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Collective psychological ownership in virtual reality: implications for intergroup prejudice

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Virtual reality (VR) offers unique opportunities for examining intergroup interactions. Even though VR-based intergroup contact has been seen as promising in reducing prejudice, researchers have faced significant challenges to deliver effective virtual contact interventions and called for better understanding of VR-specific identity-related processes that are present during and facilitate the social interactions in VR. This is a follow-up study on the virtual intergroup contact intervention conducted among 132 White Italian adult participants. The intervention failed to obtain virtual intergroup contact effects on explicit prejudice and showed only a marginal improvement in implicit intergroup bias towards people of African descent following cooperative intergroup contact with a Black avatar. Critical factors contributing to decreasing prejudice in VR were co-presence, body ownership and common cyber identity. In this follow-up study, we examine an additional mechanism that may influence intergroup outcomes in VR contact: the experience of Collective Psychological Ownership of a Virtual Space (CPO-VS). Particularly, we examine the effect of CPO-VS on explicit and implicit attitudes toward people of African ethnic descent following cooperative intergroup contact with an avatar representing a Black person. Results showed that higher perceived CPO-VS was associated with more favorable explicit attitudes toward outgroup members following VR experience across conditions, but it did not moderate the effect of contact on outgroup attitudes. These findings suggest that fostering collective psychological ownership in shared virtual spaces may improve intergroup relations.

KEYWORDS

collective psychological ownership, intergroup attitudes, intergroup contact, prejudice, virtual reality

1 Introduction

Ownership is a concept traditionally grounded in material and social arrangements. In this study, we bring ownership into digitally mediated contexts, which raises novel theoretical and empirical questions As virtual reality (VR) technologies increasingly blur the boundaries between face-to-face and simulated interaction, issues of collective ownership–the feeling that something is collectively "ours"–gain renewed significance for social psychology. By enabling avatar-mediated interaction in immersive virtual settings, VR offers new opportunities for intergroup research. Unlike traditional methods, VR enables researchers to study social phenomena in highly controlled, replicable, and ecologically valid settings (Pan and Hamilton, 2018). Building on the concept of Collective Psychological Ownership (CPO), defined as a shared sense of ownership among group members over a material or immaterial target (Pierce and Jussila, 2010), this study introduces Collective Psychological Ownership of a Virtual Space (CPO-VS). We investigate its functions in immersive simulated environments and its potential impact on intergroup attitudes (Tassinari et al., 2024).

VR's immersive nature, made possible through its technical features (Cummings and Bailenson, 2016) makes participants feel as if they are truly "there" in the virtual environment. This immersiveness has also made VR a powerful tool for studying intergroup relations. Allport's (1954) contact hypothesis is being increasingly applied in VR research, due to its robust empirical evidence from studies conducted both offline and online (Pettigrew and Tropp, 2006; Imperato et al., 2021). While the effectiveness of existing VR interventions in reducing prejudice has so far been less than optimal and highly contextual, sometimes even reinforcing existing stereotypes and biases (e.g., Banakou et al., 2016; Hasler et al., 2017; Kosic et al., 2025), the results of the systematic review by Tassinari et al. (2022b) nevertheless indicate that intergroup contact in VR has a potential to reduce prejudice, increase empathy, and boost social support for outgroup members.

In VR, a closely related concept to immersion is presence. Presence is defined as feeling physically and psychologically situated in the virtual environment (Slater and Wilbur, 1997; Wilkinson et al., 2021), and it has been shown to enhance the effectiveness of VR interventions aimed at reducing prejudice (Chen and White, 2024; Tassinari et al., 2022a). A distinct concept closely related to presence is co-presence, which includes both the sense of acknowledging presence of other individuals in the virtual environment, and the sense that these individuals actively perceive us within it (Slater et al., 2000; Youngblut, 2003). Co-presence is also an essential predictor of successful VR contact experience (Riva et al., 2014; Tassinari et al., 2022a).

Moreover, VR's ability to elicit body ownership, defined as a sense of identifying with one's virtual avatar, facilitates prejudice reduction (Barbot and Kaufman, 2020). Tassinari et al. (2022a) found that both body ownership over one's own avatar and feelings of co-presence with the avatar representing the outgroup member promoted empathy following VR interaction, with co-presence also moderating the effect of intergroup contact on empathy. These features identify VR as an invaluable tool for exploring intergroup contact and its potential to influence attitudes towards stigmatized minorities.

While the focus of previous research has often been on immersion-related constructs such as sense of (co)presence and body ownership, identity-related mechanisms of VR contact remain largely unexplored. In this study, we expand the line of research we started in our VR contact intervention (Tassinari et al., 2024), in which we showed that common cyber-identity, a shared social identity experienced by individuals interacting within VR environments, was associated with less prejudice regardless of the form of contact (positive or negative). We also re-examine the same intervention data and introduce a novel approach to address a research gap regarding the role of CPO-VS in intergroup outcomes following intergroup contact in virtual reality.

While previous research has studied psychological ownership in VR settings, it approached it as an individual level construct determining the feeling of possession over a virtual object and linking it mainly to motivation and engagement in VR (Lee and Chen, 2011; Buchem, 2012; Poretski et al., 2019). In contrast, collective psychological ownership has not yet been studied in VR settings. This gap is significant given the importance of collective ownership, specifically spatial ownership, in social identity formation and group dynamics. Along with the traditionally examined mechanisms (body ownership and co-presence), we explore whether the immersive nature of social VR fosters a sense of collective ownership over a shared virtual space. CPO also has a potential to enhance the effect of positive intergroup contact in VR on outgroup attitudes. By focusing on ownership of a virtual space, we aim at expanding the theoretical and empirical understanding of psychological ownership in immersive environments and its potential for prejudice reduction.

1.1 Collective psychological ownership of a virtual space

In this study, we argue that similar to how an individual can experience a sense of ownership over a personal space (e.g., "This is MY space"), a sense of ownership can also manifest at the group level (e.g., "This is OUR space") in VR. This proposition is anchored to the concept of Collective Psychological Ownership (CPO), which embodies the shared feeling of ownership that a group may hold over any material or immaterial target (Pierce and Jussila, 2010). Collective ownership feelings are fundamentally social in nature; they create boundaries between groups and organize the physical and symbolic world, as well as relationships and interactions between groups (Verkuyten and Martinović, 2017).

Group identity is a central aspect of CPO, as the concept collective ownership implies a shared sense of belonging to a group that has collectively invested into, has an intimate knowledge about, and controls the target of possession (Pierce et al., 2001; 2003; Pierce and Jussila, 2010). Grounded in the principles of the social identity approach (Tajfel and Turner, 1979; Turner et al., 1987), the sense of collective ownership needs to be underpinned by the social identity of the group (Pierce and Jussila, 2010) for the owned targets to become a part of the "extended self" of the owners (Dittmar, 1992). In intergroup research, CPO has primarily been applied to territorial ownership inferred from a group's claims of primo-occupancy, investment, and formation (Martinović and Verkuyten, 2024). Extending this concept to VR interactions suggests that not only virtual objects but also co-constructed and shared spaces may foster a collective sense of ownership, thereby shaping intergroup dynamics.

Territorial CPO has often been linked with positive intragroup processes and negative intergroup outcomes (e.g., Martinović and Verkuyten, 2024). Specifically, CPO has been found to foster a sense of collective responsibility toward the target of ownership and encourage intragroup cooperation, solidarity, and stewardship behaviors, while also leading to defensive behaviors driven by perceived exclusive determination rights to control the target of possession (Pierce and Jussila, 2010; Nijs et al., 2022b). For example, CPO has been linked with the exclusion of certain social groups (e.g., immigrants and refugees) by the majority group members (Nijs et al., 2021). This is because ownership principles dictate what a group believes it can do with its possessions and, crucially, what non-owners are prohibited from doing with what is considered "ours" (Verkuyten and Martinović, 2017). Thus, in national contexts, especially when majority group members feel threats to their ownership, CPO may evoke a feeling of "losing what is ours" (Nijs et al., 2022a). As Nijs et al. (2022b) have empirically shown, this predicts exclusionary attitudes and behaviors (e.g., anti-immigration).

However, CPO can also support positive intergroup attitudes and outcomes, pending it is perceived as inclusive, i.e., shared among the larger superordinate ingroup. Aligned with the Common Ingroup Identity model (Gaertner et al., 1993), perceiving an outgroup as part (i.e., sub-group) of a larger "us", particularly through positive contact, may elevate the sense of shared ownership and social identity, reducing prejudice. Thus, CPO holds promising potential to be explored as an important VR-specific mechanism to achieve positive intergroup outcomes. Interaction with other avatars in an immersive virtual space may promote the development of a collective sense of ownership over the virtual space shared among virtual agents, including those representing an outgroup based on other social characteristics (e.g., skin color). This, in turn, may enhance the feelings of unity, cooperation, and solidarity with stigmatized minority groups following such experiences. Moreover, investigating CPO as a potential facilitator of intergroup contact in VR offers valuable insights into how ownership-related processes can be leveraged to improve intergroup relations.

1.2 Previous research on psychological ownership in VR

In the context of VR, the concept of ownership has been studied at the level of individual psychological ownership (IPO), namely, an individual's feeling of possession over objects in the virtual space (e.g., Lee and Chen, 2011). Studies indicate that virtual targets can elicit ownership feelings much like physical ones (e.g., Buchem, 2012; Poretski et al., 2019), also in socially situated interactions (Lee and Chen, 2011; Poretski et al., 2021). A strong sense of ownership has been found to be important for motivating a person to spend time, engage actively, and return to a virtual space (Lee and Chen, 2011).

However, to the best of our knowledge, collective feelings of possession in VR in general and of a virtual space in particular have not yet been explored within VR. The most relevant research for this study comes from studies on shared Augmented Reality (AR). Carrozzi et al. (2019), for example, showed that shared experiences such as using shared devices, satisfying social identity needs, and enabling customization can foster collective psychological ownership of AR holograms.

Lee et al. (2024) showed that technological and social factors in the metaverse can elevate psychological ownership from the individual to the collective level. Although they did not isolate VR-specific effects, the metaverse includes multiple virtual environments, including social VR. Their findings indicated that platform controllability and interactivity, together with social factors (e.g., social support, social self-efficacy, and community support), shape social presence and social identity within metaverse communities; these determinants closely map onto core features of many VR experiences. Greater social presence and identity were, in turn, associated with higher engagement and stronger collective psychological ownership (Lee et al., 2024). Taken together, the combination of control, customization, and interactivity with the inherently social nature of many VR settings suggests that collective psychological ownership is likely to emerge in social VR experiences in which participants can move freely and interact with others.

Poretski et al. (2021) investigated IPO in AR and its impact on interpersonal tensions and ownership claims when ownership was made unclear. Their research emphasized that ownership conflicts arise when multiple users interact with the same virtual and physical objects or spaces, especially when these objects are modified. They identified five key dimensions of psychological ownership: possession, control, identity, responsibility, and territoriality, as critical to understanding how individuals in shared virtual spaces perceive their relationship to both physical and virtual objects. While these dimensions pertain to IPO, they may contribute to conceptual understanding of how shared environments might foster or disrupt a collective sense of ownership in VR, especially when it comes to collective settings where shared environments necessitate collaboration.

Building on Poretski et al. (2021) work, Seo (2024) highlighted the interplay between IPO and CPO in shared AR workspaces, emphasizing how collaborative functionalities influence these dynamics. In Seo's (2024) study, exclusive control fostered IPO by enhancing personal agency and attachment, while shared control facilitated CPO by fostering mutual investment and collective responsibility. These mechanisms are directly relevant to VR, where intergroup interactions require balancing individual agency with shared ownership to achieve a sense of "ours."

In conclusion, this study advances emerging work on (collective) psychological ownership in VR and argues that, alongside established VR-specific mechanisms such as co-presence and body ownership, CPO-VS is a key construct to examine when evaluating the prejudice-reduction potential of intergroup contact in VR.

1.3 Study aims and hypotheses

The aim of this research is to expand the focus of VR studies to better acknowledge the role of CPO as an additional VR specific mechanism that emerges during virtual collective experiences and may contribute to attitudinal change following intergroup contact in VR. Specifically, we build our study on previous CPO research focusing on territorial ownership disputes in the real-life intergroup contexts (for a review, see Martinović and Verkuyten, 2024) as well as on existing studies on psychological ownership in immersive contexts (Lee et al., 2024; Poretski et al., 2021; Seo, 2024). We suggest that while feelings of co-presence imply being in the same virtual place together, CPO-VS implies perceiving shared ownership of the virtual place ("This virtual space is ours!"). Specifically, we examine whether even a brief interactive task in VR is sufficient to elicit

CPO-VS, and whether CPO-VS is associated with and facilitates the effect of positive intergroup contact in VR on outgroup attitudes following the VR experience. This inquiry is critical for understanding the accessibility and scalability of CPO-VS as a mechanism in VR-based interventions.

This study is a part of a larger intervention study conducted in Italy and Finland that aimed at testing the direct and secondary transfer effects of positive and negative virtual intergroup contact on outgroup attitudes. The study was pre-registered prior to data collection. The pre-registration can be found at https://osf.io/dgqj9/overview. As only the Italian data set included the measure of CPO-VS, the pre-registered hypothesis concerning the potential effect of this factor has not been analysed nor reported in our previous studies on the intervention effects (Tassinari et al., 2024).

We formulate our exploratory hypotheses as follows:

H1: Higher sense of CPO-VS is associated with less prejudice towards the outgroup following positive intergroup contact in VR.

H2: Among participants exposed to positive intergroup contact in VR, greater CPO-VS is associated with reduced prejudice toward the outgroup.

We control for the sense of co-presence and body ownership in our analyses, as they are key components that may significantly influence the VR experience (Tassinari et al., 2024), as well as demographics (age and gender) associated with prejudice in previous research.

Attitudes are a manifold construct, encompassing both deliberate components and more automatic processes. To account for this complexity, our study incorporates a combination of measures that assess different dimensions of attitudes. Specifically, we include two explicit measures: a semantic differential scale (the General Evaluation Scale by Wright et al., 1997), and a visual analog scale (the feeling thermometer). To account for the automatic, less deliberate aspects of attitudes, we also employ the Implicit Association Test (IAT, Greenwald et al., 1998), which measures implicit attitudes. While we recognize that the IAT has limitations, particularly in terms of construct validity (Schimmack, 2021), it provides a critical advantage in bypassing social desirability bias–a common issue with self-report measures. Additionally, the IAT has been shown to have stronger predictive validity for discriminating behavior compared to explicit measures (Greenwald et al., 2009), making it a valuable tool for a comprehensive assessment of attitudes. By integrating these methods, we aim to provide a well-rounded analysis of how explicit and implicit processes shape intergroup attitudes in the context of this study.

2 Methods

2.1 Sample

Participants were recruited via social media outreach and snowball sampling, excluding those with educational or psychological academic backgrounds to avoid identification of the purpose of the study. Of the initial 160 participants, 28 were excluded based on pre-registered criteria (e.g., failing to identify avatar ethnicity, mixed ethnic backgrounds, VR issues, or IAT completed too fast). No additional exclusion criteria were applied. The final sample included 132 participants: 66 males, 65 females, and one identifying as “other,” aged 18–88 years with mean age 31 (SD = 14.25).

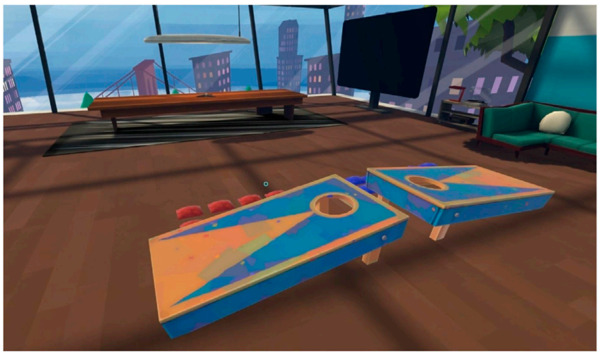

FIGURE 1
The virtual room where the interaction took place.

2.2 Procedure

The experiment was conducted at a university located in Northern Italy. A confederate, who was a White Italian female, guided participants through the process. In the laboratory, participants were first instructed on how to properly wear and operate the Oculus headset. Following this, they completed the Altspace VR tutorial to familiarize themselves with the virtual environment and practice navigating their avatars. Participants were then asked to create avatars that closely resembled their own appearance. This step was designed to enhance their sense of body ownership over their avatars and to encourage the belief that other participants they encountered in VR had also modeled their avatars to resemble themselves. The avatars in the virtual environment were gender-matched to the participants, except for the experimenter’s avatar, which was represented as a White female.

Participants were then transported to the virtual room depicted in Figure 1. The experimenter was present in the virtual space, embodied by the avatar shown in Figure 2. Participants were randomly assigned to four conditions: intergroup cooperation, intragroup cooperation, intergroup competition, and intragroup competition. They received instructions to play a virtual ball-toss game, either cooperating or competing with another participant, who was actually a confederate. They were told to score points by throwing bean bags through a hole on a board, taking 10 alternating turns each. The game’s framing emphasized team alignment (same or different team) and was designed to simulate intergroup or outgroup interactions. Participants began the game on cue, with the confederate’s skill level matched to theirs to maintain a sense of fairness. After receiving these instructions, participants and the experimenter were joined by a third avatar, representing a teammate controlled remotely by a confederate. The teammate’s avatar represented a Black person in the intergroup contact condition, and a White person in the ingroup contact condition.

Considering the limited sample size and our focus on the effect of specifically positive (i.e., cooperative) intergroup contact on

FIGURE 2
The avatars represent outgroup members, ingroup members, and the experimenter.

attitudes towards a specific outgroup (i.e., people of African descent), in this study, we restricted our main analyses to contrasting the effect of positive intergroup contact with an avatar representing a Black person (experimental condition, n = 36) with that to all other assessed conditions (n = 96).

Once the game concluded, participants moved to a virtual waiting room where they encountered an avatar representing an East Asian individual. No interaction occurred during this time, and the seating distance chosen by the participant was recorded. After 3 min, participants were informed that their team had won the game, regardless of their assigned condition, marking the end of the virtual experience. Finally, participants completed a self-report questionnaire and an implicit association test through the online platform PsyToolkit (Stoet, 2017). Afterward, they were thanked, debriefed, and dismissed.

2.3 Measures

We assessed outgroup attitudes using three distinct measures, each capturing different facets of prejudice: the General Evaluation Scale (GES), the feeling thermometer, and the Implicit Association Test (IAT).

General Evaluation Scale (GES) was used to assess explicit attitudes towards the individuals of African ethnic background using six bipolar items (Wright et al., 1997). Participants rated outgroup members described with pairs of adjectives (e.g., "cold/warm," "suspicious/trusting," "positive/negative," "friendly/hostile," "respect/contempt," and "admiration/disgust") on a 7-point scale, with higher scores indicating more negative attitudes toward people with African ethnic background. Responses were averaged into a composite score, demonstrating strong reliability (α = 0.86).

The feeling thermometer was used to assess emotional prejudice. Participants were asked to rate their feelings toward individuals of African ethnic background on a scale from 0 (unfavorable) to 100 (favorable).

Implicit attitudes were assessed using the Implicit Association Test (IAT; Greenwald et al., 1998). The IAT is a reaction-time-based task designed to measure automatic biases by assessing the ease with which participants associate Black or White faces with positive or negative words. Faster reaction times when associating Black faces with negative words and White faces with positive words indicate stronger implicit biases against individuals of African ethnic background. A higher score indicates higher implicit bias.

Collective Psychological Ownership of a Virtual Space (CPO-VS), adapted from the concept of CPO by Pierce et al. (2018), assesses participants' sense of shared ownership over a virtual space while embodying an avatar. The scale, comprising four items with a Cronbach alpha of 0.908, evaluates the extent to which individuals perceive the space as collectively owned by their and others' avatars. Items were formulated as follows: "*When I think about the virtual space and my experience in that space as an avatar, I feel that: the space was owned by us, the avatars; the space belonged to us, the avatars; the space was in our collective possession; we owned the space together.*" Responses were rated on a 7-point scale, with a higher score being indicative of a higher feeling of virtual space ownership. A one-factor CFA for the measure was estimated with WLSMV using the four observed items (N = 132). Factor loadings were high (0.85–0.91), and reliability was excellent (ω ≈ 0.94).

Co-presence in VR was assessed using a four-item scale adapted from Biocca and Harms (2002). The scale measured participants' awareness of others' presence in the virtual environment. Responses were rated on a 1–5 scale, with a higher score indicating higher sense of co-presence. This measure had a Cronbach alpha of 0.83.

Body ownership was assessed utilising a six-item scale developed by Peck et al. (2013), which evaluates the extent to which participants experienced the virtual body they controlled in VR as their own. Responses were rated on a 1–5 scale, with a higher score indicating higher sense of body ownership. The Cronbach alpha for this scale was 0.78.

2.4 Analysis

To test the hypotheses, we used moderated multiple regression analysis. Assumptions of linear regression for all the models were met except for normal distribution of residuals, confirmed by the Shapiro-Wilk normality test ($p < 0.05$). However, as our sample size ($N = 132$) is large enough for relaxing the issues of non-normality (Pek et al., 2018), we proceeded with the linear regression models.

The first step of the linear model included the experimental condition (0 = no positive intergroup contact vs. 1 = positive intergroup contact) variable, and in the second step, CPO-VS was added. The third step included the interaction between the experimental condition and CPO-VS. In the fourth and final step, the control variables (i.e., co-presence, body ownership, age, and gender) were added. This model was repeated with three dependent variables: GES, feeling thermometer and IAT. The multicollinearity of the included correlated predictors was assessed using the Variance Inflation Factor (VIF), which ranged from approximately 1.08 to 1.21, indicating no concerns.

Analyses were performed using Rstudio (R Core Team, 2024). R-packages used in the analysis included *apaTables* (Stanley, 2021), *car* (Fox and Weisberg, 2019), *gt* (Iannone et al., 2024), *lmtest* (Zeileis and Hothorn, 2002), *moments* (Komsta and Novomestky, 2022), *officer* (Gohel and Skintzos, 2024), *psych* (Revelle, 2024), *readxl* (Wickham and Bryan, 2023), *sjPlot* (Lüdecke, 2024), *table1* (Rich, 2023), and *tidyverse* (Wickham et al., 2019).

3 Results

3.1 Preliminary analyses

Regarding the VR-specific variables, participants generally showed moderate degrees of feelings of co-presence, body ownership, and CPO-VS across conditions. We next conducted independent sample *t*-tests to compare participants' feelings of body ownership, co-presence, and CPO-VS between the two conditions. Given the disparity in sample sizes, Welch's t-test was utilized to account for unequal variances. The results revealed a statistically significant difference in body ownership scores between the conditions, with the participants in the experimental condition ($M = 2.95$, $SD = 1.02$) reporting lower body ownership compared to participants in the control condition ($M = 3.46$, $SD = 0.91$); $t(57.00) = 2.63$, $p = 0.011$. The mean difference was 0.51, with a 95% confidence interval of [0.12, 0.89], indicating moderately lower levels of body ownership in the positive intergroup contact group. There were no significant differences for co-presence ($t(57.65) = 0.74$, $p = 0.461$) or CPO-VS ($t(63.55) = -0.24$, $p = 0.814$) between the conditions studied.

Next, we examined the correlations between the study's predictor and dependent variables. Body ownership, co-presence, and CPO-VS were all significantly and negatively correlated with explicit attitudes measured by GES, and body ownership also showed a significant negative correlation with IAT (see Table 1).

3.2 Main analyses

The results of the step-by-step moderated multiple linear analyses, examining the direct and interaction effects of condition (cooperative intergroup contact vs. other conditions) and CPO-VS on outgroup attitudes, are presented in Tables 2–4 for each dependent variable (GES, Feeling Thermometer, and IAT) separately. The final step of the models also included control variables specific to the VR experience (co-presence and body ownership), which are associated with successful VR interventions and reduced prejudice, as well as demographic factors (age and gender). Three *post hoc* power analyses were conducted in G*Power (F tests; linear multiple regression: R^2 deviation from zero) for the final regression model including six predictors (four control variables and two predictors). Using the observed effect sizes ($f^2_{GES} = 0.129$, $f^2_{therm} = 0.167$, and $f^2_{IAT} = 0.112$), with $\alpha = 0.05$ and $N = 132$, the achieved power for detecting a non-zero overall R^2 were 0.87 for the GES, 0.95 for feeling thermometer, and 0.81 for the IAT.

The results partly supported our H1, as CPO-VS directly predicted lower explicit prejudice towards people of African ethnic background measured through GES ($\beta = -0.23$; $p = 0.008$). This effect lasted, when the interaction effect between the experimental condition and CPO-VS was added into the model in step 3 ($\beta = -0.25$; $p = 0.012$), but lost statistical significance after the control variables were added in step 4 ($\beta = -0.15$; $p = 0.164$).

We also hypothesised that the relationship between cooperative intergroup contact and outgroup attitudes is moderated by CPO-VS, such that higher levels of CPO-VS amplify the positive effect of intergroup contact on outgroup attitudes (H2)[1]. The results showed no significant interaction between condition and CPO-VS on outgroup attitudes. However, consistent with Tassinari et al. (2024)

1 An *a priori* power analysis for the interaction effect between condition and CPO-VS was conducted using Monte Carlo simulation in R with the InteractionPoweR package. Power was estimated from 10,000 simulated datasets with sample size N = 132, assuming a correlation between predictors of r =0.02, with moderator reliability set to 0.94. Correlations were adjusted to accommodate the binary predictor, and a significance level of α = 0.05 was used. Under these assumptions, the estimated power to detect the interaction effect was 0.07 for GES, 0.14 for feeling thermometer, and 0.11 for IAT.

TABLE 1 Means, standard deviations, and correlations with confidence intervals.

Variable	M (SD)		1	2	3	4	5	6
	Control	Experiment						
1. GES	2.81 (0.91)	2.95 (0.98)						
2. Thermometer	75.73 (24.91)	73.61 (23.68)	−0.47**					
			[−0.59, −0.32]					
3. IAT	0.60 (0.48)	0.48 (0.50)	−0.00	−0.13				
			[−0.17, 0.17]	[−0.30, 0.04]				
4. CPO-VS	4.60 (1.67)	4.68 (1.65)	−0.23**	−0.05	0.08			
			[−0.38, −0.06]	[−0.22, 0.13]	[−0.09, 0.25]			
5. Co-presence	3.61 (1.01)	3.45 (1.12)	−0.26**	0.07	0.03	0.32**		
			[−0.41, −0.09]	[−0.10, 0.24]	[−0.14, 0.20]	[0.16, 0.47]		
6. Body ownership	3.46 (0.91)	2.95 (1.02)	−0.21*	0.13	−0.18*	0.19*	0.27**	
			[−0.36, −0.04]	[−0.04, 0.29]	[−0.34, −0.01]	[0.02, 0.35]	[0.11, 0.42]	
7. Age	30.26 (14.25)	32.56 (14.12)	0.10	−0.33**	0.16	−0.01	0.09	−0.14
			[−0.07, 0.26]	[−0.47, −0.17]	[−0.01, 0.32]	[−0.18, 0.16]	[−0.08, 0.26]	[−0.30, 0.03]

M and *SD* are used to represent mean and standard deviation, respectively. Values in square brackets indicate the 95% confidence interval for each correlation. The confidence interval is a plausible range of population correlations that could have caused the sample correlation (Cumming and Bailenson, 2014). * indicates $p < 0.05$. ** indicates $p < 0.01$.

study, there was a direct effect of experimental condition on IAT, with cooperative intergroup contact significantly decreasing the level of implicit prejudice ($\beta = -0.40$; $p = 0.048$) after controlling for co-presence, body ownership, age, and gender. However, the effects of the experimental condition on explicit attitude measures (GES and Feeling Thermometer) remained non-significant.

As regards the control variables, body ownership showed a significant negative effect on the IAT ($\beta = -0.24$; $p = 0.017$), and co-presence on GES ($\beta = -0.19$; $p = 0.042$), suggesting that these variables contribute to the decreasing prejudice following social interaction in VR. Out of the demographic controls, higher age was associated with more negative feelings toward the outgroup (Feeling thermometer: $\beta = -0.34$; $p < 0.001$).

4 Discussion

This study explored the experience of Collective Psychological Ownership of a Virtual Space in virtual reality. The study was built on the social psychological research on the role of territorial collective psychological ownership in intergroup relations (e.g., Martinović and Verkuyten, 2024; Verkuyten and Martinović, 2017) and research on psychological ownership in immersive environments (e.g., Lee et al., 2024; Poretski et al., 2021; Carrozzi et al., 2019). The findings revealed that CPO-VS was directly associated with reduced explicit prejudice, as measured by the General Evaluation Scale (GES).

Our study makes a novel contribution by introducing a measure of territorial collective psychological ownership in VR and testing its role within the virtual contact paradigm. By eliciting a sense of collective psychological ownership over a virtual space through simple VR interaction tasks, our procedures demonstrate that even brief VR experiences can reflect social identity processes as manifested in collective ownership. This finding underscores the potential of VR as a platform for investigating identity- and ownership-related mechanisms and their broader social implications.

We note, however, that the defining features of immersive spaces may recalibrate how CPO is formed and perceived compared to physical settings. Because key antecedents of CPO (e.g., cues of investment, control) may differ in simulated environments, the permeability and negotiability of ownership boundaries may be subject to reshaping. Nevertheless, direct empirical comparisons between CPO in physical spaces and CPO-VS remain absent. Accordingly, these contrasts should be regarded as theoretically grounded but provisional, as comparative research is required to investigate when and how VR-specific features may meaningfully differentiate CPO-VS from its physical-world counterpart.

However, no interaction effect emerged between CPO-VS and type of contact on outgroup attitudes, whether explicit or implicit. One possible explanation is that CPO-VS may function as a more of a general mechanism in VR, which similarly to co-presence and common cyber identity (Tassinari et al., 2024) enhances the positive effects of VR experience, operating independently of the content of task. This outcome may also reflect emotionally similar contact conditions used in this and our previous study (Tassinari et al., 2024), which could have enabled participants to overcome categorizations based on existing social boundaries (i.e., skin color), feel co-presence and engage in collective construction of space and identity regardless of task or partner characteristics. It is thus plausible that communal feelings that developed during the virtual encounters in a secure virtual space may relate more strongly to reported post-VR evaluations than to the type of contact *per se*. Barbot and Kaufman (2020) reached a similar conclusion in their

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TABLE 2 Step-by-step moderated multiple regression model. The dependent variable is explicit prejudice towards people of African ethnic background as measured via GES.

Predictors	Explicit prejudice (GES)											
	Estimates	*CI*	*p*	*Estimates*	*CI*	*p*	*Estimates*	*CI*	*p*	*Estimates*	*CI*	*p*
(Intercept)	−0.04	−0.24–0.16	0.681	−0.05	−0.24–0.15	0.653	−0.05	−0.24–0.15	0.652	−0.00	−0.28–0.27	0.988
Condition	0.15	−0.23–0.54	0.431	0.17	−0.21–0.54	0.389	0.16	−0.22–0.54	0.396	0.06	−0.33–0.46	0.743
CPO-VS				−0.23	−0.40–−0.06	0.008	−0.25	−0.45–−0.06	0.012	−0.15	−0.36–0.06	0.164
Condition × CPO-VS							0.09	−0.30–0.47	0.657	0.01	−0.38–0.39	0.971
Co-presence										−0.19	−0.38–−0.01	0.042
Body ownership										−0.10	−0.29–0.09	0.304
Age										0.11	−0.07–0.28	0.241
Gender (female)										−0.04	−0.40–0.32	0.824
Observations	132			132			132			131		
R^2/R^2 adjusted	0.005/−0.003			0.058/0.043			0.059/0.037			0.114/0.064		

TABLE 3 Step-by-step moderated multiple regression model. The dependent variable is prejudice towards people of African ethnic background as measured via Feeling thermometer.

Predictors	Explicit prejudice (feeling thermometer)											
	Estimates	*CI*	*p*	*Estimates*	*CI*	*p*	*Estimates*	*CI*	*p*	*Estimates*	*CI*	*p*
(Intercept)	0.02	−0.18–0.23	0.818	0.02	−0.18–0.23	0.823	0.02	−0.18–0.23	0.817	0.03	−0.24–0.30	0.813
Condition	−0.09	−0.47–0.30	0.660	−0.08	−0.47–0.30	0.669	−0.08	−0.47–0.31	0.688	−0.01	−0.39–0.37	0.961
CPO-VS				−0.05	−0.22–0.13	0.604	0.02	−0.18–0.22	0.851	−0.07	−0.27–0.14	0.525
Condition × CPO-VS							−0.25	−0.64–0.15	0.220	−0.16	−0.54–0.22	0.412
Co-presence										0.12	−0.06–0.30	0.180
Body ownership										0.03	−0.16–0.21	0.779
Age										−0.34	−0.51–−0.17	<0.001
Gender (female)										−0.03	−0.38–0.32	0.853
Observations	132			132			132			131		
R^2/R^2 adjusted	0.001/−0.006			0.004/−0.012			0.015/−0.008			0.143/0.094		

TABLE 4 Step-by-step moderated multiple regression model. The dependent variable is prejudice towards people of African ethnic background as measured via IAT.

Predictors	Implicit prejudice (IAT)											
	Estimates	CI	p	Estimates	CI	p	Estimates	CI	p	Estimates	CI	p
(Intercept)	0.07	−0.13–0.27	0.502	0.07	−0.13–0.27	0.496	0.07	−0.13–0.27	0.500	0.07	−0.21–0.35	0.621
Condition	−0.25	−0.64–0.13	0.200	−0.25	−0.64–0.13	0.193	−0.26	−0.64–0.13	0.189	−0.40	−0.80–−0.00	0.048
CPO-VS				0.09	−0.09–0.26	0.326	0.05	−0.16–0.25	0.655	0.11	−0.10–0.32	0.315
Condition × CPO-VS							0.15	−0.24–0.54	0.442	0.06	−0.33–0.45	0.759
Co-presence										0.03	−0.16–0.21	0.772
Body ownership										−0.24	−0.43–−0.04	0.017
Age										0.12	−0.06–0.30	0.184
Gender (female)										0.09	−0.27–0.45	0.618
Observations	132			132			132			131		
R^2/R^2 adjusted	0.013/0.005			0.020/0.005			0.025/0.002			0.101/0.049		

VR study on the effects of VR interactions on empathy, finding that participants' empathy increased with greater experience of agency and body ownership, regardless of whether the condition was designed to evoke empathy. In their study, the nature of the media content (storytelling, problem-solving, or perspective-taking) did not influence emotional response.

Indeed, the fact that the types of contact in our experiment were relatively emotionally neutral makes these conclusions tentative, as the results might differ under more robust experimental manipulations of positive and negative contact. This highlights the need for future studies to implement more pronounced and contrasting contact conditions to better evaluate how CPO-VS interacts with varying intergroup contact scenarios. In addition, as the effect of VR contact is largely context- and group-dependent and may even produce counterproductive outcomes (e.g., Kosic et al., 2025), there is a possibility that the outgroup embodiment paradigm could in some contexts be more efficient tool than virtual intergroup contact paradigm (Hasler et al., 2017; Hasson et al., 2019).

Moreover, the effect of CPO-VS may depend on several factors that remained unexplored in this study. Chen and White (2024) highlight the influence of key variables such as empathy and favorable intergroup attitudes in VR-based prejudice reduction interventions. Pierce and Jussila (2010) theoretically emphasize that feelings of ownership are strengthened through collective control, intimate knowledge, and shared investment. In the case of CPO-VS, higher levels of immersion and interactivity could enhance its role as a moderating factor. Increasing participants' control, customization, and agency in VR may improve realism and emotional engagement, thereby amplifying the impact of CPO-VS. This aligns with Lee et al.'s (2024) findings that platform controllability and interactivity, combined with social factors, shape social presence and identity, leading to higher engagement and collective psychological ownership.

A further caveat concerns the distinction between CPO-VS and co-presence. When co-presence was included as a covariate, the link between CPO-VS and ethnic prejudice was no longer significant, suggesting substantial overlap in their variance. This may weaken the case for CPO-VS as a new and independent driver of intergroup outcomes in its current operationalization and underscores the need for tests of discriminant validity. Future research should shed light on the relationship between CPO-VS and co-presence.

In summary, our findings position CPO-VS as a promising mechanism in VR interventions aimed at reducing intergroup prejudice. Collective ownership frameworks play a role in regulating group behaviors and boundaries (Nijs et al., 2022b; Verkuyten and Martinović, 2017). When groups perceive a target as collectively "theirs," it can influence the rules governing interactions with both ingroup and outgroup members. By fostering a shared sense of ownership, VR interventions may encourage inclusion and cooperation. Importantly, VR is not a social vacuum; interactions within virtual environments reciprocally influence real-world attitudes and behaviors. The sense of collective ownership is a crucial factor in how the social world is constructed and experienced (Martinović and Verkuyten, 2024), and virtual environments are no exception. Future research should investigate how VR mechanisms influence the formation and contact of social groups within virtual environments, and identify opportunities to represent diverse groups and foster improved intergroup relations both online and offline.

Our research offers novel insights into the sense of ownership in virtual environments. Building on Poretski et al. (2021), who examined interpersonal tensions arising from shared use of virtual and physical objects in AR, we extend this work by introducing collective psychological ownership (CPO-VS) in VR. We situate this construct within an intergroup context, focusing on its potential role in reducing prejudice. CPO-VS elevates ownership to the group level and reflects a social identity dimension within VR. Our findings are consistent with the possibility that CPO-VS reduces intergroup prejudice, a hypothesis that warrants testing in future VR experiments. Together with findings that VR can foster emerging social identities (Tassinari et al., 2024), our results suggest that VR has significant potential for intergroup research, warranting further investigation around social identities using immersive virtual environments.

5 Limitations and future directions

In addition to the limitations mentioned above, the unequal distribution of participants between the experimental and control groups has implications for the study's findings because reduced statistical power increases the risk of both Type I and Type II errors. The uneven sample size also amplifies error variance in the smaller experimental group. It is therefore important to replicate these findings with balanced group sizes. A further limitation concerns insufficient statistical power to detect interaction effects. Using Monte Carlo simulation with effect-size assumptions derived from the observed correlations, the estimated power to detect the focal interaction was low. Accordingly, any null findings for the interaction should be interpreted cautiously, as the study may have lacked sufficient power to detect small moderation effects.

Furthermore, the observed lower levels of body ownership in the experimental group raises important considerations for interpreting the study's findings and the overall impact of the intervention. Body ownership is a core feature that strongly contributes to the perceived realism of VR experiences. A reduced sense of body ownership in the experimental condition may compromise participants' engagement with the virtual environment and their identification with their avatars. This, in turn, may hinder the intervention's ability to establish the intended contact conditions. Thus, participants in the experimental group may have experienced lower immersion in the VR environment, resulting in weaker responses to the intervention. Addressing these issues in future studies will be critical to ensuring that the experimental design effectively supports body ownership. Moreover, the limited complexity of non-verbal expressiveness in avatars may have introduced bias into our study. Future research should address this limitation and explore integrating additional sensory modalities such as tactile cues to enhance presence and emotional engagement.

Furthermore, future studies could deepen understanding of how CPO-VS affects intergroup attitudes by designing experiments that directly engage with ownership dimensions, such as investment, territoriality, knowledge, ingroup membership, and control. These dimensions, previously examined in the context of IPO in augmented reality (Poretski et al., 2021), underscore the complex dynamics that emerge when ownership is ambiguous or contested.

Another critical avenue for future research is exploring the routes through which CPO-VS is formed, such as investment, control, territoriality, and intimate knowledge. Experiments that directly tap into these dimensions could yield deeper insights into how collective ownership emerges in virtual environments and its implications for intergroup dynamics. As discussed, future research should also focus on comparative designs investigating CPO in physical settings versus CPO-VS under matched tasks, to identify whether VR-specific features differentially shape ownership antecedents and consequences. Finally, the study examined only short-term effects of the intervention, limiting the generalizability of findings to long-term outcomes. Future research should assess the potential long-term impact of CPO-VS on attitudes. Moreover, all variables were measured at a single time point, which restricts our ability to infer causality.

6 Conclusion

Existing research has primarily examined individual ownership in virtual settings, leaving the collective dimension largely underexplored. Our work broadens the scope of this research by introducing the concept of Collective Psychological Ownership of a Virtual Space and demonstrating how shared ownership in VR may contribute to reducing prejudice following a VR experience. Our findings indicate that CPO-VS, experienced during the virtual social interaction, was associated with reduced explicit prejudice toward a disadvantaged minority outgroup, highlighting a promising avenue for shaping intergroup attitudes in VR. Although the effect of CPO-VS did not appear to depend on intergroup contact quality or relate to implicit attitudes, its emergence from brief interactive tasks underscores VR's potential to foster shared ownership. These insights contribute to the growing literature on psychological ownership in immersive environments and suggest that CPO-VS may serve as key component in VR interventions aimed at improving intergroup relations. The implications of this research extend beyond VR. As immersive technologies increasingly permeate education, entertainment, and social interaction, understanding the mechanisms underlying virtual experiences is crucial. CPO-VS provides a lens for examining how shared virtual spaces can both reflect and reshape real-world social dynamics.

Data availability statement

The datasets presented in this article are not readily available because the data contains identifiable participant information. Data will be made available upon reasonable request, in accordance with ethical guidelines and data protection regulations. Requests to access the datasets should be directed to era-vr@helsinki.fi.

Ethics statement

The studies involving humans were approved by this research project received ethical approval by the Research Ethics Committee of Aalto University, under the decision number D/218/03.04/2021. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

RE: Writing – original draft, Conceptualization, Writing – review and editing, Formal Analysis. MT: Writing – review and editing, Writing – original draft, Conceptualization. LV: Data curation, Writing – review and editing. VC: Data curation, Writing – review and editing. IJ-L: Conceptualization, Writing – review and editing, Writing – original draft.

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Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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