health websites.

Last, the examination of the interaction effects of different types of interactivity is nascent. This study has theoretical contributions in developing the TIME. In addition to the results regarding the practical assistance that multiple types of interactivity can provide to increase users' feeling as a source, we suggest that this line of research be used for future interactivity research.

5.2. Limitations and suggestions for future research

A few limitations found in this study can improve related future research. First, an instructional manipulation check can show more clear effects of source and modality interactivity by checking whether participants used our manipulated website functions. Similarly, if tracking users' traces of clicking (on the menu) and highlighting of text is available, richer results can be achieved. Therefore, we suggest a record of user activities during their web-browsing for future research.

Second, some of our variables (intention and pre-attitude toward PM) were not normally distributed. In particular, seeking intention was negatively skewed ($M = 5.05$) and pre-PM attitude was positively skewed ($M = 1.65$) even though attitude was controlled for. As such, participants' high concern and interest of PM reflects the current situation of air pollution in Korea. Nevertheless, the degree of asymmetry in the distribution could be resolved by increasing the sample size and giving tail weight in future research (Micceri, 1989).

Lastly, this study focused on the *action route* in the TIME, but the other route, *cue route*, is worthwhile examining. As media affordance may also lead to users' media use intention through heuristic processing (Sundar, 2008), our insignificant results regarding the highlighter in cognitive processing can be considered with a different perspective: the highlighter working as a heuristic cue.

CRediT authorship contribution statement

Jisoo Ahn: Conceptualization, Methodology, Investigation, Writing - review & editing, Supervision. **Jeong-Min Park:** Conceptualization,

Investigation, Formal analysis, Writing - original draft. **Won-Ho Lee:** Conceptualization, Formal analysis, Writing - original draft. **Ghee-Young Noh:** Supervision, Project administration, Funding acquisition.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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