



## RESEARCH ARTICLE

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# The virtual cure for real-world prejudice? Secondary transfer effects of intergroup contact in virtual reality

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## Abstract

The secondary transfer effect (STE) of intergroup contact posits that contact with one social group may reduce prejudice not only towards contacted but also non-contacted groups. Virtual reality (VR) has the potential to facilitate intergroup contact on a large scale, but its effectiveness in generating the STE of intergroup contact has not been studied before. In two pre-registered studies conducted in Finland and Italy, we examined whether cooperative (positive) contact in VR between participants' White avatar and an avatar representing a person with African ethnic background had an extended effect on more positive attitudes towards other non-contacted minority groups. Study 1 ( $N = 53$ ) revealed that positive contact with a Black avatar in VR decreased explicit prejudice towards secondary non-contacted outgroups (Middle Eastern people, Muslims, homosexual people, individuals with intellectual disabilities,

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and immigrants) via attitude generalization but not via intergroup anxiety. Study 2 ( $N = 132$ ) expanded the design of Study 1 by including a competitive (negative) contact situation to test the STE of both positive and negative contact in VR. The findings of Study 2 showed a trend towards improvement in explicit attitudes towards one secondary outgroup (East Asian people) for positive contact as compared to negative contact. Overall, our findings show the potential of VR contact to alleviate generalized prejudice through the STE of positive intergroup contact. However, caution must be exercised, as competitive activities in VR are common and may have detrimental effects on intergroup attitudes. Please refer to the Supplementary Material section to find this article's [Community and Social Impact Statement](#).

#### KEYWORDS

intergroup contact, negative contact, prejudice, secondary transfer effect, virtual reality

## 1 | INTRODUCTION

Positive intergroup contact has been shown to be effective in reducing prejudice towards stigmatized minorities (Lemmer & Wagner, 2015; Pettigrew & Tropp, 2000, 2006). Nevertheless, contact typically occurs among specific groups and thus affects group-specific prejudices. Examining the so-called secondary transfer effect of intergroup contact (STE, Pettigrew, 1997, 2009) provides a way to study whether the positive effects of intergroup contact with one outgroup extend to attitudes towards secondary non-contacted outgroups. Indeed, previous research has demonstrated emergence of the STE of positive contact in different real-life intergroup settings (see meta-analysis by Pettigrew & Tropp, 2006 and reviews by Lolliot et al., 2013; Vezzali, Di Bernardo, Cocco, Stathi, & Capozza, 2021). However, as intergroup encounters are often characterized not only by positive, but also negative contact experiences (Barlow et al., 2012; Graf, Paolini, & Rubin, 2014; Paolini, Harwood, & Rubin, 2010), their potential adversary effects on outgroup attitudes can similarly generalize through the mechanisms of STE.

Virtual reality (VR) has recently gained traction as a tool to decrease prejudice by enabling positive contact experiences with segregated groups (for a systematic review see, Tassinari, Aulbach, & Jasinskaja-Lahti, 2022a, 2022b). Given the potential of VR to improve intergroup relations in society at large, it is of utmost importance to investigate its ability to generate the STE of intergroup contact, as it would sensibly amplify its effects. If the STE of positive intergroup contact could also be achieved through VR contact, it would be possible to influence intergroup attitudes at large in a cost-effective way. However, this scalability of contact is not without risks, as competitive encounters in VR (such as but not limited to multiplayer games, sports simulations, or shooter games) may have simultaneous detrimental effects on prejudice. Thus far, it is still unknown whether positive and negative intergroup contact in VR produces STE, calling for testing the premises of STE in immersive virtual social encounters. In this study, we investigate the STE of positive (cooperative) and negative (competitive) intergroup contact with a Black avatar in VR on attitudes towards several non-contacted outgroups among Finnish and Italian White majority group members.

## 2 | STE OF INTERGROUP CONTACT

The general tenet of STE that positive effects of contact with a primary (contacted) outgroup generalize to secondary (non-contacted) outgroups has been supported by numerous empirical studies as summarized by one meta-analysis (Pettigrew & Tropp, 2006) and two reviews (Boin et al., 2021; Vezzali et al., 2021). Research on the STE has generally focused on attitude generalization as the primary psychological mechanism, meaning that contact improves attitudes and behaviours towards secondary outgroups via improving attitudes towards the primary outgroup (Vezzali et al., 2021; but see Vezzali, Pagliaro, Di Bernardo, McKeown, & Cocco, 2023 for an alternative account of attitude generalization as a mediator of the STE). The attitudes towards secondary outgroups are improved because positive experiences with the contacted outgroup prompt changes in the perception and evaluation of outgroups more generally.

Another important potential mechanism of the STE is related to emotions evoked by contact, such as intergroup anxiety that has been found to be the key mediator of the link between intergroup contact and outgroup attitudes (Brown & Hewstone, 2005; Pettigrew & Tropp, 2008). In other words, while individuals may harbour prejudice and avoid contact because of their intergroup anxiety, contact helps overcome their fears, which improves their outgroup attitudes. In their study of Italian high school students, Vezzali and Giovannini (2012) found that positive contact with immigrants was indirectly associated with improved attitudes towards gay people and individuals with disabilities via both attitude generalization (attitudes towards the primary outgroup) and decreased anxiety (and increased perspective-taking) towards the secondary outgroups (see also Vezzali & Giovannini, 2011). Similarly, Turner and Feddes (2011) found that White undergraduates' intimacy of disclosure with an outgroup person was associated with lower anxiety towards a wide range of secondary outgroups, which, in turn, predicted more positive attitudes towards these groups ~6 weeks later. As the review by Vezzali et al. (2021) points out, however, the role of intergroup emotions, in general, and intergroup anxiety, in particular, has received little attention in STE research.

Although the prejudice-reducing effects of positive intergroup contact are evident, intergroup contact can also be negative. Negative contact typically involves situations in which individuals feel threatened or are involuntarily involved in intergroup contact (Pettigrew, Tropp, Wagner, & Christ, 2011). However, relative to positive contact, the effects of negative contact on outgroup attitudes have been much less studied. While some researchers have suggested that the effects of negative contacts are stronger than those of positive contacts, despite positive contacts being more frequent than negative contacts (Graf et al., 2014; Paolini et al., 2010), many recent studies disconfirm this assumption. For example, Zingora and Graf (2019) observed that positive intergroup contact with gay individuals had a more pronounced effect in reducing discrimination towards gay individuals compared with negative interactions. Moreover, Schäfer et al. (2022) found that intergroup contact following a positive contact history had a greater influence on intergroup expectations than contact following a negative history. In a meta-analysis including 59 studies, Paolini and McIntyre (2019) found that positive and negative intergroup contact tackle different prejudices: while positive contact further improves attitudes towards positively stereotyped outgroups, negative contact has a greater negative impact on the evaluations of negatively stereotyped outgroups. It has also been noted that when contact is voluntary, the effects of negative contact are far smaller than when the contact involves involuntary contact (Pettigrew et al., 2011).

Furthermore, studies exploring the STE resulting from negative intergroup interactions remain largely under-represented compared with those exploring the STE of positive contact. In the review by Vezzali et al. (2021), only 9 out of 43 studies explored the existence of the STE in the case of negative contact. The results are inconsistent but seem to attest to the same mediating processes as those identified for the STE of positive contact. In designs assessing both contact types, while some studies found a stronger STE of positive than negative contact via attitude generalization (Lissitsa & Kushnirovich, 2018) or the STE of only positive contact experiences, but not of negative contact (Mähönen & Jasinskaja-Lahti, 2016), other studies showed the STE of both positive and negative contact (Brylka, Jasinskaja-Lahti, & Mähönen, 2016). In studies focusing on negative contact only, negative STE

was attested via attitude generalization (Ünver, Çakal, Güler, & Tropp, 2022) and via avoidance generalization and reduced willingness to engage in contact with secondary outgroups (Meleady & Forder, 2019). However, Zingora and Graf (2019) found no attitude generalization between majority Slovaks' negative contact with Roma people and attitudes towards gay people in Slovakia. Finally, two recent longitudinal tests of the STE, including those of negative contact in large-scale samples of native Germans, produced divergent results. While the two studies by Kauff et al. (2023) did not find support for the STE of either positive or negative contact with Muslims/refugees on majority Germans' attitudes towards Sinti/Roma minorities, in the three-wave panel study by Henschel and Kötting (2023), the STE of negative contact with foreigners (primary outgroup) on attitudes towards refugees (secondary outgroup) emerged among native Germans via negative attitude generalization and decreased support for multiculturalism.

Some methodological aspects need to be acknowledged when studying the STE of contact. First, methodological concerns relate to the measures used to assess attitudes towards primary and secondary outgroups. When similar scales of attitudes towards both the primary and secondary groups are used, both the risk of the shared method variance and the likelihood of socially desirable responses increase (Vezzali et al., 2021). However, there seems to be a dearth of studies that have investigated the STE of contact using different attitude measures, not to speak about behavioural measures. Second, the studies on STE reviewed above mostly used cross-sectional designs, limiting the possibilities to attest mediation effects and infer causality (Pettigrew, 2009; Tausch et al., 2010; Vezzali et al., 2021). Exceptionally, Van Laar, Levin, Sinclair, and Sidanius (2005) showed in their field experiment that White students who lived with a Latino college roommate had more positive attitudes towards Black people. Moreover, a survey-experiment testing STEs of positive and negative contact by Jasinskaja-Lahti et al. (2021) showed that STEs of both positive and negative contact were prevented among the more prejudiced majority group members who had the possibility to obtain moral credentials in the moral licensing task. Third, STE is generally group-specific and applies to groups similar (i.e., groups that are stereotyped and targeted for the same reason) to the contacted outgroup (e.g., Harwood, Paolini, Joyce, Rubin, & Arroyo, 2011; Tausch et al., 2010). This is because social attitudes form a semantic network, and changes in one attitude are more likely to generalize to other attitudes proximal to the network than to more distant ones (Harwood et al., 2011). Furthermore, the STE might be a co-product of contact with secondary outgroups, rather than of contact with the primary outgroup that generalizes beyond the contact situation; thus, this variable should be controlled for (Vezzali et al., 2021). As a consequence, there is a need for more and fully controlled experimental investigations of the STEs of both positive and negative contact that can rule out alternative explanations and demonstrate a causal relationship between contact and attitudes (measured through implicit, explicit, and behavioural measures) concerning numerous different secondary non-contacted outgroups. Finally, the influence of negative intergroup contact is especially relevant in the context of mediated interaction settings that involve competition between people and groups, such as video games. Therefore, it is of utmost importance to study the direct and STEs of both positive (e.g., cooperative) and negative (e.g., competitive) contact when examining the effects of intergroup encounters in VR.

### 3 | IMPROVING INTERGROUP RELATIONS THROUGH VR

To this day, the potential of the STE of intergroup contact has yet to be tested in VR. Over the past decade, VR has emerged as a promising tool for studying and promoting prejudice reduction (Tassinari et al., 2022a, 2022b, 2024). VR offers unique chances to reproduce realistic social environments, enabling researchers to investigate the processes underlying intergroup situations and develop and deliver prejudice-reducing interventions. Moreover, VR can provide a safe and controlled setting for participation in intergroup contact, especially for those who are unable or hesitant to engage in direct contact with outgroup members. In addition, VR can simulate face-to-face social encounters with minority group members, including highly stigmatized groups, while preserving the high emotional

relevance and intensity of real intergroup contact experience (Lui, Stringer, & Jouriles, 2023). Ultimately, VR has the potential to increase our understanding of prejudice and its underlying mechanisms and offers innovative approaches to promote positive intergroup relations.

However, existing literature on the effects of VR contact on prejudice is still scarce, limited to positive contact, and suffers from severe limitations. A recent systematic review by Tassinari et al. (2022a, 2022b) on the use of VR for prejudice reduction found that none of the 64 examined studies utilized *positive* intergroup contact satisfying Allport's (1954) optimal contact conditions, namely shared goals, cooperation, equal status, and support of authorities, limiting our ability to conclude about the effects of positive VR contact. Moreover, no studies have examined the effects of negative interaction between majority group members and minority group members in VR. Furthermore, a recent critical review by Chen and White (2024) highlighted the need for standardization in the degree of immersion and presence incorporated into VR designs and used in prejudice research, as immersiveness increases the effectiveness of VR-based interventions (Wu, Yu, & Gu, 2020).

Another limitation is that a truly diverse set of prejudice measures has been used in different VR-based prejudice reduction interventions, such as a pictorial measure of self-other overlap (Hasler, Hirschberger, Shani-Sherman, & Friedman, 2014), a self-report measure of perceived stigmatization (Redmond et al., 2019), a range of explicit measures of intergroup emotions and attitudes (anxiety, empathy, social proximity, and benevolence) (Stelzmann, Toth, & Schieferdecker, 2021), and implicit measures to assess prejudice (e.g., Banakou et al., 2020; Toppenberg, Ruiters, & Bos, 2019). However, the latter type of measure has been mainly used when studying intergroup contact via the embodiment of a minority group member in VR (see, e.g., Lopez et al., 2019; Zhang, Hommel, & Ma, 2021), but not in actual intergroup contact situations. The divergence in findings between studies using explicit and implicit measures of intergroup attitudes has been widely debated (e.g., Greenwald et al., 2009; Hofmann et al., 2005). As studies using both types are largely unrepresented, our understanding of prejudice in VR is far from complete. Moreover, researchers have also used VR to assess attitudes during intergroup contact by employing behavioural measures such as interpersonal distance (Bailenson, Blascovich, Beall, & Loomis, 2003). However, despite the potential of VR as a multimethod approach capable of integrating explicit, implicit, and behavioural measures of attitudes, the latter have yet to be employed to investigate STE in VR.

In our previous study using the same dataset (Tassinari et al., 2024), we presented evidence of the potential of VR to facilitate intergroup contact fulfilling Allport's optimal contact conditions<sup>11</sup>. We also emphasized the importance of comparing the effects of positive and negative intergroup contact in VR. We observed that participants who engaged in cooperative (positive) intergroup contact with a Black avatar in VR displayed more positive explicit attitudes towards people with African ethnic background compared with participants interacting with an ingroup member (i.e., a White avatar) and more positive implicit attitudes compared with participants in a competitive (negative) intergroup contact situation.

The current study sought to examine the STEs of positive and negative intergroup contact in VR using the same experimental paradigm. This study investigated, for the first time, the STE following positive (cooperative) intergroup contact in VR as specified by Allport's (1954) optimal contact conditions (Study 1 among the Finnish majority group members in Finland), comparing it with that of negative (competitive) contact (Study 2 among the Italian majority group members in Italy), testing two main mechanisms of the STE of intergroup contact in VR (attitude generalization and intergroup anxiety), and assessing intergroup outcomes using explicit, implicit, and behavioural measures of intergroup bias.

The present studies constitute a relevant advancement to the literature on VR and the STE specifically. In addition to testing for the first time whether VR contact produces the STE, they test both positive and negative contact in a virtual environment, two relevant mediators of the STE rarely used in combination (and this way providing a stringent test of hypotheses), using implicit measures (also a novelty in STE research), and considering a set of both similar and dissimilar outgroups, which allowed us to assess the potential for generalization of the STE following VR contact.

## 4 | STUDY 1: MIXED DESIGN

### 4.1 | Aims and hypotheses

The main purpose of this study is to investigate the STE of positive (cooperative) intergroup contact in VR. Specifically, we hypothesise that:

**H1.1.** Positive intergroup contact in VR with a Black avatar (primary outgroup) improves outgroup attitudes towards secondary, non-contacted outgroups compared with intragroup contact (with a White avatar).

The choice of the main secondary outgroup in this study had four rationales. First, as the primary outgroup, also the secondary outgroups needed to be socially relevant in the national context. Middle Eastern individuals constitute a significant minority in Finland, representing 10% of the total foreign population and representing one of the largest immigrant groups in the nation (Statistics Finland, 2022). Second, as STE is more likely to generalize across social groups perceived as similar rather than dissimilar to the contacted outgroup (Harwood et al., 2011; Tausch et al., 2010), the main secondary outgroup was chosen to represent another racialized minority group. Third, as this study also aimed to use a behavioural measure of attitudes (seating distance) in VR contact in relation to one (main) secondary outgroup, it was important to choose a secondary outgroup whose avatar representation would have distinctive visual characteristics indicative of the specific ethnic/racial background of this outgroup. Fourth, as the design of avatars was rather cartoonish in this study, in order to ease the categorisation task of the participants, all avatars needed to be recognizable with the least amount of graphical sophistication. As a consequence, Middle Eastern people were chosen to represent the main secondary outgroup, as similar to people with an African ethnic background (primary outgroup), immigrants from the Middle East represent another large, visible, and racialized minority group in Finland, and their avatar representations could be designed as highly recognizable. Thus, attitudes towards this secondary outgroup were studied using both a measure of explicit attitudes and a behavioural measure (seating distance in VR). However, we also studied STE in relation to attitudes towards several other less visible secondary outgroups (i.e., Muslims, homosexual people, individuals with intellectual disabilities, and immigrants at large), but due to resource constraints in the VR data collection process, they were assessed using an explicit measure of attitudes (feeling thermometer) only. Thus, H1.1. is presented in two parts:

**H1a.1.** There is a STE of positive contact with the primary outgroup (people with African ethnic background) on explicit outgroup attitudes towards secondary outgroups (namely Middle Eastern people, Muslims, homosexual people, individuals with intellectual disabilities, and immigrants) measured through feeling thermometers.

**H1b.1.** There is a STE of positive contact with the primary outgroup (people with African ethnic background) in VR on attitudes towards Muslim people with Middle Eastern ethnic background (secondary outgroup) measured through seating distance in VR.

**H2.1.** Improved attitudes towards the primary outgroup (people with African ethnic background) following VR contact mediate the positive effect of contact on attitudes towards all secondary outgroups (i.e., attitude generalization).

**H3.1.** A decrease in intergroup anxiety towards the secondary outgroup (i.e., Middle Eastern people<sup>2</sup>) mediates the positive effect of contact with the primary outgroup on attitudes towards this outgroup.

Research has identified intergroup anxiety towards the secondary outgroup as a viable mediator of the STE of contact (see e.g., Turner & Feddes, 2011). Although sequential mediation through intergroup anxiety towards the primary outgroup is also plausible (Vezzali & Giovannini, 2012), we chose to use intergroup anxiety towards the secondary outgroup as a mediator in order to avoid several disadvantages associated with testing sequential mediation in an intervention design with mediators and outcome variables being measured at the same time point, such as the need for greater control of potential confounding variables and statistical power, heightened chances of misinterpretation due to the assumptions of causality between sequential mediators, and increased risk of Type I error (Daniel, De Stavola, Cousens, & Vansteelandt, 2015; Vansteelandt & Daniel, 2017). By adopting this approach, we aim to gain a more comprehensive understanding of the mediating factors involved in intergroup contact.

We control for the effect of Social Dominance Orientation (SDO) and national identification, as these have been found to highly correlate with intergroup bias (Levin, Federico, Sidanius, & Rabinowitz, 2002; Verkuyten, 2001). Furthermore, in our previous study (Tassinari et al., 2022a), we found that body ownership and co-presence affect attitudes towards outgroups contacted in VR. We take into account this finding and further recommendations to take into account VR-specific features (Tassinari et al., 2022b), and especially those concerning immersion and presence (Chen & White, 2023), by controlling for feelings of body ownership and co-presence.

The hypotheses and methods of this study were pre-registered before any data were collected. The pre-registration can be read on <https://osf.io/eda4x>. The exploratory analyses of the potential role of situational empathy as an additional affective mediator of the STE in Study 1 are reported in Supplementary materials S1.

## 4.2 | Methods

### 4.2.1 | Sample

Sixty-seven participants took part in the experiment. We removed participants that reported having an African ethnic background ( $n = 1$ ), failed to identify the ethnicity of the Black avatar ( $n = 9$ ), identified the purpose of the study ( $n = 2$ ), or completed either survey significantly faster than the average ( $n = 2$ ). Upon excluding participants based on the above mentioned criteria, the final sample was  $N = 53$ . Because of difficulties loading the waiting room, 5 of them could not enter the environment. Thus, the seating distance was measured for only 48 participants. Participants were randomly assigned to either the experimental or the control condition. The 31 participants in the control condition were on average 18.3 years old and mostly female ( $n = 24$ ), with one person identifying as 'other'. Of the 22 participants in the experimental condition, 16 were female, one identified as 'other', and the remaining participants were male. The participants in the experimental condition were, on average, 20 years old. Regardless of the assigned condition, the participants reported little prior experience with VR, on average. A sensitivity power analysis with G\*power (Erdfelder, Faul, & Buchner, 1996), accounting for a mixed within-between design with correlation between repeated measures  $r = .72$  (correlations can be found in Table S1), indicated that our sample size had 80% power for a small-to-medium (Cohen, 1988) effect size of  $f = 0.15$ .

### 4.2.2 | Measures

#### *Explicit attitudes towards primary and secondary outgroups*

Feeling thermometer was used to measure explicit attitudes towards the primary (people with an African ethnic background) and five secondary outgroups (Middle Eastern people, Muslims, homosexual people, immigrants, and people with intellectual disabilities) both pre- and post-test. The instruction read: 'The following scale measures your attitude toward some groups; scores range from 0 to 100, like a thermometer. The higher the score, the more favourable the attitude toward the group; 0 indicates an extremely unfavourable attitude; 50 indicates an attitude

neither favourable or unfavourable; 100 indicates an attitude extremely favourable'. The delta score of this measure was used to test the mediating effect of attitude generalization.

#### *Seating distance*

We used the participants' chosen seating distance from the avatar representing a Middle Eastern person in the waiting room (see Figure 2b) as a behavioural measure of attitudes. There were five free chairs that the participants could choose to sit on, the first one being immediately adjacent to the outgroup avatar and the last one being the farthest from them. Thus, the values ranged from 1 (closest seat) to 5 (farthest seat).

#### *Intergroup anxiety towards the secondary outgroup*

Intergroup anxiety is the feeling of anxiety that originates from (anticipated) contact with an outgroup. For economic reasons, intergroup anxiety was measured only towards one secondary outgroup, that is, Middle Eastern people. The scale included six items by Stephan and Stephan (1985), asking participants to rate their feelings when thinking of an interaction with the secondary outgroup. For this purpose, they had to rate four adjectives (anxious, worried, awkward, and nervous) on a 5-point Likert scale ranging from 'not at all' to 'very much'. This scale had a McDonald's Omegas of .96 pre-test and .93 post-test.

The control variables are detailed in the Supplementary materials S1.

### 4.2.3 | Procedure

The data for this study were collected in Helsinki, Finland in 2021. The research protocol received ethical approval by the Research Ethics Committee of Aalto University, Finland. Participants completed a pre-test questionnaire online via Psytoolkit (Stoet, 2010, 2017), followed by a virtual experience that took place in a laboratory setting 3–7 days later. The virtual experience lasted between 40 and 60 min and began with participants wearing a VR headset and being introduced to the Altspace VR social VR app that was used as the platform for the experiment. The participants then customized their avatars to resemble themselves. After a brief tutorial, the experimenter (Figure 1d) introduced the participant to another avatar representing either a White (Figure 1a1,a2) or Black (Figure 1b1,b2) person. The avatar was supposedly controlled by another non-located participant but was actually steered by a confederate in another room. A cooperative ball-toss game (Figure 2a) was played between the participant and the avatar. Following the game, the participant was directed to a virtual waiting room (Figure 2b), where they saw an avatar representing a Middle Eastern Muslim person (Figure 1c1,c2), with whom they had no social interaction. Seating distance was measured consistently with the seat chosen by the participant. After 3 minutes, participants were informed that their team had won the game and the virtual experience was over. They then completed a post-test questionnaire on a laboratory computer and were subsequently debriefed. A total of  $n = 5$  participants finished their virtual experience before joining the room due to difficulties in loading the environment. In this case, they completed the post-test questionnaire and were debriefed. All avatars were gender-matched to participants.

In the experimental setup, positive contact was designed to satisfy Allport's optimal contact conditions as follows: participants were required to collaborate by taking turns throwing a ball with the aim of reaching a score of 10 as quickly as possible, thereby working together towards a shared goal of winning against the opposing team. Additionally, the participants and their team members were placed on an equal footing as the participants in the experiment, with no knowledge of each other's personal attributes, ensuring equal status. The entire process was facilitated and motivated by the experimenter in VR, serving as the last optimal contact condition by providing authority support.

To enhance replicability, Supplementary materials S1 have been provided with more comprehensive details about the experimental procedure.



**FIGURE 1** The avatars representing the ingroup (control condition, a1,a2), the primary outgroup (experimental condition, b1,b2), the secondary outgroup (both conditions, c1,c2), and the experimenter (d).

#### 4.2.4 | VR apparatus

The Oculus Quest 2 was used by participants during the whole experiment. This head-mounted display has a resolution of  $1,832 \times 1,920$  pixels per eye, and the lenses can be adjusted to achieve different interpupillary distances. It weighs 503 g and is provided with inside-out tracking with six degrees of freedom for head-tracking and hand-tracking.

The ball toss room (see Figure 2a) was implemented using tools integrated in AltspaceVR, which is a free social app available on most commercial headsets. It allows users to organize gatherings and events, such as concerts and workshops. Users steer avatars that are cartoony in looks, but highly customizable through built-in tools. The waiting room (see Figure 2b) was designed using Unity3D (version 2020.3.9f1) and then uploaded on AltspaceVR. All avatars used in this experiment (see Figure 1) were designed in AltspaceVR, and their appearance remained constant over the duration of the experiment.

In alignment with the highlighted need for standardization of the degree of immersion and presence of VR designs used in prejudice research, we adhered to Chen and White's (2024) framework. Notably, our design has a moderate degree of immersion and presence, as specified by the use of hand controllers (traditional input devices), and a high level of interactivity.

#### 4.2.5 | Analyses

To test H1.1, we used a multilevel linear model (MLM) with a restricted maximum likelihood estimation. MLM was chosen because the data comprised two levels: between-subjects and repeated measures (pre–post). Unlike repeated measures analysis of covariance (ANCOVA), which assumes homogeneous regression slopes and complete cases—assumptions often breached in repeated measures designs—MLM offers greater flexibility in statistical assumptions (Hoffman & Rovine, 2007). Using the MLM, we examined the fixed effect of the interaction between time (pre–



**FIGURE 2** The virtual room where participants played ball toss (a) and the virtual waiting room (b).

vs. post-contact, within-subject factor) and contact type (intragroup vs. intergroup, between-subjects factor) utilizing an omnibus *F*-test with Type III sum of squares using Satterthwaite's method. Separate MLMs were conducted for explicit attitudes towards each secondary outgroup (i.e., Middle Eastern people, Muslims, homosexual people, individuals with intellectual disabilities, and immigrants). Both main effects and interaction effects of the fixed effects of the factors were tested. Finally, we included the fixed main effects of covariates (body ownership, co-presence, SDO, and national identification) in the model. Participant ID was set as a random intercept in the models, which had no random slopes.

Given that seating distance was only measured after VR contact, we used an ANCOVA with contact type held as a between-subject factor to test the effects of contact on seating distance.

As for the mediation hypotheses (H2.1. and H3.1), we ran separate parallel mediation models for each dependant variable (DV; i.e., seating distance, explicit attitudes towards Middle Eastern people, Muslims, homosexual people, individuals with intellectual disabilities, and immigrants). Whereas the first two models included attitude change towards the primary outgroup (people with African ethnic background) and intergroup anxiety towards the secondary outgroup (here Middle Eastern people) as mediators, the other DVs only had attitudes towards the primary outgroup as a mediator, as we did not assess intergroup anxiety towards all secondary outgroups. Given that seating distance was only measured post-contact, we decided to use delta scores of attitudes towards people with African ethnic backgrounds and intergroup anxiety as mediators to account for the effect of time. In order to obtain the delta scores of every variable measured at the two time points, we subtracted the average pre-test score from the average post-test score. Body ownership, co-presence, SDO, and national identity were used as control variables in all models.

R Core Team (2022) was used to carry on the analysis. Specifically, we used the following packages: PROCESS macro (Hayes, 2022), IATscores (Costantini, 2020), forcats (Wickham, 2021), rstatix (Kassambara, 2021), corrgram (Wright, 2021), dplyr (Wickham, François, Henry, & Müller, 2020), and tidyr (Wickham, Vaughan, & Girlich, 2023).

### 4.3 | Results of Study 1

The descriptive statistics and correlations of the variables used in Study 1 are detailed in the Supplementary materials S1.

#### 4.3.1 | Effect of VR contact with a primary outgroup on explicit attitudes towards secondary outgroups and behavioural measure

Then, five multilevel linear models were computed to examine the effects of positive intergroup contact with a Black avatar (primary outgroup) on explicit attitudes (feeling thermometer) towards five secondary outgroups (Middle Eastern people, Muslims, homosexual people, individuals with intellectual disabilities, and immigrants). The results of the *F*-test of MLM fixed effects are reported in Table 1. The results remained consistent even when control variables were not included (see Supplementary material S1). We first examined the effects of contact on attitudes towards the main secondary outgroup (i.e., Middle Eastern people). Though neither time (pre vs. post-contact) nor condition (intragroup vs. intergroup) had a main effect on the DV, the interaction of time and condition was trending towards significance regarding the effect on attitudes towards this secondary outgroup ( $b = 8.33, p = .06$ ): participants who experienced positive VR intergroup contact with the primary outgroup (people with African ethnic background) showed more positive attitudes towards Middle Eastern people over time as compared with those who had experienced intragroup contact (Figure 3). Furthermore, none of the covariates showed a significant effect on outgroup attitudes, with the exception of SDO ( $b = -5.66, p = .01$ ), suggesting that participants higher in SDO showed more negative attitudes than those lower in SDO.

When attitudes towards other secondary outgroups (Muslims, immigrants, homosexual people, and people with intellectual disabilities) were investigated, neither the effect of contact ( $p_{\text{Muslims}} = .72; p_{\text{Imm}} = .93; p_{\text{Intdis}} = .89; p_{\text{Homosexuals}} = .82$ ), time ( $p_{\text{Muslims}} = .36; p_{\text{Imm}} = .80; p_{\text{Intdis}} = .72; p_{\text{Homosexuals}} = .86$ ), nor their interaction ( $p_{\text{Muslims}} = .12; p_{\text{Imm}} = .27; p_{\text{Intdis}} = .34; p_{\text{Homosexuals}} = .32$ ) reached statistical significance. Results are reported in detail in Table 1.

Given that seating distance was measured only post-contact, an ANCOVA with condition as a between-subjects factor was performed to test the effect of VR intergroup contact with the primary outgroup on behaviour towards the secondary outgroup while controlling the effect of body ownership, co-presence, SDO, and national identification. The experimental manipulation showed no statistically significant effect of contact on seating distance ( $p = .78$ ), thus we did not find confirmation for the effect of contact on the behavioural measure of prejudice postulated in H1.1. Detailed results can be found in Table 2.

#### 4.3.2 | Mediation analyses

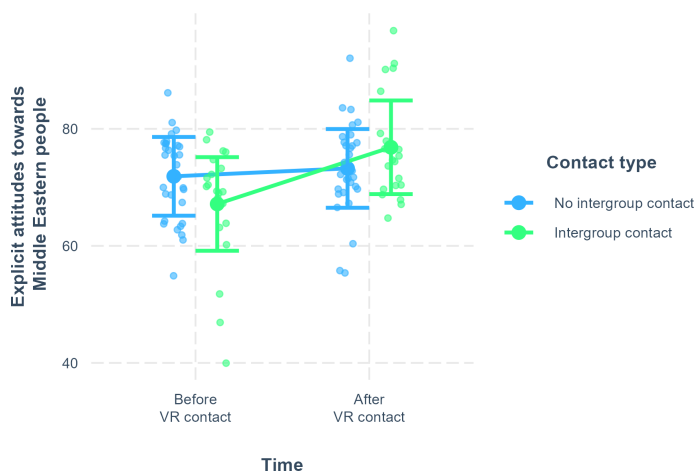
We first tested the STE of positive intergroup contact on attitudes towards the secondary outgroup (Middle Eastern people) via attitudes towards the primary outgroup (people of African origin), and intergroup anxiety (towards the secondary outgroup, that is, Middle Eastern people). Detailed reports of the mediation modelling results can be found among Supplementary material S1, as well as path diagrams for the models (Figure S1). Total and indirect effects of all mediation models are reported in Table 3. In line with H2.1, we found significant indirect effects of

**TABLE 1** *F*-test results of multilevel linear model fixed effects on explicit attitudes towards several outgroups ( $N = 53$ ).

	Explicit attitudes middle eastern			Explicit attitudes Muslims			Explicit attitudes homosexuals			Explicit attitudes intellectual disabilities			Explicit attitudes immigrants		
	df	<i>F</i>	<i>p</i>	df	<i>F</i>	<i>p</i>	df	<i>F</i>	<i>p</i>	df	<i>F</i>	<i>p</i>	df	<i>F</i>	<i>p</i>
Condition	1.00, 47.00	0.07	.80	1.00, 47.00	0.13	.72	1.00, 47.00	0.01	.93	1.00, 47.00	0.02	.89	1.00, 47.00	0.05	.82
Time	1.00, 51.00	1.20	.28	1.00, 51.00	0.86	.36	1.00, 51.00	0.07	.80	1.00, 51.00	0.13	.72	1.00, 51.00	0.03	.86
Condition*time	1.00, 51.00	<b>3.83</b>	<b>.06</b>	1.00, 51.00	2.52	.12	1.00, 51.00	1.24	.27	1.00, 51.00	0.94	.34	1.00, 51.00	0.99	.32
Body ownership	1.00, 47.00	1.69	.20	1.00, 47.00	0.34	.56	1.00, 47.00	0.11	.74	1.00, 47.00	1.07	.31	1.00, 47.00	0.54	.47
Co-presence	1.00, 47.00	0.03	.87	1.00, 47.00	0.14	.71	1.00, 47.00	2.66	.11	1.00, 47.00	0.14	.71	1.00, 47.00	0.01	.91
Social dominance orientation	1.00, 47.00	<b>7.44</b>	<b>.01*</b>	1.00, 47.00	<b>9.77</b>	<b>.00**</b>	1.00, 47.00	<b>23.09</b>	<b>.00**</b>	1.00, 47.00	<b>7.44</b>	<b>.01*</b>	1.00, 47.00	<b>7.14</b>	<b>.01*</b>
National identification	1.00, 47.00	2.06	.16	1.00, 47.00	<b>3.66</b>	<b>.06</b>	1.00, 47.00	2.14	.15	1.00, 47.00	1.97	.17	1.00, 47.00	0.41	.53

Note: Type III analysis of variance computed with Satterthwaite's method.  $p < .10$ . Significant values have been highlighted.

\* $p < .05$ . \*\* $p < .01$ .



**FIGURE 3** Interaction effect between condition (experimental vs. control) and time (pre- vs. post-test) on explicit attitudes towards middle eastern people. Note that dots represent partial residuals. The error bars represent 95% confidence intervals. VR, virtual reality.

**TABLE 2** Effects of the experimental manipulation on seating distance.

	Seating distance (N = 48)			
	df	F	p	$\eta^2$
Condition	1.00, 41.00	0.08	.78	.00
Body ownership	1.00, 41.00	0.14	.71	.05
Co-presence	1.00, 41.00	0.00	.96	.00
Social dominance orientation	1.00, 41.00	4.79	.03 *	.10
National identification	1.00, 41.00	2.67	.11	.06

Note: \* $p < .05$ ,  $\eta^2$ , generalized Eta squared.

**TABLE 3** Total and indirect effects of contact on explicit attitudes towards Middle Eastern people.

	DV: $\Delta$ explicit attitudes towards middle eastern people	
	Effect	[LLCI, ULCI]
Contact $\rightarrow$ DV (C)	9.28*	[1.53, 17.02]
Contact $\rightarrow \Delta$ attitudes African $\rightarrow$ DV (AB)	0.55*	[0.15, 0.93]
Contact $\rightarrow \Delta$ anxiety $\rightarrow$ DV (AB)	0.03	[-0.04, 0.11]

Note: Total effects (C) are reported as unstandardized coefficients, while indirect effects (AB) are partially standardized. LLCI and ULCI respectively stand for bootstrapped lower and upper 95% confidence intervals. The covariates were social dominance orientation and national identity.

\* $p < .05$ .

positive intergroup contact with a Black avatar on attitudes towards Middle Eastern people via improved attitudes towards the primary outgroup (people with African ethnic background). Specifically, despite the change in attitudes towards Middle Eastern people was directly unaffected by contact ( $c' = 1.90$ ,  $p = .80$ ), the indirect effect of the manipulation through improved attitudes towards the primary outgroup was significant ( $ab = 0.55$ , [0.15; 0.93]), and so was the total effect ( $c = 3.85$ ,  $p = .02$ ).

As regards intergroup anxiety as a potential affective mediator, there was no significant effect of intergroup anxiety on attitudes towards Middle Eastern people ( $b = 1.23, p = .26$ ), and the indirect effect of the experimental manipulation via intergroup anxiety was also non-significant ( $ab = 0.03, [-0.04, 0.11]$ ). Thus, H3.1 did not receive support.

To investigate whether the change in attitudes towards the primary outgroup mediated the effect of the intervention also for secondary outgroups other than Middle Eastern people, we tested four different parallel mediation models with explicit attitudes towards Muslims, homosexual people, immigrants, and people with intellectual disabilities as DVs. The results of all mediation models are given in Table 4, while path diagrams can be found among Supplementary material S1 (Figure S2).

Contact had a significant direct effect on the attitudes towards the primary outgroup ( $a = 3.58, p = .01$ ) which, in turn, had a direct effect on attitudes towards Muslims ( $b = 0.10, p < .001$ ). The indirect effect of contact via attitude generalization was also significant ( $ab = 0.51, [0.13, 0.86]$ ). The mediation models predicting attitudes towards the other secondary outgroups all returned similar patterns of results. Thus, the change in attitudes towards the primary outgroup (people of African origin) following the contact with a Black avatar explained the change in attitudes also towards homosexual people ( $b = 0.10, p < .001; ab = 0.55, [0.13, 0.93]$ ), people with intellectual disabilities ( $b = 0.12, p = .00; ab = 0.53, [0.12, 0.93]$ ), and immigrants ( $b = 0.10, p < .001; ab = 0.53, [0.15, 0.92]$ ). Contrary to our hypotheses, seating distance was unaffected by the experimental manipulation ( $a = 0.42, p = .71$ ) and by attitude generalization ( $b = 0.01, p = .91; ab = 0.01, [-0.26, 0.24]$ ) and intergroup anxiety ( $b = 0.26, p = .16; ab = 0.11, [-0.04, 0.41]$ ; see Table 5). A path diagram of this model can be found in Figure S3.

To sum up the results of Study 1, H1a.1 was not confirmed as neither time nor condition had a significant main effect on attitudes towards Middle Eastern people, albeit the interaction of time and condition trended towards significance. Furthermore, for other secondary outgroups (Muslims, immigrants, homosexual people, and people with intellectual disabilities), neither contact, time, nor their interaction showed significant effects. H1b.1 was also not confirmed as the experimental manipulation did not yield a statistically significant effect on seating distance.

In accordance with H2.1, we observed significant indirect effects of positive intergroup contact with a Black avatar on attitudes towards Middle Eastern people through attitude generalization: contact had a direct effect on attitudes towards the primary outgroup, which in turn influenced attitudes towards Muslims, with the mediation analysis indicating significant indirect effects of contact via attitude generalization for all secondary outgroups.

However, H3.1 was not confirmed, as intergroup anxiety did not exhibit significant effect on attitudes towards Middle Eastern people, nor mediated the effect of contact on attitudes towards the secondary outgroup.

**TABLE 4** Total and indirect effects of contact on explicit attitudes towards other secondary outgroups (Muslims, homosexual people, individuals with intellectual disabilities, and immigrants).

	DV <sub>1</sub> : $\Delta$ attitudes Muslims		DV <sub>2</sub> : $\Delta$ attitudes homosexuals		DV <sub>3</sub> : $\Delta$ attitudes intellectual disabilities		DV <sub>4</sub> : $\Delta$ attitudes immigrants	
	Effect	[LLCI, ULCI]	Effect	[LLCI, ULCI]	Effect	[LLCI, ULCI]	Effect	[LLCI, ULCI]
Contact $\rightarrow$ DV (C)	8.99*	[0.25, 17.73]	5.58	[-2.85, 14.00]	4.36	[-4.40, 13.12]	4.28	[-3.72, 12.29]
Contact $\rightarrow$ $\Delta$ attitudes African $\rightarrow$ DV (AB)	0.51*	[0.13, 0.86]	0.55*	[0.13, 0.93]	0.53*	[0.12, 0.93]	0.53*	[0.15, 0.92]

Note: Total effects (C) are reported as unstandardized coefficients, while indirect effects (AB) are partially standardized. LLCI and ULCI respectively stand for bootstrapped lower and upper 95% confidence intervals. The covariates were social dominance orientation and national identity.

\* $p < .05$ .

**TABLE 5** Total and indirect effects from contact to seating distance.

	DV: Seating distance	
	Effect	[LLCI, ULCI]
Contact → DV (C)	0.11	[-0.67, 0.89]
Contact → $\Delta$ attitudes African → DV (AB)	0.01	[-0.26, 0.24]
Contact → $\Delta$ anxiety → DV (AB)	0.11	[-0.04, 0.41]

Note: Total effects (C) are reported as unstandardized coefficients, while indirect effects (AB) are partially standardized. LLCI and ULCI respectively stand for bootstrapped lower and upper 95% confidence intervals. The covariates were social dominance orientation and national identity.

## 5 | STUDY 2: BETWEEN-SUBJECTS DESIGN

### 5.1 | Aims and hypotheses

The hypotheses and data collection plan of this study were pre-registered and can be retrieved at <https://osf.io/dgqj9>. Study 2 aims at replicating the findings of Study 1 and expand them by including the investigation of the STE of negative (competitive) contact in VR and by comparing the effects of positive (cooperative) and negative (competitive) contact with each other. As regards the measurement of outgroup attitudes, as presented in the Methods Section 4.2, Study 2 partially follows the design of Study 1 in that explicit attitudes towards the primary outgroup (people with African ethnic background) and multiple secondary outgroups are measured through feeling thermometers, and the mediation hypothesis with intergroup anxiety mediating the STE is tested for the main secondary outgroup only. Additionally, in Study 2, we used the implicit association test (IAT) to assess implicit attitudes and an additional self-report scale (the General Evaluation Scale [GES]) to assess explicit attitudes towards both the primary outgroup and the main secondary outgroup (namely East Asian people). This is due to the impossibility of assessing all measures for all secondary outgroups due to resource constraints, similar to Study 1. In addition, a behavioural measure (seating distance) was employed to assess attitudes towards the main secondary outgroup by constructing a virtual waiting room in which the avatar of a subject encountered an avatar that represented a member of the East Asian outgroup.

As in Study 1, when choosing the main secondary outgroup, we decided to opt for a group that would likely be perceived as socially relevant and more similar to the contacted group (another racialized minority group), with distinctive visual characteristics that can also be reproduced in a cartoonish avatar. Over the past few decades, East Asian populations, particularly the Chinese community, have experienced rapid growth in Italy. China is among the five countries (along with Morocco, Albania, Ukraine, and the Philippines), accounting for 45.1% of the total number of non-EU citizens in the Italian territory. Prior to the Ukrainian crisis, the Chinese community ranked third in terms of the number of individuals present in Italy, following Morocco and Albania (National Institute of Statistics – Italy, 2014, 2023). Even currently, it continues to represent one of the largest communities among all non-EU citizens present in Italy. In addition to the numerical significance of this community in Italy, the selection of this outgroup was also influenced by its underrepresentation in research. As a minority group that has received limited attention from scientific investigation, its inclusion holds considerable importance. We set the following hypotheses:

**H1.2.** Positive (cooperative) intergroup contact with the primary outgroup (people with an African ethnic background) in VR improves attitudes towards secondary outgroups (East Asian people, Muslims, homosexual people, individuals with intellectual disabilities, and immigrants) compared with intra-group contact.

In Study 2, we introduce negative (competitive) intergroup contact with an avatar representing a member of the primary outgroup (people with African ethnic background) and compare its effects with those of positive contact on attitudes towards secondary outgroups.

**H2.2.** Positive (cooperative) intergroup contact in VR with the primary outgroup leads to more positive attitudes and behaviours towards secondary outgroups compared with the negative (competitive) contact in VR.

**H3.2.** (Post hoc) Negative (competitive) intergroup contact in VR with the primary outgroup avatar leads to more negative attitudes and behaviours towards secondary outgroups compared with the negative (competitive) intragroup contact in VR.

Finally, we lay out the following mediation hypotheses to test for traditional mediators of STE in VR:

**H4.2.** Improved attitudes towards the primary outgroup (people with African ethnic background) following positive intergroup contact mediate the change in attitudes towards secondary outgroups (East Asian people, Muslims, homosexual people, individuals with intellectual disabilities, and immigrants).

**H5.2.** Decreased intergroup anxiety towards the secondary outgroup (East Asian people) mediates the change in explicit and implicit attitudes towards East Asian people, following positive intergroup contact in VR.

To rule out prior contact with the secondary outgroup as a potential source of error, we control for previous contact with East Asian people in all models holding East Asian people as the secondary outgroup. Consistent with Study 1, we controlled for the effect of VR-specific attributes such as body ownership and co-presence in all models. Additionally, the effects of age and education were controlled, as the sample of Study 2 displays considerable variability in these demographic factors, contrary to the sample of Study 1.<sup>3</sup>

## 5.2 | Methods

### 5.2.1 | Sample

Participants were enrolled through push-out strategies on social media and snowball sampling. To reduce the chance that participants recognized the purpose of the study, we only recruited participants who had not studied in educational or psychological degree programs.

The initial sample comprised 160 participants. We applied the pre-registered exclusion criteria, which led to excluding 28 participants from the initial sample. Of those, 17 did not correctly identify the ethnicity of the avatar they played with, 4 had mixed ethnic background, 2 experienced issues with VR functioning, and 5 answered 10% of IAT trials faster than 300 ms. This left us with a total sample of  $N = 132$ , of which  $n = 36$  was randomly assigned to the intergroup cooperation condition,  $n = 31$  to the intragroup cooperation,  $n = 30$  to the intergroup competition, and  $n = 35$  to the intragroup competition. The sample was composed of 66 males and 65 females, with one participant identifying as 'other'. Their age range varied from 18 to 88 years, with a mean age of 31 years.

We conducted a sensitivity power analysis to determine the minimum effect size detectable with our sample, ensuring 80% power at an alpha level of .05. *F*-tests were used as a test family, specifically ANCOVA. Our sample size was analysed for sensitivity using *G*\*power (Erdfelder et al., 1996) and was found to provide 80% power for a medium effect size ( $f = 0.25$ ) as per Cohen's (1988) classification.

## 5.2.2 | Measures

### *Feeling thermometers (attitudes towards primary and secondary outgroups)*

As in Study 1, feeling thermometers were used to assess explicit attitudes towards the primary outgroup (people of African origin) and several secondary outgroups (East Asian people, homosexual individuals, people with intellectual disabilities, Muslims, and immigrants).

### *General Evaluation Scale*

The GES by Wright, Aron, McLaughlin-Volpe, and Ropp (1997) was used as an additional measure of explicit outgroup attitudes in Study 2. Specifically, we measured attitudes towards East Asian people (i.e., the secondary outgroup, used as a dependent variable) and people with African ethnic background (the primary outgroup, used as a mediator). Participants are asked to what extent the target outgroup is 'Cold/Warm'; 'Suspicious/Trusting'; 'Positive/Negative'; 'Friendly/Hostile'; 'Respectable/Contemptible'; 'Admirable/Disgusting' on a continuum from 1 to 7, with lower scores representing more positive attitudes. The McDonald Omegas for this scale were ( $\alpha_1 = .88$  and  $\alpha_2 = .92$ ).

### *Implicit association test*

To measure implicit attitudes towards East Asian people (secondary outgroup) and people with African ethnic background (primary outgroup), we utilized a racial IAT as developed by Greenwald, McGhee, and Schwartz (1998). This test requests participants to categorize the faces of either White or East Asian [African] individuals along with positive or negative words. The difference between the accuracy and speed of categorizing, such as associating Asian faces with positive words or White faces with negative words, is used to calculate implicit racial bias. Higher scores on the IAT indicate more negative implicit attitudes towards East Asian people, as they reflect slower and less accurate associations of East Asian faces with positive words. Due to the time-consuming and demanding nature of the IAT, we were only able to measure it towards a single secondary outgroup.

### *Frequency of intergroup contact*

Two items were used to measure the amount of intergroup contact participants have had with the secondary outgroup. For economic reasons, we measured frequency of intergroup contact exclusively with East Asian people. Participants had to rate their answers on a scale from 1 ('none') to 5 ('a lot'). This measure was used as a control variable in models predicting attitudes towards East Asian people.

### *Intergroup anxiety towards the secondary outgroup*

The measure of intergroup anxiety was the same used in Study 1. To avoid excessively prolonging the survey, we only measured intergroup anxiety towards East Asian people. The McDonald omega was .95.

Seating distance was also measured, as in Study 1. However, due to most subjects not taking a clearly distinguishable seat during the virtual experience ( $na = 107$ ), we decided to discard it as a measure of intergroup behaviour. As such, we will not further discuss the outcome.

## 5.2.3 | Procedure

The data were collected in a laboratory setting at a university in Italy in 2022. The Research Ethics Committee of Aalto University, Finland, granted ethical approval for Study 2. All participants were randomly assigned to one out of four conditions: intragroup cooperative contact, intergroup cooperative contact, intragroup competitive contact, and intergroup competitive contact. The experimenters (White Italian females) followed the procedure used in Study 1, with slight changes for participants assigned to the competitive conditions. Participants in the competitive condition were instructed that they were engaged in a game against an opposing avatar, with the ultimate objective of

attaining a score of 10 points before their opponent. The avatars used in Study 2 were also different, with the avatars representing ingroup members (Figure 4a1,a2) having darker hair and those representing the secondary outgroup (i.e., sitting in the waiting room) modelled to resemble individuals with Eastern Asian ethnic background (Figure 4b1,b2). However, due to the failure of the seating distance measure (see measures section for more details), we chose to exclude it from the analysis. The avatars representing the primary outgroup and experimenter were the same in all conditions (Figure 2b1,b2,d), as were the virtual rooms (see Figure 1). At the end of the experience, all participants were informed that they had won the game. Participants did not receive any incentive upon participation.

In Study 2, the operationalization of Allport's optimal contact conditions mirrored that of Study 1.

Additional information about the experimental procedure is provided in the Supplementary materials S1 to enhance the reproducibility of the study. The VR apparatus used was the same as that used in Study 1.

### 5.2.4 | Analysis

We utilized two-way ANCOVA models to test our  $2 \times 2$  between-subject factorial designs. The factors were task type (cooperation versus competition) and contact type (intragroup versus intergroup). Since our main interest was



**FIGURE 4** The avatars representing the ingroup (a1,a2) and the secondary outgroup (b1,b2).

in examining the differences between intergroup and intragroup contact in a cooperative task (H1.2), and between competition and cooperation during intergroup contact (H2.2), we employed orthogonal contrasts to compare the relevant conditions. Each dependent variable (GES, feeling thermometer, and IAT) was analysed in a separate model.

To examine the hypotheses related to mediation through attitudes (H4.2) and intergroup anxiety (H5.2), we utilized ordinary least squares path analysis, as implemented in Process-macro for R (Hayes, 2022). Due to the high correlation between the two hypothesized mediators (i.e., explicit attitudes towards the primary outgroup and intergroup anxiety,  $r = -.46$ ), simple mediation models were calculated instead of parallel mediation models. We assessed each mediator's effect on two explicit attitude measures (feeling thermometer and GES) and one implicit attitude measure (IAT). We first tested the indirect associations of intergroup cooperation versus intragroup cooperation conditions and then those of intergroup cooperation versus intergroup competition conditions. Finally, we tested the mediation of attitude generalization on feeling thermometers towards Muslims, homosexual people, individuals with intellectual disabilities, and immigrants for both specified contrasts. To accomplish this, we used only two conditions at a time in each mediation model, which resulted in 20 separate single mediation models to analyse the indirect effects of contact via attitude generalization and intergroup anxiety towards the secondary outgroup (the latter was tested only for East Asian people as the secondary outgroup). We controlled for body ownership, co-presence, age, education and, in the models holding East Asian people as the secondary outgroup, prior contact with the secondary outgroup.

All analyses were run in R (R Core Team, 2022) using the following packages: PROCESS macro (Hayes, 2022), IATscores (Costantini, 2020), forcats (Wickham, 2021), rstatix (Kassambara, 2021), corrgram (Wright, 2021), afex (Singmann, Bolker, Westfall, Aust, & Ben-Shachar, 2022), and emmeans (Lenth et al., 2021).

There were some methodological differences compared with Study 1. First, Study 1 encompassed baseline measures of attitudes assessed before the virtual experience, whereas in Study 2, attitudes were measured exclusively after the experience. Furthermore, in Study 1, the primary hypothesis was investigated using MLMs with two factors (time and condition). In contrast, Study 2 employed two-way ANCOVAs, integrating two factors, task type and contact type, with three orthogonal contrasts. Moreover, in Study 1, the mediators examined included explicit attitudes towards people of African origin (i.e., attitude generalization), tested as a mediator of the effect on contact on various measures such as feeling thermometers towards several secondary outgroups and seating distance. Additionally, intergroup anxiety towards Middle Eastern people was tested as a mediator of contact effects on seating distance and feeling thermometers towards Middle Eastern people. Conversely, Study 2 explored mediators encompassing attitudes towards people with African ethnic background, tested on feeling thermometers, GES, and IAT specifically targeting East Asian individuals. Attitude generalization was tested as a mediator on feeling thermometers towards all other secondary outgroups. Moreover, we tested intergroup anxiety towards East Asian people as a potential mediator on feeling thermometers, GES, and IAT towards East Asian people. In Study 1, the mediation models were tested using a combination of parallel and single mediation models. Specifically, two parallel mediation models were employed, holding as DV seating distance and feeling thermometers towards Middle Eastern individuals respectively. Additionally, four single mediation models were utilized, with feeling thermometers of other secondary outgroups as the DVs. Conversely, Study 2 used only single mediation models.

## 5.3 | Results of Study 2

Descriptive statistics are reported in the Supplementary materials S1.

### 5.3.1 | Effect of VR contact on attitudes towards secondary outgroups

Initially, we conducted a two-way ANCOVA for each dependent variable to evaluate the impact of both task type (cooperation versus competition) and contact type (intergroup versus intragroup), along with their interaction. For

the East Asian secondary outgroup, a separate model was computed for each outcome variable (GES, thermometer, and IAT), while only the feeling thermometer was used for other secondary outgroups (Muslims, homosexual people, individuals with intellectual disabilities, and immigrants).

Complete outcomes of the ANCOVA models regarding the East Asian secondary outgroup are presented in Table 6. The analysis excluding the use of control variables is detailed in the Supplementary materials S1. We observed that the intervention did not affect outgroup attitudes measured either through explicit or implicit measures. Interestingly, explicit attitudes measured through GES were positively affected by the degree of body ownership and co-presence experienced by participants.

Then, pairwise comparisons were conducted using orthogonal contrasts to test H1.2, H2.2, and H3.2. For planned contrast 1, cooperation with an ingroup member (White avatar) was compared with cooperation with an outgroup member (Black avatar). The results showed that contact type did not significantly affect attitudes towards the secondary outgroup (East Asian) measured through GES ( $t[123] = -0.37, p = .71$ ), feeling thermometer ( $t[123] = -0.20, p = .85$ ), or IAT ( $t[123] = 0.89, p = .37$ ). Planned contrast 2 compared the effect of task type (cooperation with an outgroup member vs. competition with an outgroup member) in intergroup contact, and the results showed non-significant effects of task type on feeling thermometer ( $t[123] = -0.21, p = .83$ ) and IAT ( $t[123] = 1.69, p = .09$ ), but a trend towards significance on GES ( $t[123] = -1.85, p = .06$ ). Planned contrast 3 compared the impact of competition with an outgroup member to that of competition with an ingroup on attitudes towards the secondary outgroup. The findings revealed no significant differences in GES ( $t[123] = -1.51, p = .13$ ), feeling thermometer ratings ( $t[123] = -1.35, p = .18$ ) and IAT scores ( $t[123] = 0.74, p = .46$ ), indicating that attitudes towards East Asian individuals were not significantly different in the intergroup competition condition compared with the intragroup competition.

We then proceeded to explore the effect of contact type and task type and their interaction on attitudes measured through feeling thermometers towards other secondary outgroups. Neither contact, task type, nor their interaction had any effects on attitudes towards Muslims, homosexual people, individuals with intellectual disabilities, or immigrants (full results are given in Table 7).

We then utilized the same orthogonal contrasts that were previously employed for the East Asian secondary outgroup to conduct pairwise comparisons. The analysis for planned contrast 1 indicated that the contact condition did not have a significant effect on attitudes towards Muslims ( $t[124] = -0.90, p = .37$ ), homosexual people ( $t[124] = 0.27, p = .78$ ), individuals with intellectual disabilities ( $t[124] = 1.14, p = .26$ ), or immigrants ( $t[124] = 0.98, p = .33$ ). Similarly, the results for planned contrast 2 showed no significant effects of task type on attitudes towards Muslims ( $t[124] = 0.18, p = .86$ ), homosexual people ( $t[124] = 0.06, p = .95$ ), individuals with intellectual disabilities ( $t[124] = 0.36, p = .72$ ), or immigrants ( $t[124] = 0.54, p = .59$ ). Finally, the outcomes of planned contrast 3 indicated that attitudes were not significantly different in the intergroup competition condition compared with the intragroup competition towards Muslims ( $t[124] = 0.34, p = .73$ ), homosexual people ( $t[124] = -0.08, p = .94$ ), individuals with intellectual disabilities ( $t[124] = -0.26, p = .80$ ), or immigrants ( $t[124] = -0.86, p = .39$ ).

### 5.3.2 | Mediation analyses

Next, we conducted 12 single mediation models to examine whether attitude generalization (H4.2) and intergroup anxiety (H5.2) mediated the effect of contact on explicit (GES and feeling thermometer) and implicit (IAT) attitudes towards East Asian people. Each mediator was tested separately for each condition contrast (intragroup cooperation vs. intergroup cooperation, intergroup cooperation vs. intergroup competition) and outcome variable, while controlling for body ownership, co-presence, age, education and previous contact with the secondary outgroup. The relative indirect effects are reported in Table 8, while path diagrams can be found in Figures S4–S7.

First, we examined whether the effect of cooperating with an ingroup versus primary outgroup member was mediated by attitude generalization and intergroup anxiety. The results showed that experimental contact type did

**TABLE 6** Full ANCOVA results for the effects of task type and contact on explicit and implicit attitudes towards East Asian people.

	GES east Asian				Thermometer East Asian				IAT East Asian						
	df	MSE	F	GES	p-value	df	MSE	F	GES	p-value	df	MSE	F	GES	p-value
Contact (intragroup vs. intergroup)	1, 123	0.59	2.25	0.018	.14	1, 123	550.26	1.64	0.013	.20	1, 123	0.16	1.10	0.009	.30
Task type (cooperative vs. competitive)	1, 123	0.59	2.73	0.022	.10	1, 123	550.26	0.60	0.005	.44	1, 123	0.16	2.15	0.017	.15
Contact*task type	1, 123	0.59	1.74	0.014	.19	1, 123	550.26	1.18	0.009	.28	1, 123	0.16	1.29	0.010	.26
Age	1, 123	0.59	<b>8.05**</b>	<b>0.061</b>	<b>.01</b>	1, 123	550.26	<b>14.99***</b>	<b>0.109</b>	<b>.00</b>	1, 123	0.16	2.25	0.018	.14
Education	1, 123	0.59	2.08	0.017	.15	1, 123	550.26	0.43	0.004	.51	1, 123	0.16	1.18	0.009	.28
Co-presence	1, 123	0.59	<b>5.14*</b>	<b>0.040</b>	<b>.03</b>	1, 123	550.26	0.77	0.006	.38	1, 123	0.16	0.89	0.007	.35
Body ownership	1, 123	0.59	<b>8.91**</b>	<b>0.068</b>	<b>.00</b>	1, 123	550.26	0.37	0.003	.54	1, 123	0.16	2.02	0.016	.16
Contact with secondary outgroup	1, 123	0.59	2.62	0.021	.11	1, 123	550.26	0.74	0.006	.39	1, 123	0.16	<b>3.59.</b>	<b>0.028</b>	<b>.06</b>

Note: Type III analysis of variance.  $p < .10$ . Significant values have been highlighted. Abbreviations: ANCOVA, analysis of covariance; GSE, General Evaluation Scale, IAT, implicit association test, MSE, mean squared error. \* $p < .05$ ; \*\* $p < .01$ ; \*\*\* $p < .001$ .

**TABLE 7** Full ANCOVA results for the effects of task type and contact type on feeling thermometers towards Muslims, homosexual people, individuals with intellectual disabilities, and immigrants.

	Muslims			Homosexual people			Individuals with intellectual disabilities			Immigrants										
	df	MSE	F	GES	p-Value	df	MSE	F	GES	p-Value	df	MSE	F	GES	p-Value					
Contact (intergroup vs. intragroup)	1, 124	529.71	0.01	.000	.94	1, 124	632.81	0.00	0.000	.96	1, 124	676.51	0.07	0.000	.79	1, 124	490.63	0.11	0.000	.74
Task type (cooperative vs. competitive)	1, 124	529.71	0.02	.000	.88	1, 124	632.81	0.01	0.000	.91	1, 124	676.51	0.29	0.002	.59	1, 124	490.63	0.08	0.000	.78
Contact*task type	1, 124	529.71	0.14	.001	.71	1, 124	632.81	0.02	0.000	.89	1, 124	676.51	0.36	0.003	.55	1, 124	490.63	0.00	0.000	.94
Age	1, 124	529.71	<b>20.06***</b>	.139	.00	1, 124	632.81	<b>8.79**</b>	<b>0.066</b>	.00	1, 124	676.51	<b>6.72*</b>	<b>0.051</b>	.01	1, 124	490.63	<b>9.01**</b>	<b>0.068</b>	.00
Education	1, 124	529.71	0.17	.001	.68	1, 124	632.81	0.09	0.000	.77	1, 124	676.51	0.01	<0.000	.93	1, 124	490.63	0.09	0.000	.76
Co-presence	1, 124	529.71	0.35	.003	.56	1, 124	632.81	1.76	0.014	.19	1, 124	676.51	0.71	0.006	.40	1, 124	490.63	0.08	0.000	.78
Body ownership	1, 124	529.71	0.41	.003	.52	1, 124	632.81	0.10	0.000	.75	1, 124	676.51	0.06	0.000	.80	1, 124	0.42	.003	0.52	

Note: Type III analysis of variance.  $p \leq .10$ . Significant values have been highlighted.

Abbreviations: ANCOVA, analysis of covariance; GES, General Evaluation Scale.

\* $p \leq .05$ .

\*\* $p \leq .01$ .

\*\*\* $p \leq 0.001$ .

**TABLE 8** Total and indirect effects from contact contrasts (1: intergroup cooperation vs. intragroup cooperation, 2: intergroup cooperation versus intergroup competition) to explicit (GES and thermometer) and implicit (IAT) attitudes towards east asian people.

	Y: GES			Y: Thermometer			Y: IAT		
	Effect	LLCI	ULCI	Effect	LLCI	ULCI	Effect	LLCI	ULCI
Contrast 1: Intergroup cooperation vs. intragroup cooperation									
Contact → Y (C)	0.21	-0.36	0.49	5.50	-11.98	10.02	0.10	-0.27	0.11
<i>M: Attitudes African</i>									
Contact → attitudes African → Y (AB)	0.02	-0.26	0.28	-0.02	-0.39	0.36	0.06	-0.09	0.25
<i>M: Anxiety East Asian</i>									
Contact → anxiety East Asian → Y (ab)	0.02	-0.11	0.16	-0.04	-0.27	0.17	-0.01	-0.08	0.09
Contrast 2: Intergroup cooperation vs. intergroup competition									
Contact → Y (C)	0.11	-0.40	0.04	3.13	-6.29	6.23	0.05	-0.04	0.18
<i>M: Attitudes African</i>									
Contact → attitudes African → Y (ab)	-0.02	-0.16	0.13	-0.05	-0.26	0.19	-0.05	-0.17	0.03
<i>M: Anxiety east Asian</i>									
Contact → anxiety east Asian → Y (ab)	-0.01	-0.09	0.07	0.02	-0.11	0.13	0.01	-0.07	0.05

Note: Total effects (C) are reported as unstandardized coefficients whereas indirect effects (AB) are partially standardized (Standardized coefficients for categorical predictor [contact] are in partially standardized form). In case of indirect effects, the LLCI and ULCI stand for bootstrapped lower and upper 95% confidence interval, respectively. 'Y' refers to the dependent variable.

Abbreviations: GES, General Evaluation Scale; IAT, implicit association test.

not affect explicit attitudes towards the contacted outgroup when measured through GES ( $a_{GES} = 0.21$ , [-0.39, 0.45]) and feeling thermometer ( $a_{therm} = 5.53$ , [-11.68, 10.44]), but it did influence implicit attitudes ( $a_{IAT} = 0.12$ , [0.001, 0.47]). Attitudes towards the primary contacted outgroup had a significant direct effect on attitudes towards East Asian people measured through GES ( $b_{GES} = 0.11$ , [0.39, 0.81]) and thermometer ( $b_{therm} = 0.06$ , [0.73, 0.99]), but not IAT ( $b_{IAT} = 0.11$ , [-0.11, 0.31]). Intergroup anxiety did not affect attitudes towards East Asian people ( $b_{GES} = 0.17$ , [-0.03, 0.67];  $b_{therm} = 4.99$ , [-9.88, 10.09];  $b_{IAT} = 0.08$ , [-0.19, 0.13]), nor did the contact type influence intergroup anxiety ( $a = 0.15$ , [-0.24, 0.38]). There were no indirect effects, for any outcome variable, through neither attitude generalization ( $ab_{GES} = -0.07$ , [-0.42, 0.28];  $ab_{therm} = 0.17$ , [-0.26, 0.61];  $ab_{IAT} = 0.06$ , [-0.09, 0.25]) nor intergroup anxiety ( $ab_{GES} = 0.02$ , [-0.11, 0.16];  $ab_{therm} = -0.04$ , [-0.27, 0.17];  $ab_{IAT} = -0.01$ , [-0.08, 0.09]).

Then, we proceeded to test attitude generalization and intergroup anxiety as potential mediators of the effect of positive versus negative intergroup contact with the primary outgroup. Again, the task type did not significantly influence attitudes towards the contacted outgroup for GES and feeling thermometer ( $a_{GES} = 0.12$ , [-0.28, 0.21];  $a_{therm} = 3.17$ , [-7.57, 5.11]), while it did for IAT ( $a_{IAT} = 0.06$ , [-0.25, -0.00]). Task type did not influence intergroup anxiety ( $a = 0.07$ , [-0.17, 0.12]). Nonetheless, attitudes towards the primary outgroup exerted a statistically significant direct effect on attitudes towards the secondary outgroup (East Asian people) as measured by GES ( $b_{GES} = 0.10$ , [0.27, 0.66]) and thermometer ( $b_{therm} = 0.06$ , [0.77, 0.10]), but not IAT ( $b_{IAT} = 0.05$ , [-0.04, 0.18]). Moreover, intergroup anxiety was found to have a significant effect on attitudes towards individuals of East Asian

ethnic background as measured by GES ( $b_{\text{GES}} = 0.19, [0.04, 0.79]$ ) and thermometer ( $b_{\text{therm}} = 5.11, [-27.55, -7.08]$ ), but not IAT ( $b_{\text{IAT}} = 0.09, [-0.28, 0.10]$ ). However, we did not find confirmation of the hypothesized mediation neither by attitude generalization ( $ab_{\text{GES}} = -0.02, [-0.16, 0.13]$ ;  $ab_{\text{therm}} = -0.05, [-0.26, 0.19]$ ;  $ab_{\text{IAT}} = -0.05, [-0.17, 0.03]$ ) nor intergroup anxiety for any of the three outcome variables ( $ab_{\text{GES}} = -0.01, [-0.09, 0.07]$ ;  $ab_{\text{therm}} = 0.02, [-0.11, 0.13]$ ;  $ab_{\text{IAT}} = 0.01, [-0.07, 0.05]$ ). Overall, our proposed model did not provide support for a mediated STE through neither variable.

Next, we performed eight simple mediation models to investigate whether the impact of intergroup contact in VR with the primary outgroup on feeling thermometers towards other secondary outgroups, such as Muslims, homosexual individuals, people with intellectual disabilities, and immigrants, was mediated by attitude generalization (H4.2). Each model was tested separately for each condition contrast (intragroup cooperation vs. intergroup cooperation, intergroup cooperation vs. intergroup competition), and education, age, co-presence, and body ownership were controlled for. The path diagrams can be found in Figures S8 and S9. As Table 9 presents, when comparing intergroup vs. intragroup cooperation, attitude generalization did not seem to mediate the effect of contact for any of the analysed secondary outgroups.

Attitudes towards the primary outgroup had a significant direct effect on attitudes towards Muslims ( $b_{\text{Muslims}} = 0.08, [0.63, 0.94]$ ), homosexual people ( $b_{\text{homosexual}} = 0.09, [0.68, 1.03]$ ), individuals with intellectual disabilities ( $b_{\text{intdis}} = 0.10, [0.59, 0.98]$ ), and immigrants ( $b_{\text{immigrants}} = 0.08, [0.54, 0.87]$ ), but no indirect effects were observed. Similarly, there was no difference in attitudes towards the primary outgroup across these two experimental conditions in all models ( $a = 5.45, [-11.74, 10.04]$ ).

In the comparison of intergroup cooperation versus competition, again, we did not find evidence of attitude generalization mediating the effect of positive intergroup contact on attitudes towards any of the secondary outgroups analysed, as indicated in Table 9. Attitudes towards the primary outgroup had a significant direct effect on attitudes towards Muslims ( $b_{\text{Muslims}} = 0.09, [0.56, 0.91]$ ), homosexual people ( $b_{\text{homosexual}} = 0.11, [0.55, 0.97]$ ), individuals with intellectual disabilities ( $b_{\text{intdis}} = 0.11, [0.41, 0.86]$ ), and immigrants ( $b_{\text{immigrants}} = 0.08, [0.59, 0.89]$ ), but no difference in attitudes towards the primary outgroup was observed across these two experimental conditions in all models ( $a = 3.11, [-7.22, 5.22]$ ). In summary, we could not find evidence for the STEs of positive intergroup contact in VR on attitudes towards any of the secondary outgroups studied through attitude generalization and intergroup anxiety.

In conclusion, contrary to H1.2, contact type did not yield significant effects on attitudes towards any secondary outgroups. Similarly, H2.2 was not confirmed, as task type did not exhibit significant effects on GES, feeling thermometer, or IAT. Nevertheless, planned contrast 2 showed a trend towards significance for GES. No significant effects were found on attitudes towards Muslims, homosexual people, individuals with intellectual disabilities, or immigrants. Furthermore, H3.2 was not supported, as planned contrast 3, comparing the impact of competition with an outgroup member to competition with an ingroup member, revealed no significant differences in attitudes towards all secondary outgroups.

H4.2 was similarly not confirmed, as there was no mediation of attitude generalization, and the only notable association was the direct one between attitudes towards the primary outgroup and explicit attitudes towards East Asian people (GES, thermometer), Muslims, homosexual people, individuals with intellectual disabilities, and immigrants.

Finally, despite the lack of mediation through intergroup anxiety, which disconfirmed H5.2, when comparing task types, intergroup anxiety had a significant effect on explicit attitudes towards individuals of East Asian ethnic background, but not implicit.

## 6 | COMPARISON OF STUDY 1 AND STUDY 2

Since the two studies diverged significantly in their methodologies and designs, it is crucial to provide an overview highlighting both their differences and similarities. In terms of study design, while Study 1 focused on the STE of

**TABLE 9** Total and indirect effects from contact contrasts (1: intergroup cooperation vs. intragroup cooperation, 2: intergroup cooperation vs. intergroup competition) to explicit (feeling thermometer) attitudes towards muslims, homosexual people, individuals with intellectual disabilities, and immigrants.

	Y: Thermometer Muslims			Y: Thermometer homosexual			Y: Thermometer intellectual disabilities			Y: Thermometer immigrants		
	Effect	LLCI	ULCI	Effect	LLCI	ULCI	Effect	LLCI	ULCI	Effect	LLCI	ULCI
Contrast: Intergroup cooperation vs. intragroup cooperation												
M: Thermometer African												
Contact → Y (C)	5.35	-6.93	14.48	5.91	-15.44	8.22	5.89	-21.49	2.07	5.12	-16.68	3.80
Contact → attitudes African → Y (AB)	-0.03	-0.33	0.32	-0.03	-0.36	0.35	-0.03	-0.36	0.30	-0.03	-0.34	0.32
Contrast: Intergroup cooperation vs. intergroup competition												
M: Thermometer African												
Contact → Y (C)	3.09	-4.52	7.85	3.44	-6.80	6.98	3.36	-5.25	8.18	2.92	-4.21	7.46
Contact → attitudes African → Y (A)	-0.03	-0.21	0.15	-0.03	-0.22	0.15	-0.03	-0.17	0.14	-0.03	-0.23	0.17

Note: Total effects (C) are reported as unstandardized coefficients whereas indirect effects (AB) are partially standardized (Standardized coefficients for categorical predictor [contact] are in partially standardized form). In case of indirect effects, the LLCI and ULCI stand for bootstrapped lower and upper 95% confidence interval, respectively. 'Y' refers to the dependent variable. Education, age, co-presence, and body ownership were used as covariates.

positive contact only, contrasting positive intergroup and intragroup contact conditions, Study 2 represented  $2 \times 2$  design with positive versus negative contact task and intergroup versus intragroup contact type, totalling four distinct conditions. However, Study 1 adopted a longitudinal approach with pre- and post-test measures, whereas Study 2 relied solely on post-test measures. In addition, the main secondary outgroups differed between the two studies (Middle Eastern people in Study 1 and East Asian people in Study 2). However, the choice of these groups was guided by the same principles of similarity (ethnic domain) with the primary outgroup (Black people), relevance in a particular social context (large and significant immigrant groups), and graphical design constraints (visual representation of avatars representing outgroup members). Moreover, in Study 1, the outcome variables were explicit attitudes towards five secondary outgroups (measured through feeling thermometers) along with the seating distance from the Middle Eastern avatar. In contrast, Study 2 examined explicit attitudes towards all secondary outgroups using feeling thermometers alongside explicit attitudes measured via GES and implicit attitudes assessed through the IAT, specifically targeting East Asian individuals. Seating distance was ultimately discarded from the analysis in Study 2 because of difficulties in measuring it.

Finally, different control variables were used in Studies 1 and 2. In Study 1, we controlled for body ownership, co-presence, SDO and national identity. Conversely, Study 2 included control variables, such as previous contact with East Asian individuals (relevant only to specific models), body ownership, co-presence, age, and education. While education and age were controlled only in Study 2 due to the greater variance of those characteristics in the Italian sample, the addition of previous contact as a control variable was motivated by the lack of a baseline measure of attitude, which was included in Study 1.

## 7 | GENERAL DISCUSSION AND CONCLUSIONS

The aim of this research was to investigate whether cooperative (positive) intergroup contact in VR with a member of a minority outgroup (i.e., people with an African ethnic background) would lead to an improvement in White national majority group members' attitudes towards secondary, non-contacted outgroups as compared to intragroup contact (Study 1 and 2) and competitive (negative) intergroup contact (Study 2), thus testing the STE of intergroup contact in VR. Study 1 demonstrated that VR-based contact resulted in the STE on attitudes towards all secondary outgroups, with the effect being indirect and going through attitude generalization (i.e., improved attitudes towards the primary outgroup). Study 2, in turn, could not provide robust evidence for the STE. Indeed, we spotted only a trending effect on explicit attitudes towards the main secondary outgroup (East Asian people) in the positive contact condition. Furthermore, competitive (negative) contact did not deteriorate attitudes compared with cooperative (positive) contact. These findings encourage further investigation of the STE of contact in VR, besides the suggestion that fostering positive intergroup interactions in VR can serve as a tool to reduce explicit forms of prejudice. In the following, we examine the findings more thoroughly in relation to previous findings and theory.

In our Study 1, support for STE of positive intergroup contact was found on attitudes towards all non-contacted groups. However, in Study 2, the only STE trending towards significance was found on attitudes towards the main secondary outgroup (East Asian people). Although there was a clear discrepancy between the Study 1 and Study 2 findings, the limited generalization of attitudes in Study 2 could be explained by the previously demonstrated generalization gradient (Harwood et al., 2011). Namely, while previous research has provided consistent evidence of the STE of intergroup contact (e.g., Tausch et al., 2010; Vezzali et al., 2021), it has also been acknowledged that the STE is stronger for secondary outgroups perceived as more similar to the contacted outgroup (Pettigrew, 2009; Tausch et al., 2010). Indeed, East Asian people were the most similar secondary outgroup to the contacted primary outgroup (Black people) with both representing visible minority groups with an immigration background and both being stereotyped based on their ethnic background. The caveat for this interpretation is that individuals may differ in what they find similar rather than dissimilar. As an example, individuals may consider as similar groups who are in a disadvantaged position (Bergh & Brandt, 2023; Vezzali & Stathi, 2021). Future research is, therefore, needed to better

understand the STE in VR, as well as to elucidate the potential and constraints of its generalization. The current research provides some preliminary indications (from Study 1) that the STE of VR contact may apply indifferently to the primary and numerous secondary outgroups, but it remains unclear whether the generalization gradient operates also in the context of VR contact.

In previous research, both attitude change and reduction of intergroup anxiety have been found to mediate the STE. In Study 1, the STE was found to be indirect through the change in attitudes towards the contacted outgroup. The finding suggests that attitude generalization is a primary mechanism of the STE effect of VR contact. The same was not the case with intergroup anxiety, which was not found to have a mediating role. The lacking indirect effect through intergroup anxiety could be due to particularly low baseline levels intergroup anxiety in Study 1. In summary, our findings suggest attitude generalization to be the primary mechanism of STE in VR contact. However, further research is needed to scrutinize this interpretation and examine the role of other emotional mediators.

When examining STE, it is important to acknowledge that the measures selected to assess attitudes towards primary and secondary outgroups can have notable influence on the analyses and the results (Vezzali et al., 2021). In previous research on the STE of contact, mainly explicit attitude measures have been used. In the current research, evidence of STE through attitude generalization was found using explicit measures (Study 1) but not implicit attitudes (Study 2). Whereas some previous intervention studies tackling prejudice from a minority perspective have used implicit measures to assess intergroup attitudes (see e.g., Lopez et al., 2019; Zhang et al., 2021), interventions that have used explicit and implicit measures to measure attitudes among the majorities towards the minorities, in general, and in VR in particular, are very scarce. However, based on the current findings, we are inclined to suggest that VR-based intergroup contact may promote attitudinal change exclusively on an explicit level, while leaving intergroup bias at the implicit level intact.

Finally, it is worth mentioning the association found between immersion and presence-related variables and explicit attitudes towards the secondary outgroups. Especially the positive association between co-presence and outgroup attitudes underlines the importance, already stressed in Tassinari et al. (2022a, 2022b) and Chen and White (2024), of VR-related features and users' experiences in contact interventions when studying intergroup attitudes and prejudice, as they could help to explain interpersonal variation in effectiveness of the contact experience.

As regards the limitations of the study, the behavioural measure we used to assess prejudice, which involved measuring the seating distance between participants and avatars representing a secondary outgroup, did not yield significant results in Study 1 and was excluded from Study 2 due to prevailing missing values. We assume that the participants did not find it natural or intuitive to take a seat in the virtual waiting room, given that they had limited experience with VR and were only equipped with a headset and hand controllers, rather than a full-body suit.

A potential limitation of Study 1 is that we failed to account for previous contact with secondary outgroups, which is unfortunate considering the notion that the STE only occurs when there is no or little prior contact with the secondary outgroup (Eller & Abrams, 2004). This limitation was overcome in Study 2 and previous contact with the secondary outgroup of reference was used as a covariate. Although this study lacked manipulation checks to confirm the participants' perceptions of positive and negative contact, we adhered to Allport's optimal contact criteria for positive contact conditions, while we induced competition and established a zero-sum game framework for negative contact conditions, ensuring alignment with established theoretical frameworks. A constraint on generality in this study is that the samples are limited to White individuals, with a further limitation in Study 1, as the participants are predominantly young, which may affect the generalizability of our findings to more diverse populations or age groups. Finally, it is also possible that the low statistical power achieved did not allow for detecting statistically significant mediation effects.

However, the use of different measures to assess attitudes towards the primary and secondary outgroups was a notable strength of the study, as we employed both a multi-item semantic differential scale of implicit attitudes (i.e., GES) and the single-item feeling thermometer, in addition to the IAT for implicit attitudes, which enabled us to carry out a comprehensive exploration of attitude generalization.

In conclusion, these findings hold significant implications for the STE literature as they extend it for the first time to the domain of VR and show that attitude generalization (which is the main mediator of the STE identified by research; Vezzali et al., 2021) may be a key underlying process for the STE produced by positive VR contact. Our study highlights the potential of positive VR contact to contribute to the STE theory, which rests on the idea that positive contact experiences with one group can reduce prejudice following VR contact. Given the increasing affordability and availability of VR hardware and social VR applications, virtual intergroup contact experiences have become increasingly prevalent. VR allows contact between a wide range of social groups that would rarely encounter each other in the physical world. The transfer of prejudice reduction from contacted outgroups to non-contacted outgroups provides a mechanism via which VR contact experiences can generalize to intergroup relations beyond VR. By leveraging the diversity offered by the virtual environment, VR contact can potentially impact a wider range of outgroups than traditional contact. Therefore, we encourage researchers to explore the potential of VR contact to promote a genuinely diverse and harmonious society.

### AUTHOR CONTRIBUTIONS

Matilde Tassinari, Inga Jasinskaja-Lahti, and Loris Vezzali contributed to the conceptualization and development of the experimental hypotheses. Matilde Tassinari and Inga Jasinskaja-Lahti collected data for Experiment 1, whereas Loris Vezzali and Veronica Margherita Cocco collected data for Experiment 2. Matilde Tassinari and Ville Johannes Harjunen performed the data analysis. Matilde Tassinari, Inga Jasinskaja-Lahti, and Ville Johannes Harjunen wrote the article and received consultation from Loris Vezzali and Veronica Margherita Cocco during the writing process.

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### CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest to disclose.

### DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author, MT, upon reasonable request. The pre-registrations of the submitted studies are available on Open Science Framework (OSF) at the following links: <https://osf.io/eda4x>, <https://osf.io/dgqj9>, and [https://osf.io/az37e/?view\\_only=25de89fcc2844e79bef6c31d48936c43](https://osf.io/az37e/?view_only=25de89fcc2844e79bef6c31d48936c43).

### ETHICS STATEMENT

This research project received ethical approval by the Research Ethics Committee of Aalto University, under the decision number D/218/03.04/2021. All participants signed an informed consent form. Following local legislation, participants younger than 16 were allowed to take part in the experiment given that there would be a lack of objections from their legal guardians.

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## ENDNOTES

- <sup>1</sup> Please note that all measures utilized in our previous study but not included in the current analysis are detailed in Supplementary materials S1. Also note that our previous studies, while using the same dataset, had different aims, with the examination of the STE being of interest to the present set of studies only.
- <sup>2</sup> For economic reasons, we only measured intergroup anxiety towards one secondary outgroup (i.e., Middle Eastern people), as every additional secondary outgroup would require a further scale.
- <sup>3</sup> Due to the study's focus on introducing multidimensional dependent variables (such as GES and IAT) and resource constraints, measures for SDO and national identity were not included in Study 2.

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## SUPPORTING INFORMATION

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