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Immersive virtual reality helps to promote pro-environmental norms, attitudes and behavioural strategies

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A R T I C L E I N F O

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Attitudes
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A B S T R A C T

Our study focuses on the promotion of sustainable actions that individuals can adopt at home. We tested the effectiveness of different formats of conducting promotional campaigns providing pro-environmental knowledge. Specifically, we assessed whether the same message delivered in print, in a video or in an immersive virtual environment, via a virtual human that resembles the participant or not, affects norms, attitudes and behavioural strategies in relation to energy saving gestures. Results revealed that receiving pro-environmental knowledge while being immersed in virtual reality led to greater energy saving attitudes and a different use of products and appliances at home as compared to receiving the same information via more traditional means. The present work aims to sensitise governmental and pro-environmental organisations about the effectiveness of using immersive virtual reality to conduct such campaigns.

1. Introduction

The main challenge of the 21st century is to reduce greenhouse gas emissions (Intergovernmental Panel On Climate Change, 2018). This ambitious goal can only be reached through a collective change, and the adoption of pro-environmental behaviours represents one of the many approaches to tackle climate change. Both industries and individuals are concerned by this challenge. Scientists and policy makers play a major role in helping and leading industries toward the energy transition, through for instance, the development of renewable energy technologies. Nonetheless, individuals also need to become actors in achieving this goal, which requires a significant shift regarding energy consumption behaviours (Braito et al., 2017). Accordingly, promotional campaigns aiming at changing people's habits and promoting sustainable behaviours have been developed (Abrahamse and Matthies, 2018; Abrahamse et al., 2005; Burger et al., 2015; Steg and Vlek, 2009).

Most of these campaigns are conducted through traditional print and video messages and aim to provide information about environmental problems. Unfortunately, these campaigns are only partially successful as general knowledge about environmental issues seems to have only little impact on environmentally-friendly behaviours (Kollmuss and Agyeman, 2002; van Valkengoed and Steg, 2019). For instance, while large-scale mass media campaigns on the greenhouse effect did increase people's knowledge about the issue, it failed to increase their willingness to change their behaviour (Staats et al., 1996). Somewhat more successful are campaigns that provide information about social norms such as descriptions of what others are doing or approve of doing in environmental activities (Farrow et al., 2017). However, while perceived social norms have been found to be reliable determinants of pro-environmental behaviour, it is not yet clear how they can be best leveraged in the context of intervention design (Kinzig et al., 2013).

Hence, although people are conscious that reducing greenhouse gas emissions is a must, sustainable behaviours are not applied on a regular basis (Long et al., 2021; Nisa et al., 2019; van Valkengoed and Steg, 2019; Whitmarsh, 2009). A large proportion of our behaviours are habits (Wood et al., 2002) and thus difficult to change (Long et al., 2021). Habits are highly automatised behaviours; they are usually triggered by a situational stimulus and are not easily influenced by

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conscious, deliberate decision-making processes (Klöckner and Matthies, 2004). Indeed, the interventional strategies that have been shown to change undesired habits mainly target automatic and experiential factors in that they allow (or force) people to experience alternative behavioural options (Webb et al., 2009). For instance, one of the most successful interventions to switch habitual car use toward the use of public transport was related to an 8-day freeway closure, allowing the target population to experience an alternative behaviour (Fujii and Gärling, 2003). This approach is not feasible in many situations. However, new technologies such as immersive virtual reality (IVR) might render feasible this approach by enabling researchers to emulate the "being there" feeling associated to such interventions (*presence*, see Fox et al., 2009; Slater and Steed, 2000). Furthermore, as suggested by Slater and Sanchez-Vives (2016), VR tools might help to study situations that cannot be in real world, or at least that would be difficult to study due to various constraints.

The present research investigates whether the use of new technologies such as IVR can help to promote pro-environmental norms, attitudes and behavioural strategies. Specifically, we are interested in assessing whether receiving energy saving instructions while being immersed in virtual reality is more impactful as compared to traditional means (i.e., traditional informational campaigns using a print or a video message).

Virtual reality can be defined as a computer-simulated environment, mimicking real life situations (Pierce and Aguinis, 1997). In our work, we focus on IVR in which individuals are immersed in a three-dimensional virtual environment through a first-person perspective by wearing a head-mounted display (HMD). The IVR system tracks individuals' movements (i.e., head and body motions) to model real world motions in the virtual world. Specifically, to assess the effectiveness of IVR-based promotional campaigns, we run an experiment in which we randomly assigned participants to one of the four conditions. We compare the extent to which individuals' perceived norms, attitudes and behavioural strategies to save energy at home are influenced depending on whether they participate in a traditional campaign, either through a print or a video message, or in an IVR-based campaign where the message is delivered by their doppelganger or an unknown avatar. We use an interactive scenario where an avatar (a virtual human) interacts with the user to promote sustainable actions. Moreover, we test whether energy saving perceived norms, attitudes and strategies can be further promoted if the avatar delivering the message resembles the user, that is, if the avatar is a doppelganger. Doppelgangers are avatars 'that highly resemble the real self but behave independently' (Aymerich-Franch and Bailenson, 2014, p. 173).

2. Theoretical background and hypotheses development

2.1. Virtual reality: an effective intervention tool

Research has demonstrated the effectiveness of using virtual reality technology as a tool to influence people's attitudes and behaviours (Anderson et al., 2005; Botella et al., 2007; Garcìa-Palacios et al., 2002; Lindner et al., 2019; Mühlberger et al., 2006; Opris et al., 2012; Powers and Emmelkamp, 2008; Seinfeld et al., 2018). Specifically, research has revealed that virtual reality-based interventions are as effective as traditional interventions (i.e., experiencing the same situation in the real world). For instance, a meta-analysis suggests that virtual reality exposure therapy was effective in treating anxiety disorders (Opris et al., 2012). These findings are promising given the advantages of using this technology over traditional interventions for training (see Schmid Mast et al., 2018) or for education (see Freina and Ott, 2015). These advantages include, among others, reduced logistics and costs of organising interventions requiring specific locations (e.g., a conference room, a kitchen) and/or involving interaction partners (e.g., a teacher, an audience), or animals (e.g., spiders, snakes). It also offers substitute solutions to create situations that are not feasible or highly constraining in reality as well as gives the opportunities to create out-of-the-ordinary situation such as seeing oneself as a teacher (Schmid Mast et al., 2018; Slater and Sanchez-Vives, 2016). Overall, IVR offers a large degree of freedom with regards to designing intervention settings. All these advantages have contributed to the development of this technology as a learning tool.

Only a few studies have investigated the effectiveness of virtual reality-based interventions in the field of pro-environmental attitudes and behaviours (see Fauville et al., 2020), and research is lacking with regards to perceived norms. For instance, Ahn et al. (2014) have demonstrated that participants who cut a tree in IVR reported more pro-environmental behaviours one week later as compared to participants who read instructions asking them to think of this situation and as compared to those who watched a video of a similar situation. This effect was mediated by participants' internal environmental locus of control (i.e., the perception that one's actions can impact the environment). Ahn et al. (2016) have also shown that individuals immersed in a virtual nature environment and embodying animals felt more interconnected with nature as compared to those who watched a video of the same environment (see also Bailey et al., 2015; Breves and Heber, 2020; Chirico et al., 2021; Hsu et al., 2018).

Hence, to date, there is a lack of research on how IVR can help to promote everyday sustainable actions. We redirect researchers interested in this topic to Jolink and Niesten's (2021) article on the opportunities offered by the VR technology to study sustainable behaviour. Our research is in line with their suggestion to use this technology as mean to control for peer behaviours (e.g., all the avatars with whom participants interact act exactly the same way), hence allowing high standardization of the experimental setting. In our research, we investigate whether IVR is an effective tool to influence individuals' perceived norms and attitudes, as well as strategies that individuals can adopt to reduce their energy consumption at home. Based on the previously mentioned literature, receiving instructions promoting sustainable everyday actions using IVR might make individuals feel more involved with the energy saving challenge. Hence, it is expected that being immersed in a house and receiving energy saving instructions, as opposed to simply watching a video, can help individuals to process the delivered information and emulating the shown behaviours. This would subsequently influence their pro-environmental perceived norms, attitudes and strategies. Furthermore, IVR differentiates itself from watching a video through the feeling of presence experienced by individuals immersed in the virtual situation. Presence refers to the feeling that the virtual environment is real rather than artificial (Fox et al., 2009) or to the subjective experience of being in the said environment (Slater and Steed, 2000; see also Slater and Sanchez-Vives, 2016). Research has suggested that the greater the presence, the greater the transfer of training from the virtual to the real world (Price and Anderson, 2007; Slater and Wilbur, 1997). In our study, we expect this feeling of presence to be strengthened by the interaction and eye contact between the individuals and the avatar designed to talk and to look at the individuals. Accordingly, we first hypothesise that receiving instructions on how to reduce one's energy consumption in IVR increases pro-environmental perceived norms (H1a), attitudes (H1b) and strategies (H1c) to a higher extent than receiving these instructions through traditional campaigns.

2.2. Doppelganger as a tool to change perceived norms, attitudes and strategies

Beyond assessing whether IVR constitutes a more impactful tool to conduct campaigns, the present research also aims to assess under which conditions the use of IVR might add value. Specifically, IVR allows an almost unlimited number of possibilities of conducting research as well as campaigns. Specifically, IVR allows new ways of conducting promotional campaigns through, for instance, out-of-the-ordinary experiences such as meeting one's doppelganger (Schmid Mast et al., 2018). Accordingly, in our work, we propose to assess the effect of two types of

IVR-based campaigns. First, as exposed through Hypotheses 1, we investigate whether presenting the same information in IVR as in print or video might lead to different perceived norms, attitudes and strategies. Second, drawing on past research on the role of identification and doppelganger in shaping attitudes and behaviours, we propose to benefit from the possibilities offered by the IVR technology to test whether receiving knowledge on sustainable actions from oneself can further help to promote pro-environmental perceived norms, attitudes and strategies.

Past research has shown that people learn by observing models (Bandura, 2001) and identification with others plays an important role in shaping attitudes and behaviours (e.g., Ahn and Bailenson, 2011; Huguet et al., 2001; Martin et al., 2004; Rheu et al., 2020). For instance, Ahn and Bailenson (2011) have shown that individuals reported higher brand-related attitudes when they were exposed to a self-endorsing advertisement (i.e., advertisement based on a photo of themselves with the product) as compared to another-endorsing advertisement (i.e., advertisement with the photo of an unknown person with the product). Results have also revealed that the photo-based self-endorsing advertisement was more effective than a text-based self-endorsing advertisement. This literature is in line with the self-referencing effect stating that individuals learn better (i.e., learn faster and remember longer) when the new information is delivered in association with the self (Ahn and Bailenson, 2014; Kuiper and Rogers, 1979).

Furthermore, and by extension, the types of avatar used in IVR directly influence attitudes and behaviours change. On the one side, individuals tend to conform with avatars' characteristics (*Proteus Effect*, see Ratan et al., 2020). For example, the appearance of the avatars used to represent the participants (e.g., appearing taller) influences their behaviours in subsequent tasks (e.g., more aggressive and confident behaviours during a negotiation task, Yee and Bailenson, 2007). On the other side, embodying or observing an avatar that resembles oneself fosters changes in attitudes and behaviours (*Doppelganger*; e.g., Ahn and Bailenson, 2011; Aymerich-Franch and Bailenson, 2014; Fox and Bailenson, 2009; Kleinlogel et al., 2021). For instance, Fox and Bailenson (2009) have shown that participants observing their doppelganger performing a physical exercise engaged subsequently in more exercises than participants observing an unknown avatar. Drawing on this literature, we hypothesise that receiving instructions in IVR by one's doppelganger on how to reduce energy consumption at home increases pro-environmental perceived norms (H2a), attitudes (H2b) and strategies (H2c) to a higher extent than receiving these instructions by an unknown avatar.

3. Methodology

3.1. Sample

A sample of 234 students, recruited via the subject pool of a Swiss university, voluntarily participated in the experiment (43% women; $M_{age} = 21.46$, $SD = 3.29$; 81% undergraduate students). Participants received monetary compensation for their participation which depended on the condition they were assigned to (fixed hourly rate of 35 Swiss Francs, about 38$). Participants were randomly assigned to one of the four experimental conditions. In two conditions (immersive conditions), participants received energy saving instructions in IVR. They met an avatar and walked with it through a virtual flat (see Fig. 1) while it explains how to save energy in each room (i.e., living room, kitchen and bathroom) and why. In one of the immersive conditions, the participants' doppelganger delivered the instructions (DG condition). In the other immersive condition, an unknown avatar delivered the instructions (UA condition).

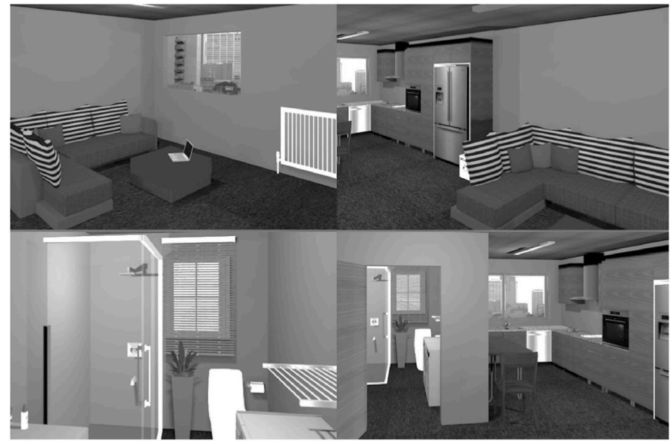

Fig. 1. Pictures showing the three main rooms (living room, kitchen and bathroom) of the virtual flat that participants in the two IVR conditions and in the VI condition saw.

In the two other conditions (traditional conditions), participants received the same energy saving instructions, either by reading a text (Print Instructions/PI condition) or watching a video (Video Instructions/VI condition).[1] Participation lasted about 2h15 in the two immersive conditions and about 1 h in the two traditional conditions, and participants received a compensation of 80 Swiss Francs (about 87$) or 35 Swiss Francs (about 38$), respectively. This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Committee on Ethics in Research from the Swiss faculty in which we conducted the study. All participants signed a consent form before their participation.

3.2. Procedure and materials

Participants in the two immersive conditions came to the laboratory three times. During sessions one and three, participants filled in the same online questionnaire designed to collect data on their energy saving perceived norms, attitudes and strategies. At the end of session one, we took photos of the participants and recorded their voice by asking them to read a script (the text that the avatar would say). During session two, they received energy saving instructions in IVR for about 3 min and afterwards, filled in a short questionnaire.

The instructions were delivered by participant's doppelganger speaking with their own voice (DG condition, $N = 55$) or by an unknown avatar of the same gender (UA condition, $N = 56$). For each instruction, the avatar showed appropriate gestures, such as pointing at the fridge when explaining how to save energy related to fridge management. Participants were immersed in virtual reality by wearing a head-mounted display headset and were tracked in the 3D environment using the HTC Vive Pro system as the hardware and Vizard from WorldViz as the VR software. Avatars were created using 3ds Max toolkit. The doppelgangers were developed using participants' photos. The unknown avatars (i.e., one male and one female) were developed using photos of lab members unknown to the participants. Specifically, we developed one male and one female unknown avatars such that participants from the UA condition saw an avatar of the same gender as their own. This approach ensured that the quality of the avatars was comparable across conditions.

Participants in the two traditional conditions came to the laboratory twice. During both sessions, they filled in the same questionnaire used during sessions one and three of the immersive conditions. At the end of

[1] The materials used in this study are available on request from the corresponding author.

session one, participants received the energy saving instructions by either reading a document (PI condition; $N = 62$) or watching a video (VI condition; $N = 61$). In both conditions, the energy saving instructions were embedded in the online questionnaire. Participants in the PI condition were asked to read attentively a document reporting the same instructions delivered in IVR. Participants in the VI condition were asked to watch and listen attentively a video. Said video was created by video-recording the virtual scene used in the UA condition. The audio and visual content shown in the VI condition was thus identical to the UA condition. The only difference between the VI condition and the UA condition is that participants in the VI condition watched the instructions on a computer screen (and so in a video format) instead of being immersed in VR. Also, similar to the UA condition, the instructions were delivered by an unknown avatar of the same gender. This approach allowed to observe the same script (i.e., same wording) across conditions while manipulating the information channel used to deliver the energy saving instructions (i.e., print vs. video vs. IVR with an UA vs. IVR with a DG).

In all conditions, participants completed the second questionnaire approximately two weeks after receiving the instructions. Accordingly, participants in the two traditional conditions came to session two about two weeks after completing session one. Similarly, participants in the two immersive conditions came to session three two weeks after session two. However, the participation time was longer for them with regards to session one and session two because we organised session two approximately three months after session one. We could not organise session two earlier for two reasons. First, it took time to create doppelgangers and second, data could only be collected during the academic semesters. Hence, for organisational reasons it was not possible to conduct the three sessions and to create all the doppelgangers within one semester.

3.3. Measures

We collected data on each measure twice, in the first and in the last session. We created each measure by averaging the items. Table 1 reports the internal reliability coefficients, means, standard deviations and correlations. The data dictionary available in the OSF repository, osf.io/4emv9, reports the items for each measure. We also made available the raw data in the OSF repository.

3.3.1. Energy saving attitudes

We measured energy saving attitudes using eight items designed to assess attitudes related to energy saving in general (e.g., loss of comfort) and to energy saving related to contextual forces (e.g., perceived social pressure; Sütterlin et al., 2011). Participants indicated the extent to which each item applies to them on a 6-point Likert-type scale ranging from 1 (does not apply at all) to 6 (totally applies).

3.3.2. Perceived social norms

We assessed perceived social norms related to energy saving using nine items developed by Thøgersen (2006). This measure was designed to assess six different norms: personal (four items), descriptive (one item), injunctive (one item), introjected (one item), integrated (one item), and moral (one item). Participants indicated the extent to which they agree with each item on a 7-point Likert-type scale ranging from 1 (strongly disagree) to 7 (strongly agree).

3.3.3. Energy saving strategies

We assessed the extent to which individuals adopt energy saving strategies at home in two ways. First, we included a measure of energy saving strategies related to the instructions that participants received during the experiment (e.g., to open the freezer only when necessary, to take short showers). This measure was composed of 24 self-developed items. Participants indicated the extent to which they engage in the described strategies in their daily life on a scale ranging from 0% (I never behave this way) to 100% (I always behave this way). Second, we assessed more general energy saving strategies that individuals can adopt at home using eigth items developed by Poortinga et al. (2003). This measure included items designed to capture popular energy saving strategies such as some of the strategies included in the instructions (e.g., switching lights off when nobody is in the room), but also other strategies not included in the instructions (e.g., buying regional and seasonal food). Participants indicated the extent to which they agree with each item on a 7-point Likert-type scale ranging from 1 (strongly disagree) to 7 (strongly agree).

3.3.4. Manipulation check

We measured the extent to which participants in the two immersive conditions identified with the avatar on a 5-point Likert-type scale ranging from 1 (strongly disagree) to 5 (strongly agree) using four self-developed items. We averaged these items to create the Identification measure, M (SD) = 3.05 (1.20), α = 0.84. Finally, we asked participants in the DG condition whether they noticed that the virtual person had their face and their voice on a Yes/No/I was not sure scale.

4. Results

We first performed an independent t-test to check whether participants in the DG condition identified with the avatar to a higher extent than participants in the UA condition. As expected, participants in the DG condition ($M = 4.03$, $SD = 0.63$) identified more with the avatar than participants in the UA condition ($M = 2.08$, $SD = 0.77$), $t(109) = 2.59$, $p < .001$. Supplementary analyses also showed that 92% and 98% of the 52 participants (three missing values) noticed that the avatar had their face and their voice, respectively. We excluded from the sample the four participants who did not notice this or were not sure.

To test Hypotheses 1a, 1b and 1c stating that receiving instructions in IVR (i.e., DG and UA conditions) increases energy saving perceived norms, attitudes and strategies, respectively, more so than receiving instructions via traditional means (i.e., PI and VI conditions), we performed one-way ANOVAs with the corresponding planned contrast (i.e., 1 1 -1 -1). We performed separate one-way ANOVAs for each of the dependent variables measured at time two using a 4-level factor

Table 1
Internal reliability coefficients, means, standard deviations and correlations.

		M	SD	1		2		3		4		5		6		7		8
1.	ESA-T2	4.24	0.73	**.70**														
2.	PSN-T2	5.43	0.95	.65	***	**.85**												
3.	ESSI-T2	68.28	13.54	.47	***	.41	***	**.86**										
4.	GESS-T2	5.68	0.79	.51	***	.53	***	.51	***	**.77**								
5.	ESA-T1	4.18	0.75	.74	***	.62	***	.40	***	.48	***	**.70**						
6.	PSN-T1	5.30	1.04	.66	***	.74	***	.37	***	.42	***	.61	***	**.86**				
7.	ESSI-T1	63.42	12.02	.45	***	.37	***	.76	***	.46	***	.43	***	.39	***	**.77**		
8.	GESS-T1	5.44	0.83	.42	***	.47	***	.36	***	.56	***	.48	***	.49	***	.38	***	**.72**

Note. $N = 230$. ESA-T2/T1 = Energy saving attitudes at time two/time one PSN-T2/T1 = Perceived social norms at time two/time one; ESSI-T2/T1 = Energy saving strategies related to the instructions at time two/time one; GESS-T2/T1 = General energy saving strategies at time two/time one. ***$p < .001$.

representing our four campaign conditions. Results revealed that participants in the two immersive conditions reported higher levels of energy saving attitudes [$t(224) = 3.11$, $p = .002$, $r = 0.20$] and energy saving strategies addressed during the intervention [$t(224) = 2.13$, $p = .034$, $r = 0.14$] as compared to participants in the two traditional conditions. However, results revealed non-significant differences for perceived norms [$t(224) = 1.90$, $p = .059$, $r = 0.13$] and general energy saving strategies [$t(224) = 1.63$, $p = .105$, $r = 0.11$]. Figs. 2–5 report the means and error bars for each measure per condition. Hypothesis 1b is thus supported and Hypothesis 1c is partially supported given that findings revealed the two immersive conditions to only have an effect on the strategies that were addressed during the intervention in IVR.

To test Hypotheses 2a, 2b and 2c stating that receiving instructions in IVR by one's doppelganger increases energy saving perceived norms, attitudes and strategies, respectively, more so than receiving instructions in IVR by an unknown avatar, we performed another set of one-way ANOVAs with the corresponding planned contrast to compare the effect of the two IVR conditions on each of the dependent variables (i.e., 0 0 1 -1). Results revealed that participants in the DG condition did not report higher levels of energy saving attitudes ($p = .715$), perceived norms ($p = .876$), energy saving strategies related to the instructions ($p = .949$) and general energy saving strategies ($p = .924$) as compared to participants in the UA condition. Hypotheses 2 are thus not supported.

To ensure that our findings were due to the effects of the different promotional campaigns and not due to pre-existing differences between participants across our experimental groups, we replicated the above analyses using our measures collected at time one as dependent variables. Results did not reveal any significant difference between participants in the two traditional conditions and those in the two immersive conditions in terms of perceived social norms, energy saving strategies related to the instructions and general energy saving strategies (all *ps* > .10). However, we found a significant difference in terms of energy saving attitudes ($p = .03$) such that participants in the two immersive conditions reported higher levels of energy saving attitudes before the intervention. According to this latter result, findings related to attitudes should be interpreted with caution. Finally, we did not find any significant pre-existing difference for the four variables when comparing the participants in the two immersive conditions (all *ps* > .10).

5. Discussion

The present study reveals that being immersed in virtual reality

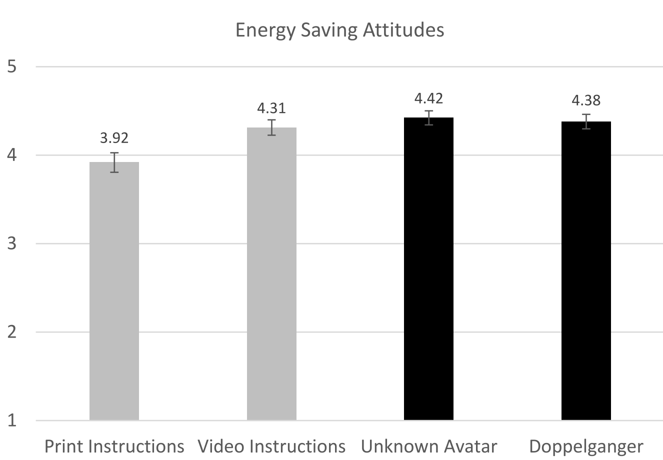

Fig. 2. Bar chart reporting the means and standard errors of participants' energy saving attitudes per condition. The X-axis represents the four experimental conditions and the Y-axis represents the dependent variable of energy saving attitudes at time two measured on a 6-point Likert-type scale. The gray bars represent the two traditional conditions and the black bars represent the two immersive conditions.

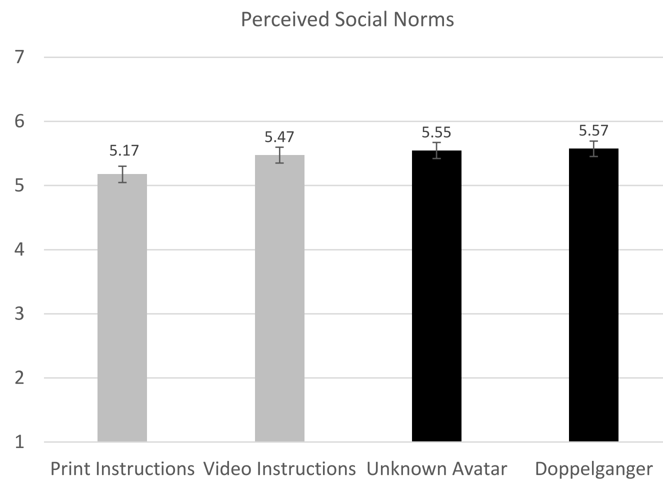

Fig. 3. Bar chart reporting the means and standard errors of participants' perceived social norms per condition. The X-axis represents the four experimental conditions and the Y-axis represents the dependent variable of perceived social norms at time two measured on a 7-point Likert-type scale. The gray bars represent the two traditional conditions and the black bars represent the two immersive conditions.

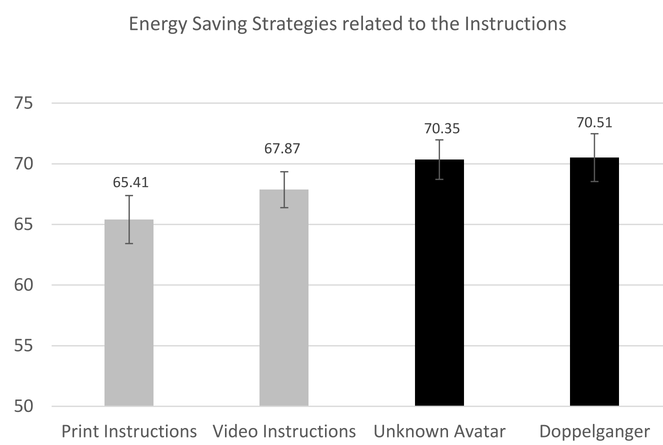

Fig. 4. Bar chart reporting the means and standard errors of participants' energy saving strategies related to the instructions per condition. The X-axis represents the four experimental conditions and the Y-axis represents the dependent variable of energy saving strategies related to the instructions at time two measured on a 100-point scale ranging from 0% (*I never behave in this way*) to 100% (*I always behave in this way*). The gray bars represent the two traditional conditions and the black bars represent the two immersive conditions.

during a promotional campaign helps to promote pro-environmental attitudes and behavioural strategies. These findings supplement past research in this field (e.g., Ahn et al., 2014, 2016). We believe that the added value of IVR-based campaigns lies in the presence mechanism and the experiential aspect of learning new behaviours. The main difference between the traditional and IVR conditions is that participants felt as though they were in another world where they had the opportunity to see the impact of specific behaviours. In this virtual world, they were more agent than in the reality, as compared to the traditional conditions in which they were more passive by reading or watching a video (see Kwon, 2019).

Importantly, the behavioural effect we observed was limited to strategies directly addressed in the intervention. These findings suggest that individuals exposed to the instructions in IVR indeed subsequently applied at home the sustainable actions delivered by the avatar, but did not transfer the received pro-environmental knowledge to other types of

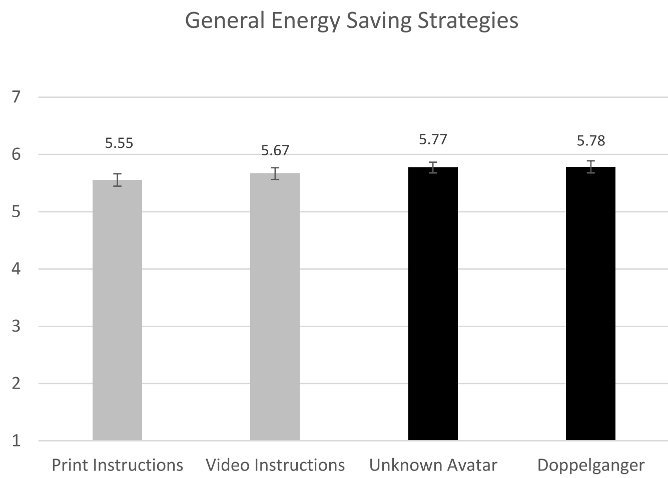

Fig. 5. Bar chart reporting the means and standard errors of participants' general energy saving strategies per condition. The X-axis represents the four experimental conditions and the Y-axis represents the dependent variable of general energy saving strategies at time two measured on a 7-point Likert-type scale. The gray bars represent the two traditional conditions and the black bars represent the two immersive conditions.

energy saving actions. Promotional campaigns using immersive technologies thus seems to be more impactful than traditional campaigns, but its effectiveness is limited due to a lack of learning transfer given that individuals did not generalise their behavioural change to other energy saving strategies not addressed during the intervention.

Finally, we did not find any effect related to perceived norms, whereas we found an effect on energy saving attitudes. This finding might be explained in two ways. First, changing norms might take more times, and hence change would only be observable through a longitudinal approach such that, as suggested by Farrow et al. (2017), changing behaviour might subsequently lead to a change in beliefs through for instance an increased salience of a norm (i.e., behaviour-induced norm activation). Second, the primary goal of the intervention was to deliver information on sustainable actions that individuals can easily put in place at home. Changing norms might require an active norm management (Farrow et al., 2017) such as through a more fine-grained intervention targeting the norms at play for the individuals with regards to energy saving and explaining the rationale behind each norm. Such intervention would require participants to further interact with an avatar as opposed to having an eye contact and observing an avatar showing sustainable actions.

5.1. Practical implications

Sustainability implies an involvement from both industries and individuals. On the one side, environmental sustainability laws and policies target industries and aim to reduce pollution by promoting for instance cleaner production and responsible consumption of natural resources. On the other side, at the individual level, traditional promotional campaigns constitute tools to provide pro-environmental knowledge and giving clear recommendations on sustainable actions that people can easily adopt on an everyday basis. Nonetheless, these campaigns are not as successful as expected given the multitude of factors that can influence people decisions and actions (e.g., Katan and Gram-Hanssen, 2021; Kollmuss and Agyeman, 2002; van Valkengoed and Steg, 2019). As a practical implication, our research aims to sensitise governmental and pro-environmental organisations about the effectiveness of using IVR to conduct such campaigns.

Given the evolving democratisation of virtual reality tools, developing IVR-based campaigns might be the next step to effectively promote sustainability. The advantage of such campaigns is that they are easily accessible, foster scalability and might be perceived as more attractive. In return, IVR-based campaigns might raise more interest and participation as compared to traditional campaigns. Furthermore, our results suggest that these campaigns do not have to be customised through the creation of doppelgangers to be effective.

5.2. Limitations and future research directions

As a first limitation, our results rely on self-reported measures on a short-term basis. We call for future research using behavioural measures as well as using a longer time framework. For instance, participants' actual sustainable behaviours can be captured through weekly reports over a period of 6 months. The second limitation is that participants in the two immersive conditions were exposed twice to the instructions as, in addition to receiving the instructions in IVR in session two, in session one we also asked them to read the instructions out loud to record their voice. Participants in the two traditional conditions were exposed only once to the instructions. Related to this point, the time intervals between the sessions were different across the conditions. All these aspects reduce the comparability of the conditions. Future research should standardise more participants' exposure to instructions. Furthermore, participants did not receive the same monetary compensation for their participation. Nonetheless, we did not provide any information related to the amount of compensation prior to participation in order to not influence participants' willingness to take part in the study nor in one specific condition.

Thirdly, our sample is not representative of the general population. Similar to related past research (Ahn et al., 2014, 2016), we relied on a sample of college students. Nonetheless, other relevant research related to the field of pro-environmental attitudes and behaviours (Breves and Heber, 2020) or to the field of virtual reality exposure therapy (see Opris et al., 2012) relied on a more diverse population and demonstrated the effectiveness of virtual reality as a tool to influence attitudes and behaviours. We would thus expect our results to generalise to the general population. We call for future research to use a representative sample, or at least to use a more diverse sample, to increase the generalisability of the findings.

As a last limitation, it is noteworthy that the difference of results between the two measures of energy saving strategies might be driven by the type of strategies addressed during the intervention. The intervention focused on delivering knowledge on how individuals can use differently their products and appliances at home, hence representing energy saving strategies aiming at reducing energy consumption in a direct way. However, individuals can adopt other strategies to save energy, namely strategies focusing on technical improvement and strategies focusing on shifts in consumption (see Poortinga et al., 2003). Technical improvement refers to strategies aiming at reducing energy use through the investment into more energy-efficient products and appliances (e.g., buying energy-efficient light bulbs). Shifts in consumption refers to strategies aiming at reducing energy use in an indirect way through changing habits of consumption (e.g., eating less meat). Contrary to our measure of energy saving strategies related to the instructions which focuses on the different use of products and appliances, our measure of general energy saving strategies is composed of items capturing these three different types of strategies.

Poortinga et al. (2003) have shown that individuals' acceptability of energy saving instructions differs depending on the promoted strategies such that shifts in consumption were evaluated the least acceptable, followed by strategies related to a different use of products and appliances. Strategies focusing on technical improvement to reduce energy use were evaluated as the most acceptable as compared to the two other strategies. The authors highlighted different reasons that might explain these findings. For instance, these findings might be driven by a lack of understanding on how shifts in consumption can contribute indirectly to reduce energy use. Individuals might also have difficulties or lack motivation to put extra effort on an everyday basis to change their behaviour such as their eating habits. Relatedly, it is plausible that individuals favour technical improvement strategies such as buying energy-efficient appliances because these strategies allows to save automatically energy without making any effort. Nonetheless, whereas these technical improvement strategies were evaluated as the most acceptable, they can also be the ones that are the least adopted given that it requires an initial investment, which is a constraint for low income households.

Future research should further investigate the role of different formats of conducting promotional campaigns in relation to these different strategies. Specifically, disentangling the different strategies individuals can adopt to save energy at home would lead to a better understanding of the factors contributing to the effectiveness of pro-environmental campaigns. For instance, it would be interesting to assess the extent to which IVR helps to promote sustainable actions as compared to traditional means by manipulating the three different energy saving strategies across different intervention conditions. It is plausible to expect that IVR is more effective in promoting behavioural strategies that individuals can adopt at home without changing their habits of consumptions and without requiring a monetary investment. Investigating the role played by these different strategies might also contribute to understand why we did not observe any effect related to energy saving norms. An intervention addressing a wider range of strategies might influence to a higher extent individuals' perceived energy saving norms as compared to an intervention addressing a limited number of strategies such as focusing only on shifts in consumption or focusing only on a different use of products and appliances as we did in our experiment.

Concerning other suggestions for future research topics, it would also be interesting to assess motivation to be exposed to campaigns involving this new technology and whether the use of doppelgangers makes these campaigns more attractive to the public or whether the use of virtual reality is sufficiently attractive. Note that the observed effects were quite small. Future research should hence investigate whether the cost of such IVR-based campaigns is proportional to its potential benefits. Finally, going beyond the information channel as a mean for change, future research might seek to test the added value of IVR combined with embodiment and interactivity. Such approaches might foster greater attitudes and behavioural strategies.

5.3. Conclusion

The present work addressed the effectiveness of using new technologies to promote sustainable actions. Specifcally, we assessed whether immersive virtual reality, as compared to traditional means of conducting campaigns (i.e., print and video messages), can help to promote energy saving norms, attitudes and strategies that individuals can adopt at home. Conducting campaigns through immersive virtual reality presents several advantages over traditional means. For instance, it offers a large degree of freedom with regards to designing intervention settings (e.g., any virtual environement can be created going from a simple kitchen to a situation that is not feasible or highly constraining in reality). Furthermore, this technology is now potentially cost-effective and accessible, hence offering new opportunities of conducting campaigns on a large scale.

Findings revealed that promotional campaigns involving IVR led to increase individuals' pro-environmental attitudes and behavioural strategies to a higher extent that traditional campaigns did. Specifically, we observed a positive effect of the virtual reality tool on the energy saving strategies that were instructed during the intervention. These strategies were mainly strategies related to a different use of products and appliances to reduce energy consumption. We did not find any significant difference between the different types of campaigns we tested with regards to other strategies (captured through a general measure including three different types of energy saving strategies that individuals can adopt). These findings suggest that new technologies can help to promote attitudes and behavioural strategies, but its behavioural effect seems to be limited to rather simple gestures that were shown during the intervention (e.g., to open the freezer only when necessary) but not to other strategies requiring extra effort (i.e., shifts in consumption) and a monetary investment (i.e., technical improvement). We call for future research to further investigate the extent to which IVR might help to promote sustainable actions and the conditions under which this type of campaigns is the most effective (e.g., campaigns focusing on a different use of products and appliances vs. shifts in consumption).

Credit author statement

The corresponding author, Emmanuelle P. Kleinlogel, and the third co-author, Laetitia A. Renier, moved affiliation during the writing process. Emmanuelle P. Kleinlogel new affiliation is CEMOI Laboratory, IAE Reunion, University of Reunion Island, 24 avenue de la Victoire, 97400 Saint Denis, France. Laetitia A. Renier new affiliation is Faculty of Business and Economics, University of Lausanne, Quartier Unil-Chamberonne, 1015 Lausanne, Switzerland.

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Declaration of competing interest

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

Data availability

The raw data and data dictionary are available in the OSF repository, osf.io/4emv9.

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