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Using a serious game to communicate risk and minimize psychological distance regarding environmental pollution

Jesse Fox[a], Jessica McKnight[a], Yilu Sun[b], David Maung[c], Roger Crawfis[d]

[a] School of Communication, 3016 Derby Hall, 154 North Oval Mall, Columbus, OH 43210-1339, United States
[b] Virtual Embodiment Lab, Cornell University, 227 Snyder Hill Rd., Ithaca, NY 14850, United States
[c] Battelle, 505 King Ave., Columbus, OH 43201, United States
[d] Department of Computer Science and Engineering, 2015 Neil Ave., Columbus, OH 43210-1234, United States

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ABSTRACT

Persuading individuals to engage in pro-environmental behavior is challenging. Interactive media, such as virtual environments and video games, present opportunities to minimize psychological distance and bolster perceived risks associated with environmental threats. In this experiment, we tested the effects of a serious game that allowed users to engage in environmental cleanup. In the virtual environment, participants ($N = 190$) navigated down a polluted river that was described as geographically and temporally close or distant. The affordance of interactivity, specifically contingency, was also manipulated. Results revealed that feeling psychologically close to the environment led to greater risk perception, which in turn led to more environmental behavior and greater support for environmental policy in the days following the experiment. In terms of interactivity, higher perceptions of contingency led to greater self-efficacy, which also led to more environmental behavior and greater support for environmental policy after the experiment. We discuss implications for environmental communication, science communication, and other prosocial persuasion efforts using interactive media such as serious games and virtual reality.

1. Introduction

Despite the fact that environmental pollution is globally relevant and has potentially catastrophic consequences for humanity, many individuals do not see it as an imminent threat. Although the majority of U.S. adults believe that humans are causing environmental problems, they do not necessarily take action or prioritize environmental issues above other political issues (Leiserowitz et al., 2017). One explanation for this disconnect is *psychological distance*. When we do not have direct experience with something or feel it is not immediately relevant to the self, we perceive it more abstractly (Trope and Liberman, 2010). In the environmental domain, this psychological distance can make individuals view environmental issues as less urgent, feel less personal responsibility for these issues, and believe that their pro-environmental efforts will have little effect (McDonald et al., 2015; Spence et al., 2012; Weber, 2006).

Given the majority of people are aware of environmental threats, promoting environmentally friendly behavior may no longer be an issue of *what* information is being delivered but rather *how* it is being delivered. *Affordances* are properties of an object that enable specific actions by a user (Gibson, 1979). Affordances, and specifically how people perceive and experience these affordances, explain

E-mail addresses: fox.775@osu.edu (J. Fox), mcknight.153@osu.edu (J. McKnight), ys767@cornell.edu (Y. Sun), maungd@battelle.org (D. Maung), crawfis.3@osu.edu (R. Crawfis).

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why various media produce different effects (Fox and McEwan, 2017). Interactive digital technologies have many affordances that are distinct from channels such as face-to-face interaction, print media, and television (Bucy and Tao, 2007; Street and Rimal, 1997). For example, interactive media require users to engage with the message rather than passively consuming it, promoting involvement, learning, and discovery (Klimmt, 2009; Liu and Shrum, 2002).

Interactive digital media have shown potential for education and environmental communication campaigns designed to inform the public about environmental issues. Several virtual environments (VEs), digital simulations, and video games have been developed for topics such as climate change, resource management and conservation, recycling, and sustainable development (see reviews by Katsaliaki and Mustafee, 2015; Reckien and Eisenack, 2013; Wu and Lee, 2015). For example, mobile games have been shown to raise awareness and motivation about household energy efficiency (Gustafsson et al., 2009; Yam et al., 2017) and even reduce energy consumption (Orland et al., 2014; Reeves et al., 2015).

Because VEs can provide vivid, interactive, immersive experiences and can portray any number of behaviors and outcomes, they may be ideal for risk communication. Specifically, their affordances may provide new methods for reducing psychological distance and encouraging prosocial behaviors that may not provide immediate rewards. In this study, we examined this potential. We also investigated the role of a key affordance, interactivity. Our goal was to determine how a VE may increase perceptions of risk, self-efficacy, behavior, and policy support in the environmental domain.

2. Literature review

2.1. VEs, simulations, and serious games in environmental communication

Virtual environments are digitally rendered spaces characterized by layers of sensory information. VEs try to make individuals feel they are within the virtual space rather than in the physical world, leading to feelings of presence and immersion (Lombard and Ditton, 1997). Video games with vividly rendered settings are considered VEs. *Serious games* are designed for purposes beyond mere entertainment, including game-based learning and persuading users to perform prosocial behaviors (Klimmt, 2009; Ritterfeld et al., 2009). Recent analyses have found that serious games and educational simulations can influence users' beliefs, affect, and behavior (Katsaliaki and Mustafee, 2015; Lamb et al., 2018).

Several scholars have offered guidelines for designing effective environmental communication. VEs and serious games can meet these criteria. One frequent theme is that message creators should use visuals to improve science communication (e.g., O'Neill and Smith, 2014; Sheppard, 2012; Stephens et al., 2014). Images are more vivid, more emotionally engaging, more efficient at conveying information, and easier to remember (see King, 2015, for a review). Images may also facilitate comprehension for people with language or cognitive difficulties (O'Neill and Smith, 2014).

A second theme for improving environmental communication is to make it more engaging (Moser, 2016; Stephens et al., 2014; Van der Linden et al., 2015). Interactivity requires user engagement (Bucy and Tao, 2007; Liu and Shrum, 2002). VEs offer high levels of interactivity, as users can navigate within the space, choose among various tasks, and experience a variety of possible outcomes based on their decisions. Because VEs often feature vivid surroundings and sensory cues, users feel immersed in the environment. They become so engaged in the virtual world that they feel that they are "there" rather than "here" in the physical world (Lombard and Ditton, 1997).

Engagement may also emerge from within. Van der Linden et al. (2015) suggest that tapping into individuals' personal, intrinsic motivations may improve environmental communication outcomes. Interactivity is intrinsically engaging for users (Liu and Shrum, 2002). Further, VEs and games are often described as intrinsically motivating, as they are designed to be enjoyable and offer users opportunities to master tasks and achieve rewards (Dindar, 2018; Klimmt, 2009). Such intrinsic motivations may promote engagement with environmentally focused VEs as well (Wu and Lee, 2015).

Finally, a third prominent theme for more effective environmental communication is the necessity of tailoring a message and making it more relevant to the individual (Bostrom et al., 2013; Moser, 2016; Van der Linden et al., 2015). Traditional mass media messages such as news stories and advertisements can be targeted to certain groups, but it is difficult to tailor them to a specific person (Bostrom et al., 2013). In a VE, each person's actions shape how the world responds, creating a customized experience.

Personal experience has been associated with greater belief in climate change and more support for environmental issues (McDonald et al., 2015; Weber, 2006). As Van der Linden et al. (2015) note, personal experience is often more persuasive than knowledge in promoting environmentalism. Given that it is difficult to offer people firsthand experience with many environmental issues, realistic VEs may offer the best alternative. Rather than reading a text description or viewing a graphic, users *experience* a VE: they personally enact, rather than simply observe, the outcome (Peng, 2008; Wu and Lee, 2015). For example, Ahn and colleagues (2015) placed users in a peaceful virtual forest. With a specially shaped controller, users physically pushed and pulled a virtual water pump to nurture a seedling that sprouted and grew with their efforts. Such experiences can give people a feeling of success and mastery, boosting their *self-efficacy*, or beliefs that they are capable of performing a behavior (Bandura, 1986; Peng, 2008).

In summary, VEs offer many advantages over other media due to their affordances. Indeed, VEs have been shown to be more persuasive than noninteractive methods such as watching video or reading a text-based description (Ahn et al., 2014; Peng et al., 2010; Ritterfeld et al., 2009). VEs deliver rich information that may enhance learning and other persuasive outcomes; they promote engagement and enjoyment; and they provide relevant, tailored experiences for users. Their affordances make VEs optimal for minimizing psychological distance (Ahn, 2015).

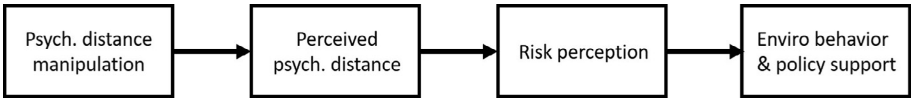

Fig. 1. The serial mediation model for the effects of the psychological distance manipulation (H1–H4).

2.2. Psychological distance and risk perception

Construal level theory suggests that people have different perceptions of events and objects depending on their self-relevance and likelihood. Things that are considered psychologically distant are perceived as more abstract; things that are considered more close are perceived more concretely (Liberman and Trope, 1998; Trope and Liberman, 2010). Four types of psychological distance have been clarified: *temporal distance*, or whether an event seems recent or far in the future or past; *spatial distance*, or whether an environment seems geographically near or far; *social distance*, which considers whether something is happening to the self or similar others as opposed to other, dissimilar people; and *probability distance*, which considers whether something is likely or unlikely to occur (Trope and Liberman, 2010).

Many environmental threats are perceived as psychologically distant (McDonald et al., 2015; Spence et al., 2012; Weber, 2006). Threats such as climate change or pollution are often framed as affecting people decades or centuries in the future, promoting feelings of temporal distance. Currently observable effects, such as melting ice caps, affect places that are geographically distant for many people. This psychological distance diminishes perceptions of risk (Jones et al., 2017; Spence et al., 2012; Van der Linden, 2017).

Given the claims of construal level theory and previous research on environmental threats, we anticipate that participants who experience a geographically and temporally close environment will experience lower psychological distance than participants who experience a distant environment (H1). In turn, lower psychological distance should yield greater perceptions of environmental risk (H2). Higher perceptions of risk and environmental threat are associated with support for environmental policy and engaging in more environmentally friendly behaviors (Van der Linden, 2017). Thus, we anticipate that experiencing a close environment (as opposed to a distant environment) should lead to lower psychological distance and in turn higher perceptions of risk, which should lead to more environmental behavior (H3) and policy support (H4). Please see Fig. 1 for an illustration of the model.

2.3. VE affordances and psychological distance

Although some studies have found that interactive media promote better outcomes than traditional media (e.g., Ahn et al., 2014; Peng et al., 2010; Ritterfeld et al., 2009), it is still not clear why these channels are superior. In reviews of the literature, scholars have noted that few studies have systematically tested the affordances and elements that may determine whether VEs and serious games are successful in promoting desired outcomes (Boyle et al., 2016; Wilson et al., 2009). Some studies have started to shed light on the important role of affordances in VEs and serious games (e.g., Chittaro and Sioni, 2015). Investigating such variables is also important to understanding the effectiveness of psychological distance manipulations, as limited research has explored how such messages are experienced in interactive environments.

A fundamental part of interactivity is *contingency*, or how the two-way communication between the user and the environment corresponds and builds upon itself (Liu and Shrum, 2002; Sundar et al., 2016). Users of interactive media enact behaviors and observe how the system responds and what outcomes occur. Users expect that a system's response will be contingent upon their behavior rather than some automatic or pre-established course of action (Liu and Shrum, 2002; Sundar et al., 2016).

Contingency has also been shown to be a key motivator for environmentally friendly behavior, as individuals must believe their actions have an impact (Moser, 2016; Schultz and Kaiser, 2012). Thus, Schultz and Kaiser suggest that to promote environmental behaviors, persuasive environmental messages should focus on contexts in which individual impact can be directly observed, particularly given it may be difficult to observe one's impact in the physical world in real time. Within a serious game, allowing users to practice and connecting users' actions to their impact should persuade users that they are capable of performing similar behaviors and making a difference in the environment (Peng, 2008).

Indeed, such self-efficacy is key to understanding whether a behavior modeled in a media message—in this case, environmental behavior in a serious game—will be imitated and performed in the physical world (Bandura, 1986). We expect contingency to impact self-efficacy for two reasons. First, observing the effects of one's environmental behaviors promotes higher self-efficacy (Stern, 2000). Second, the interactivity of a serious game has been shown to increase self-efficacy for performing prosocial behaviors outside of the game (Peng, 2008). Thus, we expect that participants whose actions are shown having an impact on the environment in the contingent condition will report more self-efficacy than those in the non-contingent condition, whose actions are shown having no impact on the environment (H5).

Studies often employ experimental manipulations of interactivity to study its effects, but scholars have argued that it is also necessary to measure user perceptions of interactivity (Lee et al., 2006; Weber et al., 2014), as perceived interactivity is a better predictor than structural interactivity (Wu, 2005). Specifically, Bucy and Tao (2007) argued that perceived interactivity should be treated as a mediator when examining the effects of interactive media. Thus, we hypothesized that perceived interactivity will mediate the relationship between the contingency manipulation and self-efficacy (H6).

Self-efficacy is considered a key predictor of behavior (Bandura, 1986), and previous research has linked environmental self-efficacy with pro-environmental behavior and policy support (Ahn et al., 2015; Hines et al., 1987; Stern, 2000). As such, we expect

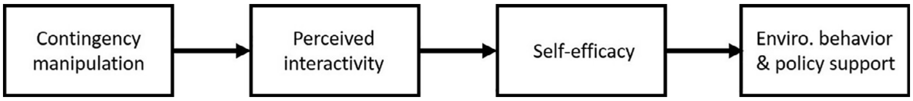

Fig. 2. The serial mediation model for the effects of the contingency manipulation (H5–H8).

that higher levels of self-efficacy produced by contingency will predict subsequent environmental behavior and policy support. Holistically, we expect that experiencing a contingent environment (as opposed to a non-contingent environment) should lead to higher perceptions of interactivity and in turn self-efficacy, which should predict more environmental behavior (H7) and greater policy support (H8). Please see Fig. 2 for an illustration of the model.

3. Method

3.1. Sample

Participants were recruited from the participant pool of a large Midwestern university in exchange for course credit. For inclusion in the analyses, participants had to attend the experimental session and complete an online post-test within one week. Twenty-four participants were dropped, predominantly due to technological issues (most frequently, participants accidentally pressed a button that terminated the game due to the original placement of controls.) The final sample ($N = 190$) included 78 men and 112 women aged 18–34 ($M_{age} = 20.25$, $SD = 2.41$). Participants identified as 77.9% Caucasian/European-American/White; 10% Asian/Asian-American; 6.3% Black/African/African-American; 3.2% other; and 2.6% multiracial.

3.2. Procedure

All study procedures were approved by the university's Institutional Review Board. Upon arrival at the lab, participants were randomly assigned to one of four conditions: near contingent ($n = 50$), far contingent ($n = 46$), near non-contingent ($n = 46$), or far non-contingent ($n = 48$). Participants were seated at a desktop computer with stereo speakers.

The game was built specifically for the purposes of this study by modifying an existing game developed in Unity, *Recovery Rapids* (2019). The game was designed as a single level with simple controls so that users would be able to learn the game quickly regardless of their experience playing video games. Although the study used an adult sample, playtesting included children as young as eight years old, who were able to master the controls and complete game tasks.

In the game, participants used keypresses on a traditional keyboard to guide their avatar in a kayak down a river surrounded by a forest-like 3D environment. Sounds of nature such as flowing water and chirping birds were audible. The river had bends and minor obstacles such as rocks for the participant to navigate. To isolate the effects of the manipulations and ensure participants would notice any changes in the surrounding environment, there was no scoreboard visible in the interface. Rather than using a countdown clock that might distract or pressure participants, the game was programmed to end automatically after 10 minutes of gameplay.

In the far conditions, the river was located in a state over 2000 miles away, and participants were told that the conditions reflected what the river would look like in 30 years due to pollution and illegal dumping. In the near conditions, the river was one of the local rivers that flowed through the city in which the study was taking place, and participants were told that the conditions reflected what the river would look like in 5 years.

At the beginning of the game, the river was discolored and the surrounding scenery was desolate and brown. The kayak floated down the river at a steady pace. Participants were given the opportunity to observe the scenery and get used to navigating the controls in the first minute of gameplay. Then, trash such as garbage bags and empty cardboard boxes began appearing in the water. Participants used keypresses to navigate toward the trash and retrieve it from the river. In the contingent conditions, the environment changed based on the participant's actions (i.e., effectively cleaning up trash). In the non-contingent conditions, the environment changed automatically. As the environment changed, the river became clear, the surrounding foliage greened, and wildlife began to appear. This design was selected so that positive change was held constant across conditions and differences could be attributed to contingency rather than differences in outcomes. Importantly, all participants in the contingency conditions retrieved enough trash so that the environment had fully transformed by the end of the game.

The next day, participants were emailed a link to the online post-test. Participants were given one week to complete the survey.

3.3. Measures

3.3.1. Psychological distance

Following Van Boven et al. (2010), psychological distance was measured with four 7-point semantic differential items, including "The river in the virtual environment feels near/distant" and "The river in the virtual environment feels very close/very far away" ($M = 3.07$, $SD = 1.11$). Reliability for the measure was Cronbach's $\alpha = 0.73$.

3.3.2. Interactivity

The Video Game Interactivity Scale (Weber et al., 2014) is a modular measure designed to assess various aspects of game interactivity, including manipulating features (e.g., music or sound effects), customization (e.g., customizing one's avatar or its characteristics), and game controls. We used a modified version of the artificial intelligence subscale as it was best suited to assess contingency. Two items were dropped because they were not relevant to the game. Participants responded to the four relevant items on a 7-point scale (1 = *Strongly disagree*; 7 = *Strongly agree*) including "The environment responded intelligently," and "The environment changed based on my actions within it" ($M = 5.33$, $SD = 1.26$; Cronbach's $\alpha = 0.87$).

3.3.3. Risk perception

To assess participants' perceptions of risk regarding the environment, we used the environmental threat subscale of the Environmental Attitudes Inventory (Milfont and Duckitt, 2010). Participants responded to 10 items on a 7-point scale (1 = *Strongly disagree*; 7 = *Strongly agree*) including "The idea that the balance of nature is terribly delicate and easily upset is much too pessimistic" (reverse-coded) and "If things continue on their present course, we will soon experience a major ecological catastrophe" ($M = 5.52$, $SD = 0.94$; Cronbach's $\alpha = 0.91$).

3.3.4. Environmental self-efficacy

To measure environmental self-efficacy and behavior, we collected items from existing research (e.g., Kaiser, 1998). A face validity check, however, identified some issues applying existing measures to the population tested in this study, namely college students. Several items were also dated (e.g., getting milk in reusable bottles) so we also generated some new items reflecting modern behaviors (e.g., using social media). We pretested items with a sample of college students ($N = 65$) separate from the participants in this study to determine which behaviors were feasible. For example, buying and installing environmentally friendly products like a low-flow showerhead was determined to be not feasible, likely because students may not have control over such installation (e.g., if they live in a dorm or are under specific terms of a rental agreement) or because they may not be able to afford to purchase such items. This process yielded 10 behaviors which can be viewed in the Appendix. Participants indicated on a fully-labeled 5-point scale (1 = *Not at all*; 5 = *Very much so*) the degree to which they felt they were able to perform these behaviors ($M = 3.70$, $SD = 0.83$; Cronbach's $\alpha = 0.89$).

3.3.5. Time 2 environmental policy support

To gauge support for pro-environmental policy, participants were asked to indicate how much they would support legislative action regarding 10 environmental issues on a fully-labeled 5-point scale (1 = *Not at all*; 5 = *Very much so*). Actions included "to clean up pollution in the environment," "to require corporations and businesses to cut back on the amount of waste they generate," and "to ban plastic shopping bags" ($M = 3.99$, $SD = 0.69$; Cronbach's $\alpha = 0.89$).

3.3.6. Time 2 environmental behaviors

At Time 2, we asked participants how frequently they had engaged in the ten behaviors described in the self-efficacy measure since participating in the experiment (1 = *Never*; 5 = *Frequently*; $M = 2.70$, $SD = 0.89$; Cronbach's $\alpha = 0.87$).

4. Results

For analyses, the near condition was coded as 0, and far was coded as 1. Non-contingent conditions were coded as 0, and contingent conditions were coded as 1. Correlations offered preliminary support for the hypothesized relationships between variables; see Table 1.

To test the proposed models, serial mediation analyses were conducted using model 6 from the PROCESS macro for SPSS (Hayes, 2013). The first set of models addressed hypotheses H1-H4 regarding the role of psychological distance. The first model examined a serial mediation from the distance manipulation to psychological distance to self-efficacy to behavior. Please see Table 2 for values for all paths. Supporting H1, the manipulation predicted psychological distance: participants in the close condition reported less psychological distance than those in the far condition. Lower psychological distance predicted greater threat, supporting H2. Greater threat in turn predicted environmental behavior at Time 2, supporting H3. Examining the model holistically, the bias-corrected bootstrap 95% confidence interval for the indirect effect (−0.028) based on 5000 samples did not include zero (−0.069 to −0.004),

Table 1
Correlations among variables.

	1	2	3	4	5	6	7	8
1. Near/Far	–	−0.03	0.17*	−0.05	−0.06	−0.08	0.06	−0.09
2. Contingent/Not		–	0.05	0.37***	0.07	0.08	0.00	0.12
3. Psych. distance			–	−0.23**	−0.31***	−0.34***	−0.23***	−0.38***
4. Interactivity				–	0.18*	0.29***	0.12	0.21**
5. Perceived risk					–	0.46***	0.34***	0.55***
6. Self-efficacy						–	0.54***	0.56***
7. Behavior							–	0.53***
8. Policy support								–

*p ≤ 0.05, **p ≤ 0.01, ***p ≤ 0.001.

Table 2
Regression coefficients, standard errors, and model summary information for distance models.

	M_1 Psychological distance		
Antecedent	Coefficient	*SE*	*p*
X (Distance manip.: Near/Far)	0.38	0.16	0.018
Constant	2.89	0.11	< 0.001
	$R^2 = 0.03$, $F(1, 188) = 5.68$, $p = .018$		
	M_2 Perceived risk		
Antecedent	Coefficient	*SE*	*p*
X (Distance manip.: Near/Far)	−0.01	0.13	0.953
M_1 (Psychological distance)	−0.26	0.06	< 0.001
Constant	6.33	0.20	< 0.001
	$R^2 = 0.10$, $F(2, 187) = 10.09$, $p < .001$		
	Y Time 2 Environmental behavior		
Antecedent	Coefficient	*SE*	*p*
X (Distance manip.: Near/Far)	0.19	0.12	0.118
M_1 (Psychological distance)	−0.13	0.06	0.029
M_2 (Perceived risk)	0.28	0.07	< 0.001
Constant	1.47	0.46	< 0.001
	$R^2 = 0.14$, $F(3, 186) = 10.35$, $p < .001$		
	Y Time 2 Policy Support		
Antecedent	Coefficient	*SE*	*p*
X (Distance manip.: Near/Far)	−0.04	0.08	0.676
M_1 (Psychological distance)	−0.14	0.04	< 0.001
M_2 (Perceived risk)	0.35	0.05	< 0.001
Constant	2.50	0.31	< 0.001
	$R^2 = 0.35$, $F(3, 186) = 32.91$, $p < .001$		

indicating support for the serial mediation. The bias-corrected bootstrap 95% confidence interval for the direct effect based on 5000 samples was not significant ($p = .118$, 95% CI −0.049, 0.431).

The second analysis examined the same predictors with Time 2 policy support as the outcome (H4); see Table 2. The bias-corrected bootstrap 95% confidence interval for the indirect effect (−0.04) based on 5000 samples did not include zero (−0.079 to −0.004), indicating support for the serial mediation. The bias-corrected bootstrap 95% confidence interval for the direct effect based on 5000 samples was not significant ($p = .676$, 95% CI −0.198, 0.129).

The second set of hypotheses (H5–H8) examined the role of interactivity, specifically contingency. Again, model 6 was employed to examine the proposed serial mediation; results for all paths can be seen in Table 3. Supporting H5, the contingent condition produced greater perceptions of risk than the non-contingent condition. As predicted by H6, the path to self-efficacy was mediated by users' perceptions of interactivity. Self-efficacy, in turn, predicted environmental behaviors at Time 2, supporting H7. Supporting the serial mediation model, the bias-corrected bootstrap 95% confidence interval for the indirect effect (0.11) did not include zero (0.049 to 0.189). The bias-corrected bootstrap 95% confidence interval for the direct effect (–0.07) based on 5000 samples was not significant ($p = .56$, 95% CI −0.30, 0.163).

The final analysis examined the same set of predictors with policy support at Time 2 as the outcome (H8). See Table 3. Supporting the serial mediation model, the bias-corrected bootstrap 95% confidence interval for the indirect effect (0.08) did not include zero (0.036 to 0.148). The bias-corrected bootstrap 95% confidence interval for the direct effect (0.09) was not significant ($p = .297$, 95% CI −0.083, 0.27).

5. Discussion

5.1. Review of findings and contributions

This study examined how manipulations of psychological distance and interactivity within a VE about cleaning up a polluted river influenced perceptions of environmental risk, self-efficacy, behavior, and policy endorsement. Variations in the game yielded different outcomes as predicted.

Consistent with the implications of construal level theory (Trope and Liberman, 2010), experiencing a geographically and temporally close river yielded more positive environmental outcomes than experiencing a distant river. When participants felt closer to the portrayed environment (i.e., when psychological distance was smaller), they perceived a greater threat to the environment. Our

Table 3
Regression coefficients, standard errors, and model summary information for contingency models.

	M_1 Interactivity		
Antecedent	Coefficient	*SE*	*p*
X (Contingency manip.)	0.93	0.17	< 0.001
Constant	4.86	0.12	< 0.001
	$R^2 = 0.14$, $F(1, 188) = 29.73$, $p < .001$		
	M_2 Self-efficacy		
Antecedent	Coefficient	*SE*	*p*
X (Contingency manip.)	−0.05	0.12	0.684
M_1 (Interactivity)	0.20	0.05	< 0.001
Constant	2.66	0.25	< 0.001
	$R^2 = 0.09$, $F(2, 187) = 8.83$, $p < .001$		
	Y Time 2 Environmental Behavior		
Antecedent	Coefficient	*SE*	*p*
X (Contingency manip.)	−0.07	0.12	0.56
M_1 (Interactivity)	−0.02	0.05	0.745
M_2 (Self-efficacy)	0.59	0.07	< 0.001
Constant	0.64	0.30	0.036
	$R^2 = 0.30$, $F(3, 186) = 25.92$, $p < .001$		
	Y Time 2 Policy Support		
Antecedent	Coefficient	*SE*	*p*
X (Contingency manip.)	0.09	0.09	0.297
M_1 (Interactivity)	0.01	0.04	0.707
M_2 (Self-efficacy)	0.46	0.05	< 0.001
Constant	2.18	0.23	< 0.001
	$R^2 = 0.32$, $F(3, 186) = 29.21$, $p < .001$		

findings suggest that reducing psychological distance can enhance perceptions of environmental risk (Jones et al., 2017; Spence et al., 2012; Van der Linden, 2017). Later, outside of the laboratory, this higher risk perception led to greater support for environmental policies as well as more environmentally friendly behavior. Our study indicates that reducing psychological distance and increasing risk perception may be crucial for breaching the knowledge-to-action gap regarding environmental issues (Kollmuss and Agyeman, 2002).

Regarding interactivity, playing a game that demonstrated contingent consequences for the user's actions yielded more positive environmental outcomes than a noncontingent game. Although previous studies have manipulated interactivity through the use of different channels (e.g., Ahn et al., 2014; Peng et al., 2010), we demonstrated that manipulations of contingency within a single channel can also evoke different outcomes. When users perceived that the positive environmental changes in the game were contingent on their actions, their self-efficacy was greater, echoing previous studies (e.g., Peng, 2008). In the days following the experiment, this boost in self-efficacy led participants to express greater support for environmental policies and engage in more environmental behaviors. Notably, our findings also supported the claims of interactivity scholars who have argued for the necessity of measuring perceptions of interactivity (Bucy and Tao, 2007; Lee et al., 2006; Weber et al., 2014; Wu, 2005) as perceptions were a necessary mediator in the model.

Our findings are consistent with previous research noting the value of interactive messages (Ahn et al., 2014; Chittaro and Sioni, 2015; Peng et al., 2010; Ritterfeld et al., 2009) and indicate that VEs may be useful for environmental communication, health communication, or other contexts where message designers are trying to inform users about risks and encourage prosocial behavior. Despite arguably clear conceptual mapping, very few studies have explored the use of VEs to minimize the psychological distance individuals experience regarding many risks (see Ahn, 2015, for a notable exception). Our results indicate that the affordances of virtual environments and serious games are useful tools for not only shaping participants' experiences and perceptions of the virtual world, but also their attitudes and behaviors outside of it. Interactive technologies may be an optimal way to make abstract risks feel more possible, close, and real, and in turn promote prosocial behavior and policy support.

Our manipulations were successful in altering participants' psychological distance, but researchers should exercise caution when designing serious games and persuasive VEs with threat-evoking content. Weber (2006) argues that individuals are more likely to have strong reactions when they experience environmental threat as opposed to just seeing descriptions of it. If an experience is too threatening, users may react negatively, particularly if it feels psychologically close (McDonald et al., 2015). They may try to minimize fear or unpleasant feelings of arousal by dismissing the threat. Thus, researchers should aim to evoke manageable, rather than paralyzing, levels of threat, fear, or other emotions. Due to interactivity, realism, and immersion, experiences in a VE may evoke stronger emotions than similar themes conveyed through other channels (Authors, in press), so researchers and developers should test VEs and serious games throughout the design process to ensure that they evoke desirable reactions.

5.2. Limitations and future directions

One limitation of our experimental design was that for all participants, the environment ended up cleaner and more beautiful at the end of the experience. We chose this because messages about environmental threats need to provide clear ways of mitigating the threat to be successful (Moser, 2016). Further, to maintain validity, we needed to avoid the confound of having different outcomes in the contingent and non-contingent conditions. However, depicting the environment improving no matter what the participant did may have conveyed the undesirable message that things will get better regardless of individual actions.

Similarly, we needed to make the game relatively easy so that self-efficacy would not be diminished. Showing such drastic ecological improvement based solely on a 10-minute cleanup effort is not realistic, however; individuals may be disappointed to find that greater sacrifices are necessary to ensure a cleaner environment on both an individual and societal level. Further, more challenging elements in the game may have led to greater learning (Hamari et al., 2016). Future research should explore the optimal balance of ease and challenge within these games to evoke self-efficacy and behavior outside of them.

A final limitation of our design is that our distance manipulation included both temporal and spatial distance rather than examining these two aspects independently. It is possible that there are distinct processes for different types of psychological distance (Fiedler et al., 2012). Future research should test various forms of psychological distance independently to determine which forms are most effective.

We were limited in the variables we could manipulate within the game we modified, but existing research suggests several exciting directions for future research. First, a deeper look at individual motivations is warranted, particularly whether participants were motivated by intrinsic or extrinsic factors (Dindar, 2018). If a serious game is to have an impact, people must want to play the game in natural settings. Our game's design may have appealed to those motivated by achievement and rewards, but further research should explore if it meets other gratifications, such as entertainment, escape, or relaxation (Chen and Leung, 2016). A second path to investigate is the use of avatars. Personalized avatars may enhance feelings of self-presence and self-efficacy (Fox and Ahn, 2014; Fox and Bailenson, 2009; Hooi and Cho, 2017) and may also reduce feelings of psychological distance. Feelings of self-presence and embodiment may enhance learning and persuasive effects and keep people motivated to continue playing the game (Hooi and Cho, 2017).

In conclusion, understanding the key affordances of serious games and virtual environments is crucial to the development of persuasive messages in realms such as environmental, health, and risk communication. VEs offer potential solutions to many of the communication challenges noted by environmental scholars (e.g., Moser, 2016; Sheppard, 2012; Van der Linden et al., 2015). Researchers should continue to explore the nature of users' experiences in these channels to further clarify the ways in which serious games and persuasive VEs may be used to promote prosocial behavior.

Declaration of Competing Interest

None.

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Appendix

1. Learn about recyling services available to me.
2. Reduce the amount of household trash by reusing and recycling items.
3. Keep my thermostat at a cooler temperature in the winter and warmer temperature in the summer to save energy.
4. Encourage friends, roommates, family members, and others to engage in environmentally friendly behavior.
5. Use reusable shopping bags, water bottles, coffee cups, etc., to reduce the amount of waste I generate.
6. Share information or links about environmental issues with people I know.
7. Recycle everyday products, like paper, plastic, and aluminum cans.
8. Tell the clerk I don't need a plastic bag when I buy something at the store.
9. Promote environmental issues on social media.
10. Unplug devices I'm not using to conserve energy.

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