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# I am here with you: an examination of factors relating to social presence in social VR

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Social VR is growing in popularity, with more users engaging in interactive VR platforms. A key aspect of these experiences is social presence, the feeling of being with others, which is essential in fostering meaningful connections and improving user engagement. While spatial presence and body ownership are considered important for social presence, interpersonal factors such as another person's warmth or competence play an important role as well. In this study ( $N = 128$ ), we examined the relationships between these four perceptions (spatial presence, body ownership, a partner's warmth and competence) and social presence in social VR, both individually and while accounting for their combined effects. Multivariate analyses showed that spatial presence and partner warmth were robustly associated with social presence, whereas body ownership and competence were not significantly related to social presence. These patterns were consistent across interactions using anonymous avatars and non-anonymous avatars. We conclude that interpersonal perceptions, particularly warmth, should be considered alongside user experience variables when studying social presence. Furthermore, anonymized interactions in social VR likely preserve the underlying processes that support social presence.

## KEYWORDS

social presence, spatial presence, body ownership, interpersonal perception, warmth, competence, anonymity, social virtual reality

## 1 Introduction

The number of users engaging with virtual reality (VR) applications is consistently increasing ([Steam Charts, 2024](#)). With the ongoing advancement of these technologies, social presence—the perception of being with others in the virtual environment—gains increasing importance as a crucial factor for enhancing the realism and effectiveness of social interactions, making virtual experiences more immersive and meaningful ([Barreda-Angeles and Hartmann, 2022](#); [van Brakel et al., 2023](#)). To achieve a sense of social presence within a virtual context, certain prerequisites appear to be necessary. An individual may need to establish spatial presence within the virtual environment before experiencing social presence with others ([Hartmann et al., 2015](#)). Furthermore, considering the importance of body language in interactions, perception of body ownership in a virtual space might also be essential to attain presence ([Gall et al., 2021](#)). Indeed, higher levels of spatial presence and body ownership have been correlated with increased levels of social presence ([Slater et al., 2010](#); [Guy et al., 2023](#); [Barreda-Angeles and Hartmann, 2022](#); [Sykownik et al., 2023](#); [Yassien et al., 2020](#)).

While research often assessed the role of spatial presence and body ownership in VR, interpersonal factors such as perceived warmth and competence of others (Fiske et al., 2007) were also found to enhance social presence (Yoganathan et al., 2021). Indeed, individuals feel more socially present with agents if they display more realistic and empathetic behaviors, including interactive cues such as nodding, mutual gaze or longer eye contact (Aburumman et al., 2022; Sajjadi et al., 2019). Similarly, the perception of an agent's competence has been robustly associated with factors related to social presence (Lee and Sun, 2022; Belanche et al., 2021; Schmid et al., 2022). Thus, the manner in which the interaction partner engages and responds in VR appears to play a role in the sense of being present with them. Considering these interpersonal factors may be essential in gaining a deeper understanding of social interactions in virtual environments.

Although significant research has been conducted on spatial presence, body ownership, and social presence in VR, the relationship between these factors in real-time social VR interactions remains underexplored (Oh et al., 2018). Most studies focus on interactions with artificial agents, making it unclear whether the findings apply to scenarios involving human interaction partners (Oh et al., 2018; Bujic et al., 2021). Similarly, while the effect of perceived warmth and competence in social interactions was examined with artificial agents displayed on computer screens (McKee et al., 2024; Harris-Watson et al., 2023) or in virtual reality (Demeure et al., 2011), and even service robots (Belanche et al., 2021), research on how these perceptions manifest in human-to-human interactions within social VR remains limited. Furthermore, the experience of the virtual environment (spatial presence and body ownership) is likely interconnected with social perception (warmth and competence), highlighting the need for research in a comprehensive model.

To address this research gap, we examined dyadic interactions in social VR under both anonymized and non-anonymized conditions. We investigated variables influencing social presence, including spatial presence, body ownership, interaction partner's perceived warmth and competence. We uniquely focused on human-to-human interactions in social VR, which utilized real-time expression of various non-verbal modalities such as head, eye and mouth movements as well as facial expressions and gestures.

## 2 Related work

### 2.1 Social interaction in virtual reality

Social VR allows people to interact in a virtual environment in a manner similar to real-life social interactions (Smith and Neff, 2018; McVeigh-Schultz et al., 2019; Maloney et al., 2020; Rogers et al., 2022; Hennig-Thurau et al., 2022; Wei et al., 2022; Son and Rubo, 2025), but, similarly to videoconferencing, allows for communication at a distance (Oh et al., 2023). Compared to traditional communication mediums, social VR has the potential to create a strong sense of presence and connection between users (Oh et al., 2023; Barreda-Angeles and Hartmann, 2022; van Brakel et al., 2023; Cheng et al., 2022). As social VR platforms become more

prevalent, understanding how to optimize social presence is crucial for designing immersive and engaging user experiences.

### 2.2 Social presence

Social presence is essential for creating realistic social interactions in VR, referring to the feeling of “being there with someone else” and implies a psychological connection with an interaction partner (Biocca et al., 2003; Short et al., 1976; Yoo and Alavi, 2001). This subjective experience is particularly crucial in social VR, where interaction—whether with a human or an agent—is the central defining feature (Oh et al., 2018). Social presence significantly influences individuals' interactions in the virtual world, and its enhancement has been linked to positive outcomes such as improved user experiences (Moreira Kares et al., 2025), increased social relatedness (Barreda-Angeles and Hartmann, 2022), perception of social support (van Brakel et al., 2023), care and empathy (Cohen et al., 2021) as well as trust and enjoyment (Hassanein and Head, 2007; Ratan et al., 2022). Furthermore, higher social presence is associated with more realistic behaviors in VR, akin to face-to-face interactions (Oh et al., 2018). Therefore, maximizing social presence is essential for authentic social interactions and desired interpersonal outcomes in virtual environments (Kreijns et al., 2021; Slater et al., 2010).

### 2.3 Spatial presence and body ownership

Spatial presence refers to “the feeling of being there” and constitutes a significant user experience variable (Schubert, 2003; Slater, 2009). It reflects the extent to which users feel physically present in the virtual environment, rather than observing it externally (Hartmann et al., 2015). This sense of being “inside” the virtual world is foundational for creating immersive experiences and can occur even when the user is alone in the environment (Slater, 2009).

When users are represented in the virtual environment by means of an avatar, embodiment—the sense of experiencing the avatar as part of one's own body—is important because the avatar serves as the primary channel for communication and expression. Having a virtual body is essential for social interactions, contributing to a natural user experience by enabling lifelike engagement through various non-verbal cues (Gonzalez-Franco and Peck, 2018; Smith and Neff, 2018). Higher embodiment has been consistently associated with increased presence (Slater et al., 2010; Slater, 2009; Schubert, 2003; Schubert et al., 2001).

Among the key dimensions of embodiment, body ownership is considered the most important (Mottelson et al., 2023), receiving the most attention due to its early and significant manipulation in experimental paradigms (Maselli and Slater, 2013; Ehrsson et al., 2005). Despite its importance, the social effects of embodiment, and body ownership in particular, remain understudied (Bujic et al., 2021).

Both spatial presence and body ownership have been consistently linked to social presence, with higher levels of presence and body ownership associated with enhanced social presence in virtual environments (Barreda-Angeles and

Hartmann, 2022; Sykownik et al., 2023; Yassien et al., 2020; Guy et al., 2023; Slater et al., 2010). Based on these findings, we hypothesize that:

- H1: Spatial presence is positively associated with social presence.
- H2: Body ownership is positively associated with social presence.

## 2.4 Perception of the interaction partner

Compared to VR environments in which the user is alone, social presence is significantly influenced by the characteristics of the interaction partner and users' perceptions of them, extending beyond the immersive qualities of the medium (Oh et al., 2018). It is shaped not only by the medium's ability to transmit social cues but also by the social affordances of the environment and group dynamics such as trust and cohesion (Kreijns et al., 2021; Short et al., 1976). It has been proposed that social presence emerges from the qualities of the interaction partner, particularly through intimacy (e.g., proximity, eye contact) and immediacy (e.g., warmth, interest) (Wiener and Mehrabian, 1968; Gunawardena and Zittle, 1997).

In fact, people feel more socially present in the virtual scene if the behavior of an agent is more realistic and warmer, such as through longer eye contact or nodding (Oh et al., 2018; Aburumman et al., 2022), indicating that social perceptions influence emotional and behavioral responses toward others, thereby shaping how users interact with others in virtual environments. A large body of research indicates that social perceptions can be organized along two broad factors: interpersonal warmth and competence (Fiske et al., 2002; 2007; Cuddy et al., 2011), which together account for up to 73% of first impressions (Wojciszke, 1994; Cuddy et al., 2011).

Warmth, reflecting perceived friendliness and positive intentions (Fiske et al., 2007), is closely related to immediacy and plays a key role in enhancing social presence. Research shows that warmth and related attributes such as empathy (Morelli et al., 2015) and intimacy (Jolink et al., 2021) positively influence social interactions, even in interactions with service robots (Belanche et al., 2021) and agents displayed on 2D screens (McKee et al., 2024; Harris-Watson et al., 2023).

Competence reflects perceived ability and knowledge (Fiske et al., 2007; Legood et al., 2022; McAllister, 1995; Cook and Wall, 1980; Butler, 1991). Competent interaction partners are viewed as capable and efficient, which fosters collaboration and engagement (McAllister, 1995; Kanawattanachai and Yoo, 2002). In human-agent interactions, competence has been robustly linked to user expectations and behavioral intentions (Belanche et al., 2021; Schmid et al., 2022), indicating that it may play an important role in enhancing social presence in social VR.

Although much research has focused on the effects of warmth and competence on social presence in human-agent and -robot interactions (Belanche et al., 2021; McKee et al., 2024; Harris-Watson et al., 2023; Lee and Sun, 2022; Schmid et al., 2022), less research has been conducted in the context of human-to-human interactions in virtual reality. An earlier study from Jin (2012) found that discrepancies in perceived partner attributes—such as competence—between face-to-face and avatar-based interactions

negatively impact social presence. Based on previous work, we hypothesize that:

- H3: Perceived warmth of the interaction partner is positively associated with social presence
- H4: Perceived competence of the interaction partner is positively associated with social presence

## 2.5 The role of anonymity

In social VR, avatars serve as a primary means of communication (Smith and Neff, 2018), and their resemblance—or lack thereof—to users' real-world appearances can influence the importance of social cues (Rahill and Sebrechts, 2021; Hussain and Griffiths, 2008). Earlier research found that visual anonymity may reduce personal identity, increase reliance on group norms (Reicher et al., 1995; Spears and Lea, 1992), and lead to uninhibited, less normative behavior (Suler, 2004), potentially diminishing the role of individual warmth and competence on social presence. Consequently, the role of interpersonal variables such as warmth and competence may be less pronounced in anonymous settings, impacting their relationship to social presence in VR environments. Prior analyses found no significant differences in social presence, spatial presence, or body ownership between anonymous and non-anonymous conditions (Son and Rubo, 2025). This challenges the idea that anonymity alone drives behavioral changes in VR and highlights the need to explore its effects on interpersonal judgments and social dynamics more deeply. We therefore hypothesize that:

- H5: When accounting for each other, spatial presence (H5.1), body ownership (H5.2), interpersonal warmth (H5.3) and competence (H5.4) are associated with social presence in both anonymous and non-anonymous conditions.
- H6: The relationships between interpersonal variables and social presence are weaker in the anonymous condition.

## 2.6 The present work

In a previously reported analysis (Son and Rubo, 2025), we observed that verbal and non-verbal patterns in social VR were comparable to those observed in face-to-face interactions, validating this artificial environment as a tool to study naturalistic interactions. Interestingly, an anonymization of the situation (realized by using generic as opposed to self-similar avatars in a non-anonymized condition) did not result in disinhibited social behavior, although such effects were observed in other forms of distance communication (Suler, 2004). The present analysis more deeply explores the sense of social presence in social VR interactions and how it relates to other experiences in virtual environments. Previous research suggests that spatial presence, body ownership, and interpersonal perceptions such as a partner's perceived warmth and competence are likely interrelated in their associations with social presence due to their shared role in enhancing immersion and connection within a virtual environment (Sanchez-Vives and Slater, 2005; Oh et al., 2018). Here we assessed and directly compared these



FIGURE 1

In Social VR, users share the same virtual environment (top image) while physically located in different places (bottom images). The top image shows the individuals interacting through the VR setup, while the bottom two images show the individuals photographed at the same time.

relationships in a comparatively large sample of participants interacting in a relatively realistic virtual setting. Specifically, our first aim was to assess the individual association of each variable with social presence, hypothesizing positive relationships. The second aim was to analyze their combined effects on social presence across conditions.

## 3 Methods

### 3.1 Participants

Self-reports from a user study involving 128 participants (105 women, 22 men, 1 undisclosed) were analyzed. The majority of the participants were students from the University of Bern, with a mean age of 22.60 years ( $SD = 3.57$ , 18–57). Participants were excluded if they could not speak the experimental language or otherwise experienced communication problems (9 dyads excluded and replaced). Participants were excluded if they had a relationship beyond casual acquaintance. While five participants (3.91%) indicated recognizing their partner and described them as someone they were acquainted with, none reported having a more personal relationship. Other exclusion criteria included neurological illnesses, use of medication affecting the central nervous system, or significant visual impairments. The majority of participants identified as Swiss nationals (119 participants, multiple nationalities possible; 92.97%). Seven participants

reported non-European nationalities, including Afghanistan, Australia, Bolivia, Canada and New Zealand. 98 participants had one or no previous experience with VR (76.59%), and no participants regularly used VR.

### 3.2 Study procedure

Participants were randomly paired and interacted with each other in VR while embodying an anonymous (generic avatar) or a non-anonymous avatar (self-similar: an avatar resembling themselves). Each dyad was assigned to the same condition. Participants were physically separated and interacted only through the VR platform. For participants in the anonymous condition, an avatar matched for gender was randomly selected from a pool of existing avatars. For participants in the non-anonymous condition, personalized avatars from their portrait photo were generated, and manually adjusted for facial, hair, eye, and body details. Both avatar types included only the head, upper body, and white hand silhouettes, wearing identical white t-shirts.

Before interaction, participants answered demographic and baseline questionnaires. They then were introduced to the virtual environment individually and given time to get accustomed to their avatar (see Figure 1). A virtual mirror within the environment allowed participants to view their avatar appearance. Adjustments to avatar proportions and eye



tracking were made based on participant feedback. After initiating the connection with the other participant, the experimenters left the room. All further instructions were provided with a pre-recorded computerized female voice and as keywords on a virtual display in the environment. Participants were instructed to hold a natural conversation on various different topics for 30 min. The duration of the conversation was informed by previous studies on dyadic interactions (e.g., Asher et al., 2020; Shatz et al., 2024). After the interaction in VR, participants completed questionnaires including social presence, spatial presence, body ownership as well as perceived warmth and competence of their interaction partner.

3.3 Hard– and software

For the VR experience, we used the Meta Quest Pro headset (Meta, 2024b), with a resolution of 1800 x 1920 and an update rate set to 90 frames per second. The virtual environment and networking were custom developed in Unity (Unity Technologies, 2024) using Fish-Net Networking (First Gear Games, 2024) and were run on a Windows 11 desktop laptop (32 GB RAM, Intel Core i9-13900HX CPU, NVIDIA GeForce RTX 4070 GPU). The network communication operated at a tick rate of 120 Hz. Participant behavior were tracked through built-in sensors of the headset and synchronized with the virtual avatar of the participant. The virtual avatars were generated using Character Creator 4 (Reallusion, 2024). Each virtual avatar was designed to accurately convey the participant’s behavior, including eye movements, blinking, facial expressions and gestures, driven by live-streamed data from Meta’s API (Meta, 2024a). In addition, Salsa Lip-Sync was utilized to enhance lip synchronizations (Crazy Minnow Studio, 2024) and Dissonance Voice Chat for voice chat (Placeholder Software, 2024). Avatars generated from portrait photos were exchanged between the computers using AvatarTransferPro (Rubo, 2024).

3.4 Measures

Social presence, the sense of being with an interaction partner in a virtual environment, was measured using the Social Presence Scale (SPS) (Herrera et al., 2018), with participants rating five items (e.g., “I felt like my partner was present”) on a 7-point scale (Cronbach’s  $\alpha = 0.79$ ).

Spatial presence, the illusion of being in the virtual environment, was assessed with the General and Spatial Presence subscales of the Igroup Presence Questionnaire (IPQ) (Schubert et al., 2001), using six items (e.g., “In the computer-generated world I had a sense of being there”) rated on a 7-point scale ( $\alpha = 0.64$ ).

Body ownership, the sense of having a virtual body, was measured with the Body Ownership subscale of the Embodiment Questionnaire (Gonzalez-Franco and Peck, 2018), using five items (e.g., “It seemed as if I might have more than one body”) on a 7-point scale ( $\alpha = 0.64$ ).

Warmth and competence were evaluated using the 4-item Stereotypes Scale (Cuddy et al., 2007), which measures perceptions of the interaction partner’s social traits. Warmth

TABLE 1 Regression analysis of factors associated with social presence by group. beta = standardized regression weight. Unique  $R^2$  = semipartial correlation squared. CI = confidence interval. \* indicates  $p < .05$ . \*\* indicates  $p < .01$ .

Variable	Beta	95% CI	$R^2$
Anonymous Group			
Spatial Presence	0.51**	[0.29, 0.72]	0.26**
Body Ownership	0.26*	[0.02, 0.51]	0.07*
Warmth	0.24	[-0.01, 0.49]	0.06
Competence	0.01	[-0.25, 0.27]	0.00
Non-Anonymous Group			
Spatial Presence	0.34**	[0.10, 0.58]	0.11**
Body Ownership	0.22	[-0.03, 0.46]	0.05
Warmth	0.60**	[0.40, 0.81]	0.37**
Competence	0.32**	[0.08, 0.56]	0.10**
Combined			
Spatial Presence	0.44**	[0.28, 0.60]	0.20**
Body Ownership	0.25**	[0.08, 0.42]	0.06**
Warmth	0.39**	[0.23, 0.55]	0.15**
Competence	0.13	[-0.04, 0.31]	0.02

(“warm,” “friendly”) and competence (“competent,” “capable”) were rated on a five-point scale. Composite scores were calculated by averaging the respective items.

3.5 Data analysis

All analyses were conducted in R (R Core Team, 2023). The variables were z-standardized to facilitate comparison of effects. The relationships between the dependent variables (presence, body ownership, perceived warmth, competence) and social presence was examined using linear regressions (H1-4). The relative contributions of dependent variables (H5-6) were assessed with multivariate regression analyses, conducted separately and combined for the anonymous and non-anonymous conditions. Multivariate regression estimated the relationship strength and direction between each variable and the outcome while accounting for the influence of other variables and the interrelationships among them. Significance was determined with an F-Test at an alpha of 5%.

4 Results

4.1 H1-4: Spatial presence, body ownership, warmth, and competence

As previously reported (Son and Rubo, 2025), there were no significant differences in mean spatial presence, body ownership, and social presence between anonymous and non-anonymous

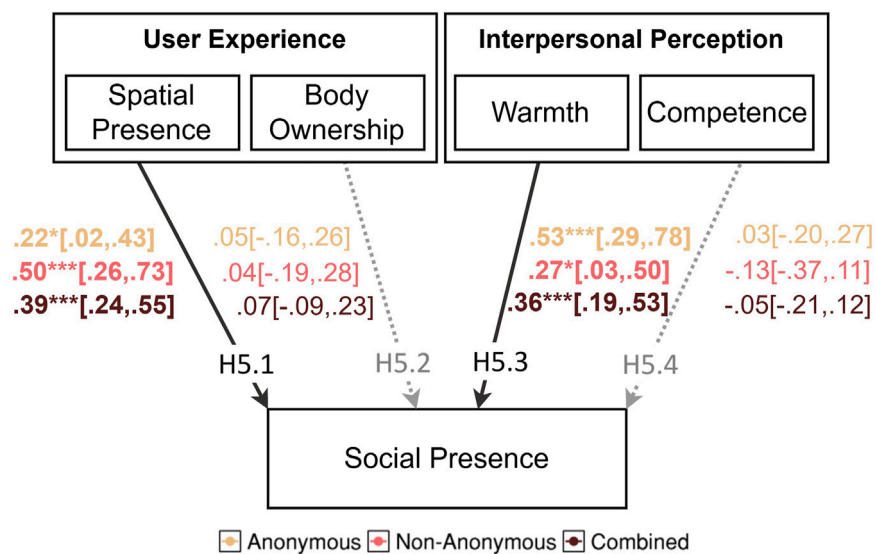


FIGURE 2

Relationships between user experiences and interpersonal perceptions with the sense of social presence. Estimates are standardized beta coefficients reflecting the multivariate regression analyses. Values in brackets represent 95% confidence intervals. \* indicates  $p < .05$ . \*\* indicates  $p < .01$ . \*\*\* indicates  $p < .001$ .

conditions. Similarly, mean perceived partner warmth ( $M = 4.69$ ,  $SD = 0.45$ ) and competence ( $M = 4.40$ ,  $SD = 0.63$ ) was high and there were no differences between the conditions for warmth ( $p = 0.698$ ,  $d = 0.07$ , 95% CI [-0.28, 0.42]) or competence ( $p = 0.189$ ,  $d = 0.23$ , 95% CI [-0.59, 0.12]).

A series of regression models were conducted to examine the relationship between the factors and social presence. A summary of the findings is shown in Table 1. Across the entire sample, analysis showed that presence, body ownership, and warmth were significant and positively associated with social presence. Both presence ( $\beta = 0.44$ , 95% CI [0.28, 0.60],  $t(125) = 5.55$ ,  $p < .001$ ) and warmth ( $\beta = 0.39$ , 95% CI [0.23, 0.55],  $t(125) = 4.71$ ,  $p < .001$ ) had positive associations with social presence and explained a larger proportion of variance (20% and 15%, respectively). Body ownership was also positively associated with social presence, which explained less than 6% of variance ( $\beta = 0.25$ , 95% CI [0.08, 0.42],  $t(125) = 2.93$ ,  $p = .004$ ). Competence was not significantly associated with social presence ( $p = .138$ ).

In the results for the anonymous condition, presence was positively associated with social presence ( $\beta = 0.51$ , 95% CI [0.29, 0.72],  $t(61) = 4.63$ ,  $p < .001$ ), followed by body ownership ( $\beta = 0.26$ , 95% CI [0.02, 0.51],  $t(61) = 2.14$ ,  $p = .036$ ). Warmth and competence were not significant ( $p = .060$  and  $p = .944$ , respectively). For the non-anonymous condition, warmth was most strongly related to social presence ( $\beta = 0.60$ , 95% CI [0.40, 0.81],  $t(62) = 5.97$ ,  $p < .001$ ), followed by presence ( $\beta = 0.34$ , 95% CI [0.10, 0.58],  $t(62) = 2.81$ ,  $p = .007$ ) and perceived competence ( $\beta = 0.32$ , 95% CI [0.08, 0.56],  $t(62) = 2.68$ ,  $p = .009$ ). Body ownership did not have a significant association with social presence ( $p = .087$ ).

## 4.2 H5-6: Multivariate regression

Figure 2 shows the standardized regression coefficients illustrating the relationships between the dependent variables and social presence in three groups (anonymous, non-anonymous, and both conditions combined). The multivariate regression models for each group were statistically significant (anonymous:  $R^2 = 0.33$ ,  $F(4, 58) = 7.09$ ,  $p < .001$ , adj.  $R^2 = 0.28$ ; non-anonymous:  $R^2 = 0.42$ ,  $F(4, 59) = 10.65$ ,  $p < .001$ , adj.  $R^2 = 0.38$ ; combined:  $R^2 = 0.33$ ,  $F(4, 122) = 14.69$ ,  $p < .001$ , adj.  $R^2 = 0.30$ ), revealing a consistent pattern across both conditions.

The effect of presence was statistically significant and positive across both groups: anonymous ( $\beta = 0.50$ , 95% CI [0.26, 0.73],  $t(58) = 4.30$ ,  $p < .001$ ), non-anonymous ( $\beta = 0.22$ , 95% CI [0.02, 0.43],  $t(59) = 2.15$ ,  $p = .035$ ), and combined ( $\beta = 0.39$ , 95% CI [0.24, 0.55],  $t(122) = 5.01$ ,  $p < .001$ ). Similarly, the effect of warmth was also significant and positive across both groups: anonymous ( $\beta = 0.27$ , 95% CI [0.03, 0.50],  $t(58) = 2.25$ ,  $p = .028$ ), non-anonymous ( $\beta = 0.53$ , 95% CI [0.29, 0.78],  $t(59) = 4.39$ ,  $p < .001$ ), and combined ( $\beta = 0.36$ , 95% CI [0.19, 0.53],  $t(122) = 4.24$ ,  $p < .001$ ). In contrast, body ownership and perceived competence were not significantly associated with social presence in any of the groups.

When including condition as a predictor in the combined model, the results reinforced the previously observed pattern: presence ( $\beta = 0.39$ , 95% CI [0.24, 0.55],  $t(121) = 5.00$ ,  $p < .001$ ) and warmth ( $\beta = 0.35$ , 95% CI [0.18, 0.52],  $t(121) = 4.14$ ,  $p < .001$ ) remained significantly associated with social presence, while body ownership ( $p = .456$ ) and competence ( $p = .690$ ) did not. The effect of condition was not significant ( $p = .262$ ).

## 5 Discussion

We investigated factors associated with the sense of social presence in dyadic interactions within social VR, contrasting spatial presence and body ownership with partner's perceived warmth and competence. Dyads interacted using either anonymous or non-anonymous avatars. Overall, participants reported high levels of social presence, spatial presence, body ownership, warmth, and competence.

For Hypothesis 1, a clear pattern emerged: spatial presence was significantly associated with social presence in both the overall sample and within each condition (anonymous and non-anonymous). These findings align with previous research showing a positive relationship between spatial presence and social presence (Oh et al., 2018; Barreda-Angeles and Hartmann, 2022; Sykownik et al., 2023). The consistency across both conditions suggests that spatial presence is universally important for fostering a sense of social presence in virtual spaces, regardless of anonymity.

For Hypotheses 2, 3, and 4, the patterns were less consistent. In Hypothesis 2, body ownership was significantly associated with social presence in the anonymous condition but did not reach significance in the non-anonymous condition. This finding partially supports prior studies, which have linked a stronger sense of body ownership to increased social presence with interaction partners (Guy et al., 2023; Slater et al., 2010; Yassien et al., 2020).

For Hypothesis 3, warmth was significantly associated with social presence in the overall sample and non-anonymous condition. In the anonymous group, the result was marginally significant, following the same pattern. This suggests that perceiving an interaction partner as warm and friendly contributes to a greater sense of social presence, consistent with prior findings (Cafaro et al., 2016; Randhavane et al., 2019).

In Hypothesis 4, partner competence was not significantly associated with social presence in the overall sample or anonymous condition, but reached significance in the non-anonymous condition. This partial finding regarding the role of competence aligns with earlier studies involving agents, which indicated that both warmth and perceived competence can affect interaction outcomes (Koelsch et al., 2021; McKee et al., 2024).

### 5.1 Multivariate relationships with social presence

Given the likely interrelationships among the variables, we conducted multivariate regression analyses to better understand their collective relationship with social presence. Indeed, the variables showed high intercorrelations, making it necessary to account for each other. When examined together, results were robust across both conditions (anonymous and non-anonymous), highlighting the necessity of considering these variables collectively when assessing their relationships with social presence.

For Hypothesis 5, social presence was significantly related to spatial presence and interpersonal warmth, but not to body ownership and interpersonal competence, partially confirming the hypothesis. Spatial presence was the most robust factor

associated with social presence, closely followed by interpersonal warmth. These findings suggest that when participants interact with each other in the virtual space, their focus shifts more toward feeling present in the virtual environment and the perceived warmth of their interaction partner, rather than their own body or perceived competence of the partner. This aligns with the prominence of warmth as a key factor, potentially due to how participants allocate their attention and cognitive resources (Sweller, 2011) – when participants focus on the interaction with their partner, there may not be enough cognitive resources left to focus on their own bodies (Mojzisch et al., 2006).

Results did not support Hypothesis 6, which posited that the relationships between interpersonal variables and social presence would be weakened in anonymous interactions. Warmth remained a significant variable associated with social presence even when participants embodied anonymous avatars. This finding suggests that perceptions of the interaction partner's warmth is highly related to the feeling of social presence regardless of anonymity, highlighting that warmth is crucial also in situations where identity cues are minimized.

The findings highlight the importance of both spatial presence and partner warmth for successful social interaction in virtual environments. Partner warmth, reflecting positive emotional engagement, plays a significant role, aligning with previous research suggesting that warmth is often valued over competence in social decision-making (Eisenbruch and Krasnow, 2022). According to Eisenbruch and Krasnow (2022), this preference for warmth may have evolved because, throughout human history, the warmth of potential cooperative partners was more predictive of future relationship benefits than competence, a priority that persists in social interactions today.

### 5.2 Limitations and future research directions

Here we report the importance of spatial presence and interpersonal warmth compared to body ownership and competence in fostering social presence during real-time interactions in social VR. This research aimed to address a gap in the field by focusing on human-to-human interactions in VR, an area that has received limited attention compared to interactions with artificial agents (Belanche et al., 2021; McKee et al., 2024; Harris-Watson et al., 2023; Lee and Sun, 2022; Schmid et al., 2022). By including mostly first-time VR users, we were able to examine the effects of multiple variables on social presence without a strong bias of user experience with VR. Familiarity and skill with VR applications may impact how easily users may feel socially present with interaction partners in VR, which should be investigated in future research.

Several factors constrain the extent to which our findings can be generalized. For example, different cultural norms around non-verbal behavior (such as the amount of eye-contact) may influence the relationship between perceived partner warmth and social presence which should be taken into account (Golson et al., 2021; Heinrichs et al., 2006). Previous research has shown that attitudes towards VR utilization are influenced by cultural differences (Monteiro et al., 2022) as well as differences in

socioeconomic status and educational attainment (Xu et al., 2022), which may impact how users interact in social VR. Furthermore, the sample primarily consisted of female participants. Participants were psychology students from the University of Bern, albeit recruited from a larger pool of more than 1,300 potential interaction partners. Although none of the dyads reported knowing each other well beforehand, the knowledge that their partner is also a student may have influenced interactions, potentially affecting perceptions of social presence.

While we utilized programs which are currently easily accessible for research and capable of producing highly realistic avatars, the avatars were nonetheless limited in quality. Moreover, we only collected selfCreport data, which introduces typical limitations, including social desirability bias (Paulhus and Vazire, 2007). Indeed, the partner's warmth and competence were rated very highly, which may also have been due to social desirability. It is also important to note that the study did not employ an experimental design aimed at predicting social presence, as it was a cross-sectional approach. Future research should systematically manipulate variables such as presence, body ownership, warmth, and competence to better understand their specific influences on social presence in social VR.

## 6 Conclusion

We analyzed self-reports from 128 participants who interacted in dyads within a newly developed social VR program. Social presence—the feeling of being present with the other in the virtual environment—was robustly associated with spatial presence and perceived warmth of the interaction partner, regardless of whether interactions were anonymous or non-anonymous. In contrast, body ownership and perceived competence were less influential, suggesting that their impact on social presence becomes negligible when spatial presence and warmth are considered. Future investigations into social presence and its contributing factors in social VR interactions may benefit from taking interpersonal perceptions into account.

## Data availability statement

Publicly available datasets were analyzed in this study. This data can be found here: <https://osf.io/qwbm8/files/osfstorage>.

## Ethics statement

This study was approved by the local ethics committee at the University of Bern (Ref-No. 2023–09–01). The study conformed to the principles expressed in the Declaration of Helsinki. and was

conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

## Author contributions

GS: Conceptualization, Data curation, Formal Analysis, Project administration, Visualization, Writing—original draft, Writing—review and editing. AT: Writing—original draft, Writing—review and editing. MR: Conceptualization, Data curation, Funding acquisition, Project administration, Software, Supervision, Writing—review and editing.

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Generative AI statement

The author(s) declare that no Generative AI was used in the creation of this manuscript.

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