Article

Environment and Behavior
2015, Vol. 47(5) 570–592

DOI: 10.1177/0013916514551604
eab.sagepub.com

The Impact of Vivid Messages on Reducing Energy Consumption Related to Hot Water Use

Jakki O. Bailey[1], Jeremy N. Bailenson[1], June Flora[1], K. Carrie Armel[1], David Voelker[1], and Byron Reeves[1]

Abstract
Research suggests that vivid and personalized interventions influence proenvironmental attitudes and behaviors. Through the use of immersive virtual environment technology, people can experience vivid environmental scenarios that are personalized to the individual. An experiment was conducted to investigate the impact of vivid and/or personal messages on energy savings behavior related to hot water use. Participants experienced a virtual shower in which they received feedback (varying in vividness and/or personalization) on the amount of energy used to heat and transport the virtual water. Participants' hot water use during hand washing in the physical world was tracked before and after treatment. Participants exposed to vivid messages used cooler water compared with not vivid messages. There was no significant effect for personal messages and no interaction effect. The results suggest that technology that leverages vividness may be effective in promoting proenvironmental behaviors.

[1]Stanford University, Stanford, CA, USA

Corresponding Author:
Jeremy N. Bailenson, Stanford University, 450 Serra Mall, Stanford, CA, 94305, USA.
Email: bailenso@stanford.edu

Keywords
proenvironmental behavior, content areas, communication, technology/computer applications, environmental psychology, research setting/place type, energy savings, immersive virtual reality, vivid, personal, hot water

Greenhouse gas (GHG) emissions have been increasing, raising global temperatures and profoundly affecting ecosystems worldwide (Intergovernmental Panel on Climate Change, 2013; Le Quéré et al., 2013). Addressing climate change often seems like a daunting task, a challenge only appropriate for large organizations or institutions. However, individual consumption activities, such as home energy use and travel, have a greater impact on the environment than most expect (Bin & Dowlatabadi, 2005; Gifford, 2011). In the United States, household energy use accounts for more than 20% of overall CO_2 emissions (Dietz, Gardner, Gilligan, Stern, & Vandenbergh, 2009; U.S. Energy Information Administration, 2011).

Scientists estimate that energy and GHG-related behavior change can reduce residential, building, and transportation energy consumption by nearly 20% (Attari, DeKay, Davidson, & de Bruin, 2010; Gardner & Stern, 2008; Parker, Hoak, Meier, & Brown, 2006). This is roughly 10% of the total U.S. energy consumption, equaling to more than the total yearly energy consumption in Brazil or the United Kingdom (U.S. Energy Information Administration, 2010). Interventions promoting energy and GHG-saving actions by individuals in the residential sector could make significant contributions to addressing the problems of climate change.

An area in the residential sector that has great potential for energy savings is in hot water use, specifically related to showering (Willis, Stewart, Panuwatwanich, Jones, & Kyriakides, 2010). The U.S. government has listed managing hot water usage as one of the top eight areas that citizens can regulate to reduce home energy expenditures (Matulka, 2013). Furthermore, the American Council for an Energy-Efficient Economy (2012) has informed the public that water heating is connected to a multitude of domestic activities and is the second largest user of energy in the home.

The gap between individual proenvironmental attitudes and actual behaviors needs to close for people to take action to protect the environment (Blühdorn, 2011; Jamieson, 2006; Kennedy, Beckley, McFarlane, & Nadeau, 2009; Schultz, 2011; Whitmarsh, 2009). Many Americans believe that climate change is “real and bad,” yet engage in contradictory behaviors (Jamieson, 2006, p. 98; Weber & Stern, 2011). According to Jamieson (2006), this environmental paradox occurs because (a) climate change is an extremely complex issue to understand or (b) individuals who believe that climate change is a real threat, believe that other issues such as national security are more salient. In addition, people often underestimate the actual amount of energy that they consume (Attari et al., 2010). Interventions need to encourage people to move beyond their day-to-day thoughts about the environment and engage in concrete actions.

We focused on two features illustrated in environmental behavior change research, personalization, and vividness, (Abrahamse, Steg, Vlek, & Rothengatter, 2005; Costanzo, Archer, Aronson, & Pettigrew, 1986; Gonzales, Aronson, & Costanzo, 1988; Lopes, Antunes, & Martins, 2012; McKenzie-Mohr, 2011; Rhode & Ross, 2008; van Vugt, Griskevicius, & Schultz, 2014), and examined how to leverage them through immersive virtual reality environment technology (IVET).

Personalization and Vividness

Personalization can be defined as "incorporating recognizable aspects of a person in the content information" (Dijkstra, 2008, p. 768). One approach would be to use a person's name or a set of features that when organized in a specific manner would be the equivalent to referring to that person by name. Simply customizing and personalizing information in an intervention improves its effectiveness (Abrahamse et al., 2005; Fogg, 2003; Hargreaves, Nye, & Burgess, 2010; Hawkins, Kreuter, Resnicow, Fishbein, & Dijkstra, 2008; Jensen, King, Carcioppolo, & Davis, 2012; Kalyanaraman & Sundar, 2006). For example, a meta-analysis of print health interventions determined that tailored or personalized information encouraged greater behavior change when compared with comparison or control groups (Noar, Benac, & Harris, 2007).

People arguably find personalized information more persuasive than non-personalized information because they perceive it to hold greater relevance (Jensen et al., 2012), which in turn elicits greater attention (King & Tester, 1999). By garnering greater attention, personal interventions encourage individuals to cognitively elaborate on the content of the message (Griffin, 2009). Jensen et al. (2012) created an intervention to increase breast cancer screenings among women. The researchers created personalized pamphlets in which the content reflected specific attributes of the participants (e.g., age, race). Those that read the personalized pamphlets expressed greater behavioral intent for breast cancer screening compared with those that read the pamphlets with stock information. Furthermore, the effect of personalized visual content was mediated by perceived self-relevance.

Personalized information not only garners greater attention but also can influence a person's decision-making process about the environment. For example, people tend to use direct personal experience to form many of their opinions, decisions, and behaviors related to climate change (Weber, 2006; Weber & Stern, 2011). Results from a national random sample survey showed a statistically significant correlation between personal involvement and energy conservation behavior (Göckeritz, et al., 2010). Furthermore, Maiteny (2002) argues that for people to engage in sustainable behaviors, they need to have direct experiences that personally connect them with the issue.

In addition to personalized messages, interventions employing vividness can enhance the persuasiveness of a message (Guadagno, Rhoads, & Sagarin, 2011) and generate changes in behaviors (Allcott, 2011; Costanzo et al., 1986; Dillard & Main, 2013; Gonzales et al., 1988). Nisbett and Ross (1980) describe vivid content as emotionally interesting, and concrete that provokes imagery in a sensory, temporal or spatial way. For example, home energy auditors signed up homeowners for retrofits more often when they vividly described the cumulative air leaks in a house as being the "size of a football" or described a lack of insulation as like having a "naked attic" (Gonzales et al., 1988). Another study on home energy conservation demonstrated electricity efficiency gains by using an interactive video game that provided vivid visual feedback on the amount of household energy used (Reeves, Cummings, Scarborough, & Yeykelis, 2013).

Vivid appeals make abstract representations concrete, and may influence people's ability or motivation to carefully review the message information, allowing for greater cognitive elaboration. Sheppard (2005) suggests that an interaction between cognitive, affective, and behavioral responses may explain why vivid visual information is effective in initiating behavior. An embodied cognition approach proposes that cognition is rooted in the body and that the brain integrates perceptual, motor, and introspective states during an experience (Barsalou, 2008; Wilson, 2002). Vivid messages that utilize strong imagery related to the senses may enable the brain to assimilate and process information more effectively than not vivid messages.

Virtual Reality: A Persuasive Technology for Proenvironmental Behaviors

IVET can act as a persuasive technology to encourage proenvironmental behaviors by leveraging vividness and personalization (Bainbridge, 2007). IVET provides the user with a first-person point of view in a three-dimensional virtual environment and provides real-time multisensory feedback via visual, haptic, auditory, and/or olfactory cues. The technology allows the user to do or see things that could not occur in the real world—for example, by speeding up time, creating infeasible physical spaces (e.g., geographically remote or fictitious), or allowing for novel, impossible, or undesirable behaviors (e.g., behaviors that would be harmful to the self, others, or the environment).

Persuasive technologies are media or computing systems that catalyze attitude and behavior change (Fogg, 2003; King & Tester, 1999). They saturate many of today's computing behaviors, often appearing in subtle ways. For example, Amazon.com acts as an online store and warehouse that processes orders for a wide spectrum of goods; however, it also contains digital components that promote products and programs based on the preferences of the user (data collected from previous site visits; Fogg, 2003). A persuasive technology can act as a tool, social actor or medium (Fogg, 1999, 2003; Ham & Midden, 2014). A persuasive tool makes a target behavior easier to achieve by creating a personalized experience based on a person's preferences or attributes. When the technology acts as a social actor, it persuades people by modeling a target behavior and/or utilizing the social presence of others to influence behaviors. The power of modeling enables people to learn through vicarious reinforcement (i.e., watching the rewards and punishments that others receive for their behaviors; Bandura, 2004; Hornik & Yanovitzky, 2003); this can occur through interacting with an artificial agent such as a virtual character (Blascovich et al., 2002) or a robot (Ham & Midden, 2014). Finally, a persuasive medium provides an experience for people to explore interactively cause-and-effect relationships.

IVET can act as a persuasive technology by acting as (a) a tool for researchers, educators, and policy makers to make environmental issues more salient to the public; (b) a social actor by illustrating the consequences of human behavior through modeling; and (c) a persuasive medium that allows users to experience complex and abstract processes such as energy use or climate change. In one such use, Zaalberg and Midden (2010) utilized IVET to raise awareness about the effects of global warming by illustrating the impact of flooding in a virtual environment. Participants either walked through a virtual environment with three-dimensional images and spatialized sound or watched a slideshow with two-dimensional images and without audio. In this experiment, participants who used the virtual environment reported a greater willingness to evacuate their virtual residence and to buy flood insurance in real life than those that watched the sideshow. In addition, participants in the virtual environment condition read more online information related to personal flood protection compared with those in the slideshow condition. This virtual flood study illustrates the impact that personal, and vivid experiences can have on motivation and attention, and that IVET can act as a persuasive technology for proenvironmental behaviors.

Sheppard (2005) presents a framework for utilizing visual communication technology such as virtual reality, to alter attitudes and behaviors about the environment. The author argues that to motivate behavior change, the technology needs to visually illustrate the effects of human actions in a way that is emotionally engaging. Sheppard outlines the following techniques to be important when using visualization technology: (a) use photorealism to make abstract concepts concrete; (b) depict personally relevant environments; (c) illustrate near-term effects or make long-term effects appear nearer; (d) use images that contain people, animals, or other symbols that have strong affective content; and (e) illustrate the future consequences of people's actions (or inactions).

Our study used IVET to explore how vivid and/or personal messages impacted proenvironmental behaviors according to Sheppard's (2005) visualization framework. We predicted that an increase in vivid and personal elements in the messages would positively impact energy savings behavior related to hot water use. Participants' actual hot water usage was measured before and after experiencing a virtual shower that provided visual feedback on the amount of energy being consumed to heat and transport water for the virtual shower. Additional data were collected as a manipulation check, in which a separate sample of participants experienced the same virtual shower, and reported the perceived level of vividness and personalization of the feedback.

To make the feedback more concrete, energy use was represented as coal consumption. Due to its negative associations, coal consumption may act as an appropriate representation to illustrate the harmful effects of energy use. Public opinion research has revealed that Americans view coal use as a less desirable energy resource compared with other energy resources because of its link to climate change (Greenberg, 2009). Furthermore, the survey respondents formed their opinion about coal as an energy source based on how harmful they believed it was to the environment, as opposed to its financial costs, which was a major factor for forming opinions about other types of energy use (Greenberg, 2009).

Method

Participants

Participants' ages ranged from 18 to 22 years old, with a mean age of 18.4 years, and were 47.1% female and 52.9% male. The sample (N = 70) was ethnically diverse in which 1.4% identified as Mexican/Chicano/Mexican American (n = 1), 41.4% identified as White/Caucasian (n = 29), 7.1%

identified as Black/African/African American (n = 5), 2.9% identified as Native American/Alaska Native (n = 2), 5.7% identified as Asian Indian (n = 4), 11.4% identified as Chinese/Chinese American (n = 8), 1.4% identified as Japanese/Japanese American (n = 1), 1.4% identified as Other Asian/Asian American (n = 1), 1.4% identified as Other race (n = 1), 22.9% identified as multiple races (n = 16), and 2.9% did not identify a race or ethnicity (n = 2). Students were recruited from the university's Communication classes and an Introduction to the Humanities class in exchange for course credit. Participants were provided informed consent, and the study was approved by the Institutional Review Board.

Apparatus

Participants viewed the study treatment through a head-mounted display, a fully immersive virtual reality helmet that allows for three-dimensional stereoscopic views (Figure 1). They wore an nVisor SX111 head-mounted display (NVIS, Reston, Virginia) with a resolution of 2,056 × 1,024 and a refresh rate of 60 frames per second (in each eye). An orientation sensor operating at 180 Hz with a 4-ms latency rate (Intersense3 Cube) was used to track participants' physical head orientation (pitch, roll, and yaw) and to update the rendered viewpoint appropriately. Participants had a first-person perspective of the virtual world but could not see their virtual bodies. The virtual environment was generated and programmed using Worldviz's Vizard VR toolkit.

To further increase immersion in the virtual shower, participants experienced spatialized sound in which audio emanated in the physical space according to where it was located in the virtual space. A 24 channel Ambisonic Auralizer Sound System was used to create this audio effect. In addition, haptic feedback (in the form of low frequency floor vibrations) was generated in conjunction with the virtual sound through the use of 16 tactile floor subwoofers.

Procedure

A 2 × 2 between-subjects design was implemented to investigate the effects of vivid and personal messages on energy savings behavior related to hot water use. Each participant was randomly assigned to one of four energy feedback conditions, and then placed in a virtual shower using IVET. In every condition, energy use was represented by individual pieces of coal, where one piece of coal was equal to 15 s of shower time and 100 watts of electricity. Vivid treatments consisted of a multisensory experience in which realistic three-dimensional images of coal moved from one pile to another. Personal

Figure 1. Immersive virtual reality headset worn by participants.

treatments placed the participant into the verbal or visual content (i.e., seeing an image of themselves, or language directed toward them). All calculations measuring the amount of coal used to generate electricity during the experiment were done using common home scenarios and based on statistics from U.S. energy agencies.

Participants were randomly assigned to one of four conditions: the avatar-coal (vivid, personal, n = 16), the coal-only (vivid, not personal, n = 17), the

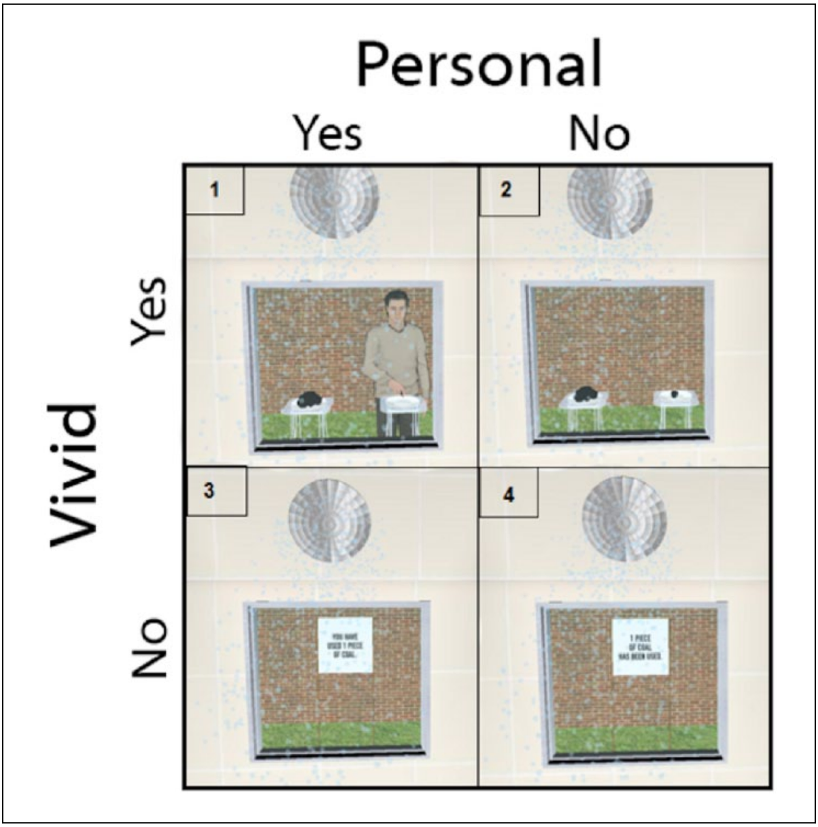

Figure 2. Each cell shows the participant's view of the virtual shower.
Note. Participants were randomly assigned to one of four experimental conditions: (1) avatar-coal condition, (2) coal-only condition. (3) personal-sign condition ("You have used 1 piece of coal"), and (4) impersonal-sign condition ("1 piece of coal has been used").

personal sign (not vivid, personal, $n = 19$), or the impersonal sign (not vivid, not personal, $n = 18$). Figure 2 illustrates the experimental design and the viewpoint of the participant in each condition. The top left cell is the avatar-coal condition in which the treatment is both vivid and personal. Each participant in this condition saw an avatar (three-dimensional digital representation of him- or herself), standing outside of the shower window. Every 15 s a piece of coal would move from a larger pile of coal on one table to another table in front of the avatar. The avatar would then eat that piece of coal. During this condition, the floor slightly vibrated in conjunction with the crunching sound of the avatar eating coal and coughing in response to eating the coal. This additional haptic feedback was used to generate a more vivid sensory experience. Two digital photographs of the participant were used to create the avatar. The vivid but not personal condition (shown in the top right cell) was the coal-only condition, in which the visual feedback was individual pieces of coal piling up, moving from a larger pile on one table to another table every 15 s. The pieces of coal moved across the participants' field of view to allow them to easily keep track of how many pieces of coal were being consumed. The appearance and movement of the coal itself was identical in the avatar-coal and coal-only conditions. The main difference was that at the very end of the coal sequence in the avatar-coal condition, the avatar picked up the piece of coal from the plate and ate it.

The two not vivid conditions provided feedback through a counting ticker on a billboard sign. The lower left cell, the not vivid but personal treatment, was the personal-sign condition. The billboard sign used personal language when counting the number of coal pieces consumed stating, "You have used 1 piece of coal." Finally, the lower right cell was the not personal and not vivid treatment, the impersonal-sign condition. Participants saw a billboard sign that used impersonal language via the passive voice to count the number of pieces of coal consumed stating, "1 piece of coal has been used."

To ensure that the experimenter remained blind to condition, every participant had his or her photograph taken prior to treatment. A separate researcher created the necessary avatars for the personal and vivid condition using software that produced a three-dimensional model of the participant's head based on the photographs. This technique produces highly accurate digital representations (Bailenson, Beall, Blascovich, & Rex, 2004).

At the start of the experiment, all participants read along and listened to a 435-word narrative describing (a) the amount of coal needed to transport and heat water for a shower (e.g., "one piece of coal is equal to 15 s of showering time and 100 watts of electricity," and "a 10-min shower uses about 3.7 pounds of coal.") and (b) the negative impact that mining and burning coal has on the environment. After the narrative, participants saw and touched 3.7 pounds (1.68 kg) of physical coal. Then, they were told that the room with the virtual reality equipment needed to remain clean for sanitation reasons and that they were required to wash their hands before entering the room. The participants used a specially installed sink to wash their hands. The pretreatment hand washing requirement allowed us to collect baseline hot water use to control for individual differences in participants' hand washing behaviors during data analysis.

Participants then entered the second experimental room for the virtual reality intervention. They were provided a few seconds to orient themselves within the virtual shower. Audio instructions with specific washing motions were played during the treatment (e.g., "Please wash your right arm"). Spatialized sound created the echo of running water, and the virtual shower lasted approximately 6 min. Participants were unable to change the length or flow of the virtual shower. After the virtual reality treatment, participants completed an online questionnaire in an adjoining survey room. After completing the questionnaire, they were told that they would be completing a communication task in the room with the virtual reality equipment. Again, all participants were asked to wash their hands before entering the room to keep the area with the technology sanitized.

During both times that participants washed their hands, they controlled the temperature and flow of the water. The sink had two handles, one for hot water and one for cold water. Before each hand washing time point, the handles were placed in the off position. The hot water took 2 to 5 s to heat up, and participants washed their hands for about 10 to 20 s.

To further explore the impact of vividness and personalization on water use, additional data was collected with a separate sample to measure how the virtual feedback appeared to participants. The same procedure was followed except participants were not required to wash their hands before or after the virtual reality treatment. The second sample consisted of a group of students from the same population as the first sample; the demographic breakdown of participants in the manipulation check was similar to the main study. There were 12 participants in the avatar-coal condition (vivid, personal) consisting of 8 women and 4 men; 13 in the coal-only condition (vivid, not personal) with 9 women, 3 men, and 1 participant who did not identify a sex; 12 in the personal-sign condition (not vivid, personal) with 7 women and 5 men; and 13 in the impersonal-sign condition (not vivid, not personal) with 11 women and 2 men. This portion of the study acted only as manipulation check, and no water measurements were collected. The specially installed sink in the lab required a large amount of space and effort to maintain, and was therefore removed shortly after initial data collection.

Measures

Water temperature. The temperature of the water that participants used during hand washing was measured in degrees Celsius. The used water drained from the sink into a hidden glass beaker with a glass thermometer. Temperature measurements were taken before and after treatment, approximately 30 to 45 s after the completion of each hand washing. After each measurement, the beaker was emptied and dried with a towel to remove excess water.

Water amount. The total volume of water that participants used during hand washing was measured in milliliters. Measurements were recorded by the same method and in the same glass beaker used to measure water temperature.

Vividness scale. The vividness scale, a four-item scale, measured how vivid the shower feedback appeared to participants (see the online appendix for exact question wording). Each question response was scored from one to five, with lower scores indicating greater levels of vividness ($\alpha = .82$, $M = 2.92$, and $SD = 0.87$). These questions were based on previous work that measured how "real" virtual environments felt to users (Ahn & Bailenson, 2011; Bailenson & Yee, 2007; Nowak & Biocca, 2003).

Personalization scale. The personalization scale, a five-item scale, measured how personal the shower feedback appeared to participants (see the online appendix for exact question wording). Each question response was scored from one to five, with lower scores indicating greater levels of personalization ($\alpha = .85$, $M = 3.24$, and $SD = 0.78$).

Results

Energy Savings Behaviors

The means and standard deviations of all the outcome variables according to condition are presented in Table 1. To determine the effect of vivid and/or personal messages on energy savings behaviors, two-way analyses of covariance (ANCOVA) tests were conducted to analyze the impact that condition had on water use (water temperature and amount). An ANCOVA was used to control for the variance due to any individual differences in hand washing that may have influenced the amount or temperature of the water used after treatment. The independent variables, vividness, and personalization, each included two levels: vivid/not vivid and personal/not personal. The covariates were either the amount or temperature of the water measured at baseline. The water temperatures and amounts of the entire sample were first examined across the four conditions. Three outlier participants (one each from the avatar-coal, personal-sign, and impersonal-sign conditions) were removed from the water temperature analysis for being three or more standard deviations from the mean of water temperature taken posttreatment.

The results showed a significant effect of virtual reality treatment on water temperature. Participants exposed to vivid messages used cooler water posttreatment compared with those exposed to not vivid messages: $F(1, 61) =$

Table 1. Mean Values of Outcome Variables According to Vividness and Personalization.

Condition	Water temperature baseline (°C)	Water temperature post (°C)	Water amount baseline (ml)	Water amount post (ml)	Vividness scale post[a]	Personalization scale post[b]
	M (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)
Overall sample	23.53 (2.73)	23.51 (2.67)	261.55 (124.92)	269.32 (166.22)	2.92 (0.87)	3.24 (0.78)
Overall not vivid	24.14 (3.06)	24.26 (2.98)	252.11 (103.18)	258.10 (131.50)	3.16 (0.91)	3.23 (0.87)
Overall vivid	22.80 (2.08)	22.59 (1.89)	273.28 (148.68)	283.62 (203.79)	2.68 (0.76)	3.24 (0.71)
Overall not personal	23.62 (2.85)	23.40 (2.68)	275.03 (127.24)	284.38 (183.24)	2.88 (0.77)	3.23 (0.87)
Overall personal	23.45 (2.65)	23.62 (2.70)	249.26 (123.37)	255.15 (149.85)	2.96 (0.98)	3.24 (0.71)
Vivid, personal	22.89 (2.62)	22.78 (2.48)	243.33 (140.06)	248.33 (163.52)	2.77 (0.90)	3.18 (0.81)
Vivid, not personal	22.70 (1.38)	22.38 (0.98)	305.36 (156.03)	321.43 (240.16)	2.60 (0.63)	3.29 (0.65)
Not vivid, personal	23.92 (2.65)	24.32 (2.74)	253.95 (112.23)	260.53 (142.48)	3.14 (1.05)	3.02 (0.89)
Not vivid, not personal	24.38 (3.51)	24.20 (3.29)	250.06 (95.45)	255.56 (122.94)	3.17 (0.80)	3.43 (0.83)

Note. The overall vivid condition reflects the aggregate results of the avatar-coal and the coal-only conditions, while the overall not vivid condition reflects the two sign conditions. The overall personal condition reflects the aggregate results of the avatar-coal condition and the personal-sign condition while the overall not personal condition reflects the coal-only condition and the impersonal-sign condition.

[a]Lower scores on the vividness scale indicate greater levels of experienced vividness.

[b]Lower sores on the personalization scale indicate greater levels of experienced personalization.

6.55, $p = .01$, $\eta^2_{partial} = .10$. As shown in Table 1, approximately two degrees separated the mean temperatures of the vivid and not vivid conditions at 22.59 (*SD* = 1.89) and 24.26 (*SD* = 2.99), respectively (estimated marginal means were at 23.01 [*SE* = 0.27] and 23.96 [*SE* = 0.26]). No significant effect ($p > .05$) of personal messages on water temperature was found, $F(1, 61) = 2.08$, $\eta^2_{partial} = .03$, nor was there an interaction effect, $F(1, 61) = 0.09$, $\eta^2_{partial} = .00$.

The main effect of vividness remained significant when including the outliers in the analysis: vivid, $F(1, 62) = 7.14$, $p = .01$, $\eta^2_{partial} = .10$; personal, $F(1, 62) = 1.75$, $p = .19$, $\eta^2_{partial} = .03$; vivid and personal interaction, $F(1, 62) = 0.26$, $p = .61$, $\eta^2_{partial} = .00$. In addition, analysis of the posttreatment water temperature without pretreatment water as a covariate revealed the same effect of vividness with a marginal significant effect: vivid, $F(1, 63) = 3.69$, $p = .06$, $\eta^2_{partial} = .06$.

With regard to the amount of water that participants used after treatment exposure, results showed no significant effect ($p > .05$) of either vivid, $F(1, 61) = 0.09$, $\eta^2_{partial} = .00$; personal, $F(1, 61) = 0.00$, $\eta^2_{partial} = .00$; or vivid and personal, $F(1, 61) = 0.00$, $\eta^2_{partial} = .00$. The amount of water participants used after being exposed to the virtual reality messages did not differ between groups. The result of the water amount analysis remained the same with all outliers included in the data: vivid, $F(1, 65) = 0.02$, $p = .88$, $\eta^2_{partial} = .00$; personal, $F(1, 65) = 0.00$, $p = .98$, $\eta^2_{partial} = .00$; and vivid and personal: $F(1, 65) = 0.00$, $p = .98$, $\eta^2_{partial} = .00$.

Experienced Levels of Vividness and Personalization

The data collected for the manipulation check (after the main study was conducted) was analyzed to determine how vivid and/or personal the virtual shower feedback appeared to participants. Table 1 presents the means and standard deviations of the vividness and personalization scales according to condition. A general linear model was used to examine participants' self-reported experience of the virtual reality treatment. Participants in the vivid condition rated the feedback in the virtual shower as more vivid compared with those in the not vivid condition, $F(1, 50) = 4.01$, $p = .05$, $\eta^2_{partial} = .08$ (a marginally significant effect). There was no significant effect ($p > .05$) of personal conditions on the vividness scale, $F(1, 50) = 0.10$, $p = .76$, $\eta^2_{partial} = .00$, nor was there an interaction effect, $F(1, 50) = 0.17$, $p = .68$, $\eta^2_{partial} = .00$.

Examination of the personalization scale, revealed no significant main effects of the vivid or personal conditions, $F(1, 50) = 0.00$, $p = .97$, $\eta^2_{partial} = .00$, and $F(1, 50) = 1.36$, $p = .25$, $\eta^2_{partial} = .00$, respectively. In addition, there was no interaction effect of vividness and personalization, $F(1, 50) = 0.46$,

p = .50, $\eta^2_{partial}$ = .00. In summary, there were no significant differences in how personal the virtual shower appeared to participants across conditions.

Discussion

The results from this study suggest that vivid messages experienced in an immersive virtual environment can elicit proenvironmental behaviors. Even with the use of computer graphics far less advanced than many consumer video games on the market, the virtual feedback impacted participants' actual energy usage. Participants exposed to vivid messages used less energy related to hot water use (cooler water temperature) compared with those exposed to the not vivid messages. The vivid conditions used images of coal, which may have made coal consumption more salient than the not vivid conditions that only used text. The results of a study by Ham and Midden (2010) demonstrated that textual feedback utilized greater cognitive resources compared with visual feedback because text was more challenging to mentally process. Perhaps the images of coal in the vivid conditions required a lower cognitive load than the text conditions, allowing participants to better process the impact of hot water use on coal consumption.

Unexpectedly, there were no observed differences in the amount of water used across the conditions. Participants may have responded to the virtual treatment based on the specific information they learned which emphasized the use of coal to heat water. The intervention may have directed their attention to the *temperature* of the water as opposed to the *amount* of water. Participants may have simply used more cold water and less hot water to consume less energy.

A manipulation check was conducted in a separate sample to measure participants' perception of the virtual shower feedback. Participants reported that the feedback with images of coal were more vivid than the feedback that used text resulting in a marginally significant effect. However, they did not report any differences in the level of personalization in any of the conditions. In other words, the virtual reality treatment likely failed to create substantial subjective differences in perceived personalization. This is fairly surprising given that one of the personal conditions displayed factual text and numbers regarding energy consumption, compared with the other in which one's photographically and behaviorally realistic avatar consumed coal. Differences between experiencing a first-person perspective of oneself compared with a third-person perspective may partially explain the lack of differences between the avatar-coal condition and the other conditions. Through the use of neural imaging techniques and digital avatars, research has shown that the brain processes information differently when watching a task being completed from the first person versus the third person (Vogeley et al., 2004), and people tend to feel a greater connection to their avatar when it is embodied from the first person as opposed to the third person (Steptoe, Steed, & Slater, 2013). Finally, each participant personally experienced the ramifications of hot water use during his or her virtual shower, and therefore the virtual feedback may have felt similarly personally relevant in all conditions. A stronger and more varied manipulation of personalization could be tested in a follow-up experiment.

One limitation of this study is that the behaviors were measured only once immediately after treatment. A longitudinal study could reveal the effectiveness of vivid messages on energy use over an extended period of time. In addition, the sample selected was within a limited age range (18-25 years of age). However, a survey study by Semenza et al. (2008) revealed that individuals with some college or higher and/or those generally younger in age are the most likely to change their behaviors to improve the environment. The results of Semenza and colleague's survey research show the importance of engaging young people in learning about proenvironmental behaviors and may explain why our results were effective immediately after treatment.

An area for future research could examine the separate psychological mechanisms underlying vividness and personalization. It is possible that coal has additional meaning outside of energy use (e.g., the holiday anecdote about receiving coal in one's stocking for being "bad"). In addition, some areas of the world may depend on other types of energy resources and using coal consumption as an energy use example may not be as applicable. Although the data set from this study was unable to isolate vividness and personalization as separate mechanisms, the results fall in line with behavior change research in other domains. A study by Dillard and Main (2013) manipulated health messages to motivate colon cancer screening, and examined the degree to which participants identified or personally connected with the character in the message (a manipulation similar to personalization) and the level of vividness. The study revealed that though identification and vividness were both positively associated with knowledge and behavioral intentions, only vividness was significantly associated with knowledge about colon cancer screening and behavioral intentions in the final analysis. It appears that vividness may be an integral part of initiating behavior change.

Our virtual shower study manipulated vividness and personalization to illustrate the negative effects of energy use to facilitate behavior change (i.e., coal consumption). The choice to use negative appeals was modeled after previous proenvironmental behavior change interventions (i.e., experiencing the negative impact of a virtual flood or describing the cracks in one's home as being equal to a football size hole; Gonzales et al., 1988; Zaalberg & Midden, 2010). A study on energy use by Midden and Ham (2014) found that participants used less energy after receiving negative feedback compared with positive feedback. As opposed to negative appeals, other research suggests that interventions that illustrate the positive consequences of an individual's behavior may also catalyze proenvironmental behavior (Ahn, Fox, Dale, & Avant, 2014). An alternative intervention could show the positive effects of certain showering behaviors. The visual feedback could illustrate a tree growing or one's avatar gaining strength when participants use less hot water. Or other sensory modalities in a virtual environment, such as sound, could be leveraged to influence proenvironmental behaviors. Experimental research by Golan and Fenko (2013) demonstrated that altering the perceptual sound of how fast or slow water flowed from a faucet influenced how much water participants indicated was needed to fill a water bottle. The next generation of interventions could combine both negative and positive strategies. The intervention could show the initial negative impact of human behaviors but then illustrate specific behaviors that improve the environment. With this approach users could practice proenvironmental behaviors in a virtual environment, which may increase self-efficacy about the target behaviors and thus increase the likelihood that those same behaviors will be enacted in the real world (Fogg, 2003).

The techniques utilized in this study could be applied to numerous proenvironmental behaviors that could add up to significant amounts of energy savings. Virtual reality hardware and software are becoming more accessible to the general public. The treatment in this study could easily be translated to commercial technology. Video game platforms, such as Microsoft's Kinect and the Oculus Rift, which are in tens of millions of homes in the United States (Rigby, 2012), could support outreach for IVET interventions. In addition, Facebook recently spent two billion dollars to buy an IVET company, signaling that the technology will soon be widespread (Solomon, 2014).

Educators could incorporate virtual reality into classroom science lessons, and government committees could experience the ramifications of their policies on domestic and international scales. Using compelling vivid simulations to warn about environmental consequences could transform the ways people teach about the environment. Interventions could be developed to change individual transportation habits, or encourage people to buy energy-efficient appliances. With the rapid development of interactive and vivid media, it is critical to understand how these technological tools can close the gap between proenvironmental attitudes and real world behaviors across a multitude of environmental domains.

Acknowledgment

We thank Cody Karutz, the lab manager for the Stanford Virtual Human Interaction Lab (VHIL), for his input and support throughout the research as well as the students and staff of the VHIL for computer programming, running experiments, and data coding.

Authors' Note

The views and opinions of authors expressed herein do not necessarily state or reflect those of the U.S. Government or any agency thereof.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: The information, data, or work presented herein were funded in part by the Advanced Research Projects Agency–Energy (ARPA-E), U.S. Department of Energy (Grant DE-AR 0000018); the California Energy Commission (Grant PIR-10-0540); and the NSF-SoCS (Grant 1143991-100-QCHAR).

References

Abrahamse, W., Steg, L., Vlek, C., & Rothengatter, T. (2005). A review of intervention studies aimed at household energy conservation. *Journal of Environmental Psychology*, *25*, 273-291. doi:10.1016/j.jenvp.2005.08.002

Ahn, S. J., & Bailenson, J. N. (2011). Self-endorsing versus other-endorsing in virtual environments: The effect of brand attitudes and purchase intention. *The Journal of Advertising*, *40*, 93-106. doi:10.2753/JOA0091-3367400207

Ahn, S. J., Fox, J., Dale, K. R., & Avant, J. A. (2014). Framing virtual experiences: Effects on environmental efficacy and behavior over time. *Communication Research*, 1-25. doi:10.1177/0093650214534973

Allcott, H. (2011). Social norms and energy conservation. *Journal of Public Economics*, *95*, 1082-1095. doi:10.1016/j.jpubeco.2011.03.003

American Council for an Energy-Efficient Economy. (2012). *Water heating*. Retrieved from http://aceee.org/consumer/water-heating

Attari, S. Z., DeKay, M. L., Davidson, C. I., & de Bruin, W. B. (2010). Public perceptions of energy consumption and savings. *Proceedings of the National Academy of Sciences of the United States of America*, *107*, 16054-16059. doi:10.1073/pnas.1001509107

Bailenson, J. N., Beall, A. C., Blascovich, J., & Rex, C. (2004). Examining virtual busts: Are photogrammetrically generated head models effective for person identification? *Presence: Teleoperators and Virtual Environments*, *13*, 416-427. doi:10.1162/1054746041944858

Bailenson, J. N., & Yee, N. (2007). Virtual interpersonal touch and digital chameleons. *Journal of Nonverbal Behavior*, *31*, 225-242. doi:10.1007/s10919-007-0034-6

Bainbridge, W. S. (2007). The scientific research potential of virtual worlds. *Science*, *317*, 472-476. doi:10.1126/science.1146930

Bandura, A. (2004). Social cognitive theory for personal and social change by enabling media. In A. Singhal, M. J. Cody, E. M. Rogers, & M. Sabido (Eds.), *Entertainment-education and social change: History, research, and practice* (pp. 75-96). Mahwah, NJ: Lawrence Erlbaum.

Barsalou, L. W. (2008). Grounded cognition. *Annual Review of Psychology*, *59*, 617-645. doi:10.1146/annurev.psych.59.103006.093639

Bin, S., & Dowlatabadi, H. (2005). Consumer lifestyle approach to U.S. energy use and the related CO2 emissions. *Energy Policy*, *33*, 197-208. doi:10.1016/S0301-4215(03)00210-6

Blascovich, J., Loomis, J., Beall, A. C., Swinth, K. R., Hoyt, C. L., & Bailenson, J. N. (2002). Immersive virtual environment technology as a methodological tool for social psychology. *Psychological Inquiry*, *13*, 103-124. doi:10.1207/S15327965PLI1302_01

Blühdorn, I. (2011). The politics of unsustainability: COP15, post-ecologism, and the ecological paradox. *Organization & Environment*, *24*, 34-53. doi:10.1177/1086026611402008

Costanzo, M., Archer, D., Aronson, E., & Pettigrew, T. (1986). Energy conservation behavior: The difficult path from information to action. *American Psychologist*, *41*, 521-528. doi:10.1037/0003-066X.41.5.521

Dietz, T., Gardner, G. T., Gilligan, J., Stern, P. C., & Vandenbergh, M. P. (2009). Household actions can provide a behavioral wedge to rapidly reduce U.S. carbon emissions. *Proceedings of the National Academy of Sciences of the United States of America*, *106*, 18452-18456. doi:10.1073/pnas.0908738106

Dijkstra, A. (2008). The psychology of tailoring-ingredients in computer-tailored persuasion. *Social and Personality Psychology Compass*, *2*, 765-784. doi:10.1111/j.1751-9004.2008.00081.x

Dillard, A. J., & Main, J. L. (2013). Using a health message with a testimonial to motivate colon cancer screening: Associations with perceived identification and vividness. *Health Education & Behavior*, *40*, 673-682. doi:10.1177/1090198112473111

Fogg, B. J. (1999). Persuasive technologies. *Communications of the Association for Computing Machinery*, *42*, 26-29. doi:10.1145/301353.301396

Fogg, B. J. (2003). *Persuasive technology: Using computers to change what we think and do*. San Francisco, CA: Morgan Kaufmann.

Gardner, G. T., & Stern, P. C. (2008). The short list: The most effective actions U.S. households can take to curb climate change. *Environment: Science and Policy for Sustainable Development*, *50*, 12-25. doi:10.3200/envt.50.5.12-25

Gifford, R. (2011). The dragons of inaction: Psychological barriers that limit climate change mitigation and adaptation. *American Psychologist*, *66*, 290-302. doi:10.1037/a0023566

Göckeritz, S., Schultz, P. W., Rendón, T., Cialdini, R. B., Goldestein, N. J., & Gŕiskevicius, V. (2010). Descriptive normative beliefs and conservation behavior: The moderating roles of personal involvement and injunctive normative beliefs. *European Journal of Social Psychology*, *40*, 514-523. doi:10.1002/ejsp.643

Golan, A., & Fenko, A. (2013). Toward a sustainable faucet design: Effects of sound and vision on perception of running water. *Environment and Behavior*, 1-17. doi:10.1177/0013916513493908

Gonzales, M. H., Aronson, E., & Costanzo, M. A. (1988). Using social cognition and persuasion to promote energy conservation: A quasi-experiment. *Journal of Applied Social Psychology*, *18*, 1049-1066. doi:10.1111/j.1559-1816.1988.tb01192.x

Greenberg, M. (2009). Energy sources, public policy, and public preferences: Analysis of U.S. national and site-specific data. *Energy Policy*, *37*, 3242-3249. doi:10.1016/j.enpol.2009.04.020

Griffin, E. (2009). *A first look at communication theory* (8th ed.). New York, NY: McGraw-Hill.

Guadagno, R. E., Rhoads, K. v. L., & Sagarin, B. J. (2011). Figural vividness and persuasion: Capturing the "elusive" vividness effect. *Personality and Social Psychology Bulletin*, *37*, 626-638. doi:10.1177/0146167211399585

Ham, J., & Midden, C. J. H. (2010). Ambient persuasive technology needs little cognitive effort: The differential effects of cognitive load on lighting feedback versus factual feedback. In T. Ploug, P. Hasle, & H. Oinas-Kukkonen (Eds.), *Lecture notes in computer science. Persuasive technology* (pp. 132-142). Berlin, Heidelberg: Springer. doi:10.1007/978-3-642-13226-1_14

Ham, J., & Midden, C. J. H. (2014). A persuasive robot to simulate energy conservation: The influence of positive and negative social feedback and task similarity on energy-consumption behavior. *International Journal of Social Robotics*, *6*, 163-171. doi:10.1007/s12369-013-0205-z

Hargreaves, T., Nye, M., & Burgess, J. (2010). Making energy visible: A qualitative field study of how householders interact with feedback from smart energy monitors. *Energy Policy*, *38*, 6111-6119. doi:10.1016/j.enpol.2010.05.068

Hawkins, R. P., Kreuter, M., Resnicow, K., Fishbein, M., & Dijkstra, A. (2008). Understanding tailoring in communicating about health. *Health Education Research*, *23*, 454-466. doi:10.1093/her/cyn004

Hornik, R., & Yanovitzky, I. (2003). Using theory to design evaluations of communication campaigns: The case of the national youth anti-drug media campaign. *Communication Theory*, *13*, 204-224. doi:10.1111/j.1468-2885.2003.tb00289.x

Intergovernmental Panel on Climate Change. (2013). *Climate change 2013: The physical science basis* (Report No. AR5). Retrieved from http://www.climatechange2013.org/images/uploads/WGIAR5_WGI-12Doc2b_FinalDraft_Chapter10.pdf

Jamieson, D. (2006). An American paradox. *Climatic Change*, *77*, 97-102. doi:10.1007/s10584-005-9044-8

Jensen, J. D., King, A. J., Carcioppolo, N., & Davis, L. (2012). Why are tailored messages more effective? A multiple mediation analysis of a breast cancer screening intervention. *Journal of Communication*, *62*, 851-868. doi:10.1111/j.1460-2466.2012.01668.x

Kalyanaraman, S., & Sundar, S. S. (2006). The psychological appeal of personalized content in web portals: Does customization affect attitudes and behavior? *Journal of Communication*, *56*, 110-132. doi:10.1111/j.1460-2466.2006.00006.x

Kennedy, E. H., Beckley, T. M., McFarlane, B. L., & Nadeau, S. (2009). Why we don't "walk the talk": Understanding the environmental values/behaviour gap in Canada. *Human Ecology Review*, *16*, 151-160. Available from http://www.humanecologyreview.org/

King, P., & Tester, J. (1999). The landscape of persuasive technologies. *Communications of the Association for Computing Machinery*, *42*, 31-38. doi:10.1145/301353.301398

Le Quéré, C., Peters, G. P., Andres, R. J., Andrew, R. M., Boden, T., Ciais, P., & Zaehle, S. (2013). Global carbon budget 2013. *Earth System Science Data Discussion*, *6*, 689-760. doi:10.5194/essdd-6-689-2013

Lopes, M. A. R., Antunes, C. H., & Martins, N. (2012). Energy behaviours as promoters of energy efficiency: A 21st century review. *Renewable and Sustainable Energy Reviews*, *16*, 4095-4104. doi:10.1016/j.rser.2012.03.034

Maiteny, P. T. (2002). Mind in the gap: Summary of research exploring "inner" influences on pro-sustainability learning and behaviour. *Environmental Education Research*, *8*, 299-306. doi:10.1080/13504620220145447

Matulka, R. (2013). *U.S. Department of Energy: Resolve to save energy this year*. Retrieved from http://energy.gov/articles/resolve-save-energy-year

McKenzie-Mohr, D. (2011). Step 3: Developing strategies. *Fostering sustainable behavior: An introduction to community-based social marketing* (3rd ed., pp. 41-128). Gabriola Island, British Columbia, Canada: New Society.

Midden, C., & Ham, J. (2014). The power of negative feedback from an artificial agent to promote energy saving. In A. Marcus (Ed.), *Lecture notes in computer science: Design, user experience, and usability* (pp. 328-338). Springer International Publishing. doi:10.1007/978-3-319-07638-6_32

Nisbett, R., & Ross, L. (1980). *Human inference: Strategies and shortcomings of social judgment*. Englewood Cliffs, NJ: Prentice Hall.

Noar, S. M., Benac, C. N., & Harris, M. S. (2007). Does tailoring matter? Meta-analytic review of tailored print health behavior change interventions. *Psychological Bulletin*, *133*, 673-693. doi:10.1037/0033-2909.133.4.673

Nowak, K. L., & Biocca, F. (2003). The effect of agency and anthropomorphism on users' sense of telepresence, copresence, and social presence in virtual environments. *Presence: Teleoperators and Virtual Environments*, *12*, 481-494. doi:10.1162/105474603322761289

Parker, D., Hoak, D., Meier, A., & Brown, R. (2006). How much energy are we using? Potential of residential energy demand feedback devices. *Proceedings of the 2006 Summer Study on Energy Efficiency in Buildings*. Retrieved from http://edit.eceee.org/library/conference_proceedings/ACEEE_buildings/2006/Panel_1/p1_19/paper

Reeves, B., Cummings, J. J., Scarborough, J. K., & Yeykelis, L. (2013). Increasing energy efficiency with entertainment media: An experimental and field test of the influence of a social game on performance of energy behaviors. *Environment and Behavior*, 1-14. doi:0013916513506442

Rhode, D. L., & Ross, L. D. (2008). Environmental values and behaviors: Strategies to encourage public support for initiatives to combat global warming. *Virginia Environmental Law Journal*, *26*, 161-187. Available from http://www.velj.org/

Rigby, B. (2012, January 9). Microsoft Kinect: CEO releases stunning sales figures during CED keynote. *Huffington Post*. Retrieved from http://www.huffington-post.com/2012/01/09/microsoft-kinect-ces-keynote_n_1195735.html

Schultz, P. W. (2011). Conservation means behavior. *Conservation Biology*, *25*, 1080-1083. doi:10.1111/j.1523-1739.2011.01766.x

Semenza, J. C., Hall, D. E., Wilson, D. J., Bontempo, B. D., Sailor, D. J., & George, L. A. (2008). Public perception of climate change: Voluntary mitigation and barriers to behavior change. *American Journal of Preventive Medicine*, *35*, 479-487. doi:10.1016/j.amepre.2008.08.020

Sheppard, S. R. J. (2005). Landscape visualisation and climate change: The potential for influencing perceptions and behaviour. *Environmental Science & Policy*, *8*, 637-654. doi:10.1016/j.envsci.2005.08.002

Solomon, B. (2014, March 25). Facebook buys oculus, virtual reality gaming startup, for $ 2 billion. *Forbes*. Retrieved from http://www.forbes.com/sites/briansolomon/2014/03/25/facebook-buys-oculus-virtual-reality-gaming-startup-for-2-billion/

Steptoe, W., Steed, A., & Slater, M. (2013). Human tails: Ownership and control of extended humanoid avatars. *IEEE Transactions on Visualization and Computer Graphics*, *19*, 583-590. doi:10.1109/TVCG.2013.32

U.S. Energy Information Administration. (2010). *Annual energy review 2009* (Report No. DOE/EIA-0384[2009]). Retrieved from http://www.eia.gov/totalenergy/data/annual/archive/038409.pdf

U.S. Energy Information Administration. (2011). *Emissions of greenhouse gases in the United States 2009* (Report No. DOE/EIA-0573[2009]). Retrieved from http://www.eia.gov/environment/emissions/ghg_report/

van Vugt, M., Griskevicius, V., & Schultz, P. W. (2014). Naturally green: Harnessing stone age psychological biases to foster environmental behavior. *Social Issues and Policy Review*, *8*, 1-32. doi:10.1111/sipr.12000

Vogeley, K., May, M., Ritzl, A., Falkai, P., Zilles, K., & Fink, G. (2004). Neural correlates of first-person perspective as one constituent of human self-consciousness. *Journal of Cognitive Neuroscience*, *16*, 817-827. doi:10.1162/089892904970799

Weber, E. U. (2006). Experience-based and description-based perceptions of long-term risk: Why global warming does not scare us (yet). *Climatic Change*, *77*, 103-120. doi:10.1007/s10584-006-9060-3

Weber, E. U., & Stern, P. C. (2011). Public understanding of climate change in the United States. *American Psychologist*, *66*, 315-328. doi:10.1037/a0023253

Whitmarsh, L. (2009). Behavioural responses to climate change: Asymmetry of intentions and impacts. *Journal of Environmental Psychology*, *29*, 13-23. doi:10.1016/j.jenvp.2008.05.003

Willis, R. M., Stewart, R. A., Panuwatwanich, K., Jones, S., & Kyriakides, A. (2010). Alarming visual display monitors affecting shower end use water and energy conservation in Australian residential households. *Resources, Conservation, and Recycling*, *54*, 1117-1127. doi:10.1016/j.resconrec.2010.03.004

Wilson, M. (2002). Six views of embodied cognition. *Psychonomic Bulletin & Review*, *9*, 625-636. doi:10.3758/BF03196322

Zaalberg, R., & Midden, C. (2010). Enhancing human responses to climate change risks through simulated flooding experiences. In T. Ploug, P. Hasle, & H. Oinas-Kukkonen (Eds.), *Lecture notes in computer science: Vol. 6137. Persuasive technology* (pp. 205-210). doi:10.1007/978-3-642-13226-1_21

Author Biographies

Jakki O. Bailey is a doctoral student in the communication department at Stanford University. Her current work examines the impact of embodied mediated experiences on cognition and behavior.

Jeremy N. Bailenson is an associate professor in the communication department at Stanford University, and the founding director of the Virtual Human Interaction Lab. His current research explores how virtual reality can change the way people think about education, environmental behavior, and health.

June Flora is a senior research scientist at the Human Sciences and Technologies Advanced Research Institute at Stanford University. She researches the understanding and advancement of energy-efficiency behaviors including behavior selection and expert ratings, behavioral plasticity, and tests of adoption.

K. Carrie Armel is a research associate for the Precourt Energy Efficiency Center at Stanford University. She investigates the variety of ways in which understanding human behavior can lead to improvements in energy efficiency, with a current focus on the use of energy sensor data and behavioral techniques as a way to achieve energy savings.

David Voelker is an adjunct professor in the communication department at Stanford University. He teaches classes on argumentation and persuasion, and communication research methods including content analysis.

Byron Reeves is the Paul C. Edwards professor in the communication department at Stanford University. His research emphasizes the psychological processing of media in the areas of attention, emotion, learning, and physiological responses.