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Experiencing Nature: Embodying Animals in Immersive Virtual Environments Increases Inclusion of Nature in Self and Involvement With Nature

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Immersive virtual environments (IVEs) produce simulations that mimic unmediated sensory experiences. 3 experiments (N = 228) tested how different modalities increase environmental involvement by allowing users to inhabit the body of animals in IVEs or watch the experience on video. Embodying sensory-rich experiences of animals in IVEs led to greater feeling of embodiment, perception of being present in the virtual world, and interconnection between the self and nature compared to video. Heightened interconnection with nature elicited greater perceptions of imminence of the environmental risk and involvement with nature, which persisted for 1 week. Although the effect sizes were small to moderate, findings suggest that embodied experiences in IVEs may be an effective tool to promote involvement with environmental issues.

Keywords: Immersive Virtual Environments, Perspective Taking, Environmental Communication, Connectedness with Nature, Spatial Presence, Body Transfer, Embodied Experiences.

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Engaging people in environmental concerns requires unique strategies, including reminding people that humans are connected to, and a part of, nature. The current paper examines the effectiveness of

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immersive virtual environments (IVEs), digitally rendered spaces offering sensory-rich simulations that allow users to experience mediated events in the virtual world as they might in the physical world, to enhance feelings of interconnectedness and involvement with nature. Using digital technology to explore existing environmental issues may facilitate creative solutions and experiences for people that would be difficult to achieve offline.

One such creative solution is to apply IVEs in the process of *perspective taking*, the mental simulation of a situation by placing oneself in the shoes of another via imagination (Batson et al., 1997). Perspective taking has been shown to facilitate a variety of favorable outcomes including helping (Batson et al., 1981), stereotype reduction (Batson et al., 1997), and improved interpersonal communication (Fussell & Krauss, 1989). A recent set of studies extended these findings by using IVEs to assist interpersonal perspective taking, demonstrating that it led to greater involvement, caring and helping behavior (Ahn, Le, & Bailenson, 2013), and facilitation of environmental negotiation tasks (Gehlbach et al., 2015).

The current study aims to build on earlier findings by applying the idea of IVE-assisted perspective taking to human-nature interactions to promote a sense of nature as a part of people's self-identity, and involvement with nature. Just as perspective taking increases feelings of empathy and helping behavior in interpersonal interactions, we anticipate that taking the perspective of animals will promote caring for nature and the environment. Across three studies, we introduce novel affordances of IVEs that allow users to experience what it might be like to be a cow in a pasture being bred for its meat, or coral reef in an acidifying ocean. As one of the first attempts to use digital media to assist human-to-nature connections, these experiments test how taking the perspective of an animal may be realized with IVEs, to see whether it promotes involvement with nature.

Challenges of Communicating about Nature

The general public fails to recognize environmental problems largely because of two characteristics of environmental risk. First, many fail to recognize the problem because environmental degradation is often not directly or immediately observable. For instance, although ocean acidification decreases the pH of the Earth's oceans and leads to a grave disruption of the entire marine system (Caldeira & Wickett, 2003), individuals perceive the risk of this disruption to be low because they rarely have the opportunity to personally see the consequences of ocean acidification on marine life. Social science research has demonstrated that exposure to information alone does not facilitate learning or change behavior as an individual must engage with and process the content of the message (Bandura, 1977). Additional research has suggested that even when individuals recognize environmental problems that are not immediately observable, they are more likely to feel less responsible for it because of the psychological distance (Uzzell, 2000).

Another characteristic of environmental problems is the temporal distance between the cause (individual behaviors) and the effect (negative consequences) of environmental damage, which occurs in slow, incremental changes. Large temporal distances between cause and effect enhance positivity towards future events, because individuals tend to have an overly "rosy" view of distant futures (Trope, Liberman, & Wakslak, 2007). To promote engagement with an issue, messages should address this psychological distance as individuals who perceive a risk to be temporally proximal perceive greater urgency and report stronger intent to modify their behaviors than those who perceive the risk to be temporally distant (Ahn, 2015).

Allowing people to personally experience environmental problems can reduce perceived temporal distance and lead people to see them as more critical than reading mere descriptions of problems (Rajecki, 1982). With personal experiences, individuals are more likely to consider the impacts of environmental damage to be personally relevant, perceive immediacy of environmental risks, and intend to engage in proenvironmental behaviors (Akerlof et al., 2013; Zaalberg & Midden, 2010). However, recommending personal experience of environmental damage in nature to promote proenvironmental behaviors would incur exorbitant individual and social costs and could be dangerous; consider a scenario wherein individuals are recommended to experience a flood to learn about the consequences of global warming. IVE technology can simulate these personal experiences and result in similar, but cost-effective and safer, outcomes.

Connecting With Environmental Problems

When people take the perspective of a person or animal, this leads to an increased mental overlap of the self and other, which induces feelings of closeness and empathy and increases helping intentions and behaviors (Coke, Batson, & McDavis, 1978; Goldstein & Cialdini, 2007). Feeling connected with nature should follow the same process: If individuals can be encouraged to take the perspective of nature and consider nature as a part of their self identities, they are likely to feel closer, empathic, and more immersed with nature, resulting in proenvironmental attitudes and behaviors (Clayton et al., 2014; Hartmann & Apaolaza-Ibáñez, 2008, 2009; Liu, Bonzon-Liu, & Pierce-Guarino, 1997; Mayer & Frantz, 2004).

Providing empirical support to this prediction, scholars have induced empathy and caring towards nature through perspective-taking manipulations in interpersonal contexts. For instance, several studies have asked participants to take the perspective of a bird in an oil spill to induce proenvironmental attitudes and behaviors (Berenguer, 2007; Schultz, 2000; Sevillano, Aragones, & Schultz, 2007). One study asked participants to take the perspective of a national park as if it were a living entity (Walker & Chapman, 2003). Another study asked participants to take the perspective of an individual living in the future experiencing the negative consequences of environmental problems (Pahl & Bauer, 2013). The collective results of these studies indicate that considering the perspective of an animal or nature encourages involvement with the environment; thus, allowing individuals to take the perspective of animals in nature could be a simple solution to increase engagement with the environment.

However, perspective taking is a controlled, effortful process that requires substantial cognitive resources (Davis et al., 1996). Outside of the controlled laboratory setting, individuals may not be willing to expend valuable cognitive energy to the perspective of animals, particularly if they are fatigued or are unfamiliar with the environmental issue (Gehlbach, Brinkworth, & Wang, 2012; Hodges & Klein, 2001). Furthermore, a number of studies note that direct experiences are more influential than indirect ones, such as reading print descriptions (Hertwing et al., 2004; Rajecki, 1982), implying that providing stimuli that are more similar to direct experiences will have a stronger impact on empathy.

Embodying Experiences of Animals in Immersive Virtual Environments

By digitally reproducing vivid sensory information, IVEs allow users to experience a scenario as if it were happening to them, which should enhance the processing of the information and influence behavior (Bandura, 1977). The rich layers of simulated sensory information mimic offline experiences better than traditional media or imagination (Ahn, Bailenson, & Park, 2014; Ahn, in press; Zaalberg & Midden, 2010), and may enhance involvement with nature, one important goal of environmental communication.

Simulating Direct Experiences in Virtual Worlds

Direct experiences become associated and stored with existing memories—*schemas*—and these schemas are later activated and recalled when the individual encounters or thinks about similar stimuli (Barsalou, 2009). IVEs offer rich layers of sensory information that allow users to see, hear, and feel external stimuli as if they were offline, experiencing the event at that moment. This cognitive perception of the space the body is occupying is labeled *spatial presence* (Lombard & Ditton, 1997), wherein one's physical body feels in sync with the movements of the virtual experience (Hartmann et al., in press). As a result, experiences in IVEs simulate direct experiences and are able to produce schemas similar to offline experiences.

Video delivers many features of IVEs, though it is not interactive and does not allow the use of naturalistic movements to control events and objects within the mediated environment (Skalski et al., 2011), making it less like a direct experience of the phenomenon. IVEs' increased capacity for interactivity and naturalistic control of stimuli is anticipated to drive greater perceptions of spatial presence in the mediated environment than watching a video of the same event. By comparing the effects of video and IVEs in delivering the same environmental experience, the current study aims to assess the optimal means of providing direct experience and enhancing involvement with the environment.

H1: Individuals exposed to an environmental experience through IVEs will perceive higher spatial presence than individuals exposed to the experience on video.

Amplifying the Effects of Perspective Taking in Virtual Worlds

In addition to spatial presence, the novel affordance of *body transfer* offers participants the realistic illusion of body ownership, that a person has become the virtual body (Slater et al., 2010). Body transfer can be induced when an individual feels a body part being touched as he or she watches an external entity being touched; the brain assigns the perception of ownership to the visible entity being touched rather than the actual body part being touched (Botvinick & Cohen, 1998). The illusion of body transfer has been demonstrated with fake limbs such as a rubber hand (Botvinick & Cohen, 1998). Slater and colleagues (2010) demonstrated that body transfer occurred between a corporeal body and a virtual human, wherein the individual feels touch while watching a virtual human being touched. This study examines the process of body transfer with nonhuman virtual representations, such as animals. We predict this process will present greater challenges than body transfer into virtual humans due to perceived dissimilarities between humans and animals and the lack of schema for experiencing the world as an animal.

Traditional perspective-taking tasks are difficult when individuals lack the direct experience required to develop schemas. For instance, few people have direct experience with certain disabilities, so using IVEs to embody the sensory experiences of a disability one has not encountered may be much more powerful than relying on an aschematic imagination. Ahn and colleagues (2013) tested this notion and demonstrated that embodying the experience of a person with a visual disability in a perspective-taking task using IVEs led to greater helping behavior in the physical world than perspective taking, which relied upon imagining the disability. Another study demonstrated that direct experiences of an opponent simulated through virtual worlds prior to a negotiation task encouraged individuals to develop a positive attitude toward the opponent and make more concessions than indirect experiences (Gehlbach et al., 2015). Body transfer extends the concept of embodiment to a point where individuals not only share sensory cues but also feel as if they are the virtual body.

Because IVEs allow individuals to put themselves inside the virtual body of an animal, they would directly feel the threats it is up against and feel connected to its plight. For instance, sharing the experience of body transfer of oneself to the cow's virtual body would clearly help people understand how a cow would feel being raised for its meat. Although body transfer has also been demonstrated with video images (Preston & Newport, 2012), we predict that, influenced by greater spatial presence (H1), embodied experiences in IVEs will lead to stronger illusions of body transfer than video:

H2: Individuals exposed to an environmental experience through IVEs will perceive stronger body transfer than individuals exposed to the experience on video.

When individuals use IVEs to embody the experiences of animals and take their perspective, the sensory-rich experience and the ability to control the embodied animal are likely to elicit stronger feelings of interconnection between the self and the nature than watching a video. This connectedness between nature and the self is conceptualized as the extent to which individuals include the nature in thinking about the self, or *inclusion of nature in self* (INS; Schultz, 2001). The concept of INS adequately represents the virtual experience of inhabiting the body of an entity in nature, and feeling an interconnection with it — a merging of identities — as a result (Schultz & Tabanico, 2007). The interconnection is assessed by selecting incrementally overlapping Venn diagram circles that respectively represent the self and nature, better evaluating the sense of embodiment than other means of assessments for environmental attitudes.

H3: Individuals exposed to an environmental experience through IVEs will perceive greater inclusion of nature in self (INS) than those watching the experience on video.

Importantly, INS is not solely driven by technology (Witmer & Singer, 1998) or the exposure to IVEs. The individual must feel he or she has become the cow, genuinely sharing its experiences, for the embodied experience to be effective. Thus, high levels of spatial presence and body transfer should increase feelings that the individual has become one with the animal:

H4: Spatial presence (H4A) and body transfer (H4B) will both mediate the relationship between experimental conditions and INS.

Overview of Experiments

Three experiments were conducted to compare the effects of embodying animals through IVEs against watching the experience on video. Experiment 1 confirmed the prediction that IVEs allow participants to take the perspective of a shorthorn cow and increase feelings of interconnectedness with nature (INS). Experiment 2 expanded these findings by showing the robustness of the embodied experience in IVEs across different contexts by including ocean acidification, exploring the moderating effect of individuals' dispositional differences in feeling connected with nature, extending the investigation of the underlying mechanism, and assessing changes in individuals' INS over one week. Finally, Experiment 3 tested the parallel mediation model from the first two studies, while controlling for individual differences in connectedness with nature on a larger sample to test the model's generalizability. All items used to measure dependent variables in the three studies may be found in the Appendix.

Experiment 1

Experiment 1 explored the extent to which embodying an animal in an IVE would be more effective in eliciting feelings of INS than watching a video.

Methods

Participants and Apparatus

A sample was recruited from a large private university in the West. From the total sample ($N = 54$), data from five participants were lost due to technical problems. The final sample consisted of 27 females and 22 males (age $M = 20.4$, age $SD = 1.24$). Participants viewed the virtual world in the

IVE condition through a head-mounted display (HMD), a fully immersive virtual reality helmet that allows for three-dimensional, stereoscopic views of a digitally rendered environment. An orientation sensor mounted to the HMD was used to track participants' physical head movements (pitch, yaw, and roll) and to update the rendered first-person perspective viewpoint accordingly. LED markers placed on the body were tracked using optical infrared cameras. To increase immersion in the virtual environment, participants experienced spatialized sound. Haptic feedback was generated in the form of floor vibrations. Participants in the video condition watched the video on a 19-inch (48.3 centimeters) monitor.

Design and Procedures

Participants were randomly assigned to either the IVE or the video condition. In the IVE condition ($n = 25$), the experimenter placed LED lights on participants' head and body, participants got down on their hands and knees, and embodied a virtual shorthorn cow in a pasture where they saw their cow avatar directly facing them as if looking into a mirror (see Figure 1). Once the participants were acclimated to their cow avatar, they heard a narration instructing them to move around the virtual world to eat the feed and drink water. They were then informed that they would proceed to be loaded onto a truck, and subsequently heard a truck backing toward them. Haptic feedback was included as they moved toward the sound of the truck to further induce the sensation of embodiment. When the virtual cattle prod hit the cow in the virtual simulation, participants heard a buzzing noise, felt a vibration on the floor that was in contact with their knees and palms, and a confederate poked them in the back.

In the video condition ($n = 24$), participants watched a recording of a previous participant's IVE experience as a cow (e.g., the virtual cow moving in the virtual pasture) on a computer monitor. Each participant in the video condition was yoked to one previous participant of the same gender in the embodiment condition. All participants answered survey questions regarding their experience.

Measures[1]

Body transfer

A 15-item, 5-point interval scale assessed how much the participants felt as if they had become the virtual cow, adapted from Slater et al. (2010). Sample items were, "When the cattle prod poked your cow avatar, how much did you feel this as if this was an attack on your body?" and "How strong was the feeling that the body of the cow was your body?" (*1 = Not at all, 5 = Absolutely*; Cronbach's $\alpha = .95$).

Spatial presence

We employed a 5-item, 5-point interval scale to measure perceived spatial presence, adapted from Bailenson et al.'s Spatial Presence scale (2005). Sample items were, "To what extent do you feel like you can reach into the mediated environment through your cow avatar?" and "To what extent did you feel like you were really inside the virtual pasture?" (*1 = Not at all, 5 = Very strongly*; Cronbach's $\alpha = .93$).

Inclusion of Nature in Self (INS)

We adopted Schultz's (2001) measure to gauge how much individuals felt interconnected with nature. The single-item, 7-point pictorial scale uses a series of seven overlapping Venn diagram circles, one circle labeled *self* and the other labeled *cow*. Participants chose the picture that best described how interconnected he or she felt with the virtual cow.

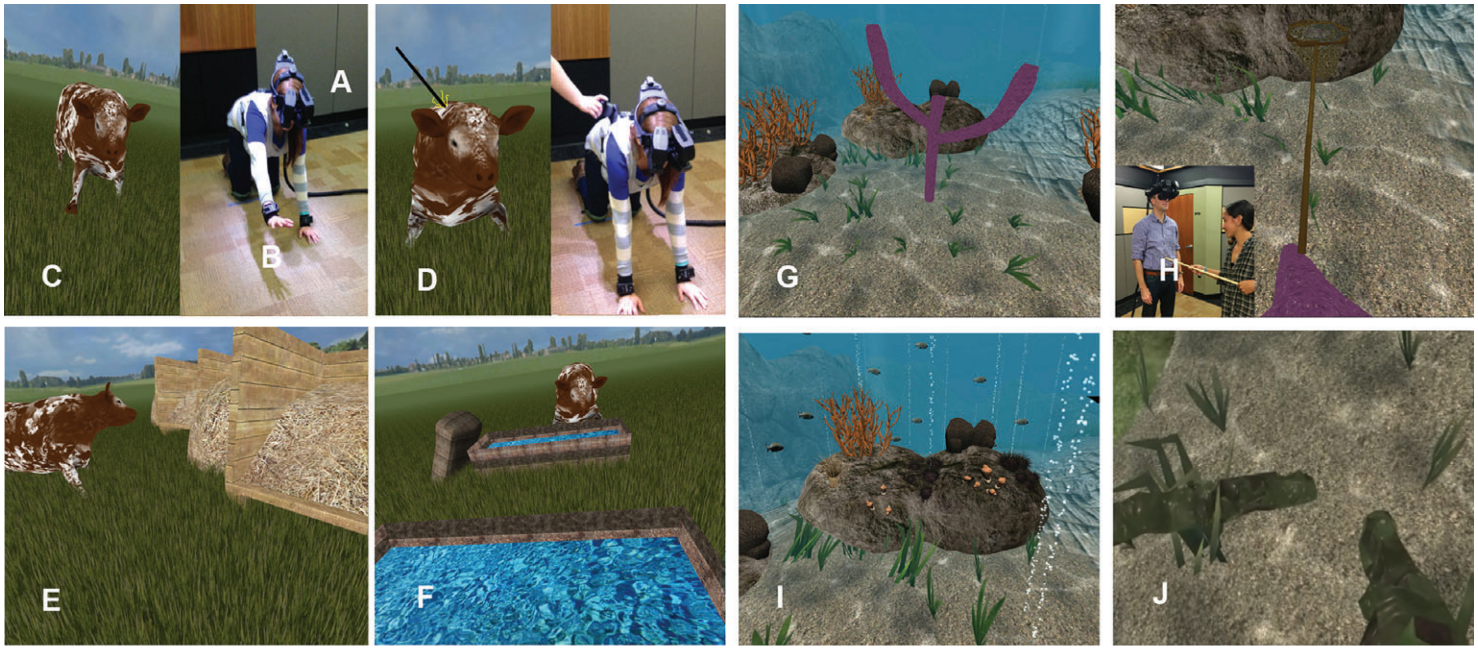

Figure 1 Progression of the virtual simulations in Experiment 1 and Experiment 2. In Experiment 1, participants in the IVE condition viewed the virtual world through a head mounted display (**A**). LED markers (**B**) tracked participants' physical movements. The tracked movements were then rendered in real time to the virtual cow (**C**). Participants were prodded in the physical world simultaneously as their virtual cow avatar was prodded with a virtual cattle prod to elicit body transfer (**D**). Participants ate (**E**) and drank water (**F**) in the virtual pasture. In Experiment 2, participants entered the virtual world and were instructed to step into the body of the coral (**G**). A researcher administered simultaneous physical stimulation to the body while participants saw the net handle intersect their coral torso in the virtual world to elicit body transfer (**H**). Participants saw the effects of ocean acidification in acceleration (**I**) and experienced the arm breaking off from their virtual coral body with a thud to the ocean floor (**J**).

Results

In support of H1, an independent samples t-test found that participants in the IVE condition perceived higher spatial presence ($M = 2.62$, $SD = .87$) than participants in the video condition ($M = 1.98$, $SD = .98$), $t(48) = 2.48$, $p = .02$, $d = .69$ (95% CI of difference [.12, 1.16]). In support of H2, an independent samples t-test found that participants in the IVE condition perceived significantly greater body transfer ($M = 2.57$, $SD = .75$) than participants in the video condition ($M = 2.05$, $SD = .93$), $t(47) = 2.16$, $p = .03$, $d = .62$ (95% CI of difference [.05, .99]). H3 was supported with an independent samples t-test showing participants in the IVE condition perceived significantly higher INS ($M = 3.08$, $SD = 1.41$) than participants in the video condition ($M = 1.96$, $SD = 1.17$), $t(48) = 3.05$, $p = .004$, $d = .86$ (95% CI of difference [.40, 1.84]).

Underlying Mechanism – Parallel Mediation Model

The PROCESS path-analysis macro for SPSS (Hayes, 2012; Model 4) was employed. Bootstrapping methods were used (1000 samples). The parallel mediation model revealed that being in the IVE condition influenced spatial presence ($b = .63$, $p = .02$) and body transfer ($b = .52$, $p = .04$). Body transfer then influenced INS ($b = 1.04$, $p < .001$) but spatial presence did not ($b = .18$, $p = .36$). The indirect effect from experimental condition to body transfer and then to INS was significant (95% CI [.08, 1.12]). The indirect effect from experimental condition to spatial presence and then to INS was not significant (95% CI [−.07, .55]). Thus, H4A was not supported whereas H4B was supported.

Discussion

These findings demonstrated the potential for using IVEs to take the perspective of nonhuman entities. Participants who virtually embodied the cow and were prodded with a virtual cattle prod felt greater spatial presence and body transfer than those watching the experience through video. The virtual experience in IVEs also led to greater INS than watching a video. However, only body transfer mediated the relationship between exposure to IVEs and INS.

Experiment 2

Building on Experiment 1, the second experiment tested the robustness of using IVEs in taking the perspective of animals by expanding the target of perspective taking to marine life endangered by ocean acidification. Several limitations of Experiment 1 were also addressed, including a deeper investigation into the underlying mechanisms, the consideration of individual trait variables, and repeated assessments of variables after one week to gauge change over time.

Following the results of Experiment 1, participants that embody the sensory-rich experience of marine life suffering as a result of ocean acidification should feel higher levels of spatial presence and body transfer than those viewing it via video. IVE participants should feel as if they have become coral on a rocky reef; seeing, hearing, and feeling its habitat destroyed and its own body suffering. The sensory-rich experience in IVE is expected to replicate H1, H2, and H3, resulting in greater perceived spatial presence and body transfer than watching the experience through video. The heightened spatial presence and body transfer should then lead to high INS. H4A and H4B will also be tested again in a parallel mediation model. Furthermore, Experiment 2 will build on the model by exploring the influence of a moderator—trait connectedness with nature (Mayer & Frantz, 2004)—to evaluate how individual trait differences in thinking about the nature influences observed outcomes.

RQ1: Does connectedness with nature moderate the parallel mediated pathway between experimental condition, spatial presence/body transfer, and INS?

IVEs facilitate the ability to depict an accelerated progression of time. Although environmental degradation occurs in gradual increments in the physical world, computer graphics are able to portray an accelerated version of these changes. Thus, users may enter a virtual ocean to experience the negative consequences of an acidification process that depicts decades' worth of devastating changes in just a few minutes. This accelerated progression of time reduces perceived temporal distances, which drives perceived imminence of the risk (Ahn, 2015). The perception of personal relevance and importance leads to issue involvement (Petty & Cacioppo, 1981). We predict that perceived imminence will lead to feelings that ocean acidification is relevant and important. Considering the earlier hypotheses (H1-H4), we predict those experiencing coral suffering from ocean acidification with IVEs will feel more INS than those who watch a video of the experience. Increased INS has been shown to lead to more compassion and active concern about the environment (Schultz, 2000; Sevillano et al., 2007). As a result, the perceived connection to nature is likely to drive perceptions that the risk of ocean acidification is real and imminent. The perceived imminence of the risk is then expected to increase issue involvement. Thus, in extension of the parallel mediation model, we hypothesize:

H5: Individuals with a high INS will feel high imminence of environmental risk, which, in turn, leads to high issue involvement.

Another point of extension from Experiment 1 is exploring the change in the effects of embodied experiences in IVEs over time. Earlier work suggests that the effects of sensory-rich virtual experiences persist longer over time than the effects of traditional media (Ahn, 2015, in press; Ahn et al., 2014). Because we lack sufficient evidence to formulate hypotheses, we ask the following research questions to investigate the persistence of the parallel mediation model over time.

RQ2: One week following exposure to treatments, will individuals exposed to an environmental experience through IVEs perceive greater INS than those who watched the experience on video?

RQ3: One week following exposure to treatments, will spatial presence (RQ3A) and body transfer (RQ3B) continue to mediate the relationship between experimental conditions and INS?

Methods

Participants and Procedures

A sample was recruited from a large private university in the Western United States. The participants' ages ranged from 18 to 37 years old, with a mean age of 21.2 years (male $n = 26$). The same apparatus from Experiment 1 was used. The experiment was conducted in two phases. At Time 1, participants were randomly assigned to one of two conditions, IVE ($n = 31$) or video ($n = 22$). In the IVE condition, participants entered a virtual ocean and saw an avatar, a scaled, three-dimensional digital representation of a piece of coral. Participants were instructed to look around the virtual world, step into the body of the coral avatar, and look down to see the body of the coral. Next, a digital representation of a fishing net attached to a pole appeared in front of the coral avatar and proceeded to bump repeatedly against the coral avatar's body. A researcher in the room simultaneously poked the participant's torso to induce body transfer (see Figure 1). Participants observed the consequences of ocean acidification and looked at their coral body corroding and its limbs breaking off. As the coral branches broke off, haptic feedback in the form of floor vibrations was combined with the sound of cracking. In the video condition, participants watched the same sequence of events on a monitor. All participants completed an online questionnaire. One week later, participants were e-mailed to assess changes in INS (Time 2).

Measures

Immediately after experimental treatments (Time 1), spatial presence (Cronbach's $\alpha = .91$), body transfer (Cronbach's $\alpha = .96$), and INS were measured. Perceived temporal distance was measured with a single 7-point interval item (*1 = Feels very close; 7 = Feels very far away*), "How far away do these consequences of ocean identification feel to you?" Issue involvement was measured with six 7-point bipolar items asking participants to rate how important, of concern, relevant, meaningful, of matter, and involving the issue of ocean acidification was to them (Cronbach's $\alpha = .91$). Connectedness with nature (Cronbach's $\alpha = .86$) was measured with fourteen 5-point Likert scale items from Mayer and Frantz (2004), assessing the extent to which participants felt connected with nature as an individual trait. Sample items included, "I often feel a sense of oneness with the natural world around me" and "I often feel a kinship with animals and plants." At Time 2, INS was measured again.

Results

In support of H1, an independent samples t-test showed that participants in the IVE condition ($M = 3.01$, $SD = .90$) perceived higher spatial presence than participants in the video condition ($M = 2.04$, $SD = .58$), $t(51) = 4.43$, $p < .01$, $d = 1.30$ at Time 1 (95% CI of difference [.55, 1.39]). In support of H2, an independent samples t-test showed that participants in the IVE condition ($M = 2.57$, $SD = .78$) felt greater body transfer than participants in the video condition ($M = 2.09$, $SD = .95$), $t(51) = 2.00$, $p = .051$, $d = .55$ at Time 1 (95% CI of difference [0, .97]). H3 was partially supported with an independent samples t-test showing differences in INS at Time 1 between participants in the IVE condition ($M = 4.48$, $SD = 1.55$) and those in the video condition ($M = 3.64$, $SD = 1.81$) approaching significance, $t(51) = 1.83$ $p = .07$, $d = .50$ (95% CI of difference [−.10, 1.78]). The direct effect of IVEs on INS ($M = 3.80$, $SD = 1.77$) weakened at Time 2 (video $M = 2.91$, $SD = 2.07$), $t(51) = 1.67$, $p = .10$, $d = .46$ (95% CI of difference [−.17, 1.95]). Ad hoc tests of direct effects of experimental condition on other dependent measures were also conducted. Independent samples t-test showed that participants in the IVE condition ($M = 3.19$, $SD = 1.40$) perceived shorter temporal distance of ocean acidification than those in the video condition ($M = 4.27$, $SD = 1.75$), $t(51) = 2.49$, $p = .01$, $d = .68$ (95% CI of difference [.20, 1.96]). Independent samples t-test showed that participants in the IVE condition ($M = 5.53$, $SD = .91$) did not perceive greater involvement than those in the video condition ($M = 5.61$, $SD = 1.03$), $t(51) = .28$, $p = .78$, $d = .08$ (95% CI of difference [−.62, .46]).

Underlying Mechanisms - Parallel Mediation Analyses with Moderator

To explore RQ1, H4A, and H4B, the PROCESS path-analysis macro (Model 5) was employed. The parallel mediation model revealed that being in the IVE condition influenced spatial presence ($b = .97$, $p < .01$) and body transfer ($b = .48$, $p = .05$). Both spatial presence ($b = .67$, $p = .04$) and body transfer ($b = .49$, $p = .07$) then influenced INS at Time 1. Connectedness with nature did not serve as a moderator ($b = -1.05$, $p = .13$), but had a significant direct effect on INS ($b = 1.43$, $p < .01$). Connectedness with nature was also significantly correlated with spatial presence ($r = .38$, $p = < .01$) but not with body transfer ($r = .22$, $p = .11$). The indirect effect from experimental condition to spatial presence and then to INS at Time 1 was significant (95% CI [.11, 1.63]). The indirect effect from experimental condition

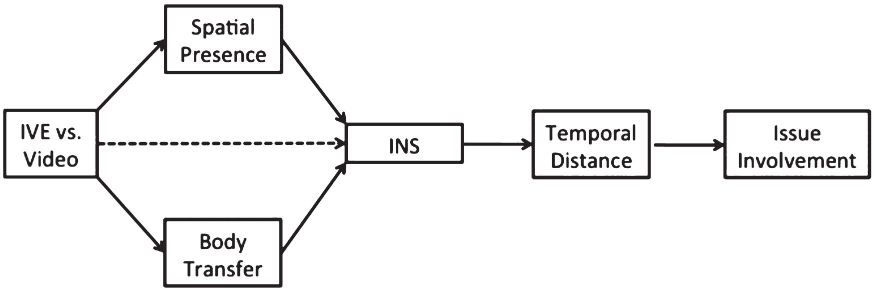

Figure 2 Final Parallel Mediation Model.

to body transfer and then to INS at Time 1 was also significant (95% CI [.01, .75]). H4A and H4B were supported.

To explore RQ2, another PROCESS analysis (Model 5) was employed. Being in the IVE condition influenced spatial presence ($b = .94$, $p < .01$) and body transfer ($b = .47$, $p = .05$). Body transfer ($b = .65$, $p = .05$) influenced INS at Time 2, but spatial presence did not ($b = .63$, $p = .11$). Connectedness with nature did not serve as a moderator ($b = -1.25$, $p = .15$). The indirect effect from experimental condition to spatial presence and then to INS at Time 2 was not significant (95% CI [−.16, 1.60]). The indirect effect from experimental condition to body transfer and then to INS at Time 2 was significant (95% CI [.001, 1.08]).

Finally, a PROCESS analysis (Model 4) was employed. The mediation model showed that the greater the INS was at Time 1, the shorter the perceived temporal distance ($b = -.46$, $p < .01$). Shorter temporal distance then led to greater issue involvement ($b = -.26$, $p < .01$). The indirect effect from INS at Time 1 to temporal distance, and then to issue involvement was significant (95% CI [.04, .22]). H5 was supported and the final model is presented in Figure 2.

Discussion

The results of Experiment 2 replicate and extend findings from Experiment 1: IVEs were more effective than video in assisting individuals in their efforts to take the perspective of animals. Both spatial presence and body transfer as a result of the virtual experience in an IVE seemed to drive greater INS at Time 1. However, only body transfer continued to drive INS at Time 2 implying the effect of spatial presence may dissipate over time. Individual trait differences in feeling connected to nature did not moderate these mediation pathways. Moreover, findings revealed that the heightened INS (Time 1) led to individuals perceiving that the environmental risk of ocean acidification was imminent. The perceived imminence of risk then triggered greater perceived involvement in the issue of ocean acidification.

Experiment 3

The third experiment tested the final parallel mediation model (H1-H5) in the context of ocean acidification with a larger pool of participants for greater power and generalizability. This experiment examined the ability of the HMD and video conditions to increase spatial presence and body transfer without the haptic feedback used in the first two experiments, as this is how people typically experience video and HMDs via commercial systems used outside of the laboratory. For instance, Samsung's Gear VR or Oculus Rift, allow for head orientation (i.e., looking around in the virtual world) but do not support virtual or physical touch (Smith, 2015).

Methods

Participants and Procedures

A sample was recruited from a large public U.S. university ($N = 126$, male $n = 44$). Participants' ages ranged from 18 to 37 years old (age $M = 20.10$, age $SD = 2.29$). The procedure for Experiment 3 was similar to Experiment 2; some experienced the coral reef on a regular computer screen ($n = 42$) and others experienced it through a HMD ($n = 84$)[2], though participants were not physically poked as they watched a fishing net poking their virtual coral body.

Measures

All measures were taken from Experiment 2. Immediately after experimental treatments, spatial presence (Cronbach's $\alpha = .95$), body transfer (Cronbach's $\alpha = .97$), INS, temporal distance, issue involvement (Cronbach's $\alpha = .92$), and connectedness with nature (Cronbach's $\alpha = .92$) were measured. All items in Experiment 3 were measured with 7-point interval scales (e.g., *1 = Not at all, 7 = Very much*).

Results

H1 was again supported, as an independent samples t-test found that participants in the IVE condition perceived significantly higher spatial presence ($M = 4.93$, $SD = 1.45$) than participants in the video condition ($M = 3.37$, $SD = 1.46$), $t(124) = 5.66$, $p < .01$, $d = 1.07$ (95% CI of difference [.75, 2.38]). H2 was also supported with an independent samples t-test finding that participants in the IVE condition felt significantly greater body transfer ($M = 3.88$, $SD = 1.40$) than participants in the video condition ($M = 2.90$, $SD = 1.35$), $t(124) = 3.76$, $p < .01$, $d = .72$ (95% CI of difference [.21, 1.75]). H3 was not supported; an independent samples t-test found no differences in INS between participants in the IVE condition ($M = 3.70$, $SD = 1.71$) and those in the video condition ($M = 3.19$, $SD = 1.60$) was not significant, $t(124) = 1.62$, $p = .11$, $d = .31$ (95% CI of difference [−.42, 1.44]).

Underlying Mechanisms - Parallel Mediation Analyses With Moderator

The PROCESS analysis (Model 5) was employed. Being in the IVE condition influenced spatial presence ($b = 1.55$, $p < .01$) and body transfer ($b = .98$, $p < .01$). Only body transfer ($b = .50$, $p < .01$) directly influenced INS. Connectedness with nature did not serve as a moderator ($b = .09$, $p = .79$), but was significantly correlated with body transfer ($r = .34$, $p < .01$) and spatial presence ($r = .17$, $p = .05$) The indirect effect from experimental condition to spatial presence and then to INS was not significant (95% CI [−.41, .40]). The indirect effect from experimental condition to body transfer and then to INS was significant (95% CI [.20, 1.01]). H4B was supported but H4A was not. Next, a PROCESS analysis (Model 4) was employed. The mediation model revealed that the greater the INS, the shorter the perceived temporal distance ($b = -.19$, $p < .01$). Shorter temporal distance then led to greater issue involvement ($b = -.26$, $p < .01$). The indirect effect from INS to temporal distance, and to issue involvement was significant (95% CI [.01, .11]). H5 was supported.

General Discussion

Summary of Findings

Results were generally consistent with predictions. Experiment 1 ($N = 49$) found that embodying the sensory-rich experience of an animal in an IVE led to greater perception of spatial presence, body transfer, and INS. However, a parallel mediation model revealed that only body transfer mediated the relationship between the IVE experience and INS.

Experiment 2 ($N = 53$) replicated these findings by showing that IVE experiences led to greater spatial presence, body transfer, and INS. Immediately following experimental treatments, both spatial presence and body transfer mediated the relationship between IVE experience and INS. However, the mediating effects of spatial presence dissipate over time. One week following experimental treatments, only body transfer drove the perception of INS. The parallel mediation model was expanded to include the process of INS increasing the perceived imminence of the environment risk, and the risk ultimately leading to increased issue involvement.

Experiment 3 ($N = 126$) tested the final parallel mediation model with a larger sample and the HMD system without haptic feedback. IVE experiences led to greater spatial presence and body transfer but did not affect INS. As in Experiment 1 and Experiment 2 (Time 2), only body transfer mediated the relationship between experimental condition and INS, which led to an increase in perceived imminence of risk and ultimately increased involvement in the issue of ocean acidification, substantiating results from Experiment 2.

Theoretical Contributions and Practical Implications

Results across three experiments and 228 participants lend support to predictions that IVEs can simulate perspective taking of an animal with digitally reproduced sensory information, and the promise of these systems to promote a feeling of interconnectedness between nature and the self. Embodied experiences in IVEs allowed users to share the animals' experiences in a more sensory-rich way than watching the video of the same experience. Because IVEs offer a wider array of sensory information than video, allowing users to see, hear, and feel environmental damage, participants perceived greater spatial presence and felt that their experiences as an animal were more genuine than watching a video of the same experience.

The studies reported here take the investigation of perspective taking to a new level by allowing participants to go beyond imagining the perspective of the cow or coral. Participants felt ownership of the virtual animal's body and perceived a mental merging of the self and nature. The current study is one of the first efforts to extend the applicability of the concept of self-other merging outside interpersonal (including virtual humans) interactions. Earlier research has demonstrated that applying IVEs in the context of interpersonal perspective taking elicits greater self-other merging and helping behavior than using traditional means of perspective taking (Ahn et al., 2013). The application of virtual experiences in IVEs may augment the findings of prior studies that have relied on traditional means to ask participants to take the perspective of plants and animals (e.g., Berenguer, 2007; Sevillano et al., 2007), and suggests body transfer should be considered in future studies that explore the use of perspective-taking to induce environmental attitudes and behaviors, particularly when using advanced digital technologies.

The results also contribute to the conceptual development of embodied experiences in IVEs by suggesting insights into a preliminary model of underlying mechanisms and the change in their effects over time. Although embodying the sensory-rich experience of animals in IVEs led to both increased spatial presence and body transfer, only body transfer seemed to strongly and consistently drive increased INS in all three experiments. Furthermore, the mediating effect of body transfer persisted over time (Experiment 2). As a result of mediation by body transfer, the direct effect of experimental condition on INS became nonsignificant. This demonstrates the importance of the perception of body transfer in that although, on the surface, the mere exposure to IVE experiences alone seems to be driving the feeling of INS, it is important that the individual feels that he or she actually owns the body of the animal.

Experiments 2 and 3 expanded the parallel mediation model to demonstrate the power of accelerating the progression of time during an embodied experience in IVEs. Echoing earlier results (Ahn, 2015;

Ahn et al., 2015), the acceleration of time in IVEs rendered the causal relationship concrete by depicting present behavior and future consequences. As a result, individuals were more likely to perceive the environmental risk to be imminent. The perceived imminence increased involvement in the environmental issue at hand. Similarly, perceived imminence of health risk has been shown to increase desired health behaviors (Ahn, 2015, in press). We did not measure behavior, but given earlier demonstrations of the link between issue involvement and environmental behavior (Gregory & Di Leo, 2006), high issue involvement in the current experiments is likely to lead to environmental behavior.

Our interpretation of the mediators remains cautious, as further research is necessary. A growing body of literature has noted that mediation pathways, particularly in an experimental context, may be difficult to establish in a single study (e.g., Bullock, Green, & Ha, 2010). Despite support for the proposed mediators across three studies, particularly for the perception of body transfer, there are inconsistencies in how these indirect effects manifest in the proposed parallel mediation model. One explanation for these inconsistencies may be the variance in sample sizes across the studies. For studies with relatively smaller samples, individual differences could have yielded stronger variance on the manifestation of psychological mediators. For instance, it may be that users vary in their motivations for engaging with the novel affordances offered by IVEs and videos in different ways (Sundar & Limperos, 2013). Our findings consistently demonstrate that it is the psychological perception of having shared an animal's experience (e.g., spatial presence, body transfer), rather than exposure to IVEs alone, that drives feelings of interconnectedness with the nature. These results should be understood as preliminary suggestions for considering the role of psychosocial variables in investigating the effects of advanced digital technology on environmental attitude and behavior change.

On the surface, the variables of body transfer and INS may seem similar. However, conceptual definitions delineate clear differences: Body transfer refers to the perception of physical ownership over another body, whereas INS is more related to the perception of the self as an integral part of nature—a state of self-nature merging. Results imply that even when IVE experiences elicit high spatial presence, INS is not influenced without increased perceptions of body transfer between the individual and the target entity.

The findings demonstrate the importance of direct experiences in promoting interconnectedness with nature and involvement with environmental issues. Earlier studies show that even when individuals recognize an environmental problem as a serious issue, they fail to feel responsible if they have not directly experienced the problem (Uzzell, 2000). On the other hand, when individuals feel responsible for an environmental issue, they are likely to feel that the problem is not serious. IVEs may be able to resolve this dilemma by emphasizing the seriousness and imminence of the environmental risk while maintaining personal relevance of the risk through palpable experiences of negative consequences.

Practically, the results from Experiment 3 emphasize the potential of using lower-immersive virtual reality systems. Participants in the IVE condition felt higher body transfer than those in the video condition, even without incorporating the haptics used in the other two studies. This suggests that controlling only the visual aspect of the virtual experience provided sufficient sensory information for users to feel ownership of their avatars and to perceive body transfer. This introduces a novel mode of communicating and learning about environmental risk. The concept of learning through direct experiences is not new—students participate in field trips, and on-the-job training is an effective form of preparing new employees. IVEs extend the applicability of learning through direct experiences to environmental risks that are too serious to allow personal experiences. As the industry continues to develop accessible and affordable IVE systems, embodied experiences in IVEs may be used in tandem with traditional education materials to allow individuals to augment their learning processes through vivid and palpable experiences, reducing the challenge of literacy or language barriers to effective learning.

Limitations and Future Directions

Although the results across three experiments yielded encouraging patterns of findings, several qualifications warrant future research. First, readers should take into consideration when interpreting these results that the effect sizes reported are small to moderate. Although small to moderate effect sizes may have substantial accumulated effects across large populations, it implies that a single exposure to IVE experiences may not lead to powerful changes to an individual's environmental involvement. It should also be noted that IVE experiences' effect did not demonstrate meaningful differences from video experiences on all of the measured variables.

Furthermore, the current experiments studied student samples of limited representativeness. College students spend considerable amounts of time with digital media, which may make the effects of IVEs different for this demographic. College students may also be more sensitized to environmental issues than other groups. Future studies should investigate effects of embodied experiences in IVEs across a wider range of populations and with a larger sample for greater generalizability of results. Also, although the individual difference in connectedness with nature was not a significant moderator in the current experiments, this trait was significantly correlated with body transfer and spatial presence. Individuals with the trait of being connected with nature may be more likely to feel present in IVEs and experience body transfer. Earlier research demonstrates that individuals have inherent trait differences in perspective taking abilities (Davis, 1996). Prior research also suggests that the sensory-rich experience of embodiment in IVEs may offer greater assistance to individuals with lower trait ability for perspective taking (Ahn et al., 2013). Future research should explore the possibility of using IVEs to encourage all, even those with lower perspective taking abilities, to view environmental problems from the viewpoint of nature rather than of humans.

Finally, the three studies deal with two animals that may be perceived in very different ways — cows and coral. In fact, some people might not even recognize coral as an animal, which might influence their schema construction during the IVE experience. For instance, coral may be considered inanimate, and participants may have controlled the two avatars differently, despite being given similar capacities for movement in the IVE. Future studies should further investigate the relationship between existing schema of the perspective-taking target and how it impacts embodied experiences in IVEs.

Conclusion

These experiments demonstrate the promise of using digital media technology to provide direct experiences that meaningfully engage individuals with environmental issues. However, it seems that technology alone is not sufficient to induce the sense that nature is part of the self, or to induce involvement with nature. Psychological variables that promote feelings of having genuinely shared an animal's experience seem to drive feelings of interconnection and involvement with nature. As Schultz (2000) argues, "We can be interconnected with other people, or more generally, we can be interconnected with all living things" (p. 394). Through three experiments, we demonstrate the potential of embodied experiences within IVEs to facilitate the formation of such connections between humans and nonhuman entities.

Notes

1 An implicit association task that evaluated participants' implicit attitudes toward meat consumption, and two additional scales that assessed their attitude and intentions to reduce meat consumption were also included but were not significant. Data from these variables are available upon request.

2 Participants were assigned to condition based on the day they came to the lab and more participants arrived on the days when the lab was setup for HMD than on the video days. However, Levene's test results for ensuing analyses confirmed equal variances across conditions so the imbalance in cells is not discussed further.

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Appendix

Measurement Items

Items retained after tests of internal consistency and reliability	Notes
Spatial Presence (Exp 1, 2: 1 = *Not at all*; 5 = *Very strongly*, Exp 3: 1 = *Not at all*; 7 = *Very strongly*)	
1. To what extent did you feel like you were really inside the virtual pasture/rocky reef?	Exp 1: Variable correlations: Spatial presence and body transfer ($r = .96$, $p = .000$), spatial presence and INS ($r = .80$, $p = .000$), body transfer and INS ($r = .79$, $p = .000$)
2. To what extent did you feel surrounded by the virtual pasture/rocky reef?	
3. I felt like I really visited the pasture/rocky reef.	
4. The pasture/rocky reef seemed like the real world.	
5. I felt like I could reach out and touch the objects in the pasture/rocky reef.	
Body Transfer (Exp 1, 2: 1 = *Not at all*; 5 = *Very strongly, E*xp 3: 1 = *Not at all*; 7 = *Very strongly*)	
1. When you were looking at your cow avatar/coral body how much did you feel a strong connection as if you were looking at yourself?	Exp 2: Variable correlations: spatial presence and body transfer ($r = .75$, $p = .000$), spatial presence and INS ($r = .43$, $p = .001$), body transfer and INS ($r = .36$, $p = .01$).
2. When the cattle prod/fishing net poked your cow avatar/coral body, how much did you feel this as if this was an attack on your body?	
3. After you resumed moving around the virtual environment, how much did you feel that the cattle prod/fishing net might hurt you?	
4. How much did you feel that the cow's body/coral body was your body?	
5. How strong was the feeling that the cattle prod/fishing net you saw was directly touching you on the back?	
6. How much did you feel pain from the cattle prod/fishing net that you saw?	
7. How strong was the feeling that the body of the cow/coral was your body?	
8. How strong was the feeling that the touch you felt was caused by the cattle prod/fishing net you saw?	
9. When using the virtual environment, how much do you feel your cow avatar/coral body is part of your body?	
10. To what extent do you feel like you can reach into the virtual environment through your cow avatar/coral body?	
11. When something happens to your cow avatar/coral body, to what extent does it feel like it is happening to any part of your body?	
12. When your cow avatar/coral body is poked by the cattle prod/fishing net, to what extent do you feel angry?	
13. When your cow avatar/coral body is poked by the cattle prod/fishing net, to what extent do you feel aroused?	
14. When your cow avatar/coral body is poked by the cattle prod/fishing net, to what extent do you feel surprised?	
15. When your cow avatar/coral body is poked by the cattle prod/fishing net, to what extent do you feel disgusted?	

Appendix

Continued

Items retained after tests of internal consistency and reliability	Notes
Connectedness with Nature (Exp 1, 2: 1 = *Not at all;* 5 = *Very strongly,* Exp 3: 1 = *Not at all*; 7 = *Very strongly*)	
1. I often feel a sense of oneness with the natural world around me.	Exp 3: Variable correlations: spatial presence and body transfer ($r = .74$, $p = .000$), spatial presence and INS ($r = .17$, $p = .06$), body transfer and INS ($r = .34$, $p = .000$).
2. I think of the natural world as a community to which I belong.	
3. I recognize and appreciate the intelligence of other living organisms.	
4. I often feel disconnected from nature.*	
5. When I think of my life, I imagine myself to be part of a larger cyclical process of living.	
6. I often feel a kinship with animals and plants.	
7. I feel as though I belong to the Earth as equally as it belongs to me	
8. I have a deep understanding of how my actions affect the natural world.	
9. I often feel part of the web of life.	
10. I feel that all inhabitants of Earth, human and nonhuman, share a common 'life force.'	
11. Like a tree can be a part of a forest, I feel embedded within the broader natural world.	
12. When I think of my place on Earth, I consider myself to be a top member of a hierarchy that exists in nature.*	
13. I often feel like I am only a small part of the natural world around me, and that I am no more important than the grass on the ground or the birds in the trees.	
14. My personal welfare is independent of the welfare of the natural world.*	

*indicates item is reverse-coded.