Food-Related Social Interaction Fosters Collective Action and Identification with Climate Action Supporters: An Experimental Study in Virtual Reality

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Abstract

Social interaction is theorized to be a key mechanism for crystallizing environmental identities, promoting individual and collective action, and through these embedding societal shifts toward sustainability. This preregistered study utilizes networked immersive virtual reality (VR) to investigate these processes in a controlled setting. In a preregistered lab-in-the-field study, participants (255 tested, 194 analyzed) were randomly assigned to one of three conditions: (1) social interaction with environmental feedback; (2) social interaction without environmental feedback, or; (3) no-social interaction without environmental feedback. All participants engaged in a sustainable cooking task in VR, either alone or in a dyad based on the interaction condition. Environmental feedback was achieved by visualizing the impact of food choices dynamically as participants engaged in the cooking task or by not providing such a visualization. Consistent with theory, social interaction conditions significantly increased both social identification with climate-action supporters and collective action intentions compared to the individual condition, and in combination with environmental feedback further increased the emotional experience of hope. The social interaction condition coupled with environmental feedback also led to significantly higher intentions to reduce meat consumption compared to interaction without feedback. No direct effects of conditions were observed on objectively assessed pro-environmental behavior. Exploratory analyses revealed that social identification was significantly correlated with all behavioral predictors with correlations ranging from high for collective action and meat reduction to low for objectively assessed pro-environmental behavior. The study underscores the influential role of social interaction in fostering social identification and through this potentially shifting collective, and sometimes individual, pro-environmental behavior.

Keywords: social interaction, collective action, climate change, behaviour change, spillover, virtual reality

1. Introduction

Scientific consensus points to the significant threats associated with climate change and to an understanding of this problem as human-caused. Despite global commitments to limit greenhouse gas emissions, recent reports indicate that these continue to rise (IPCC, 2023). The standard approach of changing individual choices and behaviors is falling short of increasingly ambitious climate goals (Dietz et al., 2009). Individually-focused behavioral interventions often bear weak results (Bergquist et al., 2023; Nisa et al., 2019), and can even result in negative spillover – that is, reduced engagement in different pro-environmental behaviors adjacent to those specifically targeted by the intervention (Maki et al., 2019; Truelove et al., 2014). Some argue that the individualistic approach ultimately deflects attention from the need for more wide-ranging, systematic, and structural efforts (Chater & Loewenstein, 2022; Schmitt et al., 2020).

Against this backdrop, there is a need to identify and test interventions that (1) promote collective (not just individual) action towards societal transformations, and (2) result in consistent behavioral change across adjacent domains (rather than negative spillover). The concept of identity – that is, people's sense of who they are in relation to others within society – may be central to these aims. Because identity typically incorporates specific values and norms into the individual's self-concept, it is a plausible mechanism for promoting behavioral consistency across time and domains (Truelove et al., 2014; Whitmarsh & O'Neill, 2010). For example, people who identify as "an environmentalist" (versus just holding pro-environmental attitudes) should be motivated to act environmentally not just in relation to food choices, but also energy consumption and travel behavior (e.g., Lacasse, 2016; Xu et al., 2020). Although environmental self-identity has to some degree been empirically connected to positive spillover effects (Poortinga & Whitmarsh, 2017; Whitmarsh & O'Neill, 2010), it is often conceptualized as personal identity (e.g., "I think of myself as an environmentally-friendly consumer"; Whitmarsh & O'Neill, 2010) rather than a social identity that is shared with others (e.g., "I identify with other people who are environmentally-friendly consumers"). However, identification with others based on *shared* values and opinions is especially linked to mutual social influence, interpersonal coordination, and collective action (Schulte et al., 2020; van Zomeren et al., 2008, 2004). Fostering shared social identities around environmentalism would therefore seem particularly important, not just for supporting consistent individual behavior but also for fostering the kinds of transformative societal changes that are necessary to address climate change (Schulte et al., 2020). In the sections that follow we unpack both the behavioral consequences of shared social identity and the social processes that feed into this. We then present an innovative experimental paradigm that systematically explores the potential of social interaction to support the crystallization of shared identity, and through this to generate behavioral change across three behavioral outcome measures, including intentions toward sustainable consumption, engagement in politicized collective action, and objective pro-environmental choices.

1.1. Social Identity and Climate Action

Social psychological perspectives typically distinguish between different facets of identity within the self-concept. Following social identity (Tajfel & Turner, 1979) and self-categorization theories (Turner et al., 1987; see Hornsey, 2008 for an overview), personal identity represents the individual's understanding of themselves as unique in comparison to others. This might include personal tastes, preferences, and traits that set one apart from others. Social identity instead represents understandings of the self grounded in group memberships and social categories – typically in comparison to alternative groups and categories that exist in the social sphere. Social identity includes the characteristics, norms, and values that we share with others based on common group membership.

Identities are critical for navigating the social world because knowing who one *is* defines self-other relationships (i.e., “me & you” under personal identity, versus “us & them” under social identity), thereby guiding who we engage with, attend to, and are influenced by versus who we disengage and potentially polarize away from (e.g., McGarty et al., 1994). Shared identity between people makes social influence more likely (Turner, 1991). Moreover, when individuals identify with a group, social influence can occur without explicit external pressure (Turner, 1991) because group identification increases the motivation to achieve alignment between individual attitudes, beliefs, and behaviors and the norms and values associated with the group (Schultz et al., 2007; Tajfel & Turner, 2001).

In the environmental domain, social identities have been linked to a range of environmental outcomes, including individual behavioral choices, intergroup environmental conflicts, and collective action in response to climate change (Fielding & Hornsey, 2016; Vesely et al., 2021). Consistent with theory, these effects of social identity occur via multiple pathways. When group norms are pro-environmental, individuals who identify with that group will themselves be influenced to behave more environmentally (e.g., Rabinovich et al., 2012). Interventions that target social norms in the field have been found to be quite effective in changing behavior (e.g., Schultz et al., 2007) especially when social norms are linked to relevant identities (Lede et al., 2019)**.** Furthermore, according to the Social Identity Model of Pro-Environmental Action (SIMPEA), self-categorization into environmentalist groups promotes both a sense of collective responsibility for the environmental crisis and a sense of collective efficacy to act on that responsibility (Fritsche et al., 2018). Broader models of collective action (i.e., not specific to environmental action), such as the Social Identity Model of Collective Action (SIMCA; van Zomeren et al., (2008), similarly position social identity, together with efficacy and feelings of injustice (e.g., manifest in emotions like anger), as the main predictors of collective action participation. SIMCA has been investigated widely, and the roles of identity, efficacy, and emotion in driving (environmental) collective action are supported correlational, experimentally, and meta-analytically (Bamberg et al., 2015; Schulte et al., 2020; van Zomeren et al., 2019).

1.2. Social Interaction and Social Identity

Social identity researchers typically focus on variation in the situational salience of group membership as a key process for understanding social influence and identity-consistent actions. However, drawing on classic and contemporary perspectives, researchers in this tradition have increasingly paid attention to the processes that occur between individuals and within groups as important for understanding both identity and its consequences. Key among these processes is social interaction.

Already the pioneering work of Kurt Lewin demonstrated the impact of social interaction on behavioral change (Lewin, 1947) by showing that discussion between people was more effective in promoting behavioral change than individual contemplation alone. In the social identity literature, this idea has been especially taken up in work on identity formation and opinion-based groups. Elaborations of self-categorization theory (e.g., Postmes et al., 2005) have observed that social identity formation can be both deductive – that is, informed by observing the commonalities among group members and comparative differences between groups – or inductive – that is, produced from individual group member's interactions and contributions, independent of explicit top-down intergroup comparisons. While deductive understandings of the self vary according to context, inductive social identity formation, or identity crystallization, is proposed to lead to more stable and enduring identities (Thomas et al., 2009). These identities are also often more specific than the broad categorical understandings that might be arrived at deductively, since they are based on the consolidation of specific concerns, values, or opinions that are shared with others, and therefore also more intimately connected to action (Jans, 2021; Smith et al., 2015; Thomas et al., 2016, 2009).

Illustrative of this approach, Thomas et al. (2016) investigated the role of small-group interaction in crystallizing social identification and guiding collective action in response to waterborne diseases. Across three samples, participants were divided into small interactive groups or assigned to a control group where they were either passive or involved in brainstorming alone about the issue. Group discussion was found to intensify social identity and lead to higher perceived efficacy and stronger collective action intentions. Similarly, Bongiorno et al. (2016) examined small-group interaction in the context of climate change mitigation, asking participants to interactively come up with solutions to global warming. Their results indicated that the sense of action voice (i.e., the desire to publicly express the content of group discussions) and action efficacy (i.e., the belief that the solutions agreed by the group would produce social change) following group discussion significantly contributed to individual social identification and through this to collective climate action intentions. However, the causal role of interaction in triggering this chain of responses was not directly confirmed in this work due to the absence of a no-interaction comparison group.

1.3. Interaction in immersive environments

While social interaction seems crucial in crystallizing social identity, and through this encouraging action, further experimental evidence is needed to identify which aspects of social interaction drive identification, and to further confirm the role of interaction in fostering both collective action and potential positive spillovers to individual actions. Our study seeks to address this need by investigating whether a carefully designed task that integrates social interaction can stimulate social identification and subsequently influence intentions to engage in environmentally-beneficial individual and collective actions. Furthermore, we aim to investigate whether these effects can be amplified by employing immersive environments that are contextually relevant and foster emotional engagement. To elaborate on the second aim, we draw from theory and research on technology and instructional design (Makransky & Petersen, 2021; 2023).

Virtual Reality (VR) offers unique opportunities to the field of environmental psychology. Climate change is something that people rarely experience directly, especially in the global north. In the absence of direct experience of environmental change, simulated and interactive environments can serve as persuasive tools for eliciting emotional reactions and activating the psychological drivers of pro-environmental behavior (Plechatá et al., 2024). More than this, virtual reality offers a potentially important – but currently under-used – experimental resource for environmental psychologists. VR has the capability to create precisely manipulated environmental experiences that are perceived as real, inducing sensations as if the events were happening to us, despite knowing it is an illusion (Slater, 2009). This phenomenon, known as the place and plausibility illusions, leads to realistic affective and behavioral reactions (Taufik et al., 2021). Moreover, the high level of social presence afforded by immersive VR enables the adoption of realistic social behaviors such as social distance and gestures (Bailenson et al., 2003; Bailenson & Yee, 2005). These aspects provide behavioral scientists with a unique opportunity to study human behavior and social interaction in ecologically valid contexts while maintaining experimental control.

In this study, we designed a VR simulation featuring a structured social interaction activity centered around sustainable cooking. Participants were given the task of preparing a meal that met the criteria for both sustainability and nutrition. The participants performed the task either in a dyad, where each participant adopted a different role, either of an environmental or nutritional specialist, and collaborated to complete it, or alone. Additionally, to capitalize on the affordances of VR, we introduced a third condition where participants interacted in an environment impacted by climate change. The environment dynamically changed based on the choices made by the participants. Such an immersive experience has the potential to intensify inductive processes of social identification by making the social interaction more emotionally compelling and validating shared efforts (Plechatá et al., 2024; Rees & Bamberg, 2014; Thomas et al., 2009).

1.4. The current research

This study aims to address three primary objectives. Firstly, we seek to investigate the efficacy of social interaction in fostering behavioral change within a standardized task and controlled environment, while isolating its specific impact from engaging in pro-environmental action. Secondly, we aim to explore the potential of social interaction as a mechanism for crystallizing shared identity, a process that should promote collective action intentions and facilitate positive spillover to individual intentions and behavior (via the internalization of norms). For this purpose, we measured changes in individual intentions to engage in environmental collective action, intentions to reduce meat consumption, and behavior in a pro-environmental dilemma task as outcomes. Thirdly, we aim to examine the potential of interactive environmental feedback in a virtual environment to amplify social interaction's efficacy in promoting identification and pro-environmental behavioral change.

2. Methods

2.1. Study design

The study adopted a mixed design with pre-post measurements within-participants and between-participant assignment to VR simulations. The study's design, hypotheses, and analysis plan were preregistered on November 2, 2023, prior to data collection, via the Open Science Framework (https://osf.io/yf4w7/?view_only=c17d5d832e944f2591178639d55304b2). Unless otherwise noted, all steps below follow the preregistration plan. We provide open access to the data, materials, analysis scripts, and supplementary materials via the Open Science Framework: https://osf.io/y7br6/?view_only=41a041d967b948d881a89a7cddd9ac1a. The full study procedure was approved by the Institutional Review Board at the [blinded for the review], approval number IP-EC-09062023-01.

2.2. Participants

The participants were recruited in November 2023 from high school students in a large European city. Students participated in the experiment as part of their classes, but they were instructed that their participation in the study was voluntary and that they could terminate their participation during the experiment. As per our pre-registration, we aimed to collect data from 200-250 students and the final sample was dependent on the number of students presented in the class on the scheduled date. The sample size was limited by study resources.

The final sample consisted of 255 participants who completed the pre-post questionnaire of which 21 reported severe cybersickness and 40 did not pass the manipulation check. Therefore, the analyzed sample consisted of 194 participants with an average age of

17.41 years (*SD* = 1.08). The sample comprised 92 (47 %) students who identified as female, 96 (50%) who identified as male, 3 (2%) who identified as other, and 3 (2%) who preferred not to state their gender. The sample was quite diverse in terms of experience with VR: 27 participants (14%) had never tried VR; 45 (23%) tried it once; 61 (31%) tried it 2-5 times; 20 (10 %) tried it 5-10 times, and; 41 (21 %) participants tried it more than 10 times. Due to technical issues with the Pro-Environmental Behavior Task (PEBT), only 166 participants were able to complete it and therefore only 166 were included in the analyses related to this outcome measure.

2.3. Procedure

Participants were randomly assigned to one of the three conditions based on their assigned ID number and they were paired into dyads using a random generator. Subsequently, all participants completed the pre-treatment survey on their smartphones. Following the survey, participants were escorted to designated rooms where, in assigned pairs, they completed the VR simulation using the Oculus Quest 2 headset. Subsequently, participants completed the post-treatment questionnaire and finally PEBT. This sequence was consistent for all participants.

2.4. Conditions

Between participants, we manipulated three VR conditions: social interaction with environmental feedback, social interaction without environmental feedback, and no social interaction without environmental feedback. In all conditions, participants participated in the task in dyads but the conditions differed in terms of social interaction (interaction vs no-interaction) and the environment, Figure 1 illustrates the main difference between conditions.

Figure 1 Participant's view of their partner and immersive environment across different conditions. The social interaction with environmental feedback (A), located in the national park, social interaction without environmental feedback (B,) located in a kitchen, and no-social interaction condition without environmental feedback (C) with the matched participant facing another direction and working on their own task.

In all conditions, the participants first selected an avatar from eight options. They were then embodied in the full-body avatar, which they had control over meaning that when they moved their real body the virtual body also acted accordingly ensuring a high social presence.

In the *social interaction condition with environmental feedback*, paired participants were immersed in a virtual natural park that had been affected by climate change. They collaborated on a task to create a dish that was both nutritious and climate-friendly, with one participant assigned the role of an environmental specialist and the other as a nutritional specialist (to allow distinct contributions to the task, thereby ensuring interaction). The participants switched roles after completing the first dish and then prepared a second recipe. The virtual environment dynamically changed based on the environmental impact of their selected options (see Figure 2), providing exaggerated feedback (Chirico et al., 2020) to highlight the consequences of their choices. This feedback was framed as the potential consequences of their choices based on a scenario in which everybody in the world would make the same choice. This feedback was individualized to each dyad based on how well participants performed in terms of the carbon footprint of their dish. An illustrative video can be accessed via OSF https://osf.io/n6axf?view_only=41a041d967b948d881a89a7cddd9ac1a.

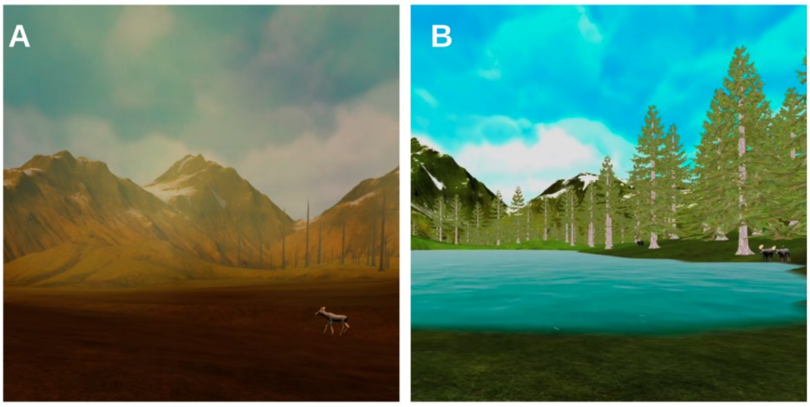

Figure 2 Participant's view of the virtual environment in the social interaction condition with environmental feedback. All participants started in the future environment where the natural park was impact by climate change (A). The environmental dynamically changed after finishing a recipe based on the CO2 emissions of the prepared dish with very low impact leading to restoration of the environment (B).

In the *social interaction condition without environmental feedback*, participants engaged in the same task but within a virtual living room. After completing the first dish, they switched roles and prepared a second recipe. An illustrative video can be accessed via OSF https://osf.io/txd74?view_only=41a041d967b948d881a89a7cddd9ac1a.

In the *no-social interaction condition without environmental feedback*, each participant received information on both the nutrition and environmental impact of the dish and completed the task in parallel without interacting with each other or observing each other's choices in a virtual living room. Similarly, as in the previous two conditions, each participant completed two dishes but they completed the task separately, that is they had their own task and could only see the other person in the same virtual room (see Figure 1C). An illustrative video can be accessed via OSF https://osf.io/kzdr5?view_only=41a041d967b948d881a89a7cddd9ac1a.

2.5. Measures

In a pre-survey, we assessed participants' demographics (gender, age, experience with VR, and their dietary lifestyle) and potential moderators of the effectiveness of the intervention.

Specifically, we used three items to assess climate anxiety (Clayton & Karazsia, 2020) evaluated as a five-point frequency response scale from (1) *never* to (5) *almost always*, and four items from the HEXACO questionnaire (Ashton & Lee, 2007) to assess participants sociability using a five-point scale from *Strongly disagree* to *Strongly agree*. We also use one item to assess if participants categorized themselves as climate-action supporters (*yes – no*).

2.5.1. Main outcome measures

To capture the impact of the intervention on behavior and identification, in the pre- and post-surveys, we measured four main behavioral variables: intention to collective action, intention to reduce meat consumption, and objective pro-environmental behavior captured using a laboratory-based PEBT. Social identification with climate supporters was assessed only in the post-test in order to limit the priming effects.

Intention to engage in collective action was captured using three items adapted from van Zomeren et al. (2004): 'I would like to participate in a group action, such as a march or rally, in support of reducing carbon emissions', 'I would like to be involved in some way in a community-based group that aims to promote the reduction of carbon emissions', 'I would like to be involved in a group that speaks out about climate change issues to other people.' The items were measured on a seven-point scale from *Strongly disagree* to *Strongly agree*.

Intention to reduce meat consumption was measured with two items: 'In the following three weeks, I intend to eat more vegetarian food than usual' and 'In the following three weeks, I intend to cut down the number of meals with meat' on the seven-point Likert scale from *Strongly disagree* to *Strongly agree*.

Pro-environmental behavior was measured using an adapted version of the PEBT validated as a pro-environmental behavior measure by Lange et al. (2018). The adapted computerized task consisted of a series of 36 transport decisions (between more and less sustainable options) and was implemented using OpenSesame. The more sustainable option prolonged the waiting time for participants for the next trial. Nevertheless, when choosing the less sustainable option, the special USB-controlled lights emitted CO_2. Therefore, the task represented a dilemma where participants repeatedly chose between reducing the length of the assessment (personal cost) versus minimizing their carbon footprint (environmental benefit). On average participants made 20 sustainable choices out of 36. The Open Sesame file can be accessed via OSF repository.

Social identification with climate action supporters was assessed using a scale adapted from Cameron's (2004) three-factor model of social identity, as employed by Thomas et al. (2016). Each factor was measured with three items. The ingroup ties factor was represented by items such as 'I have a lot in common with climate action supporters.' Centrality was assessed with statements like 'In general, being a climate action supporter is an important part of my self-image.' Ingroup affect was measured with items such as 'Generally, I feel good when I think about myself as a climate action supporter.' Responses were recorded on a five-point scale ranging from *Strongly Disagree* to *Strongly Agree*.

2.5.2. Pro-environmental behavior predictors

In the post-survey, we assessed a number of additional psychological factors that have been linked either with pro-environmental behavior (Klöckner, 2013; Plechatá et al., 2023; van Valkengoed & Steg, 2019) or to collective action (van Zomeren et al., 2008).

Based on Meijers et al. (2022) we assessed diverse types of efficacy beliefs. In particular, three items were adapted to measure personal efficacy (e.g. ‘I am able to change my lifestyle in a way that minimizes my carbon emissions’) and two items covering personal efficacy related to sustainable cooking (e.g., ‘I believe I have the ability to prepare a sustainable meal’). Furthermore, we used three items to assess collective efficacy (e.g., ‘Most people are capable of behaving in a way that minimizes their carbon emissions'). Finally, we used three items to assess personal response efficacy (e.g. 'My personal behavior can contribute to solving environmental problems') and three items to measure collective response efficacy (e.g., 'When everyone tries to limit the use of natural resources, it helps the environment'). All efficacy items were assessed on a five-point scale from *Strongly disagree* to *Strongly agree*.

Descriptive norm and injunctive norm were assessed by three items each phrased as 'I believe that people behave in a way that minimizes their carbon emissions,' and 'I believe people SHOULD behave in a way that minimizes their carbon emissions,' respectively. The items were assessed using a five-point scale from *Strongly disagree* to *Strongly agree*.

Furthermore, inspired by Thomas et al. (2016) we assessed emotions of outrage related to climate change but we also included positive emotions related to hope which has been previously linked to collective action (Cohen-Chen & Van Zomeren, 2018; van Zomeren et al., 2019) and fear relevant to climate-related behavior (van Valkengoed & Steg, 2019).

Finally, following Bongiorno et al (2016) we assessed action voice ('I would like other people to be aware of the issues discussed by our group during the VR simulation') and efficacy ('I think that the strategies that our group came up with during the VR simulation can make an important contribution to efforts to reduce carbon emissions.') on a five-point scale from *Strongly disagree* and *Strongly agree*. I would like other people to be aware of the issues discussed by our group during the VR simulation.

Additional variables that were assessed but not the core of the presented study are described in the supplementary.

2.5.3. Manipulation check and adverse effects

To verify participants' perception of the social interaction manipulation, all participants were asked to respond to the following item: 'During the virtual experience, I actively interacted and collaborated with another person to complete the cooking task.' Additionally, to test whether participants in the condition with environmental feedback perceived the environmental change, they were asked to indicate whether they noticed the following statement to be true: 'The virtual environment changed when the recipe was finished'. The participants responded to the questions as *Yes*, *I do not know*, or *No*.

Cybersickness was assessed using three items adapted from Sevinc & Berkman (2020): ‘Please indicate how much each symptom below was affecting you during the VR intervention: headache, dizziness, nausea’ assessed on a four-item scale from *Not at all* to *Severely*.

2.6. Data analysis

As preregistered, the main analysis involved multilevel modeling techniques using the lmerTest package in R to examine the impact of conditions on meat reduction and collective action intentions (controlled for pre-scores) and pro-environmental behavior (PEBT) measured after the VR intervention, and pro-environmental identity measured in post-questionnaire. Multilevel models account for the nested nature of the data (participants within dyads and schools) and allow modeling of the effects of grouping variables (i.e., dyad or school, included as *random effects*), from the investigated independent variables (included as *fixed effects*). In order to test the differences between the conditions we used their dummy-coded variables to obtain contrasts between them. In the case of intentions to reduce meat consumption, we analyzed data only for participants reporting that they consume meat (dietary lifestyle question). The Pearson correlation coefficient was used to assess the relationship between behavioral measures and social identity.

2.7. Deviation from the preregistration

Although not specifically preregistered as an exclusion criterion, we found it necessary to exclude participants who did not pass the manipulation check from the data analysis, as they did not perceive the manipulation as intended. Specifically, 31 participants (78% of all excluded participants due to the manipulation check) participants in the non-interactive condition perceived the condition as collaborative and interactive as they were either unsure about or agreed with the statement 'During the virtual experience, I actively interacted and collaborated with another person to complete the cooking task.' Although participants in the non-interactive condition could not hear each other via headphones and had their own tasks without the ability to see the other person's ingredients, they could still see another person in the environment and potentially wave or participate in non-verbal communication that might have undermined the otherwise non-interactive intention of this condition. The results before the exclusion can be found in the supplementary materials. Additionally, during data collection, we recognized the nested nature of the data within schools, each presenting unique characteristics. Therefore, we included school as a random effect to account for any variability or clustering at the school level. This allowed for a more accurate estimation of the effect of our experimental conditions and helped to reduce the risk of bias due to unobserved school-level factors. To improve readability, we present the results of the models without school only if they differed from the models including school. Furthermore, for models where the normality assumptions for multilevel models were violated, as indicated by visual inspection of the residuals (see Supplementary), we applied logarithmic transformations to the outcome measures. Complete results can be found in the Supplementary materials.

3. Results

The final sample demonstrated balance across groups concerning age ($F(2, 191) = 0.90$, $p = .408$, $\eta^2_{xi} = .009$, 90% CI [0.00, 0.04]), gender ($\chi^2(6) = 4.33$, $p = .632$), diet ($\chi^2(6) = 8.65$, $p = .194$), VR experience ($\chi^2(8) = 5.95$, $p = .652$), and pre-survey intention to engage in collective action ($F(1, 192) = 2.41$, $p = .122$, $\eta^2_{xi} = .009$, 90% CI [0.00, 0.05]). However, groups differed in terms of food intentions ($F(2, 174) = 4.89$, $p = .009$, $\eta^2 = .053$, 90% CI [0.01, 0.11]). This difference was present before the exclusion of the participants who failed the manipulation check ($F(1, 175) = 9.83$, $p = .002$, $\eta^2 = .053$, 90% CI [0.01, 0.12]), indicating that this imbalance was not created by this exclusion. Given the preregistered plan to investigate the impact of the condition on food intention including pre-survey intention as a covariate, this imbalance was controlled for in the presented results.

3.1. Effect of social interaction on outcome variables

We first investigated the effect of social interaction conditions on our four main outcome measures: intentions to participate in collective action, intentions to reduce meat consumption, pro-environmental behavior, and identification with climate action supporters. We used multilevel models with the condition as a fixed effect and dyad and school as random effects. The pre-treatment scores were included as covariates when available, i.e. in models involving intentions to engage in collective action and intentions to reduce meat consumption.

First, testing the role of interaction for promoting collective action intentions, we found a positive impact of interaction conditions compared to the no interaction condition on collective action, $\beta = 0.08$, 95% CI [0.00, 0.16], $t(107.40) = 2.08$, $p = .040$[1], supporting our

[1] The effect was not significant when excluding school as a random effect, $\beta = -0.08$, 95% CI [-0.15, 0.00], $t(108.13) = -1.96$, $p = .052$.

Hypothesis. For visual comparison see Figure 3. Nevertheless, investigating the effect of interaction on intention to reduce meat consumption, a multilevel model revealed no significant impact of social interaction compared to the no-social interaction condition among omnivorous participants (n = 176), β = 0.10, 95% CI [-0.27, 0.46], t(172.21) = 0.52, p = .605, rejecting our Hypothesis. Finally, when looking at the proportion of pro-environmental choices in PEBT (n = 166), we found no evidence for the effect of social interaction on pro-environmental behavior, β = -0.78, 95% CI [-11.82, 10.26], t(102.75) = 0.28, p = .89, rejecting our Hypothesis.

As the next step, in line with theory, we investigated the potential underlying mechanism of social interaction on pro-environmental behavior via crystallizing social identification with climate action supporters. The multilevel model revealed that interaction conditions led to significantly higher identification with climate action supporters compared to no interaction condition, β = 0.30, 95% CI [0.07, 0.53], t(189.02) = 2.58, p = .011, see Figure 3. This supports the notion that social interaction can significantly enhance a collective identity among climate action supporters, which plays a role in collective action efforts.

In the next step, we ran multilevel models to investigate our hypotheses regarding the potential amplifying effects of environmental feedback on pro-environmental behavior. We found no difference between the social interaction with (n = 63) and without (n = 81) environmental feedback in terms of collective action intentions, β = -0.02, 95% CI [-0.10, 0.06], t(98.43) = -0.54, p = .590, rejecting our Hypothesis. In terms of intentions to reduce meat consumption, the social interaction with (n = 55) environmental feedback led to higher intentions compared to the social interaction without (n = 75) environmental feedback, β = 0.42, 95% CI [0.05, 0.79], t(171.23) = 2.21, p = .029, supporting our Hypothesis. Finally, the social interaction with environmental feedback (n= 40) did not lead to more pro-environmental behavior (PEBT) compared to the social interaction without (n = 68) environmental feedback, β = 0.07, 95% CI [-0.04, 0.18], t(102.20) = 1.24, p = .219. rejecting our Hypothesis.

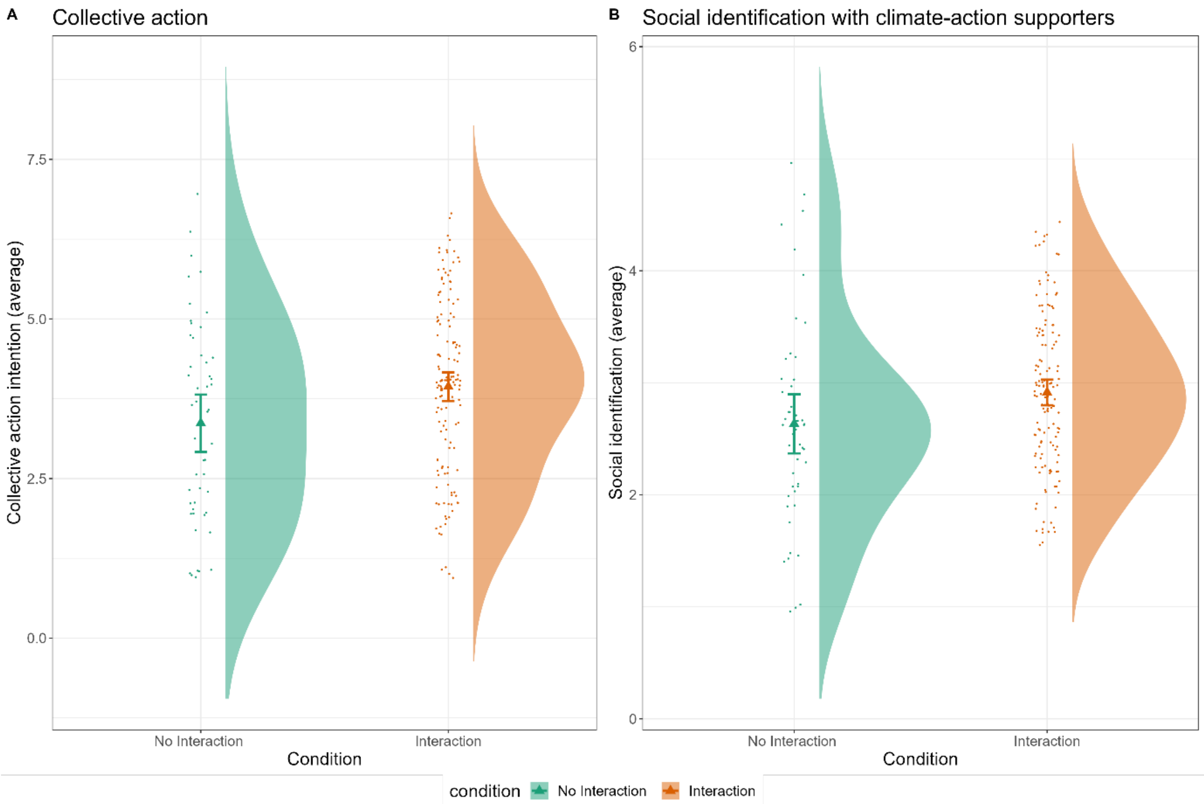

Figure 3 Differences in Intentions to participate in collective action (A) and Identification with climate action supporters (B) measured in post-test across the conditions. Social interaction conditions (with and without environmental feedback) are grouped together. Dots indicate single data points, triangles represent means, and error bars indicate 95% confidence intervals.

3.2. Exploratory analyses

To further investigate underlying mechanisms of observed effects, we conducted exploratory analyses investigating the impact of social interactions on emotions relevant to social identification and collective action (Thomas et al., 2012; van Zomeren et al., 2008), specifically hope and outrage anger, and on efficacy beliefs and social norms. The multilevel model showed that social interaction conditions resulted in significantly higher hope than the individual condition, $\beta = 0.35$, 95% CI [0.07, 0.62], $t(109.30) = 2.49$, $p = .014$. Specifically, social interaction with the environmental feedback condition, exhibited significantly higher hope when thinking about climate change compared to the no-interaction group, $\beta = 0.49$, 95% CI [0.18, 0.80], $t(110.88) = 3.08$, $p = .003$. The difference between the social interaction with and without environmental feedback did not reach significance, $\beta = 0.26$, 95% CI [-0.02, 0.54], $t(102.31) = 1.81$, $p = .073$. We found no differences in the social interaction and no-interaction conditions in terms of outrage, $\beta = -0{,}08$, 95% CI -0.17, 0.01], $t(111.83) = -1.65$, $p = .101$, nor in terms of collective response efficacy, $\beta = -0.01$ 95% *CI* [-0.07, 0.06], $t(96.25) = -0.16$, $p = .875$, nor descriptive, $\beta = -0.07$, 95% *CI* [-0.24, 0.38], $t(114.97) = -0.44$, p = .662, nor injunctive norms, $\beta = 0.00$, 95% *CI* [-0.06, 0.7], $t(102.79) = 0.12$, $p = .903$.

Finally, we were interested in the role of social identity as an overarching construct potentially securing consistency across different pro-environmental behaviors. We found that social identity significantly correlated with all behavioral measures including the intention to meat reduction, $r = 0.60$, 95% *CI* [0.50, 0.68], $t(192) = 10.30$, $p < .001$, intention to participate in collective action, $r = 0.62$, 95% CI [0.50, 0.68], $t(192) = 10.95$, $p < .001$ and pro-environmental behavior, $r = 0.27$, 95% CI [0.12, 0.40], $t(164) = 3.60$, $p < .001$, indicating positive relationship between identification with climate-supporters and cross-situational pro-environmental action varying from weak for objective behavior to strong for collective action.

4. Discussion

The aim of this study was to investigate the role of social interaction in promoting collective action, sustainable behavior, and social identification with climate-action supporters. Employing a novel approach using networked virtual reality (VR), we aimed to examine how social interaction influences participants' engagement in a task unrelated to climate collective action and whether these effects can be enhanced via environmental feedback in immersive contexts. In the controlled setting, participants either performed a task alone, with another person, or with another person with or without environmental feedback, providing insights into the types of social interaction that lead to social identification and collective action.

Our results indicate that the conditions involving social interaction showed an advantage over the no-interaction condition, especially in promoting identification with climate action supporters and support for climate collective action, nevertheless with a small effect size. When looking at the comparison between all three conditions, it is clear that the environmental feedback afforded by immersive VR plays an important role in these processes by promoting the emotional experience of hope. Our findings support prior work on the role of group-based interaction in crystallizing identification and fostering group-based action in pursuit of social change (e.g., Bongiorno et al., 2016; Thomas et al., 2016).

Yet, contrary to the seminal work by Lewin (1947), our results suggest that social interaction may not necessarily promote personal pro-environmental behavior targeted by the intervention – in this case, sustainable eating intentions – compared to participating in the intervention alone. Meta-analytical evidence (Schulte et al., 2020) indicates that social identity is linked primarily to collective action ($r+ = .56$-$.63$) and to a significantly lower extent to private behavior ($r+ = 0.35$). Therefore, the pathway from social interaction to identity formation is potentially not as strong for individual behaviour as for collective action and other processes, and in the case of the former building individual self-efficacy to perform the target behavior might also be relevant. This is in line with the previous literature (Plechatá et al., 2023) that an engaging intervention that allows for practicing the desired behavior and receiving interactive feedback can be an effective tool to promote sustainable consumption through effects on efficacy. In the present study, we observed that social interaction when combined with environmental feedback resulted in higher intentions to reduce meat consumption compared to the social interaction without such feedback. This highlights the importance of aligning social interaction with efficacy-building environmental feedback to effectively promote positive behavioral outcomes.

Building on previous studies that focused on social interaction and behavior change (e.g., Bongiorno et al., 2016; Thomas et al., 2016), our aim was to more precisely isolate the effect of social interaction from both active involvement in the intervention/ task and the effect of being observed, as all conditions involved completing a task with another person. In our more controlled experiment, facilitated by interactive VR, the social interaction condition allowed verbal communication and collaboration in the task, whereas the no-interaction control condition still involved participating in an active task—preparing a sustainable and nutritional dish – in the presence of another person but without the capacity for dynamic interaction over the task itself. The engaging nature of the intervention, which allowed participants in the individual condition to actively interact with the environment and practice desired behaviors, might still be powerful in boosting other predictors of identity formation and collective action, such as efficacy or outrage. Nonetheless, we think this design showcases the potential utility of VR as an experimental tool – not just to researchers interested in environmental psychology, but also to researchers interested in the consequences of interaction more generally.

Previous research on social identity and collective action has shown that both emotionality and efficacy beliefs can play a role in social identification and collective action (Bamberg et al., 2015; Thomas et al., 2009; van Zomeren et al., 2008). Arguably these aspects too are facilitated by adaptive immersive VR environments. Previous research has pointed out the ability of VR simulations to promote efficacy beliefs, which might be facilitated via emotionality and the relevance of the experience (Plechatá et al., 2024). Our exploratory results indeed indicate some differences in emotional response between the conditions. Specifically, social interaction with environmental feedback led to a significantly higher perception of hope linked to climate change. Hope has been proposed as a potential moderator of the impact of efficacy on collective action (Cohen-Chen & Van Zomeren, 2018) and therefore might be responsible for our findings on collective action, with which hope was significantly correlated.

Finally, we explored the potential role of identification with climate action supporters in promoting cross-situational behavioral change via positive spillovers. Our findings reveal a positive correlation between identification and all behavioral predictors in this study: intentions to reduce meat consumption, engage in collective action, and objective pro-environmental behavior. This suggests that social identification may contribute to consistency across behaviors – an outcome that would be explained within the theory by the internalization of pro-environmental group-based values and norms. The correlational pattern, whereby identification was most strongly correlated with collective action intentions (r = 0.62) and more weakly with objective personal behavior (r = 0.27) aligns with meta-analytic findings (Schulte et al., 2020) about social identity being specifically relevant to public sphere pro-environmental behavior rather than the private sphere one. The medium-size (r = 0.60) correlation with the intention to reduce meat consumption can also be understood via lenses of self-reported measures serving as a means to performing the social identity (Koller et al., 2023).

4.1. Limitations and future directions

The observed results should be interpreted within the context of several limitations. Firstly, the extent of social interaction within the immersive VR environment may be constrained. Despite evidence suggesting that behavior in VR mirrors real-life behavior (Plechatá et al., 2023; Taufik et al., 2021) and that social norms are adapted in VR, such as interpersonal distance and gestures (Bailenson et al., 2003; Bailenson & Yee, 2005), certain aspects of social interaction may inherently be limited in virtual environments. Thus, the observed effects may have been stronger if conducted in real-life settings or with more advanced technology. Participants in the social interaction conditions reported relatively high social presence, scoring 3.86 and 3.91 on the five-point scale in the conditions with and without environmental feedback. However, given that networked VR is a relatively novel technology, advances in the field will likely support stronger feelings of social presence through more realistic and smooth interactions (Makransky & Petersen, 2023). Secondly, as our primary focus was on isolating the effect of social interaction, we did not include a passive control condition. Although we consider having an active control condition a methodological strength, this also means it was not possible to estimate the unique contribution of our three experimental conditions to participants' behavior. It might be beneficial for future research to further investigate these effects compared to a neutral control condition to fully identify potential sources of change involved in this kind of paradigm.

4.2. Conclusions

Our findings support the notion that social interaction, even within structured activities not explicitly targeting collective action, has the potential to promote social identification with climate supporters. Moreover, especially when coupled with immersive environmental feedback promoting positive emotional reactions, like hope, social interaction can promote support for environmental collective action. The role of interaction and identity crystallization in producing individual behavior change and positive spillover to non-targeted behavior was less evident in our data. Yet, the findings presented here still show potential for drawing on social identity principles and processes for contributing to the social transformations that might be necessary for meeting increasingly ambitious climate change goals. From a methodological perspective, the present study also showcases how the affordances of new technology, specifically networked immersive VR, can be leveraged by researchers interested in isolating and exploring the social processes that might lie behind individual and collective transformations.

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