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Navigating Prejudice in Virtual Reality

Direct, Indirect, and Secondary Transfer Effects of Positive and Negative Intergroup Contact in VR

Matilde Tassinari

DOCTORAL DISSERTATION

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Pre-examiners

Teaching Fellow Jose Salvador Alvidrez Villegas, Queen's University Belfast, Northern Ireland

Professor Alessandro Gabbiadini, University of Milano Bicocca, Italy

Supervisors

Professor Inga Jasinskaja-Lahti, University of Helsinki, Finland

Professor Iiro Jääskeläinen, Aalto University, Finland

Dr. Ville Johannes Harjunen, University of Helsinki, Finland

Opponent

Senior Researcher Béatrice Hasler, University of Liechtenstein, Liechtenstein

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To O. You being part of this world is my greatest motivation to make it a better place.

Abstract

Virtual reality (VR) has emerged as a novel tool in social psychology research, offering great opportunities for exploring social dynamics in immersive simulations of intergroup scenarios. In recent years, VR has garnered significant attention as a promising avenue for studying prejudice and developing interventions aimed at its reduction. Despite this growing interest, our knowledge of the effectiveness of prejudice-reducing interventions in VR remains limited, as does our understanding of the challenges and limitations inherent in this new technology.

Intergroup contact theory (Allport, 1954), a foundational concept in social psychology, posits that positive interactions between members of different social groups can lead to reduced prejudice and better intergroup attitudes. Extensive research spanning decades has demonstrated the efficacy of intergroup contact interventions across various groups and in both direct and indirect forms of contact (Pettigrew & Tropp, 2006; Lemmer & Wagner, 2015). However, the applications and impact of intergroup contact within VR environments have yet to be comprehensively explored. This dissertation seeks to address these gaps by systematically investigating the effects and features of intergroup contact interventions in VR.

The research questions of this dissertation encompass a critical inquiry on how VR has been utilized to study and fight prejudice towards stigmatized minority groups. As a central focus of this dissertation, I aim to investigate the efficacy of positive intergroup contact in VR as a means of reducing prejudice towards stigmatized outgroups. Furthermore, the research questions extend to exploring the effects of negative intergroup contact in VR. The role of intergroup anxiety and empathy as emotional mediators of intergroup contact in VR represents another focal point of my inquiry. Finally, an examination of the Secondary Transfer Effects (STE) of intergroup contact in VR addresses the broader impact of intergroup interactions in VR on attitudes beyond the directly involved social groups. This dissertation explores VR's potential as both a tool for studying and reducing prejudice and as a technology with distinct features that influence the perception of intergroup encounters in immersive simulated environments. I argue that VR is an environment that introduces unique variables that affect intergroup contact interventions. By examining elements such as co-presence and body ownership within VR environments, this research aims to elucidate how these factors affect individuals' perceptions during intergroup contact experiences in VR and further. Additionally, this dissertation introduces the novel concept of Common Cyber-Identity (CCI) — a shared social identity experienced by individuals interacting within VR environments.

This dissertation consists of four sub-studies. Study I provides a systematic review of literature examining the use of VR in reducing prejudice. The review includes 64 studies that employed VR to simulate interactions with outgroup avatars or embodiment in outgroup members. Findings suggest that VR contact has the

potential to improve intergroup relations, but under certain circumstances, it may also increase prejudice. Initial evidence of emotional and immersion-related variables as potential mediators and moderators is examined. Study II investigates the effect of VR-based positive intergroup contact on empathy towards a stigmatized outgroup in a Finnish sample. Using a between-participants design, 64 Finnish majority group members experienced either positive contact with a Black avatar or encountered a White avatar representing the ingroup. Although VR intergroup contact did not have a direct effect on empathy, the experimental group saw an increase in post-intervention empathic interest as feelings of co-presence intensified. Study III, conducted among national majorities in Finland (N = 53) and Italy (N = 134), assessed the impact of positive and negative intergroup contact in VR on implicit and explicit attitudes towards Black people. Participants, embodied as White avatars, engaged in cooperative or competitive interactions with Black or White avatars. Cooperative contact led to improved attitudes towards Black people, with positive effects observed at the explicit level in the Finnish sample and at the implicit level in the Italian sample. Lastly, CCI was found to positively influence implicit attitudes in the Finnish sample. Study IV explores the STE of intergroup contact in VR using the same samples as Study III. Findings from two studies revealed that positive contact with a Black avatar in VR decreased explicit prejudice towards secondary non-contacted outgroups via attitude generalization. Additionally, a trend towards improved attitudes towards secondary outgroups was observed for positive compared to negative contact.

This dissertation makes significant contributions to social psychological research on intergroup relations by consolidating VR's role as an effective method for studying and reducing prejudice. It also investigates the STE of intergroup contact for the first time in VR, providing encouraging preliminary evidence of its potential to diminish generalized prejudice beyond directly contacted groups. Furthermore, this dissertation pioneers the study of negative intergroup contact in VR, showing that positive effects on intergroup attitudes are limited to positive contact. It also contributes to a more comprehensive understanding of different types of intergroup interactions in virtual settings. Additionally, preliminary evidence of Common Cyber-Identity suggests VR's potential to influence intergroup interactions beyond being a mere medium. This finding highlights the potential of VR to build inclusive social environments leveraging common identities. This dissertation also sheds light on the mechanisms underlying prejudice reduction in VR by demonstrating how immersion-related constructs, such as co-presence, can affect emotional correlates of prejudice, such as empathy. Finally, it contributes to the debate surrounding the interplay between explicit and implicit measures of prejudice, emphasizing the importance of considering both simultaneously as they may tap into different aspects of prejudice. By integrating both types of measures, this dissertation provides a more comprehensive assessment of attitudes towards outgroups in VR contexts.

Tiivistelmä

Virtuaalitodellisuus (VR) on noussut uudeksi työkaluksi sosiaalipsykologian tutkimuksessa, tarjoten ainutlaatuisia mahdollisuuksia tutkia sosiaalisia dynamiikkoja immersiivisissä simulaatioissa ryhmien välisissä tilanteissa. Viime vuosina VR on saanut huomattavaa huomiota lupaavana väylänä ennakkoluulojen tutkimiseen ja interventioiden kehittämiseen niiden vähentämiseksi. Tästä kasvavasta huomiosta huolimatta tietomme ennakkoluulojen vähentämiseen tähtäävien interventioiden tehokkuudesta virtuaalitodellisuudessa on rajallista, kuten myös ymmärryksemme tämän uuden teknologian haasteista ja rajoituksista.

Sosiaalipsykologian peruskäsitteisiin kuuluva ryhmien välisen kontaktin teoria (Allport, 1954) esittää, että positiiviset vuorovaikutukset eri sosiaaliryhmien jäsenten välillä voivat vähentää ennakkoluuloja ja parantaa ryhmien välisiä asenteita. Laaja tutkimus vuosikymmenten ajalta on osoittanut ryhmien välisten kontakti-interventioiden tehokkuuden eri ryhmissä sekä suorissa että epäsuorissa kontaktimuodoissa (Pettigrew & Tropp, 2006; Lemmer & Wagner, 2015). Ryhmien välisen kontaktin sovelluksia ja vaikutuksia VR-ympäristöissä ei kuitenkaan ole vielä kattavasti tutkittu. Tämä väitöskirja pyrkii paikkaamaan näitä aukkoja tutkimalla järjestelmällisesti ryhmien välisen kontaktin interventioiden vaikutuksia ja ominaisuuksia virtuaalitodellisuudessa.

Tämän väitöskirjan tutkimuskysymykset käsittelevät kriittisesti sitä, kuinka virtuaalitodellisuutta on käytetty ennakkoluulojen tutkimiseen ja torjumiseen leimattuja vähemmistöryhmiä kohtaan. Väitöskirjan keskeisenä tavoitteena on tutkia positiivisen ryhmien välisen kontaktin tehokkuutta virtuaalitodellisuudessa ennakkoluulojen vähentämisessä leimattuja ulkoryhmiä kohtaan. Lisäksi tutkimuskysymyksissä tarkastellaan negatiivisen ryhmien välisen kontaktin vaikutuksia virtuaalitodellisuudessa. Ryhmärajat ylittävän ahdistuksen ja empatian rooli tunteiden välittäjinä virtuaalitodellisuudessa tapahtuvassa ryhmien välisessä kontaktissa on myös keskeinen osa tätä tutkimusta. Lopuksi ryhmienvälisen kontaktin toissijaisten siirtovaikutusten (Secondary Transfer Effect, STE) tarkastelu virtuaalitodellisuudessa käsittelee ryhmienvälisten vuorovaikutusten laajempaa vaikutusta asenteisiin myös sellaisten sosiaalisten ryhmien osalta, jotka eivät ole suoraan mukana vuorovaikutuksessa. Tämä väitöskirja tutkii virtuaalitodellisuuden potentiaalia sekä ennakkoluulojen tutkimisen, että vähentämisen työkaluna, ja samalla tarkastelee teknologian erityispiirteitä, jotka vaikuttavat ryhmien välisiin kohtaamisiin immersiivisissä simuloiduissa ympäristöissä. Esitän, että virtuaalitodellisuus on ympäristö, joka tuo mukanaan ainutlaatuisia muuttujia, jotka vaikuttavat ryhmien välisen kontaktin interventioihin. Tutkimalla VR-ympäristöissä ilmeneviä elementtejä, kuten yhteisläsnäolon (co-presence) ja kehon omistajuuden tunteita, tutkimus pyrkii selvittämään, miten nämä tekijät vaikuttavat yksilöiden käsityksiin ryhmien välisen kontaktin kokemuksista virtuaalitodellisuudessa ja laajemminkin. Lisäksi väitöskirja esittelee uuden käsitteen nimeltään Yhteinen

Kyberidentiteetti (Common Cyber-Identity, CCI) — jaetun sosiaalisen identiteetin, jonka yksilöt kokevat ollessaan vuorovaikutuksessa virtuaalitodellisuuden ympäristöissä.

Väitöskirja koostuu neljästä osatutkimuksesta. Ensimmäisessä tutkimuksessa esitellään systemaattinen katsaus kirjallisuudesta, joka käsittelee VR:n käyttöä ennakkoluulojen vähentämisessä. Katsauksessa tarkastellaan 64 tutkimusta, joissa VR:ää on käytetty simuloimaan vuorovaikutuksia ulkoryhmän avatarien kanssa tai ruumiillistamalla ulkoryhmän jäseniä. Tulokset viittaavat siihen, että VR-kontaktilla on potentiaalia parantaa ryhmien välisiä suhteita, mutta tietyissä olosuhteissa se voi myös lisätä ennakkoluuloja. Katsauksessa tarkastellaan myös tunteisiin ja immersioon liittyviä muuttujia mahdollisina välittäjinä ja moderaattoreina. Toinen tutkimus tutkii VR-pohjaisen positiivisen ryhmien välisen kontaktin vaikutusta empatiaan leimattua ulkoryhmää kohtaan suomalaisessa otoksessa. Käyttäen osallistujien välistä koeasetelmaa (between-participants) tutkimuksessa 64 suomalaisen enemmistöryhmän jäsenen kokemus koostui joko positiivisesta kontaktista mustan avatarin kanssa tai kohtaamisesta valkoisen, sisäryhmää edustavan avatarin kanssa. Vaikka ryhmien välinen kontakti virtuaalitodellisuudessa ei vaikuttanut suoraan empatiaan, kokeellisessa ryhmässä havaittiin interventiota seuraavan empaattisen kiinnostuksen lisääntyneen yhteisläsnäolon tunteen voimistumisen myötä. Kolmas tutkimus, joka toteutettiin Suomen (N = 53) ja Italian (N = 134) kansallisen enemmistön keskuudessa, arvioi positiivisen ja negatiivisen ryhmienvälisen kontaktin vaikutusta virtuaalitodellisuudessa implisiittisiin ja eksplisiittisiin asenteisiin mustia ihmisiä kohtaan. Osallistujat, jotka ruumiillistuivat valkoisiksi avatereiksi, osallistuivat yhteistyöhön tai kilpailuun mustien tai valkoisten avatarien kanssa. Yhteistyöllinen kontakti johti parantuneisiin asenteisiin mustia kohtaan, ja positiiviset vaikutukset havaittiin eksplisiittisellä tasolla suomalaisessa otoksessa ja implisiittisellä tasolla italialaisessa otoksessa. Lopuksi havaittiin, että Yhteinen Kyberidentiteetti (CCI) vaikutti myönteisesti implisiittisiin asenteisiin suomalaisessa otoksessa. Neljäs tutkimus tutkii ryhmienvälisen kontaktin toissijaisia siirtovaikutuksia (STE) virtuaalitodellisuudessa käyttäen samoja otoksia kuin kolmannessa tutkimuksessa. Kahden tutkimuksen tulokset osoittivat, että positiivinen kontakti mustan avatarin kanssa virtuaalitodellisuudessa vähensi eksplisiittisiä ennakkoluuloja toissijaisia, ei-kontaktissa olleita ulkoryhmiä kohtaan asenteiden yleistymisen kautta. Lisäksi havaittiin trendi kohti parantuneita asenteita toissijaisia ulkoryhmiä kohtaan positiivisen kontaktin yhteydessä verrattuna negatiiviseen kontaktiin.

Tämä väitöskirja tekee merkittäviä myötävaikutuksia ryhmienvälisten suhteiden sosiaalipsykologiseen tutkimukseen vahvistamalla virtuaalitodellisuuden roolin tehokkaana menetelmänä ennakkoluulojen tutkimisessa ja vähentämisessä. Lisäksi se tutkii ensimmäistä kertaa ryhmienvälisen kontaktin toissijaisia siirtovaikutuksia (STE) virtuaalitodellisuudessa ja tarjoaa rohkaisevaa alustavaa näyttöä sen potentiaalista vähentää yleistettyjä ennakkoluuloja myös kontaktissa olleiden ryhmien ulkopuolella. Lisäksi väitöskirja edistää negatiivisen ryhmienvälisen kontaktin tutkimusta virtuaalitodellisuudessa ja osoittaa, että positiiviset vaikutukset ryhmienvälisiin asenteisiin rajoittuvat positiiviseen kontaktiin. Se myös laajentaa ymmärrystä erilaisista ryhmien välisistä vuorovaikutuksista virtuaaliympäristöissä. Lisäksi alustava näyttö Yhteisen Kyberidentiteetin olemassaolosta viittaa siihen, että virtuaalitodellisuudella voi olla vaikutusta ryhmien välisiin vuorovaikutuksiin teknologiana, joka ylittää pelkän viestintävälineen. Tämä löytö korostaa VR potentiaalia rakentaa yhteisöllisiä sosiaalisia ympäristöjä hyödyntämällä yhteisiä identiteettejä. Väitöskirja valaisee myös niitä

mekanismeja, jotka ovat ennakkoluulojen vähentämisen taustalla virtuaalitodellisuudessa, osoittamalla, miten immersioon liittyvät rakenteet, kuten yhteisläsnäolo, voivat vaikuttaa ennakkoluulojen emotionaalisiin korrelaatteihin, kuten empatiaan. Lopuksi se antaa panoksensa eksplisiittisten ja implisiittisten ennakkoluulojen mittaamisen välisen suhteen ympärillä käytävään keskusteluun, korostaen molempien samanaikaisen huomioimisen tärkeyttä, sillä ne voivat paljastaa ennakkoluulojen eri puolia. Integroimalla molemmat mittaustavat väitöskirja tarjoaa kattavamman arvioinnin asenteista ulkoryhmiä kohtaan virtuaalitodellisuudessa.

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List of abbreviations

CCI	Common Cyber-Identity
CIIM	Common Ingroup Identity Model
CMC	Computer-Mediated Contact
GES	General Evaluation Scale
HMD	Head-Mounted Displays
IAT	Implicit Association Test
SDO	Social Dominance Orientation
STE	Secondary Transfer Effect
VR	Virtual Reality

Index

List of original publications

This thesis is based on the following publications:

I Tassinari, M., Aulbach, M. B., & Jasinskaja-Lahti, I. (2022). The use of virtual reality in studying prejudice and its reduction: A systematic review. *PloS one*, 17(7). https://doi.org/10.1371/journal.pone.0270748

II Tassinari, M., Aulbach, M. B., & Jasinskaja-Lahti, I. (2022). Investigating the influence of intergroup contact in virtual reality on empathy: An exploratory study using AltspaceVR. *Frontiers in psychology*, 12. https://doi.org/10.3389/fpsyg.2021.815497

III Tassinari, M., Aulbach, M. B., Harjunen, V. J., Cocco, V. M., Vezzali, L., & Jasinskaja-Lahti, I. (2024). The effects of positive and negative intergroup contact in virtual reality on outgroup attitudes: Testing the contact hypothesis and its mediators. *Group Processes & Intergroup Relations*, https://doi.org/10.1177/13684302241237747

IV Tassinari, M., Harjunen, V. J., Cocco, V. M., Vezzali, L., & Jasinskaja-Lahti, I. (2024). The virtual cure for real-world prejudice? Secondary transfer effects of intergroup contact in virtual reality. *Journal of Community & Applied Social Psychology*, 34(5), e2879. https://doi.org/10.1002/casp.2879

1 Introduction

Prejudice and intergroup conflict have been persistent and pervasive issues throughout human history, often leading to profound social, economic, and psychological divides. Traditional approaches to reducing and studying prejudice, such as direct intergroup contact, have shown promise but are frequently limited by practical and contextual barriers (Dovidio et al., 2011). In the digital age, however, new frontiers in technology offer unprecedented opportunities to address these rooted social issues. In this doctoral thesis, I explore the potential of virtual reality not only as a medium, but also as an actor for prejudice reduction. I concentrate on how simulated, immersive interactions between social groups can enhance positive intergroup dynamics.

Virtual reality, with its ability to create rich, immersive environments, provides a unique platform for replicating and enhancing intergroup contact (Allport, 1954), which has been extensively shown to improve intergroup attitudes (Pettigrew & Tropp, 2006, 2008; Lemmer and Wagner, 2015). This thesis investigates both positive and negative forms of contact within VR, examining their respective impacts on intergroup attitudes. A critical component of this research is understanding how such virtual interactions can lead to the generalization of attitudes towards other, non-contacted outgroups—i.e., the Secondary Transfer Effect of contact (Pettigrew, 2009). This aspect of the study seeks to uncover whether positive changes in attitudes towards one group can extend to other social categories, thereby amplifying the benefits of VR-facilitated contact.

Affective mediators, such as empathy and intergroup anxiety, play a crucial role in the dynamics of intergroup contact (Pettigrew & Tropp, 2008). This thesis delves into how these traditional mediators operate within the context of VR, providing insights into the emotional and psychological processes that underpin changes in prejudice.

Perhaps the most novel and intriguing contribution of this thesis is the introduction of the concept of Common Cyber-Identity. In VR, individuals are not merely social actors interacting through avatars; they are participating in a shared digital space that can foster a sense of collective identity. This thesis explores how the emergence of a common social identity within VR can enhance the effectiveness of intergroup contact. By identifying with a shared cyber-identity, participants may transcend their pre-existing social categories, leading to a stronger sense of unity and reduced intergroup bias.

This research, which is part of the PREVENT project ("Development of the neurobiologically and social scientifically informed approach to prejudice and its reduction") funded by Academy of Finland (grant 332311) and led by professors Iiro Jääskeläinen (Aalto University), Inga Jasinskaja-Lahti, and Niklas Ravaja (University of Helsinki), is positioned at the intersection of social psychology and human-computer interaction, offering insights into how VR can be leveraged to address one of society's most enduring challenges. By exploring the dimensions of intergroup contact in virtual environments, this thesis aims to contribute to the development of innovative strategies for prejudice reduction, aspiring to pave the way for future research and practical applications that leverage the power of VR to build more inclusive societies.

2 Theoretical background

The theoretical and methodological background of this doctoral dissertation is situated at the intersection of two significant research areas: intergroup contact and VR. These domains, while distinct, converge in their potential to transform our understanding of intergroup encounters and prejudice reduction.

The theoretical background of this dissertation begins with a focused exploration of intergroup contact, a concept with a rich historical lineage. While it is beyond the scope of this work to delve into this history, the dissertation focuses specifically on key aspects of intergroup contact. Specifically, it examines the contact hypothesis, the generalization of contact effects to non-contacted outgroup, and the mediators of contact.

The second research area is social VR, a relatively nascent but rapidly evolving field. The literature review details the defining features of VR and explores its applications in relation to intergroup contact research.

2.1 Intergroup contact

This dissertation is grounded in Allport's (1954) contact hypothesis, a theoretical framework that suggests positive interactions between individuals from different social groups can reduce prejudice and foster positive intergroup relations. Extensive research supports this notion, with meta-analytic reviews by Pettigrew and Tropp (2006, 2008) and Lemmer and Wagner (2015) showing that contact between social groups typically diminishes prejudice. Recent research suggests that positive and negative intergroup contacts are qualitatively different and have varying consequences depending on the context (Paolini & McIntyre, 2019; Fuochi et al., 2020), challenging the idea of a simple asymmetry between them (Barlow et al., 2012; Hayward et al., 2017). Recent advancements in intergroup contact research, such as Vezzali et al.'s (2021) review on the STE of intergroup contact, explore the idea that enhanced attitudes toward a specific outgroup may extend to other uncontacted outgroups. This section critically examines the effects of intergroup contact, with a specific focus on the STE. In addition, the Common Ingroup Identity Model (Gaertner & Dovidio, 2000, 2012) will be examined in the context of intergroup contact. This model suggests that perceiving outgroups as part of an overarching, shared group can help reduce prejudice and improve intergroup relations. Next, I will delve into the significant role of affective mediators, such as

empathy and intergroup anxiety, in shaping attitudes towards different social groups. Lastly, the discrepancies and features of implicit and explicit measures of outgroup attitudes will be explored, examining the distinct characteristics of these two types of measures, their strengths and limitations, and how they contribute to our understanding of prejudice and bias.

2.1.1 The contact hypothesis

The intergroup contact hypothesis, first articulated by Gordon Allport in 1954, represents a seminal theoretical framework positing that, under specific conditions, interpersonal interactions between members of distinct social groups hold the potential to mitigate prevailing negative intergroup attitudes, consequently diminishing prejudice. Central to this hypothesis are the optimal contact conditions, which encompass factors such as equal status, common goals, cooperation, and institutional support. Allport (1954) envisioned that when individuals engage in intergroup contact within this context, they are more likely to cultivate more positive attitudes towards one another. The hypothesis underscores the importance of not merely any form of contact but rather a strategic engagement that fosters cooperation and equality among groups. As such, the intergroup contact hypothesis serves as a guiding principle in understanding the dynamics of social interactions and prejudice reduction, explaining the essential conditions under which contact can effectively contribute to positive intergroup relations.

Pettigrew and Tropp (2006) conducted a comprehensive meta-analysis, scrutinizing 515 studies to assess the efficacy of the contact theory in reducing prejudice. Their analysis revealed a robust and consistent effect of positive intergroup contact in diminishing prejudice across a diverse array of target outgroups. Notably, the meta-analysis uncovered that the prejudice-reducing impact of intergroup contact was even more pronounced in instances where the contact was involuntary, as opposed to deliberate intergroup interactions. Furthermore, while interventions adhering to Allport's optimal conditions were more effective at reducing prejudice, it was noteworthy that these conditions were not indispensable for the observed reduction in prejudice. Despite the significance of their findings, it is crucial to acknowledge a key limitation in Pettigrew and Tropp's (2006) meta-analysis—the predominant inclusion of cross-sectional studies in their database, which may limit the ability to establish causal relationships.

To address the limitations associated with cross-sectional studies, Lemmer and Wagner (2015) conducted a meta-analysis that provided insights into the effectiveness of interventions aimed at reducing ethnic prejudice through intergroup contact. The findings from their meta-analysis including 79 studies revealed a consistent reduction in prejudice resulting from these interventions, showcasing the potential for targeted actions to positively influence interethnic relations. Importantly, the effects were observed to be stable over time, underscoring the

enduring impact of interventions, even though the number of longitudinal designs in the study pool was relatively limited. Furthermore, the meta-analysis highlighted the efficacy of both direct and indirect interethnic contact in reducing prejudice. However, an intriguing result emerged: while effective overall, intergroup contact interventions were found to be less useful for minorities compared to majorities in mitigating interethnic prejudice.

2.1.2 Negative intergroup contact

The existing literature supports the effectiveness of positive intergroup contact as a means to alleviate prejudice (Pettigrew & Tropp, 2006; Lemmer & Wagner, 2015). However, it is essential to acknowledge the multifaceted nature of intergroup dynamics, recognizing that contact experiences are not exclusively positive. The understanding of negative intergroup contact is equally vital, yet the scholarly landscape reveals a notable asymmetry in research emphasis, with considerably fewer studies investigating negative contact experiences (Pettigrew & Tropp, 2006).

Past research, such as the foundational work by Baumeister et al. (2001) and Barlow et al. (2012), highlighted the asymmetry between positive and negative contact, showing that negative experiences carry greater psychological weight and more strongly predict increased prejudice than positive contact predicts reduced prejudice. Graf et al. (2014) further found that negative contact, despite being less frequent, had a stronger negative impact on outgroup attitudes than the positive impact of more frequent positive contact, possibly due to the valence-salience effect, where negative contact heightens category salience and generalization (Paolini, et al., 2010).

However, recent research suggests that positive and negative contact are qualitatively different and have distinct consequences depending on the context. For instance, Árnadóttir et al. (2018) found that positive contact nearly matched the detrimental effects of negative contact and could buffer against subsequent negative experiences. Paolini and McIntyre's (2019) meta-analysis encompassing 47 experimental studies confirmed the stronger influence of negative contact in stigmatizing contexts, but Fuochi et al. (2020) demonstrated that the impact of negative contact is more substantial in superficial interactions, while positive contact becomes more influential in intimate relationships. These findings indicate that while negative contact generally has a stronger effect, the context and nature of the contact play crucial roles in determining the overall impact on intergroup attitudes.

Moreover, negative contact is suggested to have different consequences than positive contact. Barlow et al. (2019) found that positive contact has a greater impact on positive emotions, while negative contact affects negative emotions. Aberson (2015) showed that both types of contact are similarly predictive of affective dimensions of prejudice, but negative contact is more strongly associated with cognitive dimensions like stereotypes. Meleady and Forder (2019) have, in turn,

evidenced a generalized avoidance effect of negative contact, when the negative intergroup contact reduces intentions to engage in contact not only with the contacted but also non-contacted outgroups in the future.

2.1.3 Affective mediators of intergroup contact

Research on the mediators of intergroup contact has traditionally explored both cognitive and affective variables. A seminal meta-analysis conducted by Pettigrew and Tropp (2008) investigated the three most frequently studied mediators: knowledge about the outgroup, intergroup anxiety, and empathy. The meta-analysis encompassed exhaustive samples, with knowledge about the outgroup involving 17 samples and 2,543 subjects, intergroup anxiety with 60 samples and 13,343 subjects, and empathy with 14 samples and 2,362 subjects. Pettigrew and Tropp's (2008) findings revealed that while increased knowledge about the outgroup has mediational value, its strength appears to be less pronounced compared to the reduction in intergroup anxiety and the increase of empathy.

In this section, I will delve into the role of empathy and intergroup anxiety as affective mediators in the context of intergroup contact.

2.1.3.1 Empathy

Empathy has gained increasing attention in empirical research on intergroup contact due to its role in facilitating positive interactions between individuals from different social groups. This heightened interest stems from the notion that positive intergroup contact may lead to improved intergroup attitudes through enabling individuals to adopt the perspective of outgroup members, thus empathizing with their experiences.

Empathy itself has been conceptualized through various lenses within the literature. On one hand, it has been viewed as a cognitive mechanism, often referred to as role-taking or perspective-taking, allowing individuals to adopt the viewpoint of others (Borke, 1971). On the other hand, empathy has also been conceptualized as an emotional mechanism, which involves individuals emotionally reacting to the internal states of others (Batson et al., 1987). While Pettigrew and Tropp's (2008) meta-analysis of intergroup contact mediators acknowledged this distinction, the insufficient amount of studies hindered a thorough examination of the separate effects of perspective-taking and affective empathy. Furthermore, empathy can be understood as both dispositional or trait empathy, representing a stable personality characteristic (Davis, 1980), and situational or state empathy, which refers to transient emotional responses in specific situations (Hein et al., 2018). This multifaceted understanding of empathy underscores its complexity and significance in the context of intergroup dynamics.

The conceptualization of empathy within social psychology has been greatly influenced by the work of Batson and colleagues (1987; 1997a; 1997b; 2005), who have offered a comprehensive framework for understanding affective empathy. According to Batson et al. (1987), situational empathy comprises two distinct components, namely empathic interest and personal distress. Empathic distress denotes the drive to lessen one's own negative arousal when experiencing empathy, whereas empathic interest is directed toward alleviating the needs of the other individual.

Several studies have demonstrated the relevance of empathy, particularly affective empathy, in mediating the effects of intergroup contact. For instance, Johnston and Glasford (2018) found that affective empathy mediated the relationship between positive intergroup contact and intentions to assist individuals from ethnic outgroups. Similarly, Hecht and colleagues (2021) observed that affective empathy played a mediating role in the improvement of attitudes toward individuals with mental illness following exposure to a video depicting their experiences.

Furthermore, affective situational empathy is a vital aspect in the realm of intergroup contact interventions. Studies have shown that evoking empathy for a person belonging to a devalued group can lead to beneficial consequences, including improved attitudes toward the specific individual and the broader group. Concerning the generalization of contact-specific empathy to empathy towards the whole outgroup, a study by Fuochi and colleagues (2020) underscored the strong correlation between affective situational empathy toward an individual with an immigrant background and empathy toward immigrants in general, underscoring the potential of situational empathy to go beyond individual interactions and foster empathy toward an outgroup at large. Interestingly, the degree of empathy generalization from the individual to the outgroup is influenced by the salience of the contacted outgroup. Fuochi et al. (2020) observed that category salience, namely the prominence of the contacted outgroup identity, moderates the extent to which empathy extends beyond the individual encounter. Those findings highlight the complex relationship between situational empathy and the broader intergroup context, suggesting that identity salience may influence empathy-mediated attitude change in intergroup settings.

2.1.3.2 Intergroup anxiety

Intergroup anxiety, as described by O'Donnell et al. (2019), is an emotional state that emerges during interactions between different social groups. It is characterized by a state-like anxious response towards members of an outgroup, particularly in situations perceived as threatening.

The Integrated Threat Theory of prejudice, proposed by Stephan & Stephan (1996), identifies intergroup anxiety as a key contributor to prejudice, outlining various factors influencing intergroup anxiety. The influencing variables, which include prior intergroup relations, intergroup cognitions, and situational factors, play a crucial role in shaping intergroup anxiety and its subsequent behavioral, cognitive, and affective consequences. The frequency and nature of past interactions significantly influence anxiety levels. Situations with a history of conflict between two groups can heighten intergroup anxiety, especially in competitive environments with limited resources and high stakes (Gudykunst, 1988, 1998). Intergroup cognitions, which encompass prior knowledge, expectations, and stereotypes about the outgroup, also contribute to intergroup anxiety. Greenland et al. (2012) identified two dimensions of intergroup anxiety: self-anxiety, related to fears of displaying prejudiced thoughts or behaviors, and other-anxiety, centred around concerns about potential actions from the out-group. Situational factors, including the structure, composition, and status of the social groups, are another determinant of intergroup anxiety. Lower status groups typically experience more anxiety compared to higher status groups. Furthermore, the size of the minority group is a key factor in perceived intergroup threat, with larger minority groups often perceived as more threatening, leading to increased intergroup anxiety among the majority (Quillian 1995, 1996). This perception of threat is not necessarily based on objective reality, but rather on subjective interpretations and biases.

The outcomes of intergroup anxiety encompass affective, cognitive, and behavioral dimensions (Stephan & Stephan, 1985). Affective outcomes include heightened emotional reactions and evaluations, regardless of whether interactions are positive or negative. Cognitive outcomes include information processing biases, motivational biases, and increased self-awareness, often leading to a greater reliance on stereotypes and stronger in-group identification. Studies have shown that intergroup anxiety is associated with reduced cognitive control (Amodio, 2009) and changes in physiological responses (Mendes et al., 2002). Behavioral responses primarily involve avoidance of the out-group, serving as a coping mechanism to reduce individual and intergroup anxiety levels.

However, successful interactions with out-group members can alleviate intergroup anxiety, leading to a realization that such encounters are not necessarily threatening (Crisp & Abrams, 2009). Thus, intergroup anxiety has been the most examined mediator of the impact of intergroup contact on attitudes towards outgroups (Brown & Hewstone, 2005; Pettigrew & Tropp, 2008; Stephan & Stephan, 2000). Furthermore, recent research by Fuochi and colleagues (2020) showed that quantity of contact was a significant moderator of the degree of generalization of intergroup anxiety from individual to outgroup level, with anxiety towards a single member of the outgroup being moderately correlated with anxiety towards the outgroup as a whole.

2.1.4 Common ingroup identity

While the sense of belonging to a shared, overarching ingroup does not serve as an emotional mediator in the impact of intergroup contact on attitudes, it seems to provide insight into the possible routes that link intergroup contact to prejudice (e.g., Eller & Abrams, 2003, 2004, 2006). The Common Ingroup Identity Model (CIIM; Gaertner & Dovidio, 2000; 2012), builds upon social identity theory (Tajfel & Turner, 1979) and self-categorization theory (Turner et al., 1987). These theories suggest that social categorization organizes individuals into ingroups and outgroups, with ingroup attachment providing both material and psychological benefits, such as sense of belonging and security (Correll & Park, 2005).

Social categorization is not static and can be influenced by contextual features (Dovidio et al., 2007). For example, an employee might see their department as their primary ingroup during a company meeting but adopt a company-wide identity when representing the organization at a conference. The CIIM leverages this flexibility to reduce intergroup bias by transforming the cognitive representation of two separate groups into one unified group (Dovidio et al., 2007). This process involves using cues to promote a superordinate identity, leading to the recategorization of former outgroup members as ingroup members and thus fostering more positive attitudes through ingroup bias.

More than two decades of research underscores the effectiveness of fostering a common ingroup identity in lessening intergroup bias. For instance, envisioning interactions with an outgroup member as part of a shared group enhances helping intentions and the intentions to engage in contact (Vezzali et al., 2015). Empirical tests have verified the efficacy of the CIIM across diverse settings, indicating that stronger perceptions of a shared superordinate identity result in more favorable intergroup attitudes in various contexts (e.g., Houlette et al., 2004; Guan et al., 2011). These studies further reveal that fostering a common ingroup identity not only improves attitudes but also increases the motivation for intergroup contact (Gómez et al., 2008) while promoting positive behaviors (Dovidio et al., 1997; Levine et al., 2005).

Furthermore, research indicates that a common ingroup identity may mediate the effects of intergroup contact on attitudes. Gómez et al. (2013) found that ingroup identity verification mediates the impact of intergroup contact on attitudes, both cross-sectionally and longitudinally. This suggests that the CIIM plays a critical role in shaping attitudes following intergroup contact, highlighting its relevance for prejudice reduction and the promotion of intergroup relations.

2.1.5 The Secondary Transfer Effect

Pettigrew's influential research in 1998 serves as a fundamental basis for exploring the Secondary Transfer Effect (STE) of contact. He distinguishes three distinct types

of attitude generalization, later grounded by Pettigrew and Tropp's comprehensive meta-analysis in 2006. The first form of attitude generalization unfolds when attitudes towards an individual extend to encompass the outgroup as a whole; the second type emerges as attitudes cross social contexts, spreading through different intergroup situations; the third type of attitude generalization occurs when attitudes towards one outgroup extend to attitudes towards other outgroups—a process known as secondary transfer effect of contact.

A meta-analytic examination of 18 tests (Pettigrew & Tropp, 2006), reported a modest yet statistically significant effect size ($r = -.19$, $p < .001$) of the STE, which found support also for the longitudinal persistence of the STE (Eller & Abrams, 2004; Van Laar et al., 2005).

In 2013, Lolliot's doctoral thesis emerged as a key contribution, providing an extensive body of cross-sectional and experimental evidence shedding light on the STE. The thesis comprised six studies investigating various forms of the STE and its underlying mechanisms in different national contexts. Lolliot's work demonstrated that contact with one group, such as Asians, improved attitudes toward homosexual men, and vice versa, indicating reciprocal positive attitude generalization between different groups. This work also supported the mediation of STE by diversity beliefs, affecting attitudes towards secondary outgroups via the primary group, and the attitude generalization gradient (Harwood et al., 2011), where attitudes generalize more strongly towards groups perceived as similar in warmth and competence, compared to less warm and competent groups. Further, Lolliot's research supported the deprovincialization hypothesis, showing that intergroup contact reduces ethnocentric views and prejudice towards secondary outgroups. It also linked social dominance orientation (SDO) with ingroup identification, finding that high-SDO individuals had more negative outgroup attitudes. Additionally, it was showed that attitude generalization is more pronounced for groups facing similar types of stigmatizations. Finally, Lolliot (2013) provided experimental evidence from a South African sample, showing that extended contact, rather than direct contact, leads to stronger attitude generalization. This suggests that extended contact is more likely perceived as intergroup interaction due to heightened group identity salience.

In their review of 43 studies conducted in 2021, Vezzali and colleagues provide an extensive analysis of the several mediators hypothesized to contribute to the STE. Vezzali et al.'s (2021) categorization organizes these mediators into three distinct categories, namely mediators involving outgroup perceptions, ingroup representation, and changes in the self.

The first category, outgroup perceptions, expands the traditional attitude generalization mediator to encompass intergroup emotions, outgroup morality, and intergroup threat. Intergroup emotions such as intergroup anxiety and empathy are established mediators for direct contact effects on attitudes, but cross-sectional evidence has also emerged about empathy and intergroup anxiety mediating the STE of contact (e.g., Turner & Feddes, 2011; Giovannini and Vezzali, 2011). While a single

correlational study offers evidence supporting the role of perceptions of morality mediating the STE for both majority and minority group members (Vezzali et al., 2019), the mediation role of intergroup threat remains somewhat controversial, with conflicting evidence hinting at its potential involvement in mediating the STE (see Mähonen & Jasinskaja-Lahti, 2016; Zingora & Graf, 2019). The second category, involving ingroup representation, involves the deprovincialization hypothesis (Pettigrew, 1997, 1998) and social identity complexity (Schmid et al., 2013), while the final category identified by Vezzali et al.'s review (2021) revolves around personal traits, such as SDO (Shook et al., 2016; Vezzali et al., 2018).

While the STE has predominantly been associated with positive intergroup contact, emerging research suggests its presence even in instances of negative intergroup interactions (e.g., Brylka et al., 2016; Lissitsa & Kushnirovich, 2018). However, investigation into the STE of negative contact remain limited, as the review by Vezzali et al. (2021) identified only 9 out of 43 studies that explored this phenomenon. Meleady and Forder (2019) discovered an avoidance generalization effect, indicating a decreased willingness to engage with secondary outgroups at large following negative contact with the primary outgroup. The implications of such effects could be significant, potentially leading to social segregation and exacerbating intergroup conflict. However, evidence for the avoidance generalization effect is still in its initial stages. A recent large-scale longitudinal study by Kauff et al. (2023) aimed to test the STE of negative intergroup contact and its mediating variables but did not yield conclusive evidence. While the study did not find final evidence for the STE of negative contact nor its mediation by attitude generalization, ingroup identification, or diversity beliefs, it is worth noting that the research came with limitations, including single-item measures of attitudes. However, another longitudinal study by Henschel and Kötting (2023) presented different findings, showing evidence of the STE of negative contact. Additionally, they observed a mediating effect of attitude generalization and multiculturalism, although results did not support the mediation of intergroup threat. It is important to note that the primary (immigrants) and secondary (refugees) outgroups in this study partially overlapped, representing a notable weakness. Recent findings in research on the STE of negative contact underscore the need for further investigation to address these contradictory contributions and shed light on the mechanisms underlying the STE of negative intergroup contact.

2.1.6 Explicit and Implicit Attitudes

Understanding outgroup attitudes involves examining both explicit and implicit attitudes, two distinct yet interconnected constructs. Explicit attitudes are generally assessed using self-report scales, which rely on individuals' conscious self-assessment and reporting of their attitudes. Even subtle measures like the Modern

Racism Scale (McConahay, 1986) are deemed explicit as they mirror deliberate thought processes and are influenced by conscious attitudes (Axt, 2017; Dovidio et al., 2002).

On the other hand, implicit bias is rooted in automatic cognitive processes and associations (Greenwald & Krieger, 2006; Pearson et al., 2009). Such bias is triggered by the presence, either actual or symbolic, of attitude targets, highlighting their less regulated nature (Pearson et al., 2009). The Implicit Association Test (IAT; Greenwald et al., 1998), is a popular instrument to measure these automatic associations, which captures the speed and accuracy of responses to different concepts (Greenwald et al., 1998). However, the IAT and the term "implicit" have been subject to varying interpretations. The term "implicit" is defined by some with reference to measurement tools that apprehend psychological attributes without soliciting them directly (Greenwald & Banaji, 2017), whereas others emphasize its inherent automatism of mental representations and reactions (Moors, 2016). This diversity in understanding necessitates a cautious approach to interpreting the results of implicit measures, since it implies that the processes underlying these responses should be treated as theoretical hypotheses warranting empirical evaluation (Rothermund et al., 2020; Van Dessel et al., 2020).

Explicit and implicit measures serve thus distinct roles in capturing different facets of psychological constructs. Explicit measures tap into explicit attitudes, often influenced by social desirability when concerning sensitive topics, reflecting individuals' conscious self-assessment of their attitudes. In contrast, implicit measures tap into automatic associations less accessible to conscious introspection, thus being less susceptible to social desirability biases (Greenwald & Krieger, 2006; Pearson, et al., 2009).

The relationship between implicit and explicit attitudes has been extensively studied, revealing that these constructs, while distinct, have a small but meaningful correlation. Meta-analyses by Hofmann et al. (2005) and Greenwald et al. (2009) reported average correlations of .24 and .21, respectively, indicating that they capture different facets of attitudes. Specific studies on outgroup bias show even lower correlations, highlighting the independence of these measures (e.g., Fazio et al., 1995).

The predictive validity of implicit and explicit measures varies significantly, with each predicting different kinds of behaviors. Predictive relations are influenced by the correspondence principle, which states that greater predictive accuracy is achieved when implicit measures match the processing conditions of the behaviors they aim to predict (Ajzen & Fishbein, 1977). Implicit measures are better predictors of spontaneous, low-deliberation behaviors, whereas explicit measures are more effective for deliberate actions (Fazio, 2007; Strack & Deutsch, 2004). Therefore, explicit biases have been linked to controlled behaviors, such as verbal expressions and self-reported actions (Wilson et al., 2000; Dovidio et al., 2002; Fazio et al., 1995). In contrast, implicit biases are more predictive of automatic, nonverbal

behaviors, such as mimicry, which are often beyond conscious control (Word et al., 1974; McConnel & Leibold, 2001). Greenwald et al. (2009) found that implicit biases (r = .24) were better predictors of discriminatory behavior than explicit biases (r = .12), emphasizing the significant role of automatic processes in shaping behavior.

Despite the utility of both measures, several challenges remain. One significant issue is the low temporal stability of implicit measures, which can undermine their predictive value over time (Friese et al., 2008; Perugini et al., 2010). Aggregating data from multiple administrations of the same implicit measure at different points in time has been suggested as a potential solution, though its practicality is debatable (Greenwald et al., 2020; Ajzen, 1987).

Another challenge is ensuring reliability and comparability between implicit and explicit measures. Implicit measures often show lower internal consistency, failing to meet the psychometric standards applied to explicit measures (Gawronski & De Houwer, 2014; Greenwald & Lai, 2020). Additionally, discrepancies in focal stimuli used in these measures can lead to ambiguities in interpreting their differences (Gawronski, 2019; Payne et al., 2008).

The importance of using both implicit and explicit measures lies in their ability to provide a more comprehensive understanding of attitudes and behaviors. Implicit and explicit biases together offer incremental validity in predicting discriminatory behaviors, capturing variance that neither measure can account for alone (Greenwald et al., 2009). Explicit and implicit attitudes also interact to influence behavior, with their effects varying based on the context and nature of the behavior being predicted (Dovidio & Gaertner, 2004; Gaertner & Dovidio, 1986). Furthermore, the dual attitudes that individuals hold—where explicit and implicit attitudes may differ—can lead to complex patterns of behavior reflecting both conscious beliefs and automatic responses. This interaction suggests that comprehensive assessments of bias and prejudice require consideration of both types of measures to fully understand and address these phenomena in social contexts (Greenwald et al., 2009).

2.2 Virtual reality

As a transformative medium, VR is reshaping the way we interact with digital environments and each other, offering unprecedented opportunities for studying and reducing prejudice. In this chapter, I will begin by defining VR and outlining its main features, providing an overview of what constitutes VR and how it differentiates from other forms of digital interaction. This will be followed by an exploration of the current state-of-the-art VR technology, delving into the hardware and software powering immersive experiences.

Moving forward, I will delve into a critical evaluation of VR as a tool for studying and reducing prejudice.

Finally, I will address the risks and ethical challenges associated with the use of VR.

2.2.1 Definitions and Features

The definition of VR remains a subject of ongoing discourse, reflecting the intricacies related to this evolving technology. Jaron Lanier is credited with introducing the term in the late 1980s, initially conceptualizing VR as a technology that utilizes computerized clothing—primarily glasses and gloves—to synthesize a shared reality (Lanier, 1988). VR operates by recreating our interaction with the physical world through our sense organs (eyes, ears, nose, mouth, and skin). This transformative experience occurs after wearing the specialized clothing, offering an alternative perception of reality beyond the physical world. In essence, VR redefines our relationship with the digital environment by augmenting sensory input.

Building upon this, Burdea and Coiffet (2003) describe VR as an interface that situates users in an interactive simulation which stimulates multiple sensory channels, contrasting it with conventional desktop computers that provide exclusively visual and auditory stimulation. Ambrosio and Fidalgo (2020) propose that three core elements characterizing VR can be extrapolated: immersion (achieved through multisensory experience), presence, and interactivity.

The development of VR has been marked by several technological milestones. Although Sega announced a VR headset with LCD screens and earphones in 1991, which aimed to provide immersive experiences, it was ultimately cancelled, leading to a period of stagnation in VR development. After more than two decades, the 2010s saw a resurgence in VR development, resulting in heightened realism and a renewed interest in its possibilities (Della Croche et al., 2016). Head-Mounted Displays (HMD) with motion tracking systems allow software to respond to user actions and provide a fully immersive 3D simulated environment. The headset in HMD systems creates depth perception by generating two stereoscopic images with offset viewpoints, which induces binocular disparity and blocks the visual perception of the real world. This level of immersion enables users to feel as if they are actually in the virtual environment, a phenomenon known as presence. According to Wilkinson et al. (2021), the degree of presence enabled by a VR device affects the immersive nature of the virtual environment. In other words, a higher level of immersion leads to a stronger sense of presence. As a result, immersion and presence are key features of VR technologies, as emphasized by Ryan (2015).

VR systems comprise both input and output devices, which play different roles in shaping the user's interaction with the virtual environment. Input devices, which allow user agency within the virtual world, encompass a spectrum of tools, from basic joysticks to sophisticated hand controllers or gloves equipped with finger tracking technology. Traditional input devices used with desktop computers are

mouse and keyboards. Input devices empower users to actively influence and navigate the virtual landscape, facilitating an interactive user experience.

Conversely, output devices serve the purpose of conveying information from the virtual world to the user's sensory perception. Essentially, they translate virtual content into sensory stimulation. Output devices enable users to visualize, hear, and touch the virtual environment. Examples of output devices include speakers, haptic devices providing tactile feedback, and screens. Notably, HMDs themselves function as output devices.

2.2.2 Research on Social Interactions in VR

The integration of VR into social scientific, particularly social psychological research is acclaimed as a transformative innovation, owing to its unique features, such as immersiveness. The features of VR offer researchers unprecedented opportunities to enhance the control of experimental manipulations, particularly compared to traditional field experiments. Unlike field experiments where environmental variables are challenging to manage, VR provides a controlled and customizable virtual environment where researchers can manipulate stimuli in terms of nature, onset, and duration. This heightened control opens avenues for exploring social phenomena with a precision unattainable in traditional laboratory settings. The high degree of customization inherent to VR environments allows researchers to tailor experimental protocols according to the design-specific requirements. This flexibility not only allows for the creation of dynamic and responsive virtual scenarios, but also enhances the ecological validity of experimental designs, namely the generalizability and fidelity of experiences across research settings and the physical world. The immersive nature of VR environments lends itself to the creation of scenarios that closely mirror real-world experiences, allowing researchers to capture the multifaceted nature of social interactions with greater sense of authenticity. However, it is essential to acknowledge a potential limitation in the ecological validity of VR, stemming from the challenge of precisely replicating human actions within virtual environments. While VR excels in providing immersive experiences, the extent to which these experiences faithfully mirror the complex behaviors observed in the physical world remains contingent on the fidelity of interactions replicated within the virtual space. Thus, the ecological validity of VR is intricately linked to the capability of design features to match those of the physical world. Researchers face the task of ensuring that the virtual environments they construct represent the contextual intricacies encountered in the physical world. This consideration underscores the importance of thoughtful design of VR scenarios to align with the ecological validity required for meaningful social psychological research.

In their seminal article, Blascovich and colleagues (2002) explored the potential of VR as a tool for investigating social psychology. Their work not only shed light on the initial applications of VR in this field but also laid the theoretical foundation for subsequent research. Blascovich et al. (2002) anticipated current trends and challenges in social psychology by addressing the ongoing trade-off between experimental control and ecological validity. While field experiments were praised for their high ecological validity capturing real-world complexities, they were criticized for their susceptibility to extraneous variables and the difficulty of quantitatively coding observed phenomena. On the other hand, laboratory experiments, which provided meticulous control over variables, often lacked the context essential to social psychological phenomena. Blascovich and colleagues (2002) recognized the need for a paradigm that could reconcile this trade-off, proposing that VR could be a viable solution. VR's immersiveness and adaptability allowed social psychologists to conduct experiments without sacrificing control or ecological validity, bridging the gap between tightly regulated laboratory conditions and real-world social interactions. The authors also emphasized that VR's key advantage over traditional telecommunications media lies in its ability to provide presence, achieved through immersion in virtual environments. In the context of social psychological research, the concept of presence is as critical as social presence, and VR delivers a variety of signals that convey the presence of other individuals in a way similar to face-to-face interactions.

Blascovich et al.'s (2002) theoretical model proposes that the level of social influence in VR is influenced by two interrelated factors: behavioral realism and social presence. Behavioral realism refers to how closely avatars and virtual entities in VR mimic real-world behavior, while social presence concerns the participant's perception of actually being present and interacting with real human beings in real time within the virtual environment. According to this model, social influence effects in VR occur when there is a complementary relationship between behavioral realism and social presence, reaching or exceeding a threshold. In simpler terms, if the sense of being present with real people is high, the realism of their behavior need not be as high for social influence effects to take place, and vice versa.

2.2.3 The Use of VR for Studying Prejudice

The research utilizing VR to study and combat prejudice is in its infancy, but rapidly accumulating. Christofi and Michael-Grigoriou (2017) provided the first overarching view of the studies using VR as a tool for reducing prejudice. The review includes a total of 11 studies and shows that embodying different virtual bodies in VR can reduce bias and foster empathy towards different stigmatized groups classified according to Goffman's (1963) forms of social stigma: overt deformations, deviations in personal traits, and tribal stigmas. In their review, the authors discuss various

measures of empathy used in research, including physiological responses, behavioral methods, and the Interpersonal Reactivity Index (IRI). For prejudice measures, they note self-reports and implicit measures as being commonly used. The authors suggest that VR has a potential to induce perspective-taking and empathy and through them reduce negative stereotyping.

Christofi and Michael-Grigoriou's (2017) paper is notable for its attempt to provide a comprehensive overview of VR's potential in reducing prejudice, highlighting the transformative power of VR in fostering empathy and reducing bias. However, the review also has notable limitations. Notably, it is not systematic, including only a small portion of the published studies, which may not provide a complete picture of the field. Additionally, while there is a focus on empathy, this sometimes overlaps with the goal of reducing prejudice. While the methodology of the included studies is discussed in detail, the actual effectiveness of these VR interventions is not explored as thoroughly, leaving a gap in understanding the practical outcomes of these studies. Moreover, while the authors focus extensively on the embodiment of outgroup members as a means to reduce prejudice, the potential of VR to recreate intergroup contact is overlooked. Finally, the study lacks a thorough examination of the mediators and moderators that could influence the effectiveness of VR interventions.

Addressing the heterogeneity of VR interventions that Christofi and Michael-Grigoriou (2017) also noticed, a recent critical review by Chen and White (2024) underlines the lack of standardization in immersion and presence levels across studies aiming to reduce prejudice through VR interventions, which hampers cross-study comparisons. Furthermore, considerable challenges exist in adapting VR to fit within traditional prejudice reduction frameworks, further complicating the research landscape (Breves, 2018). To address these issues, Chen and White (2024) propose a new guiding framework based on dimensions that influence VR immersion and presence, aiming to provide a standardized approach that can enhance the comparability and efficacy of VR interventions. The framework consists of two primary dimensions: the type of VR input device and the level of interactivity and mobility within the virtual environment.

The first dimension, VR input devices, categorizes devices into two types based on their impact on user interaction and the level of immersion they offer. Category 1 devices include motion-tracking technologies such as full-body motion capture systems and bend-sensing gloves. These devices allow for full-body interaction within the virtual environment, significantly enhancing both immersion and presence. In contrast, Category 2 devices encompass more traditional desktop equipment, such as joysticks, keyboards, hand controllers, and mice. While these devices are more cost-effective and user-friendly, they offer lower levels of immersion and presence compared to motion tracking devices.

The second dimension, interactivity and mobility, classifies VR experiences based on the degree of freedom and interaction users have within the virtual environment.

It includes three distinct levels: Interactive VR, Limited Mobility VR, and 360°-3D VR Video. Interactive VR allows users to move and interact freely, facilitating intergroup contact and avatar embodiment, while Limited Mobility VR offers users restricted movement and interactivity within the virtual environment. The third level, 360°-3D VR Video, involves users watching videos without any interaction, resulting in the least immersion and presence. While Chen and White's framework aims to standardize the evaluation of VR interventions in prejudice reduction, empirical testing of this framework is necessary to confirm its effectiveness and to explore additional variables that may influence outcomes, such as technology literacy and advancements in VR technology (Gitlow, 2014). As VR technology continues to evolve, it is crucial that researchers build on up-to-date frameworks to identify and classify their VR strategies, enabling better comparability of methods and findings in the pursuit of effective prejudice reduction interventions.

Despite these advancements, there is a pressing need to update and further develop our understanding of the effectiveness and mechanisms of prejudice-reducing interventions in VR. It is particularly important to determine whether the perspective of majority or minority group members is more effective and to identify VR-specific mediators and moderators that should be acknowledged. Additionally, there is a critical need to develop theory-driven interventions. The contact hypothesis (Allport, 1954), which has proven effective in a wide range of settings, offers a promising foundation for such interventions. Furthermore, including well-known theoretical mediators, such as emotional responses, could enhance these interventions. Building on previous research on the CIIM (Gaertner & Dovidio, 2000, 2012), in this doctoral dissertation I will propose the concept of Common Cyber-Identity (CCI), denoting a shared social identity with individuals encountered in VR. The CIIM could be applied within VR environments to test its potential for reducing prejudice in the context of intergroup contact. Another promising area for exploration is the STE of contact, which examines how changes in attitudes towards one outgroup can influence attitudes towards other outgroups. By investigating these aspects, research can aim to develop comprehensive and effective VR-based interventions for prejudice reduction.

3 Aims

The aim of this study is to comprehensively understand and leverage the use of VR as a medium for studying and reducing prejudice through intergroup contact. To achieve this, it was necessary to systematize previous research and to develop and test a theory-driven intervention aimed at reducing prejudice in VR settings.

The first aim of this doctoral dissertation pointed at establishing the current landscape and progress of research concerning intergroup contact in VR and its role in prejudice reduction. This endeavour was particularly crucial as research lacked a comprehensive examination of evidence concerning the effect of intergroup contact in VR. To lay a robust foundation for experimental and correlational studies on intergroup contact in VR and its impact on prejudice, a systematic review was conducted. The main aim of the systematic review was to explore the methods used to study prejudice towards stigmatized minority groups in VR and assess their overall effectiveness. To guide this exploration, a set of pre-registered research questions[1] were formulated for Study I (systematic review):

> RQ1a: How has virtual reality been utilized to investigate prejudice towards stigmatized minority groups?
>
> RQ1b: To what extent do VR interventions based on intergroup contact succeed in decreasing prejudice?
>
> RQ1c: Which variables serve as mediators or moderators in influencing the impact of VR-based intergroup contact on prejudice?
>
> RQ1d: What are the methodological strengths and weaknesses inherent in VR-based intergroup contact in comparison to conventional forms of intergroup contact?

Informed by the results of Study I, in this doctoral dissertation I will employ experimental investigations of positive contact in VR with an avatar representing an

[1]The research questions pre-registered for the systematic review can be accessed via the following link: https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=222294

outgroup member, notably focusing on Allport's optimal contact condition, to ascertain the efficacy of contact-based interventions in VR to increase empathy (Study II) and reduce prejudice (Studies III-IV). Furthermore, I will compare the effect of positive contact in VR with that of negative contact, introducing an element of competition with the outgroup through a zero-sum game (Study III). Specifically, I ask the following research questions:

RQ2a: Do the effects of positive (cooperative) VR intergroup contact differ from ingroup contact in VR concerning various aspects of empathy? (Study II)
RQ2b: Do body ownership and co-presence affect empathy in VR? (Study II)
RQ3a: Does positive (cooperative) intergroup contact in VR improve intergroup attitudes compared to positive intragroup contact? (Study III)
RQ3b: Does positive (cooperative) intergroup contact in VR improve intergroup attitudes compared to negative (competitive) intergroup contact? (Study III)

A further aim of this dissertation is to explore potential mediating mechanisms of the effect of intergroup contact in VR, including established emotional mediators of intergroup contact such as empathy and intergroup anxiety, particularly in their interaction with variables related to virtual immersion and presence (Studies II-IV). Moreover, particular emphasis will be placed on identity-related mediators, which have not previously been studied in VR contexts. Specifically, I will elaborate on the concept of Common Cyber-Identity (CCI), namely a collective social formed with individuals met in VR, and test it as a potential mediator of the contact effect (Study III). My research questions are:

RQ4a: Do intergroup emotions (i.e., intergroup anxiety and empathy) mediate the effects of positive and negative intergroup contact in VR on intergroup attitudes? (Study III)
RQ4b: Does Common Cyber-Identity (CCI) mediate the effects of positive and negative intergroup contact in VR on intergroup attitudes? (Study III)

Investigating the potential of the Secondary Transfer Effect (STE) of intergroup contact in VR, encompassing both positive and negative interactions, bears significant implications, as the potential transfer of positive attitudes from directly contacted outgroups to those not directly engaged in contact would offer a mechanism for positive VR contact experiences to influence intergroup relations beyond the virtual realm. The STE of contact and its mechanisms have not been previously examined in VR and will be addressed in Study IV. The research questions guiding this part of my dissertation are:

RQ5a: Does positive (cooperative) intergroup contact in VR with a primary outgroup improve outgroup attitudes towards secondary, non-contacted outgroups differently compared to positive intragroup contact? (Study IV)

RQ5b: Does positive (cooperative) intergroup contact in VR with a primary outgroup lead to improved outgroup attitudes towards secondary, non-contacted outgroups compared to negative (competitive) intergroup contact with the primary outgroup? (Study IV)

RQ5c: Does negative (competitive) intergroup contact in VR with the primary outgroup result in more negative attitudes towards secondary outgroups compared to negative (competitive) intergroup contact with the primary outgroup? (Study IV)

RQ6a: Does the improvement in attitudes towards the primary outgroup following positive contact in VR mediate the effect of contact on attitudes towards secondary outgroups? (Study IV)

RQ6b: Is the effect of intergroup contact with an outgroup on attitudes towards a secondary, non-contacted outgroup mediated by decreased intergroup anxiety towards the secondary outgroup? (Study IV)

Importantly, the hypotheses of Studies III and IV have been pre-registered before data collection, ensuring transparency and rigor in the research process[2]. Studies III and IV will incorporate a wide range of attitude measures, encompassing explicit, implicit, and behavioral assessments.

[2] The pre-registered experimental hypotheses for Study III are available at https://osf.io/eda4x , and for Study IV, they can be accessed at https://osf.io/dgqj9 .

4 Materials and methods

The methodology employed in this doctoral dissertation encompassed a range of different approaches to address the research questions.

Study I constituted a systematic review, aimed at investigating the use of VR to enact intergroup contact and its subsequent impact on prejudice reduction.

Study II focused on the influence of positive intergroup contact in VR on different components of empathy levels among a Finnish sample.

Study III concentrated on the direct impact of both positive and negative intergroup contact in VR on explicit and implicit attitudes towards the outgroup, while also assessing the mediation role of intergroup anxiety, empathy, and CCI. The study encompassed two sub-studies, the first examining a Finnish sample (the same used in Study III), and the second examining an Italian sample.

Study IV concerned the STE of positive and negative intergroup contact in VR on attitudes towards various secondary outgroups, and also evaluated the mediation role of intergroup anxiety. Similar to Study III, Study IV comprised two sub-studies, utilizing the same datasets of Study III.

Three out of the four studies were pre-registered on either the PROSPERO register (Study I) or the Open Science Framework (Studies III and IV), and all methods were followed unless specified otherwise in the articles.

The studies are part of the PREVENT project ("Development of the neurobiologically and social scientifically informed approach to prejudice and its reduction") funded by Academy of Finland (grant 332311), which received ethical approval by the Research Ethics Committee of Aalto University under the decision number D/218/03.04/2021.

All scales (reported in full in Appendix 1) were translated from English to Finnish or from English to Italian, depending on the relevant sample.

4.1 Study I

4.1.1 Search strategy

To systematically gather relevant literature on virtual reality and intergroup relationships, we developed a robust search strategy. First, we established 16 search

terms, which were selected to encompass various aspects related to VR and intergroup dynamics. The specific terms used resulted in the following search string: *(Vr OR virtual reality OR immersive virtual environment OR simulation-based assessment OR virtual reality exposure therapy OR virtual OR augmented reality) AND (intergroup relations OR ingroup outgroup OR prejudice OR discriminat* OR bias OR stereotyp* OR stigma* OR intergroup attitude* OR outgroup attitude*)*.

Following the development of our search terms, we implemented the search across three major academic databases: PsycInfo, Scopus, and Web of Science. These databases were chosen for their extensive coverage of literature relevant to the field of interest. The finalized search strategy was executed within each database following tailoring of the search syntax[3].

Our search encompassed articles published until January 2022, and was limited to articles published in English, German, Finnish, or Italian.

Following the initial search process and removal of duplicates, a total of 15,504 citations remained for screening. For a detailed overview of the search and screening process, including a visual representation of study selection, refer to the PRISMA flow diagram presented in Figure 1.

The authors of all included studies identified through title and full-text screening were contacted to inquire about additional articles and unpublished data. This approach aimed to minimize potential publication bias and ensure a comprehensive review of the literature.

Following the screening process, the final sample comprised 64 studies. Among these, 51 were published in peer-reviewed journals, 11 were presented as conference papers, and two were doctoral dissertations. Furthermore, four of the 64 included studies were provided directly by authors in response to our inquiry.

[3] The detailed search strategy can be accessed through the following link: https://mfr.de-1.osf.io/render?url=https://osf.io/rp3wg/?direct%26mode=render%26action=download%26mode=render

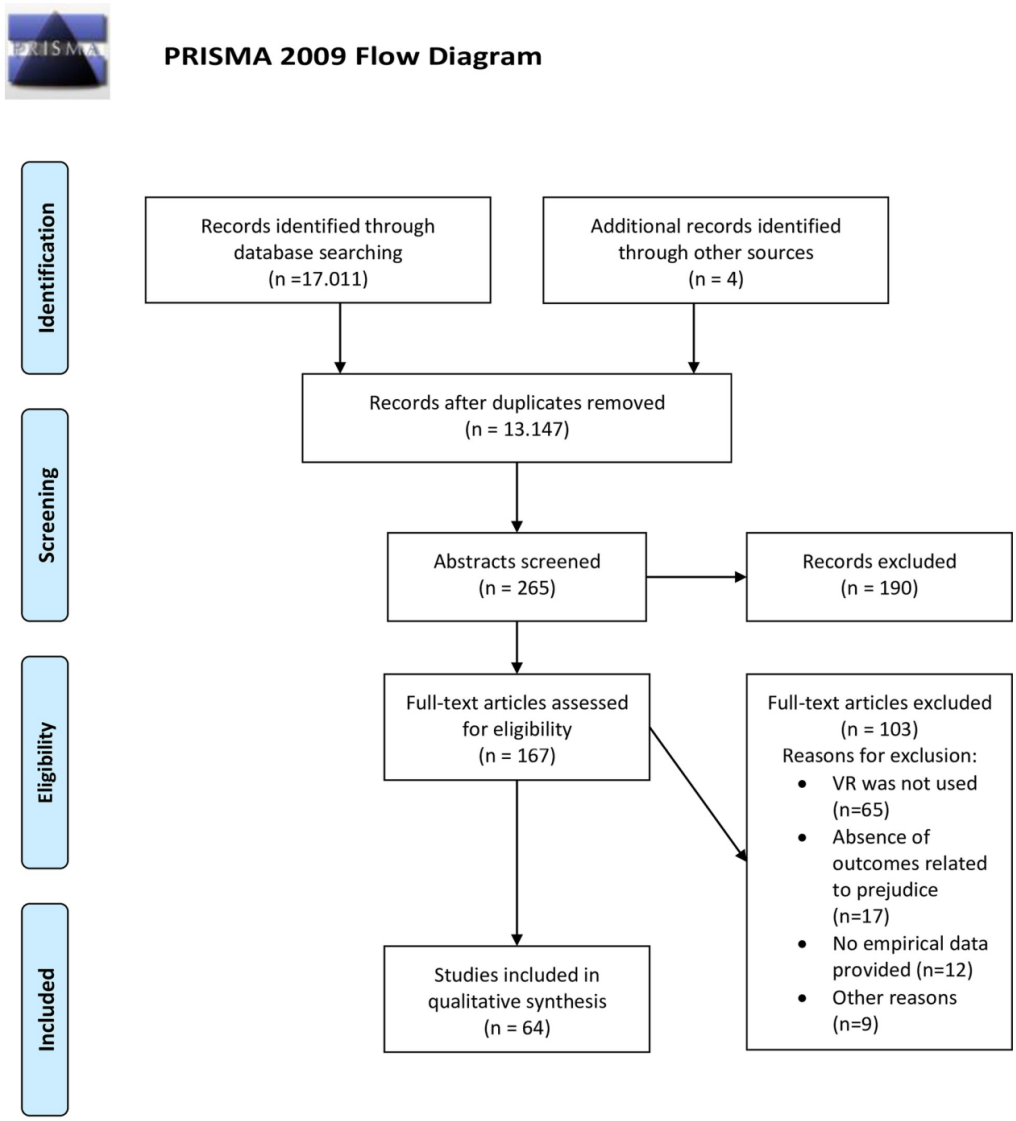

Figure 1 PRISMA flow diagram.

4.1.2 Inclusion criteria

In our systematic review, we applied a set of inclusion criteria to ensure the relevance and quality of the included studies.

Firstly, we excluded qualitative studies and opinion pieces, focusing exclusively on empirical research.

We then examined the method used in the pool of studies, including only studies employing immersive virtual reality (IVR) methodology. Specifically, we included studies where participants either engaged in VR experiences using a head-mounted display, were situated in rooms transformed into virtual environments via projectors or utilized devices inducing augmented reality. While augmented reality studies were not initially pre-registered, we decided to include them due to their significant methodological similarities with immersive VR experiences. Studies exclusively utilizing laptops or desktop computers were not eligible for inclusion.

Furthermore, we established criteria related to intergroup contact. Participants in the eligible studies were required to take on the role of an avatar representing an outgroup, adopt the perspective of a social group they did not belong to, or engage in interactions with at least one member of an outgroup within the virtual environment.

In the case of intervention studies, we included those featuring control groups receiving interventions to reduce prejudice, either outside of VR (e.g., perspective-taking exercises) or through intragroup contact experiences within VR. Control groups could also not face any social interaction.

Lastly, to be eligible for inclusion, studies were required to report at least one measure of intergroup bias.

4.1.3 Data extraction

The data extraction process was carried out by the first two authors, who conducted all literature searches and screened titles, abstracts, and full-text articles individually. At each stage of the selection procedure, any title or abstract deemed relevant by either researcher proceeded to the next step of the selection process.

Following individual screening, both authors collaboratively reviewed and agreed upon the final set of articles to be included in the systematic review. In instances where disagreement arose regarding the inclusion of an article ($k = 8$ articles), the third author was consulted. The ultimately included 64 studies, which were documented in 62 separate articles.

Subsequently, data were extracted from each of the included studies. The extracted data encompassed various key aspects, including year of publication, study design, country of data collection, characteristics of the sample, the VR apparatus used, the group targeted by prejudice, the representation of outgroups in VR (e.g.,

360º video, avatars, virtual agents), the design of intergroup contact, the measure of intergroup bias, and finally any examined mediators and moderators.

4.1.4 Risk of bias

To evaluate the risk of bias across the included studies, we utilized the Cochrane Collaboration's tool (Higgins et al., 2019). We assessed various domains of bias, including performance bias, attrition bias, detection bias, selection bias, and reporting bias. Each domain was categorized as either high, low, or unclear risk of bias.

The assessment of bias for all studies was conducted independently by the first authors. In cases where discrepancies arose between the individual assessments, they were resolved through critical discussion between the evaluators.

4.2 Study II

4.2.1 Participants

Sixty-four participants were involved in the experiment, and randomly assigned to one condition. The average age was 20 years in the experimental condition (n1 = 32), with minimal prior experience with VR. In contrast, participants in the control condition (n2 = 32) had an average age of 17 years[4]. Similar to the experimental group, participants in the control group had minimal to no prior VR experience. Among the participants in the control condition, 29 out of 33 identified as White, with an additional four participants of Asian ethnicity and one reporting African background. To maintain consistency in the analyses, the data from this participant were excluded, resulting in a final count of 32 participants in the control group. In the experimental setup, all 32 participants identified as White, with one individual identifying as Asian.

[4] The age discrepancy between the groups arose from modifications in the recruitment approach, with a shift towards targeting high school students following the initial recruitment of university students.

4.2.2 Procedure

Data collection occurred between May and November 2021, with participants required to acknowledge an informed consent form prior to participation. For participants under 18, approval from their legal guardians was necessary to participate in the experiment, along with the participants' own acknowledgment of the informed consent form. As compensation for their participation, each participant received a 10EUR gift card upon study completion.

Participants completed an online pre-test questionnaire using Psytoolkit (Stoet, 2010, 2017) and then scheduled a session to engage in the VR experiment at Aalto University in Espoo, Finland. The pre-test questionnaire encompassed demographic information and various baseline measures, with the entire process lasting approximately 20 minutes and taking place 3 to 7 days before the VR experiment.

All participants were situated in laboratory settings for the experiment. They received guidance from the experimenter on how to utilize the Oculus headset and received assistance in adjustments as needed, including the addition of adapters for those wearing glasses. Subsequently, participants commenced the Altspace tutorial to familiarize themselves with navigating the environment and controlling their avatars. Upon completion of the tutorial, participants were tasked with creating avatars resembling themselves, a step taken to enhance the sense of body ownership and the relevance of the experience. This process also aimed to establish an expectation that other players in the game had similarly personalized their avatars, thus promoting a sense of group membership. Following avatar customization, participants embodied their avatars throughout the experience.

The experimenter then guided participants to the first virtual environment (Figure 2), wherein the experimenter's avatar (Figure D) was also present, controlled from a separate location via a desktop computer.

Figure 2 The virtual space where the ball toss game took place (shown above), and the waiting room (depicted below).

Upon arrival, the participant encountered the following set of instruction:

"*We now ask you to play ball toss with another participant in the experiment, that is playing simultaneously from another location. You and your partner belong to the SAME TEAM and need to score 10 points by throwing the red and blue bags through the hole on the board (1 point = bag through the hole). You can find the*

bean bags next to the game board. You and your partner are supposed to TAKE TURNS at throwing. The game is over once you have scored a total of 10 points as a team. Another team is currently playing or will shortly begin to play in another room. The team that will score 10 points first will be the winner. Please, we ask you to respect TURN TAKING with your partner. The game starts when you are ready. Please, position yourself on the opposite side of the other player. YOU throw first. The experimenter informs when you have reached 10 points. Good luck!"

Shortly afterward, a third avatar, controlled by a confederate (Figure 3A and 3B), would enter the room. Communication between avatars was limited to non-verbal gestures, so not to compromise the standardization of the experience. However, participants could engage with each other by waving and sending emojis.

Figure 3 The Avatars Representing the Ingroup (Control Condition, A1, A2), an Individual with African Ethnic Background (Experimental Condition, B1, B2), a Middle Eastern individual (Both Conditions, C1, C2), And the Experimenter (D).

Depending on the randomly assigned condition, participants engaged in a cooperative ball toss game with an avatar representing a White (control) or a Black (experimental) avatar. Randomization was achieved using the online tool Research Randomizer 4.0 (Urbaniak & Plous, 2013). Upon reaching a team score of 10 points between the participant and the confederate, the experimenter halted the game. Subsequently, participants were directed to enter a separate virtual room (refer to Figure 2) while team scores were computed. In this room, participants received the following message: "*The other team is still playing or we are assessing scores and game time. Please, take a seat while we set the next stage of the experiment. We will let you know the results as soon as possible.*" Another avatar, controlled by the

confederate via a desktop computer, was positioned at the farthest seat and displayed Middle Eastern physical features (Figure 3C), irrespective of the experimental condition. Participants spent 3–5 minutes in this room to familiarize themselves with the new environment and find a seat. Similar to the prior phase, communication between avatars was limited to non-verbal gestures. Following this period, participants were informed of their team's victory and instructed to remove the headset when ready.

Afterward, the participant completed a post-test questionnaire via Psytoolkit (Stoet, 2010, 2017). Additionally, participants provided feedback on their VR experience. After the post-test questionnaire, participants received a debriefing regarding the study's objectives.

4.2.2.1 Virtual Reality Stimuli and Apparatus

The experiment was carried out by participants using an Oculus Quest 2 headset, which is a head-mounted display that boasts a resolution of 1,832 × 1,920 pixels per eye and can support refresh rates of up to 120 Hz. The hand controllers and headset are equipped with inside-out tracking, which provides 6 degrees of freedom for head and hand tracking, allowing for precise orientation and positional tracking in VR. The headset weighs 503 grams and incorporates adjustable interpupillary distance through the lens's three-position sliding mechanism.

The experiment took place within the social VR application AltspaceVR, which, as of 2023, is no longer available for download from app stores following its discontinuation. AltspaceVR was a freely accessible platform compatible with most VR headsets, serving as a hub for social interaction and collaboration in VR and offering users the opportunity to host and participate in various events within customizable virtual environments. Avatars within AltspaceVR were highly customizable and supported both voice communication and text messaging.

AltspaceVR was chosen as the platform for this experiment since its flexible customization features allowed for the creation of diverse virtual environments suitable for different experimental conditions, ranging from bustling social events to remote extraterrestrial settings.

Confederate avatars used in the experiment were exclusively generated within AltspaceVR. Participants in the experimental condition interacted with avatars representing individuals of African ethnicity, while those in the control condition engaged with avatars depicting individuals of Caucasian ethnicity. Additionally, all participants briefly encountered avatars reflecting individuals of Middle Eastern ethnicity (excluding n = 3 due to technical difficulties in loading the virtual environment). To mitigate potential gender-specific interaction effects, participants only interacted with avatars corresponding to their self-identified gender.

The virtual environment was designed using a combination of the built-in tools provided by Altspace and software Unity3D (version 2020.3.9f1), to be then imported into AltspaceVR.

A total of 6 avatars were designed to interact with participants, as depicted in Figure 2. A constant presence within the virtual environment was maintained by a confederate, whose avatar remained the same (Figure 4), providing assistance and guidance throughout the experiment.

4.2.2.2 Pilot Study

To test our methodology, we conducted an online pilot study to evaluate whether the virtual experience and apparatus enabled the development a satisfactory degree sense of body ownership and co-presence. Three participants engaged in this preliminary investigation, utilizing their personal VR headsets to immerse themselves in the experience. Given that headsets had to support AltspaceVR, the only allowed models were HTC VIVE, Oculus Rift, Rift S, Quest, and Quest2.

Upon registering for the VR experiment online, they received detailed instructions via email, prompting them to download the AltspaceVR app onto their devices in preparation for the upcoming session. Thirty minutes before the scheduled experiment commencement, participants were furnished with comprehensive instructions, along with a unique username and password granting access to a pre-configured account tailored for the virtual environment. Throughout the experiment, an experimenter was present within the throwing game room to facilitate and guide participants through the immersive experience.

Analysis of feedback from our three online pilot participants revealed an average score of 4 for body ownership and 3.67 for co-presence, confirming the efficacy of our procedure.

Since the procedures for these participants diverged slightly from the main study, the pilot data wasn't included in the sample.

4.2.2.3 Measures

Empathy

This study's dependent variable was empathy, assessed initially during the pre-test phase, 3-7 days before the experiment, with post-test measurements conducted immediately after the experiment.. To measure empathy, we utilized the affective empathy scale developed by Batson et al. (1987). This scale assesses situational empathy rather than dispositional empathy, making it particularly sensitive to contextual factors and less consistent over extended periods. This scale consists of 14 adjectives representing various emotional states, with participants rating the extent

to which they experience these emotions on a scale ranging from 1, indicating "not at all," to 7, corresponding to "very much." The scale has two subscales: personal distress (including adjectives such as annoyed, alarmed, embarrassed, upset, embittered, uncomfortable, baffled, and worried) and empathic interest (encompassing terms like affable, affectionate, compassionate, empathetic, moved, and sensitive). For this study, we chose to account for distinct scores to study the potential impact of VR contact on each component of empathy, even though the scale can be utilized also as a difference score, by deducting the distress subscale score from the total score as proposed by Batson et al. (1987).

Reliability analyses using Cronbach's alpha yielded satisfactory results for the empathy scales: 0.76 and 0.82 for personal distress pre- and post-intervention respectively, and 0.88 and 0.86 for empathic interest pre- and post-intervention.

Co-presence

We utilized a four-item scale to assess feeling of co-presence in VR, aimed to assess the degree of salience of the other individuals in the virtual interaction. Adapted from Biocca and Harms (2002), the items were evaluated using a five-point Likert scale, with ratings spanning from 1, signifying "strongly disagree," to 5, signifying "strongly agree." The reliability of this scale was satisfactory, with a Cronbach's alpha coefficient of $\alpha = 0.76$.

Body ownership

We utilized a measure of body ownership adapted from Peck et al. (2013) to evaluate participants' identification with the avatar they steered during the VR experience. Using a five-point Likert scale, responses could be provided that range from 1, indicating a strong disagreement, to 5, indicating a strong agreement.

4.2.2.4 Analysis

To examine RQ2a, we conducted an analysis of personal distress and empathic interest, as well as the disparity score between general empathy and distress, utilizing a mixed Analysis of Variance (ANOVA). The condition was designated as between-subjects variable, while the time frame (pre-VR session and post-VR session) acted as the within-subjects. Moreover, to evaluate the distinctions among the conditions in relation to co-presence, body ownership, and the perceived control over the avatar (RQ2b), we performed separate t-tests.

R software (R Core Team, 2017) was used for data analysis. Specifically, we used the following packages: ltm (Rizopoulos, 2006), rstatix (Kassambara, 2021), Routliers (Delacre and Klein, 2019), tidyverse (Wickham et al., 2019), stargazer (Hlavac, 2018), dplyr (Wickham et al., 2020), apaTables (Stanley, 2018), corrgram (Wright, 2021), ggplot2 (Wickham, 2016, p. 2), cowplot (Wilke, 2020), and forcats (Wickham, 2021).

4.3 Study III

Study III includes two sub studies investigating the effects of direct intergroup contact on attitudes towards Black people in a Finnish sample (N = 53, utilizing the same dataset of Study II) and an Italian sample (N = 134), respectively.

4.3.1 Sub-study 1

4.3.1.1 Participants

Sixty-seven individuals participated in the experiment. Nevertheless, we implemented pre-registered exclusion criteria that led to excluding 14 participants from the final sample. Specifically, one participant reported an African ethnic background, two identified the study's purpose, one completed the questionnaire notably faster than the average rate, and one exhibited exceptionally rapid responses in 10% of IAT trials, surpassing the predetermined threshold of 300ms. Furthermore, nine participants failed to identify the ethnicity of the avatar encountered in VR. These individuals were excluded, in accordance with pre-registration, because perceiving intergroup contact as such was an essential prerequisite of the study.

The final sample comprised N = 53 participants, with 22 assigned to the experimental group and 31 to the control group. The mean age of participants was 20 years in the experimental condition and 18.3 years in the control condition. Within the experimental group, 72.7% identified as female, 22.7% as male, and 4.5% as "other", while the control group consisted of 77.4% females, 19.3% males, and 3.2% "other". On average, participants reported minimal to no prior experience with VR.

We were unable to achieve the desired sample size of n = 150 due to the constraints on time and resources caused by the challenges to laboratory research during the Covid-19 pandemic. Consequently, we had to conclude data collection by December 2021, as stipulated in our pre-registration. A sensitivity power analysis using G*Power (Erdfelder et al., 1996; Faul et al., 2007) revealed that our sample provided 80% power to detect a true effect size of f = 0.20, 70% power for an effect size of f = 0.17, and 60% power for an effect size of f = 0.15 in a mixed within (time) - between (condition) ANOVA.

4.3.1.2 Procedure

The procedure is described in Study II.

4.3.1.3 Virtual Reality Stimuli and Apparatus

The stimuli and apparatus were the same used in Study II.

4.3.1.4 Measures

Explicit outgroup attitudes

We evaluated explicit attitudes toward the racialized outgroup, namely people with African ethnic background, using feeling thermometers adapted from the American National Election Studies (1979). This measure served as the dependent variable. Participants rated the emotional valence of their feelings toward individuals with an African ethnic background on a scale ranging from 0 to 100. A score of 0 indicated very cold or unfavourable feelings, while a score of 100 indicated very warm or favourable feelings. Participants' explicit attitudes were assessed both before and after the intervention.

Implicit outgroup attitudes

Implicit outgroup attitudes were tested as a dependent variable. To gauge implicit attitudes toward people with African ethnic background, we employed a racial Implicit Association Test (IAT) developed by Greenwald et al. (1998). This test requires participants to categorize faces representing either White or Black individuals and words categorized as positive or negative. The disparity in accuracy and speed during the categorization task, such as associating Black faces with positive words or White faces with negative words, is used to calculate implicit racial bias. Elevated IAT scores denote more negative implicit attitudes towards people with African ethnic background, as they signify slower and less accurate associations of Black faces with positive words.

Intergroup anxiety

Intergroup anxiety, examined as a mediator, was assessed both before and after the experiment. This was accomplished through a six-item scale developed by Stephan and Stephan (1985), which measures anxiety deriving from contact with outgroup members. Participants were prompted to express their emotions regarding potential interactions with individuals of African ethnic background by rating six adjectives (worried, nervous, awkward, comfortable, safe, at ease, and anxious) on a scale ranging from 1, indicating "not at all," to 5, representing "very much." The scale a Cronbach Alpha coefficient of .86 both pre-test and post-test.

Empathy

To measure empathy, which served as the mediator, we used the same measure described in Study II.

The scale showed strong internal consistency, as indicated by Cronbach alphas of .88 (empathic interest pre-test), .84 (empathic interest post-test), .77 (personal distress pre-test), and .79 (personal distress post-test).

Common cyber-identity

We examined the role of Common Cyber-Identity (CCI) as a potential mediator. CCI, which refers to the degree to which participants identify with a new social group formed within VR, was evaluated using two ad-hoc items specifically developed for this study. Participants were asked to assess their agreement with statements reflecting their sense of belonging to the virtual group. Responses were evaluated using a scale that ranged from 1 to 7, with 1 signifying "not at all" and 7 "very much." The Cronbach alpha coefficient for this scale was found to be .71.

Body ownership

Body ownership, or the sense of control over a virtual body in VR, was evaluated using a six-item scale from Peck et al. (2013). This scale measured the participant's self-overlap with the avatar and their degree of control over it and was rated on a 5-point Likert scale. The scale's Cronbach alpha was .73.

Co-presence

Co-presence refers to the awareness of the presence of others in a virtual environment. We utilized an adapted version of the scale developed by Biocca and Harms (2002) to measure this concept. This measure comprises four items that are evaluated using a 5-point Likert scale, and its overall reliability, as determined by Cronbach alpha, is .78.

National Identity

We used a scale developed by Jetten et al. (2001) to assess the extent to which participants identified with the Finnish national ingroup. This scale consists of four items, such as "Being a Finnish person is an important part of who I am" and "I identify strongly with the other Finns," with participants rating their level of agreement on a seven-point Likert scale. National identity was included as a control variable in the analysis. The scale demonstrated strong internal consistency, as indicated by a Cronbach's alpha coefficient of .88.

Social Dominance Orientation

We measured Social Dominance Orientation (SDO) using the SDO7(s) scale developed by Ho et al. (2015). This abbreviated version of the SDO7 scale comprises 8 items, each rated on a seven-point Likert scale. Example items include statements such as "We should work to give all groups an equal chance to succeed" and "An ideal society requires some groups to be on top and others to be on the bottom." SDO was included as a control variable in the analysis. The scale showed strong internal consistency, with a Cronbach's alpha of .88.

4.3.1.5 Analysis

We employed a multilevel linear model (MLM) with restricted maximum likelihood estimation to investigate RQ3a, which concerns the potential improvement of outgroup attitudes following positive contact in VR. We chose MLM over repeated measures ANCOVA due to data non-compliance with ANCOVA's assumption of homogenous regression slopes.

Distinct MLMs were conducted for IAT and explicit attitudes (feeling thermometer) ratings. The models encompassed fixed effects of time (pre- vs. post-contact) as a within-subject factor and contact type (intragroup vs. intergroup) as a between-subject factor. Additionally, fixed main effects of control variables (SDO and national identification) were examined alongside the factors and their interaction, while participant ID was included as a random intercept. H1a was evaluated by testing the fixed effect of the interaction between time and contact using an omnibus F-test conducted with Type III sum of squares and Satterthwaite's method.

For answering RQ4a and RQ4b, OLS regression-based path analysis was employed, assessing relative direct and indirect effects and their direction between contact and mediators, as well as between mediators and outcome, following Hayes' protocol (2022). The process-macro for R (Hayes, 2022) facilitated these analyses. Separate models were constructed for IAT scores and explicit attitude ratings, considering each mediator individually due to their moderate-to-strong intercorrelations. We chose simple mediation models over parallel mediation to mitigate multicollinearity between mediators. We controlled for SDO, national identification, and baseline DV measures. Relative direct effects were reported as standardized beta weights, while total, direct, and indirect effects were estimated along with their 95% confidence intervals and standard errors using 5000 percentile bootstrap samples.

All analyses were conducted using R Studio (Rstudio Team, 2020). To this aim, the following packages were used: lme4 (Bates et al., 2015), IATscores (Costantini, 2020), tidyverse (Wickham et al., 2019), dplyr (Wickham et al., 2020), interactions (Long, 2019), ggplot2 (Wickham, 2016), and forcats (Wickham, 2021).

4.3.2 Sub-study 2

4.3.2.1 Participants

A sample of 160 participants was initially collected. Twenty-six participants were then excluded from the analysis based on pre-registered criteria. Of those, 2 experienced poor VR functioning, 4 had mixed ethnic background, 17 were unable to identify correctly the ethnicity of the confederate's avatar, and 3 answered 10% of IAT trials in less than 300ms. The final sample consisted in $N = 134$ of which 67 were

males, 66 females, and 1 identified as “other”. Participants were on average 32 years old, with the youngest participant being 18 and the eldest one 88 years old. There were four conditions, to which participants were allocated randomly. The conditions were: intergroup cooperation (N = 36), intragroup cooperation (N = 33), intergroup competition (N = 30), and intragroup competition (N = 35). The recruitment process relied on push-out strategies on social media and snowball sampling.

A sensitivity power analysis conducted with G*Power (Erdfelder et al., 1996; Faul et al., 2007) indicated that our sample yielded 80% power for detecting a medium effect size of f = .29, as per Cohen’s classification (1988).

4.3.2.2 Procedure

The headset utilized for Sub-study 2 remained consistent with that of Sub-study 1 (i.e., Oculus Quest 2), as did the virtual rooms (see Figure 2). The experiment was conducted at an Italian university and facilitated by female researchers of White Italian ethnicity.

Figure 4 The Avatars Representing the Experimenter (A1, A2) and an East Asian Individual (secondary outgroup; B1, B2).

The procedure closely mirrored that of Sub-study 1, with adaptations to accommodate two new conditions, namely competitive intergroup contact (Caucasian/African) and competitive intragroup contact (Caucasian/Caucasian). These adjustments included the enhancement of avatars to better resemble the ingroup (Figure 4A), along with modifications to participant instructions upon entering the virtual scenario, which now read:

"*We now ask you to play ball toss by cooperating with (or by competing with) another participant in the experiment, who is playing simultaneously from another location. You and your partner (or opponent) belong to the same (or different) team*

and need to score as many points as possible by throwing the red and blue bags through the hole on the board (1 point = bag through the hole). You can find the bean bags next to the game board. You will have 10 shots each. You and your partner (or opponent) are supposed to take turns throwing. The game ends once everyone has made 10 shots. At the same time, another team will start playing in another room (or a member of your team will start playing against a player from your opponent's team). The team that will have scored more points will be the winner. The game starts when you are ready. Please, position yourself on the opposite side of the other player. You throw first. The experimenter informs you when you have reached 10 shots. Good luck!".

The remaining procedure and instructions aligned with those of Sub-study 1, with the exception that participants encountered avatars representing individuals of East Asian descent (Figure 4B) in the seating room. To mitigate the potential risk of fostering negative attitudes in the outgroup competition condition, we took additional care in debriefing participants regarding the study context of the study.

4.3.2.3 Measures

The complete scales can be found in Appendix I.

Explicit outgroup attitudes

Explicit outgroup attitudes were used as a dependent variable. To provide a more comprehensive assessment of participants' attitudes towards the racialized outgroup, we used two different instruments. Specifically, feelings thermometers and the General Evaluation Scale (Wright et al., 1997) were employed. The feeling thermometers we used are the same as in Sub-study 1.

The General Evaluation Scale (GES) comprised six bipolar items consisting in opposed objectives describing their attitudes towards people with African ethnic background: "Cold/Warm"; "Suspicious/Trusting"; "Positive/Negative"; "Friendly/Hostile"; "Respect/Contempt"; "Admiration/Disgust". Participants had to answer on a scale from 1 to 7, with higher averaged scores representing more negative outgroup attitudes. The scale had a Cronbach alpha of .85.

Intergroup anxiety

Intergroup anxiety was tested as a mediator, and measure with the scale Stephan and Stephan (1985) used in Sub-study 1. The Cronbach alpha was .93.

Body Ownership

Body ownership served as a control measure, utilizing the same employed in Sub-study 1, which exhibited a Cronbach alpha of .77.

Co-presence

Co-presence functioned as a control measure and was assessed with the same instrument as in Sub-study 1. This scale's Cronbach alpha was .83.

Common Cyber-Identity

CCI was tested as a mediator and assessed with the same scale as in Sub-study 1. Its Cronbach alpha was .86.

Frequency of intergroup contact

To mitigate the limitation implied by the absence of direct measurement of pre-test attitudes towards the outgroup in Sub-study 2, we controlled for prior contact with the outgroup. We assessed the frequency of participants' interactions with individuals of African ethnic background using a single item ("In everyday life, how often do you interact with people with African ethnic background?") rated on a 1-5 continuum. This measure was utilized as a covariate.

4.3.2.4 Analysis

The 2x2 between-subject factorial design, investigating task type (cooperation vs. competition) and contact (intergroup vs. intragroup), was tested with two-way ANOVA models, with orthogonal contrasts used to compare specific conditions of interest. Specifically, we focused on the difference between intergroup and intragroup contact during cooperative tasks (H1a), and between competition and cooperation during intergroup contact (H1b). Each dependent variable (IAT, feeling thermometer, and General Evaluation Scale) was tested with a different model.

Parallel mediation models were employed to assess mediation hypotheses (H2b, H3) for explicit (feeling thermometer and General Evaluation Scale) and implicit (IAT) attitudes. Mediation was examined within cooperation vs. competition and intergroup vs. intragroup contact conditions.

Finally, four distinct parallel mediation models were constructed to evaluate the indirect effects of contact via intergroup anxiety and CCI on explicit and implicit attitudes.

Each model controlled for prior outgroup contact, as well as age and gender, considering their increased variability compared to the sample of Sub-study 1.

All analyses were carried out using R Studio (Rstudio Team, 2020). Specifically, we used packages PROCESS macro (Hayes, 2022), IATscores (Costantini, 2020), forcats (Wickham, 2021), rstatix (Kassambara, 2021), corrgram (Wright, 2021), afex (Singmann et al., 2022), and emmeans (Lenth, 2021).

4.4 Study IV

Study III encompasses two separate sub-studies that examine the consequences of direct intergroup contact on the attitudes towards people with African ethnic background in a Finnish sample (consisting of 53 participants) and an Italian sample (comprising 134 participants), both employing the same dataset as Study II.

4.4.1 Sub-study 1

4.4.1.1 Participants

The sample of this Study was the same used in Study III, specifically Sub-study 1.
To ensure adequate statistical power, a sensitivity power analysis was conducted using G*Power (Erdfelder et al., 1996; Faul et al., 2007). We accounted for a mixed within-between design with a correlation between repeated measures of r = 0.72. The results indicated that our sample size provided 80% power to detect a small-to-medium effect size (Cohen, 1988) of f = .15.

4.4.1.2 Procedure

The procedure is described in Study II.

4.4.1.3 Measures

The complete scales can be found in Appendix I.

Explicit outgroup attitudes
Feeling thermometers were used to assess explicit attitudes towards people with African ethnic background (i.e., the primary outgroup; measure detailed in Study III, Sub-study 1), as well as five secondary outgroups, namely Middle Eastern people, homosexual people, immigrants, Muslims, and people with intellectual disabilities.

Seating distance
As a behavioral indicator of attitudes, we assessed participants' chosen seating distance from the avatar portraying a Middle Eastern individual in the waiting room (refer to Figure 3C). Five empty chairs were available for participants to select from, with the first chair placed right next to the outgroup avatar and the last chair positioned farthest away. Therefore, seating distance values ranged from 1 (closest seat) to 5 (farthest seat). Due to technical issues with loading the waiting room, five participants were unable to enter the environment. As a result, seating distance data were collected from 48 participants.

Intergroup anxiety

Intergroup anxiety towards one secondary outgroup (i.e., Middle Eastern people) was measured using the same scale as in Study III, Sub-study 1, namely the six-item scale by Stephan and Stephan (1985). This measure had high internal consistency, with a Cronbach alpha coefficient of .91 in the pre-test assessment and .84 in the post-test one.

Control variables included national identity, SDO, body ownership, and co-presence. These measures were detailed in Study III.

4.4.1.4 Analysis

To investigate RQ5a, we employed a multilevel linear model (MLM) with restricted maximum likelihood estimation, chosen due to the data's dual-level structure (i.e., between-subjects and repeated measures). MLM offers greater flexibility in terms of statistical assumptions compared to tradition repeated measures ANCOVA, which makes assumptions of homogeneous regression slopes and complete cases—assumptions often violated in repeated measures designs. Using MLM, we assessed the fixed effect of the interaction between time (pre vs. post-contact, within-subject factor) and contact type (intragroup vs. intergroup, between-subjects factor) via an omnibus F-test with Type III sum of squares employing Satterthwaite's method. Separate MLMs were conducted for explicit attitudes towards each secondary outgroup, testing both main and interaction effects of the fixed factors. Participant ID served as a random intercept in the models. Additionally, the fixed main effects of covariates (SDO, national identification, body ownership, and co-presence) were included in the model.

Since seating distance was only measured post-VR contact, we used ANCOVA with contact type as a between-subject factor to examine its effects.

To investigate research questions regarding mediation (RQ6a, RQ6b), we conducted separate parallel mediation models for both dependent variables, namely seating distance and explicit attitudes towards all secondary outgroups. The first two models incorporated attitude change towards the primary outgroup (individuals with African ethnic background) and intergroup anxiety towards the secondary outgroup (Middle Eastern people) as mediators, while attitudes towards the primary outgroup was the only mediator tested on the other dependent variables. To adjust for the effect of time, delta scores of attitudes towards individuals with African ethnic background and intergroup anxiety were used as mediators, calculated by subtracting the averaged pre-test score from the averaged post-test score. Body ownership, co-presence, SDO, and national identity served as control variables in all models.

The analysis was conducted using R, utilizing packages such as PROCESS macro (Hayes, 2022), IATscores (Costantini, 2020), forcats (Wickham, 2021), rstatix (Kassambara, 2021), corrgram (Wright, 2021), dplyr (Wickham et al., 2020), and tidyr (Wickham et al., 2023).

4.4.2 Sub-study 2

4.4.2.1 Participants

The sample of this Study was the same used in Study III, Sub-study 2.
To establish the minimum detectable effect size with our sample, we performed a sensitivity power analysis. We set the statistical power at 80% and a significance level of 0.05, with F-tests (specifically ANCOVA) employed as the test family. The analysis, performed with G*power (Erdfelder et al., 1996; Faul et al., 2007), revealed that our sample size offers 80% power for detecting a medium effect size (f = .25), as classified by Cohen (1988).

4.4.2.2 Procedure

The procedure is described in Study III, Sub-study 1.

4.4.2.3 Measures

Feeling thermometers
Similar to Sub-study 1, feeling thermometers were used as a dependent variable to evaluate explicit attitudes towards the primary outgroup (individuals with African ethnic background) and various secondary outgroups (East Asian individuals, individuals with intellectual disabilities, homosexual individuals, Muslims, and immigrants).

General Evaluation Scale (GES)
The General Evaluation Scale (GES) by Wright et al. (1997), which was described in Study III, Sub-study 2, was used as an additional measure of explicit outgroup attitudes in Study IV. Specifically, we measured the GES towards the primary outgroup (i.e., people with African ethnic background, $\alpha = .86$) and one secondary outgroup, namely East Asian people ($\alpha = .80$).

Implicit Association Test (IAT)
The IAT (Greenwald et al., 1998), which was described in detail in Study III, Sub-study 1, was used to assess implicit attitudes towards East Asian people (i.e., secondary outgroup).

Seating distance

Consistent with Sub-study 1, seating distance was assessed as a behavioural measure of attitudes. However, since most participants did not distinctly choose a seat during the virtual encounter (n = 107), we opted to exclude it as a measure of intergroup behavior.

Intergroup anxiety

Intergroup anxiety towards one secondary outgroup (i.e., East Asian people) was tested as a mediator. Consistent with the previously described studies, the six-item scale intergroup anxiety scale by Stephan and Stephan (1985) was used. In this study, the Cronbach alpha was .92.

Control variables included frequency of intergroup contact with East Asian, body ownership, and co-presence.

4.4.2.4 Analysis

We employed two-way ANCOVA models to investigate our 2x2 between-subject factorial designs, holding task type (cooperation or competition) and contact type (intragroup or intergroup) as factors. Our focus was on investigating differences between intergroup and intragroup contact within a cooperative task (RQ5a), between competition and cooperation during intergroup contact (RQ5b), and between intergroup and intragroup contact within a competitive task (RQ5c). To achieve this, we applied orthogonal contrasts comparing relevant conditions for each dependent variable (GES, feeling thermometer, and IAT), each one of them analyzed in a different model.

Nest, ordinary least squares path analysis with Process-macro for R (Hayes, 2022) was used to investigate the hypotheses concerning mediation through attitudes towards the primary outgroup (RQ6b) and intergroup anxiety (RQ6a). Given that attitudes towards the primary outgroup and intergroup anxiety (i.e., the tested mediators) had a substantial correlation (r = -.46), we opted for simple mediation models instead of parallel mediation. We evaluated each mediator's impact on feeling thermometer, GES (measuring explicit attitudes), and IAT (measuring implicit attitudes). The indirect associations between the intergroup cooperation versus intragroup cooperation conditions were tested first, followed by indirect associations between the intergroup cooperation versus intergroup competition conditions.

Lastly, we examined the mediation of attitude generalization on feeling thermometers towards Muslims, homosexual people, individuals with intellectual disabilities, and immigrants, considering one specified contrast at a time. To conduct

this analysis, we employed two conditions at a time in each mediation model, resulting in 20 separate single mediation models analyzing the indirect effects of contact via attitude generalization and intergroup anxiety[5] towards the secondary outgroup. In all models, we controlled for body ownership, co-presence, age, education, and, in models involving East Asian people as the secondary outgroup, prior contact with the secondary outgroup.

R (R Core Team, 2022) was used to perform the analyses, specifically using PROCESS macro (Hayes, 2022), forcats (Wickham, 2021), emmeans (Lenth, 2021), rstatix (Kassambara, 2021), corrgram (Wright, 2021), afex (Singmann et al., 2022), IATscores (Costantini, 2020).

[5] Intergroup anxiety was tested as a mediator only in the models holding East Asian people as the secondary outgroup.

5 Main results

5.1 Study I

5.1.1 Descriptive results

The systematic review encompassed 64 eligible original studies, all of which are reported in Appendix 2. The main characteristics of the included studies are reported in Table 1.

Table 1 Features of the studies included in the systematic review.

	N
Observational	10
Interventions	54
Longitudinal	4
Within-subjects design	16
Between-subjects design	38
Mixed design	8
Interacting with virtual agent	18
Interacting with human-steered avatar	3
Embodiment in outgroup member	28
Augmented reality	2
360° video	13
Explicit measures of attitudes	37
Implicit measures of attitudes	25
Neurophysiological measures	5
Controlled for immersion-related constructs	30

5.1.2 Types of contact

Among the included studies, two primary modes of contact emerged: the outgroup perspective and the ingroup perspective. In 36 studies, participants from the majority group engaged with VR experiences from the viewpoint of an outgroup member, it being either embodying an avatar representing an outgroup member or taking a non-embodied perspective, while 28 studies adopted the ingroup perspective, wherein majority group participants interacted with avatars or virtual agents representing outgroup members. However, it's essential to note that not all VR experiences involve participants steering a virtual body. For instance, in 360-degree videos, participants encounter contact from a non-embodied perspective, providing a distinct form of immersive engagement with intergroup interactions (see e.g., Hasson et al., 2019, and Lesur et al., 2020).

The non-intervention studies employing a majority group perspective to investigate prejudice in VR (k = 10) revealed persistent real-world prejudice replicated in virtual environments. Studies adopting a minority perspective to address prejudice (k = 36) yield mixed results. Thus, while several intervention studies (Zhang et al., 2021; Christofi et al. 2020; Banakou et al., 2016; Salmanowitz, 2018; Chowdhury et al. 2021; Peck et al., 2013; Chen et al. 2021a, 2021b; Tong et al., 2017, 2020) demonstrated that adopting the perspective of a minority outgroup member improves attitudes towards that group, other studies showed that embodying an outgroup member might exacerbate intergroup attitudes (Banakou et al., 2020; Hadjipanayi et al., 2020; Kalyanaraman et al., 2010; Lopez et al., 2019; Schulze et al., 2019). Intervention studies employing the majority perspective to address prejudice (k = 28) also yielded mixed results. While some studies (Collange et al., 2020; Kuuluvainen et al., 2021; Redmond et al., 2020) found no significant change, others (Hasler et al., 2024; Muller et al., 2017) suggested a reduction in prejudice toward minority outgroups following intergroup contact in VR, and two recent studies (Stelzman et al., 2021; Peña et al., 2021) even reported increased prejudice toward the outgroup contacted in VR.

5.1.3 Types of stigma

In our systematic review, we employed Goffman's (1963) classification of stigma to categorize the studies based on the type of stigma affecting the target outgroup. Stigma was classified into three main categories: tribal stigmas (stemming from ethnic or socio-cultural backgrounds), overt or external deformations (related to physical appearance or age), and deviations in personal traits (such as stigmatizing behaviors, health conditions, or disorders). Additionally, due to the complex intersectionality of some stigmatizing characteristics, we introduced a further category termed intersectional stigma.

Of the articles assessed in our review, 31 focused on tribal stigma, with African ethnicity being the most frequently studied ethnic outgroup. Eight studies addressed stigma related to external or overt physical deformations, such as elderly individuals, people with disabilities, and obese individuals. Thirteen studies investigated stigma associated with personal traits, including conditions like schizophrenia, HIV, and substance abuse. Furthermore, our review identified 12 studies exploring intersectional stigma, where stigmatization intersected with other identity markers like gender. One study specifically examined prejudice towards transgender individuals, while the remaining studies focused on women-related issues. Research conducted by Hasler et al. (2014) and Hasson et al. (2019) indicates that exposure to contact in VR can significantly enhance attitudes towards outgroup members in critical intergroup conflict situations, as well as reduce racial biases through intergroup contact and outgroup avatar embodiment.

Although some studies have found that embodiment in virtual reality can lead to more positive attitudes towards minority groups (Banakou et al., 2020), other studies have failed to produce significant results. For example, two trials involving embodiment in an outgroup avatar (Theriault et al., 2021) and 3D videos depicting interactions with a Middle Eastern man (Kuuluvainen et al., 2021) did not show improvement in intergroup attitudes compared to control conditions. In terms of personal trait deviations, VR-based interventions have yielded mixed results. Some studies have shown increased empathy towards individuals with schizophrenia (De Silva et al., 2017) and improved attitudes towards individuals with chronic pain (Tong et al., 2020), but other studies have found increased prejudice towards individuals with Asperger syndrome (Hadjipanayi and Michel-Grigoriou, 2020) and a political outgroup (Peña et al., 2021). On the other hand, embodiment in VR has been shown to decrease prejudice towards individuals with overt or external deformations, such as elderly people (Banakou, 2018) and wheelchair users (Chowdhury et al., 2021).

In addressing intersectional stigma, interventions exhibit a similar trend of mixed results. For example, two studies (Lopez et al., 2019; Kalyanaraman et al., 2010) indicate that assigning male individuals to female avatars can negatively impact implicit attitudes, even during tasks not specifically designed to evoke negative emotions. Conversely, two other studies demonstrate improved attitudes following intergroup contact in VR and the embodiment of an outgroup member (Muller et al., 2017; Zhang et al., 2021).

5.1.4 Outcome measure

Considering the differences between explicit and implicit measures of prejudice, it's important to analyze the findings based on the outcome measures employed.

Among the 16 intervention studies measuring only explicit intergroup attitudes, the majority demonstrated an improvement in attitudes following the embodiment of an outgroup member in VR (Perksy et al., 2011; Toppenberg et al., 2015; Christofi et al., 2020; Chen et al., 2021a, 2021b; Tong et al., 2017; Yuen & Mak, 2021). However, studies by Hadjipanayi and Michel-Grigoriou (2020) and Kalyanaraman et al. (2010) reported increased prejudice after embodiment of a member belonging to a stigmatized minority. Findings from Steltzmann et al. (2021) and Peña et al. (2021) demonstrated increased explicit prejudice following intergroup contact with an outgroup member.

Among the twelve intervention studies measuring only implicit intergroup attitudes, most indicated a clear enhancement of outgroup attitudes following the embodiment of an outgroup member in VR (Banakou et al., 2016, 2018; Peck et al., 2013; Zhang et al., 2021; Starr et al., 2019). Conversely, research conducted by Schulze et al. (2019) and Lopez et al. (2019) revealed that unconscious biases declined following the intervention.

Nine out of sixteen intervention studies that use measures of implicit and explicit attitudes take the perspective of the majority. Interestingly, none of these studies have yielded consistent findings across outcome measures.

Three of the studies revealed a reduction in intergroup bias as assessed through implicit measures following the embodiment of an outgroup member, yet no significant change was observed in explicit measures (Salmanowitz et al., 2018; Banakou et al., 2020; La Rocca et al., 2019; Groom et al., 2009). Conversely, Breves (2020) reported a decrease in prejudice based on explicit measures but found no effect on implicit measures.

The lack of convergence in findings may be attributed to the inherent discordance between implicit and explicit measures, likely influenced by social desirability effects. Furthermore, comparing studies using implicit measures to those employing explicit measures presents challenges, as studies utilizing implicit measures often exclusively focus on embodiment of an outgroup member as an intervention, potentially leading to changes primarily in implicit rather than explicit attitudes.

5.1.5 Mediators and moderators

Among the 14 studies examined in the systematic review, two investigations emphasized the significance of physiological measures, such as skin conductance and EEG-measured alertness, in understanding the mechanisms underlying prejudice in virtual reality (VR) environments. Dotsch and Wigboldus (2007) found correlations between implicit attitudes and skin conductance, while D'Errico et al. (2020) discovered a connection between alertness and attitudes. In addition, the studies

revealed that emotional mediators, including feelings of closeness (Christofi et al., 2020) and warmth towards the outgroup (Collange et al., 2020), play a significant role in the positive impact of VR contact on prejudice reduction. Furthermore, Chen et al. (2021a) highlighted the importance of embodying an outgroup member in fostering empathy. Notably, Hasler et al. (2020) revealed that feelings of presence in VR played a mediating role in mitigating negative affect towards the majority ingroup.

Among the thirteen studies included in the systematic review, six investigated moderating variables that could influence the effects of VR contact on prejudice. Two of these studies focused on social identities, revealing that individuals with higher identification with the embodied avatar experienced a greater reduction in intergroup bias (Starr et al., 2019). On the other hand, Chen et al. (2021a) found that participants attributing greater importance to their various group memberships exhibited stronger intervention effects after embodying an avatar representing an ethnic outgroup member. The remaining four studies explored moderators related to specific features of the VR experience, such as the valence of intergroup contact during embodiment of an outgroup member (Banakou et al., 2020), the amount of exposures to an intervention based on being embodied in an outgroup member (Banakou et al., 2016), and customization of the subjects' avatar to resemble themselves (Peña et al., 2021). A study conducted by Chowdhury et al. (2021) revealed that individuals who were exposed to a disabled narrator experienced a more significant decrease in prejudice towards disabled people, particularly in the case of embodiment of a person using a wheelchair. In addition, Christofi and colleagues (2020) revealed that individual characteristics, particularly trait empathy, moderated the enhancement of outgroup attitudes. This finding suggests that individuals with higher levels of empathy exhibited less prejudice following virtual reality contact compared to those with lower levels of empathy.

5.1.6 Risk of bias assessment

Appendix 2 provides a comprehensive evaluation of the risk of bias in the studies that were included. Overall, there appears to be a low risk of reporting and attrition bias across the studies, primarily due to the frequent reporting of null results for various assessed variables. However, the absence of pre-registration makes it challenging to determine if additional variables were assessed but left unreported. Moreover, the lack of disclosure of the methods used to allocate participants into conditions and a high or unclear risk for performance bias in participants was identified in most studies.

5.2 Study II

5.2.1 Effects of positive intergroup contact on empathy (RQ2a)

The mixed between-within ANOVA, which was conducted to investigate RQ2a, revealed a significant effect of time on personal distress ($F(1, 62) = 41.46$; $p < 0.001$; $\eta^2 = 0.156$) and empathic interest ($F(1, 62) = 9.72$; $p = 0.003$; $\eta^2 = 0.023$). This finding indicates a decrease in scores for both variables from pre- to post-intervention, regardless of the experimental or control group assignment. The trends depicted in Figure 5 illustrate this decline in scores across both groups. However, no substantial impact was detected for the discrepancy score ($F(1, 62) = 2.66$; $p = 0.11$; $\eta^2 = 0.006$). It is worth noting that the pattern of results observed was not disrupted by the exclusion of participants who did not identify as having an African background in the experimental group.

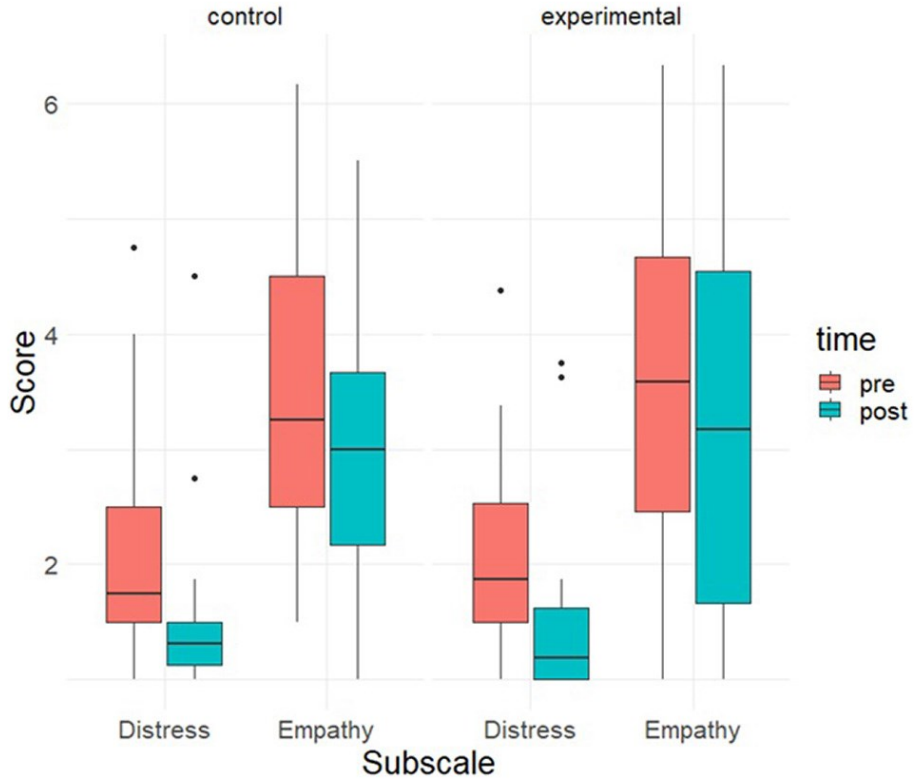

Figure 5 The boxplots depict the sub-dimensions of empathy, which are categorized according to the timepoint and condition. Each boxplot features lines that represent the median, as well as upper and lower limits indicating the 75th and 25th percentiles, respectively.

5.2.2 Effects of body ownership and co-presence on empathy (RQ2b)

To address RQ2b, we explored correlations between the empathy variables and body ownership and co-presence. Notably, we found significant correlations between the empathy difference score post-VR experience and both control over the avatar ($r = 0.35$, $t = 2.90$, $df = 62$, $p = 0.005$) and feelings of body ownership ($r = 0.34$, $t = 2.89$, $df = 62$, $p = 0.005$). This suggests that participants who reported greater control over and identification with their avatars tended to exhibit higher levels of general empathy following the intervention. Moreover, after the intervention, the empathic interest demonstrated a strong correlation with co-presence, particularly in the experimental group ($r = 0.48$, $t = 3.00$, $df = 30$, $p = 0.005$). Further investigation via regression analysis revealed a significant interaction effect ($b = 0.87$, $t = 2.48$, $p = 0.016$) between condition and co-presence on empathic interest, indicating that co-presence moderated the effect of intergroup contact on empathetic interest.

5.3 Study III

5.3.1 Sub-study 1

5.3.1.1 Direct effect of contact on attitudes (RQ3a)

We started by investigating the impact of positive intergroup contact on implicit and explicit attitudes towards Black people (RQ3a). The multilevel model fixed effects analysis revealed no significant main effect nor interaction effects of time (pre vs. post-contact) and condition (intergroup vs. no intergroup contact) on the IAT score (for detailed results, see Table 2). Nevertheless, a significant main effect of national identification on IAT scores emerged ($b = 0.10$, $p = .011$). As concerns explicit attitudes, consistent with the pre-registered hypothesis, attitudes towards the outgroup became more favorable from pre- to post-contact in the intergroup contact condition compared to the control group. Namely, the main effect of time on explicit attitudes was significant, as was the interaction between time and condition (reported in Table 2).

Table 2 F-test results of MLM fixed effects on implicit and explicit attitudes.

	Implicit Attitudes (IAT; N = 49)			Explicit Attitudes (Thermometer; N = 53)		
	df	*F*	*p*	df	*F*	*p*

Contact	1.00, 48.00	0.28	.597	1.00, 49.00	0.38	.538
Time	1.00, 50.00	1.08	.303	1.00, 51.00	4.36	.042
Contact*Time	1.00, 50.00	0.88	.352	1.00, 51.00	4.63	.036
SDO	1.00, 48.00	<0.01	.952	1.00, 49.00	11.74	.001
National Identification	1.00, 48.00	7.09	.011	1.00, 49.00	4.65	.036

Note. *F*-tests conducted with Type III sum of squares with Satterthwaite's method.

5.3.1.2 Mediation of intergroup anxiety, empathy, and CCI (RQ4a, RQ4b)

To examine whether intergroup anxiety and empathy mediate the impact of intergroup contact on implicit attitudes (RQ4a), we analyzed both the direct and indirect effects of contact on these potential mediators and their subsequent influence on post-contact IAT scores. Each mediator was analyzed separately due to their intercorrelations, with covariates including pre-contact IAT score, national identification, and SDO.

Results, presented in Table 3, revealed that neither mediation through anxiety (ab = 0.06 [−0.11, 0.25]) nor mediation through empathy (ab = −0.03 [−0.19, 0.11]) were supported.

Next, to investigate whether intergroup anxiety or empathy mediated the impact of intergroup contact on explicit outgroup attitudes, we conducted two more simple mediation models. Results showed that no evidence supported mediation through anxiety (ab = −0.01 [−0.10, 0.15]), nor through empathy (ab = 0.05 [−0.05, 0.21]). Nevertheless, a significant positive effect of empathy on post-contact attitudes was observed (b2 = 0.20, p = .043). Furthermore, the relative direct effect of intergroup contact on post-contact attitudes (c´ = 0.41, p = .033), as well as the total effect of contact (c = 0.40, p = .039), were significant.

Table 3 Total and Indirect effects from contact to implicit and explicit attitudes

	DV: IAT			DV: Explicit attitudes		
	Effect	LLCI	ULCI	effect	LLCI	ULCI
Unstandardized Total Effect (C)						
Contact → DV	-0.12	-0.32	0.08	7.76*	0.40	15.12
Partially Standardized Indirect Effects (ab)						
Contact → Anxiety → DV	0.06	-0.11	0.25	-0.01	-0.10	0.16
Contact → Empathy → DV	-0.03	-0.18	0.11	0.05	-0.05	0.20
Contact → CCI → DV	0.10	-0.07	0.41	-0.03	-0.14	

Note. Total effects are presented as unstandardized coefficients, while indirect effects are partially standardized. Standardized coefficients for the categorical predictor (contact) are provided in partially standardized form. For indirect effects, LLCI and ULCI denote bootstrapped lower and upper 95% confidence intervals, respectively. "Y" represents the dependent variable. SDO, national identity, and the pre-test measure of intergroup contact were used as covariates. *p < .05.

Next, we tested a further simple mediation model to explore the mediating role of CCI (RQ4b). The results indicated that positive intergroup contact did not significantly influence CCI compared to the control condition (a1 = −0.31, p = .229). However, the relationship between CCI and IAT score was significant (b1 = −0.33, p = .037), suggesting that higher CCI predicted reduced implicit bias post-experiment across both contact conditions. Notably, the total and relative effects of contact condition on post-contact IAT were not significant in the models (ps > .230). The indirect effects did not support mediation through CCI.

Lastly, a simple mediation model was constructed to assess the mediation effects of CCI on explicit attitudes. In line with the previous models, the model found no evidence supporting mediation through CCI.

5.3.2 Sub-study 2

5.3.2.1 Direct effect of contact on attitudes (RQ3a, RQ3b)

An ANCOVA model was performed for each dependent variable to examine the effects of task type (cooperation vs. competition) and contact (intergroup vs. intragroup), as well as their interaction effects on implicit attitudes (measured through IAT), and explicit attitudes (measured through GES and feeling thermometers). Age, body ownership, and previous outgroup contact were included as control variables, as well as the tested mediators. The effect of task type, contact, and their interaction was nonsignificant on all outcome measures. Notably, body ownership had a significant association with IAT (F = 7.41, p = 007).

Next, we employed orthogonal contrasts for pairwise comparisons to investigate RQ3a and RQ3b. Planned Contrast 1 compared cooperation with a member of the ingroup (used as the reference category) to cooperation with a member of the outgroup. These contrasts showed that while GES was not influenced by the factor (t = 0.59, df = 124, p = .599, d = 0.05), as were not feeling thermometers (t = -0.74, df = 124, p = .461, d = -0.07), the effect of contact on IAT scores was significant, indicating that intergroup cooperation resulted in less bias than intragroup cooperation (t = -2.12, df = 124, p = .035, d = -0.19). Next, planned contrast 2 compared cooperation with a member of the outgroup and competition with a member of the outgroup, with the latter used as category of reference. Similarly, Contrast 2 revealed no significant difference between conditions in GES (t = 0.16, df = 124,

p = .877, d = 0.01), feeling thermometers (t = -0.60, df = 124, p = .548, d = -0.05), or IAT (t = -1.82, df = 124, p = .071, d = -0.16).

5.3.2.2 Mediation of intergroup anxiety and CCI (RQ4a, RQ4b)

The research questions RQ4a and RQ4b related to intergroup anxiety and CCI being potential mediators of the effect of contact on outgroup attitudes were investigated by first taking into account the intragroup cooperation condition as compared to the intergroup cooperation one, and then comparing the intergroup cooperation and the intergroup competition conditions. The relative indirect effects of the path analysis are detailed in Table 4.

Initially, we examined whether the influence of cooperating with an ingroup versus outgroup member was mediated by intergroup anxiety or CCI. While we did not find any support for mediation through intergroup anxiety or CCI, the former had a direct association with both GES and thermometer ratings (b_{GES} = 0.29, p_{GES} = .012; b_{therm} = -0.56, p_{therm} < .001), and the latter with GES scores (b3 = -0.30, p = .008).

Lastly, we explored whether intergroup anxiety or CCI mediated the impact of intergroup cooperation versus competition on attitude change. While intergroup anxiety had a significant direct association with explicit attitudes ($a1_{GES}$ = 0.33, p_{GES} = .018; b_{therm} = -0.39, p = .004), no support for mediation was found (see Table 4).

Table 4 Indirect and Total Effects of Contact Contrasts (1: Intergroup Cooperation vs. Intragroup cooperation, 2: Intergroup cooperation vs. Intergroup Competition) on Explicit (GES & Thermometer) and Implicit (IAT) Attitudes

	Y: GES			Y: Thermometer			Y: IAT		
	Effect	LLCI	ULCI	effect	LLCI	ULCI	effect	LLCI	ULCI
Contact: Cooperation intergroup vs. intragroup									
Total Effect (C)									
Contact → Y	-0.12	-0.58	0.34	2.95	-8.15	14.04	0.18	-0.05	0.42
Indirect Effects (ab)									
Contact → Anxiety → Y	0.02	-0.13	0.17	-0.04	-0.32	0.24	-0.01	-0.19	0.08
Contact → CCI → Y	-0.03	-0.22	0.13	-0.01	-0.09	0.07	-0.01	-0.08	0.08
Contact: Intergroup cooperation vs. competition									
Total Effect (C)									
Contact → Y	0.04	-0.21	0.28	-1.83	-7.84	4.19	-0.11	-0.22	0.02
Indirect Effects (ab)									
Contact → Anxiety → Y	< 0.01	-0.10	0.08	<-0.01	-0.12	0.11	<0.01	-0.02	0.02
Contact → CCI → Y	0.03	-0.03	0.12	0.01	-0.04	0.06	0.01	-0.02	0.05

Note. Total effects are presented as unstandardized coefficients, while indirect effects are partially standardized. Standardized coefficients for the categorical predictor (contact) are provided in partially standardized form. For indirect effects, LLCI and ULCI denote bootstrapped lower and upper 95% confidence intervals, respectively. "Y" represents the dependent variable. Age, gender, and prior outgroup contact were included as covariates.

5.4 Study IV

5.4.1 Sub-study 1

5.4.1.1 STE of positive contact on attitudes towards secondary outgroups (RQ5a)

Five separate multilevel linear models were executed to investigate the repercussions of positive intergroup contact with an avatar representing a person with African ethnic background (main 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 documented in Table 5. We initially assessed the effects of contact on attitudes towards the primary secondary outgroup (i.e., Middle Eastern people). Although time (pre-contact vs. post-contact) and condition (intragroup vs. intergroup) did not exhibit a primary impact on the dependent variable, the interaction of time and condition revealed a trend towards significance regarding its effect on attitudes towards this secondary outgroup (b = 8.33, p = .06). Participants who experienced positive virtual reality intergroup contact with the primary outgroup (people with African ethnic background) demonstrated more favorable attitudes towards Middle Eastern people over time compared to those who underwent intragroup contact.

When examining attitudes towards other secondary outgroups (Muslims, immigrants, homosexuals, and individuals with intellectual disabilities), the impact of contact failed to reach statistical significance. The data is fully reported in Table 5.

Table 5 F-test results for the analysis of MLM fixed effects on explicit attitudes towards secondary outgroups (N = 53).

	Explicit Attitudes Middle Eastern			Explicit Attitudes Muslims			Explicit Attitudes Homosexuals			Explicit Attitudes Intellectual Disabilities			Explicit Attitudes Immigrants		
	df	*F*	*p*	df	*F*	*p*	df	*F*	*p*	df	*F*	*p*	df	*F*	*p*
Condition	1.00, 47.00	0.07	.80	1.00, 47.00	0.13	0.72	1.00, 47.00	0.01	0.93	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	**3.83**	**.06 .**	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
SDO	1.00, 47.00	**7.44**	**.01***	1.00, 47.00	**9.77**	**.00 ****	1.00, 47.00	**23.09**	**.00 ****	1.00, 47.00	**7.44**	**.01 ***	1.00, 47.00	**7.14**	**.01***
National Identification	1.00, 47.00	2.06	.16	1.00, 47.00	**3.66**	**0.06.**	1.00, 47.00	2.14	.15	1.00, 47.00	1.97	0.17	1.00, 47.00	0.41	.53

Note. Type III Analysis of Variance computed with Satterthwaite's method. . p < .1, * p < .05, ** p < .01.

Since seating distance was only measured after the intergroup contact, an ANCOVA was performed to analyze the effect of VR intergroup contact with the primary outgroup on behavior towards the secondary outgroup, while controlling for the effects of body ownership, co-presence, SDO, and national identification. The results showed no significant impact of contact on seating distance (p = .78).

5.4.1.2 Mediation of attitudes towards the primary outgroup and intergroup anxiety (RQ6a, RQ6b)

We initially examined the mediating role of positive intergroup contact on attitudes towards the secondary Middle Eastern outgroup through attitudes towards the primary outgroup (people of African origin) and intergroup anxiety towards Middle Eastern people. The total and indirect effects of the mediation models are presented in Table 6. Our results indicated significant indirect effects of positive intergroup contact with a Black avatar on attitudes towards Middle Eastern people through improved attitudes towards the primary

outgroup. Specifically, although the contact with the primary outgroup did not have a direct impact on attitudes towards Middle Eastern people (c' = 1.90, p = .80), the manipulation had a significant indirect effect on attitudes towards them via improved attitudes towards the primary outgroup (ab = 0.55, [0.15; 0.93]), and the total effect was also significant (c = 3.85, p = .02).

As for intergroup anxiety's potential role as an affective mediator, there was no evidence of mediation.

Table 6 *Total And Indirect Effects of Intergroup Contact on Explicit Attitudes Towards Middle Eastern people.*

	DV: Δ Explicit attitudes Middle Eastern	
	Effect	[LLCI, ULCI]
Contact → DV *(C)*	9.28*	[1.53, 17.02]
Contact → Δ Attitudes African→ DV *(AB)*	0.55*	[0.15, 0.93]
Contact → Δ Anxiety → DV *(AB)*	0.03	[-0.04, 0.11]

Note. The total (C) and indirect (AB) effects are presented as unstandardized and partially standardized coefficients, respectively. LLCI and ULCI denote the bootstrapped 95% confidence intervals. The analysis included covariates SDO and national identity. * p < .05.

We examined if the shift in attitudes towards the primary outgroup influenced the effect of the intervention on other secondary outgroups. This was done by testing four parallel mediation models, with explicit attitudes towards Muslims, homosexuals, immigrants, and people with intellectual disabilities as dependent variables. Table 7 presents the results of all mediation models.

The findings revealed that contact significantly influenced attitudes towards the primary outgroup in a direct way (a = 3.58, p = .01), which then directly affected attitudes towards Muslims (b = 0.10, p < .001). The indirect effect of contact through attitude generalization was also significant (ab = 0.51, [0.13, 0.86]). Hence, attitudes towards the primary outgroup (people with African ethnic background), mediated the change in attitudes towards Muslims. Similarly, the shift in attitudes towards the primary outgroup accounted for the change in attitudes towards homosexual people (b = 0.10, p < .001; ab = 0.55, [0.13, 0.93]), people with intellectual disability (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]).

Seating distance remained unaffected by all tested mediators.

Table 7 Total and Indirect Effects of intergroup Contact on Explicit Attitudes Towards Other Secondary Outgroups.

	DV_1: Δ Attitudes Muslims		DV_2: Δ Attitudes Homosexuals		DV_3: Δ Attitudes Intellectual disabilities		DV_4: Δ Attitudes Immigrants	
	Effect	[LLCI, ULCI]	Effect	[LLCI, ULCI]	Effect	[LLCI, ULCI]	Effect	[LLCI, ULCI]
Contact → 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 → Δ Attitudes African→ 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. The total (C) and indirect (AB) effects are presented as unstandardized and partially standardized coefficients, respectively. LLCI and ULCI denote the bootstrapped 95% confidence intervals. The analysis included covariates SDO and national identity. * p < .05.

5.4.2 Sub-study 2

5.4.2.1 STE of positive and negative contact on attitudes towards secondary outgroups (RQ5a, RQ5b, RQ5c)

We performed a two-way ANCOVA for each dependent variable to assess the effects of task type (cooperation vs competition), contact type (intergroup vs intragroup), and their interaction. we computed a distinct model for each outcome variable measuring attitudes towards East Asian people (GES, thermometer, and IAT), while only the feeling thermometer was used for other secondary outgroups (Muslims, homosexuals, individuals with intellectual disabilities, and immigrants).

Table 8 presents the full results of the ANCOVA models for the East Asian secondary outgroup. We found that the intervention had no significant impact on outgroup attitudes measured through GES, feeling thermometer, or IAT. Next, we explored the effect of contact type, 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 shown in Table 9).

Table 8 Results from the ANCOVA analysis on the influence 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	.018	.14	1, 123	550.26	1.64	.013	.20	1, 123	0.16	1.10	.009	.30
Task type (cooperative vs. competitive)	1, 123	0.59	2.73	.022	.10	1, 123	550.26	0.60	.005	.44	1, 123	0.16	2.15	.017	.15
Contact*Task type	1, 123	0.59	1.74	.014	.19	1, 123	550.26	1.18	.009	.28	1, 123	0.16	1.29	.010	.26
Age	1, 123	0.59	**8.05 ** **	**.061**	**.01**	1, 123	550.26	**14.99 *** **	**.109**	**.00**	1, 123	0.16	2.25	.018	.14
Education	1, 123	0.59	2.08	.017	.15	1, 123	550.26	0.43	.004	.51	1, 123	0.16	1.18	.009	.28
Co-presence	1, 123	0.59	**5.14 * **	**.040**	**.03**	1, 123	550.26	0.77	.006	.38	1, 123	0.16	0.89	.007	.35
Body ownership	1, 123	0.59	**8.91 ** **	**.068**	**.00**	1, 123	550.26	0.37	.003	.544	1, 123	0.16	2.02	.016	.16
Contact with secondary outgroup	1, 123	0.59	2.62	.021	.108	1, 123	550.26	0.74	.006	.391	1, 123	0.16	**3.59 .**	**.028**	**.06**

Note. Type III Analysis of Variance. $p < .1$, * $p < .05$, ** $p < .01$, *** $p < .001$.

Table 9 ANCOVA Results on the Impact of Task and Contact Types on Feeling Thermometers for Muslims, Homosexual people, People with Intellectual Disabilities, and Immigrants.

	Muslims					Homosexual people					People with intellectual disabilities					Immigrants				
	df	MSE	F	ges	p.value	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	.000	.96	1, 124	676.51	0.07	.000	.79	1, 124	490.63	0.11	.000	.74
Task type (cooperative vs. competitive)	1, 124	529.71	0.02	.000	.88	1, 124	632.81	0.01	.000	.91	1, 124	676.51	0.29	.002	.59	1, 124	490.63	0.08	.000	.78
Contact*Task type	1, 124	529.71	0.14	.001	.71	1, 124	632.81	0.02	.000	.89	1, 124	676.51	0.36	.003	.55	1, 124	490.63	0.00	.000	.94
Age	1, 124	529.71	**20.06 *****	**.139**	**00**	1, 124	632.81	**8.79 ****	**.066**	**.00**	1, 124	676.51	**6.72 ***	**.051**	**.01**	1, 124	490.63	**9.01 ****	**.068**	**.00**
Education	1, 124	529.71	0.17	.001	.68	1, 124	632.81	0.09	.000	.77	1, 124	676.51	0.01	<.000	.93	1, 124	490.63	0.09	.000	.76
Co-presence	1, 124	529.71	0.35	.003	.56	1, 124	632.81	1.76	.014	.19	1, 124	676.51	0.71	.006	.40	1, 124	490.63	0.08	.000	.78
Body ownership	1, 124	529.71	0.41	.003	.52	1, 124	632.81	0.10	.000	.75	1, 124	676.51	0.06	.000	.80	1, 124	0.42	.003	.52	

Note. Type III Analysis of Variance. $p \leq .10$, * $p \leq .05$, ** $p \leq .01$.

5.4.2.2 Mediation of attitudes towards the primary outgroup and intergroup anxiety (RQ6a, RQ6b)

To determine if attitude generalization and intergroup anxiety mediated the effect of contact on explicit (GES and feeling thermometer) and implicit (IAT) attitudes towards East Asian people, 12 single mediation models were conducted. Each mediator was separately tested 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. Table 10 reports the relative indirect effects.

We first tested whether the effect of cooperation with an ingroup versus primary outgroup member was mediated by attitude generalization and intergroup anxiety. The findings indicated that the experimental contact type did not significantly influence 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 have an impact on implicit attitudes (a_{IAT} = 0.12, [0.001, 0.47]). Attitudes towards the primary contacted outgroup significantly affected 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]). No indirect effects were observed. There was no evidence of mediation through intergroup anxiety.

Table 10 Total and Indirect Effects from Contact Contrasts (1: Intergroup Cooperation Vs. Intragroup Cooperation, 2: Intergroup Cooperation Vs. Intergroup Competition) to Explicit (GES & 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
M: Attitudes African									
Contact → Attitudes African → Y (ab)	0.02	-0.26	0.28	-0.02	-0.39	0.36	0.06	-0.09	0.25
M: Anxiety East Asian									

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
M: Attitudes African									
Contact → Attitudes African → Y (ab)	-0.02	-0.16	0.13	-0.05	-0.26	0.19	-0.05	-0.17	0.03
M: Anxiety East Asian									
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, denoted as (C), are presented as unstandardized coefficients, while indirect effects, denoted as (ab), are partially standardized (The coefficients for the categorical predictor, which is 'contact', are in a partially standardized format). In the context of indirect effects, the terms LLCI and ULCI represent the lower and upper 95% confidence interval, respectively, derived from bootstrapping. "Y" denotes the dependent variable.

The next step was to test attitude generalization and intergroup anxiety as potential mediators of the effect of positive vs. negative intergroup contact with the primary outgroup. While there was no mediation through intergroup anxiety, explicit attitudes were directly affected by it (b_{GES} = 0.19, [0.04, 0.79]; b_{therm} = 5.11, [-27.55, -7.08]). Similarly, attitudes towards the primary outgroup had a statistically significant direct effect on explicit attitudes towards East Asian people (b_{GES} = 0.10, [0.27, 0.66]; b_{therm} = 0.06, [0.77, 0.10]) despite overall lack of mediation.

Eight simple mediation models were then performed to test whether attitude generalization mediated the potential effects of intergroup contact in VR with the primary outgroup on feeling thermometers towards other secondary outgroups, namely Muslims, homosexual individuals, people with intellectual disabilities, and immigrants. For each contrast condition, every model underwent individual testing, with education being a control variable. There was no mediation by attitude generalization of the contact effect when comparing intergroup cooperation with intragroup cooperation for any of the secondary outgroups under analysis. Nevertheless, the attitudes towards the primary outgroup significantly influenced attitudes towards Muslims ($b_{Muslims}$=0.08, [0.63, 0.94]), homosexual people ($b_{homosexual}$ = 0.09, [0.68, 1.03]), individuals with intellectual disabilities (b_{intdis} = 0.10, [0.59, 0.98]), and immigrants ($b_{immigrants}$ = 0.08, [0.54, 0.87]).

When comparing intergroup cooperation with competition, the same pattern or results was found, with attitudes towards the primary outgroup significantly influencing attitudes towards Muslims ($b_{Muslims}$ = 0.09, [0.56, 0.91]), homosexual people ($b_{homosexual}$ = 0.11, [0.55, 0.97]), individuals with intellectual disabilities (b_{intdis} = 0.11, [0.41, 0.86]), and immigrants ($b_{immigrants}$ = 0.08, [0.59, 0.89]) but an overall lack of support for mediation.

6 Discussion

6.1 Overview of findings

The main objective of this study is to gain insight into and leverage the potential of VR as a means of examining and diminishing prejudice through intergroup contact. In order to achieve this aim, one systematic review on prejudice reduction in VR and three empirical studies testing the effect of intergroup contact in VR on empathy and outgroup attitudes were conducted. I will first describe the insights gained from the systematic review and then provide an overview of the primary empirical results from various studies.

Study I identified two primary modes of VR contact in the included studies: the outgroup perspective, where participants embody an avatar embodying an outgroup member, and the ingroup perspective, where participants interact with avatars representing outgroup members. Results were mixed, with many studies showing improved attitudes towards outgroups, while others reported no change or even increased prejudice, especially in the case of outgroup perspective. The systematic review also examined the impact on implicit and explicit measures of prejudice. Both types of outcome measures were equally used in the sample, but discrepancies in findings between these measures arose. Mediators such as emotional responses (e.g., empathy, warmth) and feelings of presence in VR were significant in reducing prejudice. Moderators, including social identities, the valence of intergroup contact, exposure frequency, and avatar customization, also influenced outcomes.

Study II examined how VR-based interventions affect empathy levels. The findings showed that participants generally felt less empathy and personal distress after the VR experience. Additionally, participants who felt a stronger sense of presence with others in VR reported different levels of empathic interest, suggesting that the sense of presence influenced how much empathy was felt during intergroup contact.

Study III investigated the effects of direct intergroup contact in VR with two sub-studies in Finland and Italy. In the Finnish sample, the intervention decreased prejudice measures through explicit attitudes, even though there were no significant changes in implicit attitudes. Empathy directly influenced these improved explicit attitudes, and participants who felt a stronger shared identity

with others in VR also had better implicit attitudes towards people of African ethnicity. In the Italian sample, some differences in findings emerged, as the intervention did not significantly change explicit measures of prejudice, but intergroup cooperation in VR reduced implicit bias more effectively than intragroup cooperation. Reduced anxiety during intergroup contact led to better explicit attitudes, and a stronger sense of shared identity with others in VR also improved explicit attitudes towards people with African ethnic background.

Study IV focused on how attitudes towards one contacted outgroup might influence attitudes towards other groups. In the Finnish sample, while the intervention did not directly succeed at improving attitudes towards secondary outgroup, further analysis revealed improved attitudes towards the contacted outgroup mediated the effect of the intervention and led to more positive attitudes towards Middle Eastern people and other groups, including Muslims, homosexual people, individuals with intellectual disabilities, and immigrants, showing support for the STE of contact in VR through attitude generalization. In the Italian sample, the intervention did not improved attitudes towards any secondary groups. However, participants who felt a stronger presence and sense of body ownership in VR had better explicit attitudes towards East Asians. Improved attitudes towards the primary outgroup also positively influenced attitudes towards Muslims, homosexuals, individuals with intellectual disabilities, and immigrants.

6.2 Interpretation of the empirical findings

The findings of Study III, shared in both Italian and Finnish samples, that positive intergroup contact in VR with an avatar that represented an individual with African ethnic background led to a decrease in prejudice (i.e., implicit bias in the Italian sample sample and explicit bias in the Finnish sample) towards people of African ethnic background underscores the potential of VR as a powerful medium for prejudice reduction, provided that the contact is structured in a positive manner.

The effectiveness of VR-based intergroup contact can be attributed to several factors. Firstly, VR allows for immersive and engaging interactions that can simulate real-life social encounters more effectively than traditional methods. Moreover, the structured nature of the positive contact in VR is crucial. According to Allport's (1954) optimal contact conditions, intergroup contact is most effective when it includes elements such as equal status, common goals, intergroup cooperation, and support from authorities or norms. In the studies conducted, these conditions were closely adhered to, ensuring that the contact was positive in nature. Specifically, participants were engaged in a collaborative task that required them to take turns throwing a ball to reach a score of 10. This task created a shared goal and the need to cooperate to achieve it. Then, to ensure

equal status among participants, they were informed that the other avatar was steered by another student taking the experiment, and they were not given any additional information about each other's personal attributes, which helped eliminate potential biases and power imbalances. Finally, the presence and involvement of the experimenter in VR provided the necessary authority support, which is crucial for facilitating positive contact.

The significant decrease in prejudice observed in both the Finnish and Italian samples also suggests that VR can effectively transcend cultural and contextual differences, providing a universally applicable tool for prejudice reduction. By leveraging VR technology, interventions can be designed to target specific intergroup dynamics while maintaining a high level of control over the interaction parameters.

The findings from the Finnish and Italian samples reveal an intriguing pattern: the intervention was successful at improving explicit attitudes in the Finnish sample and implicit attitudes in the Italian sample. This outcome is consistent with the extensive body of research indicating that implicit and explicit attitudes, while related, are distinct constructs that capture different facets of attitudes. Explicit attitudes are conscious beliefs and opinions that individuals can deliberately reflect upon and report (Wilson et al., 2000; Dovidio et al., 2002; Fazio et al., 1995). These attitudes are closely linked to controlled behaviors (for instance, actively supporting policies promoting diversity or speaking in favour of a minority group). The Finnish sample's improvement in explicit attitudes suggests that the VR intervention effectively influenced participants' conscious and deliberate evaluations of people with African ethnic backgrounds. This may partly depend on Finland's cultural context, where explicit attitudes might be more malleable due to a societal emphasis on egalitarian values and inclusivity. Furthermore, the Finnish sample had a narrow age range, mostly spanning between 18 and 20 years old, which could mean that participants were more open to adjusting their conscious beliefs in response to the VR intervention. On the other hand, implicit attitudes are automatic, unconscious responses that can influence behavior without conscious awareness (Word et al., 1974; McConnel & Leibold, 2001). These attitudes are often revealed through nonverbal behaviors, such as facial expressions, body language, and spontaneous reactions, which are typically beyond an individual's conscious control. Implicit measures are thus better predictors of spontaneous, low-deliberation behaviors. The Italian sample's improvement in implicit attitudes indicates that the VR intervention was effective in altering participants' automatic, unconscious biases towards people with African ethnic backgrounds. This might be due to Italy's more heterogeneous cultural context, in which deeply rooted social norms and diverse societal attitudes could make it more challenging to shift explicit attitudes. On the other hand,

implicit attitudes, may be more susceptible to change through immersive VR experiences that bypass regulated resistance.

The success of the VR intervention in influencing both explicit and implicit attitudes, albeit in different samples, underscores the versatility of VR as a tool for prejudice reduction. By creating realistic and engaging virtual environments, VR can target both facets, leading to comprehensive attitude change. The findings from these studies contribute to the growing evidence that VR-based intergroup contact can be a powerful method for reducing prejudice, capable of addressing multiple dimensions of attitudes.

When examining the STE of intergroup contact in VR, the intervention on the Finnish sample revealed indirect effects through attitudes towards the primary outgroup (i.e., people with African ethnic background) on all secondary outgroups tested. This finding highlights the potential for VR interventions to induce widespread changes in attitudes beyond the directly contacted group, emphasizing the utility of VR as a medium for exploring the mechanisms of attitude generalization, as well as the significance of accounting for attitude generalization when studying STE. In the Italian sample, these results were partially supported, suggesting some level of consistency across different cultural contexts, though the effects were not as robust as in the Finnish sample. This partial support indicates that while VR-based intergroup contact has potential, there are variations in how effectively it facilitates attitude generalization across different settings. Therefore, while the initial findings are promising, further research with better-powered studies is needed to solidify our understanding of how VR can influence attitude generalization following intergroup contact.

An intriguing aspect of the empirical findings is the absence of mediation effects of intergroup contact on attitudes through empathy and intergroup anxiety. This lack of mediation could be attributed to several methodological factors, such as the potential lack of adequate statistical power in the studies. With larger sample sizes, the power to detect subtle mediation effects might have been increased.

Additionally, the measure of empathy employed in the Finnish sample focused on state empathy, which reflects participants' immediate empathic responses rather than their empathy towards specific outgroups. This broader measure of empathy may not have been sensitive enough to capture the nuances of intergroup empathy that are crucial for understanding changes in attitudes towards outgroups. Despite the absence of mediation through empathy, the role of intergroup anxiety should not be overlooked. In the Italian sample, intergroup anxiety had a direct effect on explicit attitudes towards both the primary outgroup (i.e., people with African ethnic background) and secondary outgroup (i.e., East Asian people). This suggests that reducing intergroup anxiety can lead to more

favorable explicit attitudes towards outgroups, pointing to the importance of targeting specific emotional responses in prejudice reduction efforts.

In general, the intervention was more effective in the Finnish sample compared to the Italian one, both for direct contact and STE in VR. Several factors could explain this discrepancy. One significant consideration is the composition of the samples. The Finnish sample was notably young and relatively homogeneous in age, which could have contributed to a more uniform response to the intervention. In contrast, the Italian sample was more heterogeneous, encompassing a wider age range and potentially leading to more varied responses.

Another plausible explanation is that the Italian sample was underpowered to detect a potential effect of the intervention in terms of STE. If the expected effect in Italy was smaller than in Finland, the sample size might not have been sufficient to reveal significant results. This possibility underscores the need for larger and more adequately powered studies to accurately assess the intervention's impact across different cultural contexts.

Beyond sample composition, cultural context and social norms also likely played a crucial role. Finland and Italy differ significantly in their cultural attitudes and social norms regarding ethnic diversity and minority groups, as Finland may have a more inclusive culture with stronger social norms against prejudice, which can enhance the effectiveness of interventions aimed at reducing bias. Conversely, Italy might have deeper-rooted prejudices and less supportive social norms concerning diversity (e.g., Pesarini, 2021), making it more challenging for such interventions to yield significant results. The societal orientation towards collectivism versus individualism could further influence the intervention's success. Finland, known for higher levels of social trust and collective responsibility, might be more receptive to interventions that promote social cohesion and intergroup harmony (Holmberg & Rothstein, 2017).

Historical and political contexts also merit consideration. Finland's shorter and more recent history of significant immigration (Broström et al., 2022) may result in a society more adaptable to new diversity and, consequently, more responsive to interventions fostering inclusivity. Italy, with its longer history of immigration, may have more entrenched biases that are harder to overcome. Moreover, the political climate in each country can significantly influence the success of such interventions. If the political discourse in Finland is more supportive of minority rights and integration, this could create a conducive environment for the intervention. In contrast, a more polarized or hostile political climate regarding minorities in Italy could hinder the intervention's effectiveness.

The findings also underscore the significance of considering immersion-related mechanisms when designing and evaluating VR-based interventions. Co-presence, moderated the effect of the intervention on empathy, suggesting that participants

who felt a stronger sense of co-presence during the VR experience were more likely to develop empathetic attitudes towards the outgroup.

Furthermore, both co-presence and body ownership were positively associated with attitudes towards both the primary and secondary outgroups across samples. These relationships highlight that the immersive qualities of VR, such as how real the virtual body feels and how present the virtual environment seems, can significantly impact social perceptions and attitudes. These findings confirm that immersion and presence are not merely technical features of VR but are deeply interrelated with social perceptions and attitudes within virtual environments. When participants feel genuinely present in the virtual setting and identify with their virtual bodies, the impact of the intervention on their attitudes may be enhanced. This suggests that for VR-based interventions to be truly effective, they must be designed to maximize these immersive experiences.

One of the most novel and impactful contributions of this study was the introduction and exploration of the concept of Common Cyber-Identity (CCI). CCI refers to a shared identity that unites individuals interacting in VR through avatars. Remarkably, the study found that participants in both the Finnish and Italian samples reported a strong sense of CCI, regardless of the experimental condition. This was evidenced by high CCI scores (5.58 in the Finnish sample and 4.61 in the Italian sample), indicating that participants felt a significant sense of belonging to the same social group as the avatars they encountered in VR. Despite not mediating the effects of the intervention directly, CCI had a direct effect on attitudes towards the contacted outgroup in both samples. This suggests that a stronger identification with a shared identity in the VR environment leads to more positive attitudes towards minorities encountered in VR, bringing support for the CIIM (Gaertner et al., 1996), which posits that intergroup bias can be reduced by transforming the cognitive representation of separate groups (such as ethnical majority and minorities) into one unified group (such as VR users). Whereas we did not prime the immersive nature of VR to promote a superordinate identity, findings suggest that recategorization took place to some extent, fostering more positive attitudes towards the contacted outgroup.

Additionally, it appears that common identities related to the virtual environment itself are more significant than inducing common identities related to contexts that are not particularly relevant during the virtual experience (Alvidrez & Peña, 2020a, 2020b). Those findings have profound implications, highlighting that the sense of shared identity in virtual environments can be a powerful tool for prejudice reduction. The feeling of belonging to a common cyber-identity appears to foster positive intergroup attitudes, suggesting that VR can create inclusive social spaces where traditional boundaries and biases are diminished. Future research should continue to explore how CCI can be leveraged

to enhance the effectiveness of VR-based interventions and examine the mechanisms through which CCI influences social attitudes and behaviors.

6.3 Theoretical and methodological merits of the studies

The studies conducted possess several strengths across theoretical, methodological, and practical dimensions, contributing to the study of VR-based intergroup relations in significant ways.

One of the primary strengths lies in the novelty of the research. The systematic review conducted is pioneering, as it is the first to consolidate VR-based research focused on intergroup contact and prejudice reduction. Furthermore, the examination of negative contact and the STE of contact within VR environments had not been previously tested, marking a significant advancement in the understanding of these dynamics. Furthermore, encompassing Allport's (1954) optimal contact conditions within a VR framework constitutes another theoretical strength. Prior to these studies, the application of Allport's conditions to VR-based intergroup contact had not been examined.

Methodologically, the decision to have participants interact in VR with avatars steered by real individuals is a noteworthy strength. This approach allows for more natural and interactive contact compared to interactions with computer-steered avatars. Thanks to motion tracking, human-steered avatars can mirror a wide range of non-verbal cues in real time, enhancing the authenticity and richness of the interaction experience.

A practical strength of the experimental studies is the use of a social media app (i.e., Altspace VR) as the platform for VR interactions. This choice is unprecedented in this area of research and is particularly advantageous as social VR media are already in use for intergroup contact globally. Participants interact daily through avatars in such apps, providing realistic and relevant contexts for studying intergroup relations. Additionally, Altspace VR was widely available on most HMDs and free of charge, thus enhancing the accessibility of VR encounters.

One notable merit of our study is that both the systematic review and the experimental studies (Studies III and IV) were pre-registered before data collection. Pre-registration practices enhance methodological rigor by ensuring transparency and helping to prevent data-driven hypothesis adjustments, thereby improving the credibility and reproducibility of the findings.

The implementation of a mixed within-between subjects design for the Finnish sample is a further methodological advantage. As highlighted by our systematic review, this design is underrepresented in VR research. Moreover, mixed designs can enhance the robustness of experimental findings, while offering methodological advantages by eliminating potential biases related to

randomization failures in between-subject experiments, ensuring more reliable results (Heck & Bockting, 2021).

One of the key methodological strengths of this dissertation lies in its comprehensive approach to measuring outcomes, which included both explicit and implicit measures of outgroup attitudes. The relationship between implicit and explicit attitudes has been extensively studied, revealing that these constructs, while distinct, capture different facets of underlying biases (Hofmann et al., 2005; Greenwald et al., 2009). The importance of using both implicit and explicit measures in this dissertation lies in their ability to provide a more comprehensive understanding of attitudes and behaviors. Implicit and explicit biases together offer incremental validity in predicting discriminatory behaviors, capturing variance that neither measure can account for alone (Greenwald et al., 2009). Furthermore, individuals often hold dual attitudes, where explicit and implicit attitudes may differ. This can lead to complex patterns of behavior reflecting both conscious beliefs and automatic responses. Such interaction suggests that comprehensive assessments of bias and prejudice require consideration of both types of measures to fully understand and address these phenomena in social contexts (Greenwald et al., 2009).

6.4 Methodological limitations

The most relevant limitation of our research is the low statistical power of the samples in Studies III and IV, particularly the Finnish sample. The small sample sizes restrict the generalizability of our results and increase the risk of Type II errors, where true effects may not have been detected. This limitation suggests that caution is needed when interpreting the findings and that replication with larger, more representative samples is necessary to confirm the robustness of the results.

Secondly, in designing our interventions, we aimed to closely fulfill Allport's (1954) positive contact conditions in cases of cooperative contact or to introduce threat via stimulating competition to potentially create negative contact. However, a notable limitation is that we did not verify whether these conditions corresponded to participants' own perceptions as a manipulation check. Future research should include measures to assess participants' perceptions to ensure that the conditions of contact are accurately understood and experienced as intended.

Another limitation concerns our behavioral measure (i.e., seating distance), used to assess attitudes towards a secondary outgroup in Study IV, which did not yield the anticipated results. Future studies could benefit from leveraging HMDs to measure more precise behavioral indicators such as proximity or head

orientation. These measures could provide more reliable data on participants' attitudes and interactions within the virtual environment.

Similarly, Altspace VR, the virtual environment employed for the experimental manipulation, presents some limitations, such as the restricted capacity for capturing behavioral measurements, which a custom-madeVR environment would in turn allow. Additionally, the low realism of Altspace avatars may hinder immersion. This is supported by studies indicating that avatars closely resembling participants' appearances can enhance body ownership and co-presence (Waltemate et al., 2018; Heidicker et al., 2017). However, contrasting evidence suggests that the realism of avatars does not affect social presence when compared to more stylized, cartoon-like avatars (Yoon et al., 2019).

One more limitation pertaining the assessment of constructs is the empathy scale used in our studies. Batson's Affective Empathy Scale (1987) focused on situational empathy, which captures the participants' general feelings of empathy at the time of answering the pre- and post-test surveys, rather than empathy directed specifically towards an outgroup or an individual. This choice was intended to detect changes in empathy attributable to the medium. However, this measure might not fully capture the nuances of intergroup empathy, potentially affecting the interpretation of results. Future research should consider employing measures of intergroup empathy to more accurately capture the targeted emotional responses relevant to target outgroups.

Further notable limitations arise from the differences in the design and data collection methods between the Italian and Finnish samples. The Finnish study employed a mixed within-between design with longitudinal measures, allowing for a comprehensive assessment of changes over time. In contrast, the Italian study utilized a between-subjects design with measurements at a single time point. Additionally, different measures were assessed in each study, further complicating direct comparisons between the results. These differences in design and measures make it challenging to draw definitive conclusions about the effectiveness of the interventions across the two samples.

Another limitation pertains to the homogeneity of the Finnish sample in terms of age. The majority of participants in the Finnish study fell within the narrow age range of 18 to 20 years old. This lack of variability in age limits the generalizability of the findings, as attitudes and responses to interventions may vary across different age groups. The limited age range also restricts the extent to which the findings can be extrapolated to broader populations with greater age diversity.

While the VR technology we used enabled interaction with the environment and other avatars, we chose not to allow for verbal exchanges between participants and the avatars they encountered. This decision was made to maintain standardization and avoid introducing variability that could affect the positive valence of contact. However, this limitation might have impacted the perceived

genuineness of the intergroup contact, potentially affecting participants' engagement and the ecological validity of the interactions. Future research should explore the implications of incorporating verbal exchanges in VR-based interventions to enhance the realism and authenticity of intergroup interactions.

6.5 Ethical considerations

While VR technology offers significant advantages for research, it also introduces several ethical considerations that must be diligently addressed. Kenwright (2018) underscores the necessity of acknowledging the associated risks and ethical challenges, emphasizing a responsible research and innovation approach. The dynamic nature of VR and its rapid evolution make it difficult to foresee all potential uses and effects, necessitating agile regulation to keep pace with advancements and mitigate associated risks.

Kenwright (2018) raises concerns about the impact of VR on young adults and children, who may struggle to distinguish between virtual and physical realities. Avatars and virtual agents in VR can exert significant influence on younger users, potentially leading to ethical issues regarding the persuasive power of VR experiences. Kaimara et al. (2021) identify risks such as obesity, sleep disorders, and social isolation associated with inadequate VR use in children and adolescents. However, they also note that regulated VR use can support cognitive and social development. Given that our participants were often as young as 18 and 19, ensuring their safety was paramount. In our studies, we took these concerns into account, ensuring that the VR content and duration were suitable for our young adult participants. Kenwright (2018) also highlights the risk of desensitization associated with immersive VR experiences, drawing parallels to violent video games. The immersive nature of VR could potentially intensify desensitization, raising concerns about the psychological impact of prolonged exposure to certain virtual stimuli. To mitigate these risks, we ensured that the VR content was appropriate for all participants. We carefully reviewed the features of the virtual experience to ensure they were appropriate and safe for all age groups. Moreover, after each VR session, we conducted thorough debriefing sessions to clarify the scope and purpose of the experiment. This was particularly important in scenarios involving negative contact to prevent any adverse effects on participants' attitudes. We explicitly informed participants that the avatars they interacted with were steered by an experimenter, reinforcing the experimental nature of these interactions and mitigating any potential negative impacts on their perceptions of the outgroup.

During our data collection in Finland, some COVID-19 measures were still in place. Therefore, we were especially cautious to maintain high hygiene standards. All equipment, including HMDs and hand controllers, was thoroughly disinfected between uses. Researchers and participants wore masks and adhered to safety distance protocols to minimize the risk of viral transmission, ensuring a safe environment for all participants.

6.6 Implications for future research and practice

The findings from our studies underscore the potential of VR as a critical tool for reducing prejudice and enhancing intergroup relations. However, they also highlight several areas that warrant further investigation and methodological refinement.

Firstly, our systematic review identified a notable absence of longitudinal measures in VR research designs. Understanding whether attitude changes following VR contact are sustained over time is crucial for evaluating the long-term effectiveness of these interventions. Future research should incorporate longitudinal designs to track the persistence of attitude changes and determine whether the positive effects of VR-mediated intergroup contact endure beyond the immediate post-intervention period.

Another significant gap in the current literature is the investigation of attitude change following intergroup contact in VR among minority groups. Most existing research focuses on majority group attitudes toward minorities, leaving a critical need to explore how VR experiences affect minorities' attitudes towards other groups. This line of inquiry is essential for developing comprehensive VR interventions reducing prejudice across all societal groups. However, beyond improving attitudes toward the out-group, positive contact affects disadvantaged-group members' perceptions of intergroup inequality in ways that can undermine their support for social change toward equality. For example, Saguy et al. (2009) found that commonality-focused contact, compared to difference-focused contact, produced heightened but unrealistic expectations for fair behavior among members of disadvantaged groups. Reimer and Sengupta (2023) further support this critique, revealing through a meta-analysis that intergroup contact often has the ironic outcome of decreasing support for social change among the underprivileged. Thus, it is crucial to acknowledge the critique of the contact paradigm in terms of its potential demobilizing effect on promoting social change, particularly among disadvantaged groups.

Given these findings, it is essential to develop theory-driven interventions that carefully consider these potential adverse effects. The contact hypothesis (Allport, 1954), which has proven effective in various settings, offers a promising

foundation for such interventions. Including well-known theoretical mediators, such as emotional responses, could enhance these interventions. Moreover, the Common Ingroup Identity Model (CIIM) could be applied within VR environments to test its potential for reducing prejudice in the context of intergroup contact. Another promising area for exploration is the secondary transfer effect (STE), which examines how changes in attitudes towards one outgroup can influence attitudes towards other outgroups. By investigating these aspects, researchers can aim to develop comprehensive and effective VR-based interventions for prejudice reduction while being mindful of the complexities involved in promoting social change among disadvantaged groups.

Despite the promising results of individual studies, the heterogeneity in VR research methodologies presents a challenge in determining the average effect size of VR interventions on prejudice reduction. Meta-analytical results are needed to synthesize findings across studies, providing a clearer picture of the overall impact and effectiveness of VR-based interventions. Such an analysis would offer valuable insights into the magnitude of effect sizes and help identify the most effective VR intervention strategies, as well as their effectiveness compared to traditional interventions. Strictly contingent to this aspect, it is crucial to address the issues of standardization and comparability in VR research, as highlighted by Chen and White (2024), who proposed a framework incorporating VR input devices and the level of interactivity and mobility in the VR environment to guide future research. This framework aims to standardize the degree of immersion and presence, making it easier to compare findings across studies and enhancing the reliability of conclusions drawn from VR prejudice reduction research.

A critical step forward is the continued integration of both explicit and implicit measures of attitudes in VR studies. Our findings demonstrate that VR contact impacts both explicit attitudes, which are linked to deliberate, controlled behaviors, and implicit attitudes, which predict automatic, nonverbal behaviors. By incorporating both types of measures, researchers can gain a more comprehensive understanding of the effects of VR interventions on prejudice reduction.

Notably, the generalization of attitudes towards the primary outgroups to secondary outgroups emerged as a significant mediator in our research, but other potential mediators, such as empathy and intergroup anxiety, did not show significant mediation effects. Future research should focus on confirming these results with larger, more statistically powerful samples to determine whether these factors truly do not mediate the effects of VR contact or whether the lack of mediation in our studies was due to insufficient power. Understanding the mechanisms through which VR reduces prejudice is essential for refining and enhancing interventions.

Sample size and representativeness are further critical areas in need of improvement. Replication with solid sample sizes and more diverse, representative samples are necessary to ensure the generalizability and robustness of findings. This includes not only larger sample sizes but also greater variability in participant demographics to capture a wide range of experiences and attitudes.

The need for better behavioral measures is another important consideration. Our measure of seating distance did not yield the expected results, highlighting the necessity for more effective and reliable behavioral measures. Yaremych and Persky (2019) emphasize the unique advantage of VR in providing detailed and continuous measurement of behavioral variables. Unlike traditional methods that often rely on one-time point observations or fixed time intervals, VR's integrated tracking capabilities allow for continuous monitoring of behaviors such as head orientation and position tracking. These measures can serve as proxies for eye contact and interpersonal distance, respectively, and have been shown to correspond well with real-world interactions (Pfeiffer et al., 2013; Rubo & Gamer, 2018; Bailenson et al., 2003, 2018, 2021). This enhances the ecological validity of VR studies, making them robust tools for investigating social psychological phenomena with high behavioral accuracy.

Finally, the concept of CCI emerged as a novel and significant finding in our studies. Participants reported strong feelings of shared identity with avatars in VR, regardless of the experimental condition. This suggests that VR can foster a sense of belonging and shared social identity, which directly influences attitudes towards outgroups. Future research should explore how social identities change in VR and how pervasive such changes are, as well as the potential for VR to create inclusive, shared identities that potentially transcend social boundaries.

The practical implications of this research are manifold. Firstly, VR-based interventions can be employed by educational institutions and community organizations to promote intergroup understanding and reduce prejudices. The ability of VR to create immersive and controlled environments makes it an ideal tool for structured contact experiences. Schools and educational actors can utilize VR-based interventions to promote intergroup understanding and reduce prejudices among students. By integrating VR into their curricula, educators can create immersive and controlled environments for contact experiences, which can be tailored to address specific biases. These interventions can be especially effective when designed as collaborative tasks, where students work together towards common goals, fostering mutual support and understanding.

Additionally, private actors can utilize VR to enhance diversity and inclusion efforts, providing employees with virtual experiences that foster empathy and understanding of different perspectives. Such tasks not only enhance engagement but also encourage participants to work together towards shared goals, reinforcing positive intergroup interactions. Collaborative VR experiences can be a powerful

tool in reducing prejudice and fostering a sense of common identity, ultimately leading to more inclusive and harmonious communities.

The gaming industry can harness the findings to support game development that promote positive intergroup interactions and by so doing reduce biases. Furthermore, by incorporating elements that encourage players to embody and understand perspectives of outgroup members, game developers can create experiences that foster empathy and inclusion. This approach may enhance the gaming experience while also contributing to broader social goals of reducing prejudice and promoting diversity.

Moreover, the insights from this research can be leveraged by policymakers and social planners to design VR-based community programs. By incorporating VR into public education and outreach initiatives, communities can harness technology to bridge divides and promote social harmony.

7 Concluding remarks

The results of this dissertation shed light on the significant potential of VR as a tool for reducing prejudice and improving intergroup relations. The findings demonstrate that positive intergroup contact in VR can effectively decrease prejudice towards a wide range of stigmatized minorities, as observed in both the Finnish and Italian samples. This effect reaches beyond the contacted outgroup, and extends to both explicit and implicit attitudes, suggesting that VR interventions can influence a broad spectrum of prejudicial behaviors and beliefs. Furthermore, the concept of a Common Cyber-identity emerged as a powerful factor, directly impacting attitudes towards outgroups and highlighting the importance of shared identities in virtual environments.

Despite some differences in study design and sample composition, our research consistently points to the effectiveness of VR in fostering positive intergroup interactions. The findings underscore the necessity of considering immersion-related mechanisms, such as co-presence and body ownership, which were associated with improved attitudes towards both primary and secondary outgroups.

This research holds significant relevance for communities as it explores the effectiveness of VR in promoting positive relationships between different social groups. By demonstrating the role of VR technology in reducing prejudice, this study suggests that VR can be a powerful medium for fostering inclusivity within communities. The positive effects of VR-mediated contact extend beyond the directly engaged groups, indicating potential benefits for broader social cohesion. Understanding the potential of VR to facilitate meaningful connections and attitude changes towards diverse groups can inform community initiatives aimed at promoting diversity, equity, and social cohesion.

This research has broad practical implications. VR-based interventions offer effective tools for reducing prejudice, applicable in a variety of sectors, with VR's immersive nature enabling controlled contact experiences tailored to address specific biases, making it valuable for educational, community, and corporate settings. Furthermore, research insights can inform policymakers and social planners in designing VR-based programs to promote social cohesion through public education and outreach initiatives.

Lastly, the findings advocate for the careful and ethical use of VR technology, ensuring that the content and experiences provided are conducive to positive social outcomes and do not inadvertently reinforce negative stereotypes or prejudices.

In conclusion, this doctoral dissertation highlights the transformative potential of VR in reducing prejudice and fostering positive intergroup relations. By integrating VR into various societal domains, significant strides can be made towards achieving greater inclusiveness and cohesion.

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Author note

In the process of writing my doctoral thesis, I have utilized AI technology to enhance the clarity of my work. Specifically, ChatGPT-4, a language model developed by OpenAI, has been used. The use of ChatGPT-4 in my thesis writing has been strictly limited to streamlining the presentation of ideas—paraphrasing, refining sentence structure, and improving overall readability.

It is important to emphasize that the content of my doctoral thesis remains entirely original, developed through rigorous research and critical analysis. The AI's role has been confined to assisting with linguistic refinement, ensuring that my arguments and findings are communicated as effectively as possible. At no point has the AI been used to generate content, and all information presented in the thesis has been thoroughly verified and refined.

Appendix 1 – Scales

Feeling Thermometers
The following scale measures your attitude toward some groups; scores range from 0 to 100, like a thermometer. The higher the score, the more favorable your attitude toward the group; 0 indicates an extremely favorable attitude; 50 indicates an attitude neither favorable nor unfavorable; 100 indicates an attitude extremely unfavorable.
Evaluate the following groups by using the scale indicated (from 0 to 100).
Immigrants _____
Homosexual people _____
Individuals with intellectual disabilities_____
People with an African background _____
People with an Arabic background _____

General Evaluation Scale (GES)
How do you generally evaluate people of African/Asian ethnicity? Respond to the following items by selecting the option corresponding to your choice. Response option range from 1 to 7.

People with African/Asian ethnic background are:

1. Cold |Warm
2. Suspicious|Trusting
3. Positive|Negative
4. Friendly|Hostile
5. Respect |Contempt
6. Admiration|Disgust

Empathy
On a scale from 1=not at all to 7=very much, how strongly are you feeling each emotion described in the following list?
I feel…
1. Alarmed
2. Embittered

3. Annoyed
4. Uncomfortable
5. Baffled
6. Embarrassed
7. Worried
8. Upset
9. Empathetic
10. Sensitive
11. Affable
12. Compassionate
13. Affectionate
14. Moved

Intergroup Anxiety

How do you feel when you think about a possible future interaction with *people with African background / people with Arabic background *?

I feel (on a scale from 1=Not at all to 5=Very much):

1. Worried
2. Nervous
3. Awkward
4. Anxious
5. Safe
6. Relaxed

Co-Presence

Rate your agreement with the following statements on a scale from 1=strongly disagree to 5=strongly agree.

1. I often felt as if (my partner) and I were together in the same (room)
2. I was often aware of (my partner) in the same (room)
3. I hardly noticed (my partner) in the (room)
4. I often felt as if we were in different places rather than together in same (room)

Body Ownership

Rate your agreement with the following statements on a scale from 1=strongly disagree to 5=strongly agree.

1. I felt as if the body I saw in the virtual world might be my body.
2. I became nervous when the other avatars approached me.
3. I felt like I controlled the avatar as if it was my own body.
4. I felt like the avatar was not me.
5. I liked being able to control the movements of the avatar.

6. I wanted to say hello to the avatars.

Common Cyber-Identity
This scale was made ad-hoc for the current study.

Rate your agreement with the following statement by ticking the preferred option. (from 1=not at all to 5=very much)

1. When I was in virtual reality, I felt as if the other people I met and I belonged to the same group.
2. When I was in virtual reality, I felt as if the other avatars I met and mine belonged to the same group.

Social Dominance Orientation (SDO_7 short version)
People may have different opinions about how social groups relate to each other in society. Indicate how much you favor or oppose each idea below by selecting a number from 1 to 7 on the scale below. You can work quickly; your first feeling is generally best.
1=Strongly Oppose 2=Somewhat Oppose 3=Slightly Oppose 4=Neutral 5=Slightly Favor 6=Somewhat Favor 7=Strongly Favor

1. An ideal society requires some groups to be on top and others to be on the bottom.
2. Some groups of people are simply inferior to other groups.
3. No one group should dominate in society.
4. Groups at the bottom are just as deserving as groups at the top.
5. Group equality should not be our primary goal.
6. It is unjust to try to make groups equal.
7. We should do what we can to equalize conditions for different groups.
8. We should work to give all groups an equal chance to succeed.

Identification with the National Ingroup
People belong to various cultural and national groups. What do you think about Finnishness? Please evaluate the following statements on a scale from 1 (strongly disagree) to 7 (strongly agree).

1. I identify strongly with the other Finns
2. Being a Finnish person is an important part of who I am
3. I feel strong ties with other Finnish people
4. I feel a sense of solidarity with other Finnish people

VR Use
Respond to the following questions by choosing the preferred option.

1. How familiar were you with VR before our experiment? (1=not at all - 5=very much)
2. How easy or difficult did you find using/navigating in VR? (1=very easy - 5=very difficult)
3. How well did the AltspaceVR app work on your headset? (1=very badly - 5=very well)

Appendix 2 – Supplementary Material Relative to Study I

Table 11 List of studies included in Study I.

Title	Authors	Year	Country of data collection	Total N	Percent female	Ethnic composition	Sample age	Type of design	Control condition	Prejudice target	Kind of interaction	Prejudice-related measures	Examined mediators	Examined moderators	Main results

Title	Authors	Year	Country of data collection	Total N	Percent female	Ethnic composition	Sample age	Type of design	Control condition	Prejudice target	Kind of interaction	Prejudice-related measures	Examined mediators	Examined moderators	Main results
Contact in VR: Testing Avatar Customisation and Common Ingroup Identity Cues on Outgroup Bias Reduction	Alvidrez, S. & Peña, J.	2020	USA	135	82.3	52.5% Asian ; 20.6% Hispanic; 17% Caucasian; 9.9% other	20.47 (sd = 2.05)	between	avatar self-resembling vs not and common ingroup identity cues vs not	Hispanics in the US	avatar	social distance scale	engagement presence scale	common ingroup identity (university)	Having a self-resembling avatar resulted in decreased engagement presence and higher engagement presence was linked to larger social distance. Common ingroup identity cues had no effect on outcomes.

Title	Authors	Year	Country of data collection	Total N	Percent female	Ethnic composition	Sample age	Type of design	Control condition	Prejudice target	Kind of interaction	Prejudice-related measures	Examined mediators	Examined moderators	Main results
Verbal Mimicry Predicts Social Distance and Social Attraction to an Outgroup Member in Virtual Reality	Alvidrez, S. & Peña, J.	2020	USA	54	87	54.1% Asian, 18.5% Hispanic, 18.5% Caucasian,9% other	N/A (18-32)	between	avatar self-resembling vs not and common ingroup identity cues vs not	Hispanics in the US	avatar	social distance scale	verbal mimicry	common ingroup identity (university)	Neither avatar customization nor a common ingroup identity predicted verbal mimicry in VR interactions with a Hispanic outgroup member. Verbal mimicry predicted social attraction positively and social distance negatively.

Title	Authors	Year	Country of data collection	Total N	Percent female	Ethnic composition	Sample age	Type of design	Control condition	Prejudice target	Kind of interaction	Prejudice-related measures	Examined mediators	Examined moderators	Main results
Virtual body ownership and its consequences for implicit racial bias are dependent on social context	Banakou, D., Beacco, A., Neyret, S., Blasco-Oliver, M., Seinfeld, S., & Slater, M.	2020	Spain	92	100	100% white	21.8	between-subjects	Embodying a white virtual body	black people	embodiment	black-white IAT; 'attitudes to Blacks' questionnaire	N/A	positivity/negativity of interaction	Negative experiences while embodying a Black avatar can lead to worse implicit attitudes towards Black people in White participants.
Virtual Embodiment of White People in a Black Virtual Body Leads to a Sustained Reduction in Their Implicit Racial Bias	Banakou, D., Hanumanthu, P. D., & Slater, M.	2016	Spain	90 (in 2 studies)	100	100% white	21.9	between-subjects	Embodying a white virtual body	black people	embodiment	black-white IAT	N/A	number of exposures	Practicing Tai Chi while embodying a Black avatar can reduce White participants' implict bias against Black people.
Virtually Being Einstein Results in an Improvement in Cognitive Task Performance	Banakou, D., Kishore, S., & Slater, M.	2018	Spain	30	0	N/A	22	between-subjects	Embodying a young male adult body, i.e. similar to the subjects'	elderly people	embodiment	age IAT	N/A	N/A	Participants who embodied an avatar that looked like older Einstein performed better on a

Title	Authors	Year	Country of data collection	Total N	Percent female	Ethnic composition	Sample age	Type of design	Control condition	Prejudice target	Kind of interaction	Prejudice-related measures	Examined mediators	Examined moderators	Main results
and a Decrease in Age Bias									own bodies						cognitive task and showed reduced implicit bias against older people, compared to a control condition.
Racial bias and in-group bias in virtual reality courtrooms.	Bielen, S., Marneffe, W., & Mocan, N.	2021	Belgium	275	N/A	N/A	N/A	within	white vs non-white defendants	non-white Belgians	3D video	convictions and sentence harshness in a trial	Perception of terrorism being a very important problem	N/A	Conviction rates are higher for defendant minority member defendant than for white defendants in 3D video staged trials, regardless of the evaluator's group membership. In terms of sentence harshness there is ingroup bias overall.
Presence, what is is good for? Exploring the benefits of virtual reality at evoking empathy towards the marginalized	Boehm, N.	2020	USA	199	66	84% White	N/A	between	VR vs desktop version vs mere perspective-taking vs imagination exercises	drug users	3D video	drug user stereotypes	Empathy: Interpersonal Reactivity Index scale	presence was positively related to empathy	A VR perspective taking intervention led to stronger feelings of physical presence than a desktop version. Feelings of

Title	Authors	Year	Country of data collection	Total N	Percent female	Ethnic composition	Sample age	Type of design	Control condition	Prejudice target	Kind of interaction	Prejudice-related measures	Examined mediators	Examined moderators	Main results
															presence were correlated with empathy towards drug users but did not differ between conditions.
Reducing Outgroup Bias through Intergroup Contact with Non-Playable Video Game Characters in VR	Breves, P.	2020	Germany	86	50	100% White	20.9	between-subjects	Helping a Black NPC in a non-VR video game OR Helping a white confederate	black people	virtual agent	black-white IAT; explicit prejudice against Blacks (Pettigrew & Meertens, 1995)	N/A	N/A	Helping a Black video game character reduced explicit but not implicit bias towards Black people and more so when the game was played in a VR compared to desktop version.
Perspective-Taking in Virtual Reality and Reduction of Biases against Minorities (Study 1)	Chen, V., Chan, S. & Tan, Y.	2021	Singapore	71	46	100% Singaporean Chinese	24.28 (sd = 1.75)	between/mixed	comparison between affective and cognitive instructions	Malay Singaporean	embodiment	feeling thermometers towards ingroup and outgroup	self-other overlap; empathic feelings	N/A	Experiencing an ethnic discrimination scene from the outgroup perspective led to less ingroup bias by decreasing ingroup attitudes, independently from whether participants received a cognitive or

Title	Authors	Year	Country of data collection	Total N	Percent female	Ethnic composition	Sample age	Type of design	Control condition	Prejudice target	Kind of interaction	Prejudice-related measures	Examined mediators	Examined moderators	Main results
															affective perspective-taking instruction.
The Effect of VR Avatar Embodiment on Improving Attitudes and Closeness Toward Immigrants	Chen, V., Ibasco, G., Leow, V., & Lew, J.	2021	Singapore	171	58.5	100% Singaporean Chinese	22.43 (sd = 2.07)	between	ingroup embodiment	PRC Chinese in Singapore	embodiment	feeling thermometer towards target outgroup	empathy; Self-Other overlap	social identity orientation	Experiencing ethnicity-based discrimination embodying an immigrant outgroup avatar improves attitudes and closeness towards that group.
A Virtual Reality Simulation of Drug Users' Everyday Life: The Effect of Supported Sensorimotor Contingencies on Empathy	Christofi, M., Michael-Grigoriou, D., & Kyrlitsias, C.	2020	Cyprus	40	52.5	N/A	N/A	between-subjects	same content presented on a desktop computer	Drug users	embodiment	Attitudes towards drug users	Empathy; Inclusion of Other in the Self (IOS) scale	Interpersonal reactivity index (IRI)	Self-reported attitudes towards drug users improved after experiencing different situations from a drug user's perspective, both in a VR and a desktop application.
VR Disability Simulation Reduces Implicit Bias Towards Persons With Disabilities	Chowdhury, T., Ferdous, S., & Quarles, J.	2021	USA	71	39	N/A	20.3 (sd = 4.6)	between	2X2 design (interface: wheelchair vs gamepad; immersion: VR vs	People with disabilities	embodiment	IAT towards with people with disabilities	N/A	N/A	Embodying a person in a wheelchair in VR with a wheelchair interface reduced implicit

Title	Authors	Year	Country of data collection	Total N	Percent female	Ethnic composition	Sample age	Type of design	Control condition	Prejudice target	Kind of interaction	Prejudice-related measures	Examined mediators	Examined moderators	Main results
									desktop)						bias against people with disabilities more than a desktop version and a gamepad.
A Wheelchair Locomotion Interface in a VR Disability Simulation Reduces Implicit Bias	Chowdhury, T. & Quarles, J.	2021	USA	40	35	N/A	23.6 (sd = 3.1)	between	no wheelchair interface	People with disabilities	embodiment	IAT towards with people with disabilities	N/A	Narrator abled vs disabled	Self-reported attitudes towards drug users improved after experiencing different situations from a drug user's perspective, both in a VR and a desktop application.
Influence of weight etiology information and trainee characteristics on Physician-trainees' clinical and interpersonal communication.	Cohen, R. W., & Persky, S.	2019	USA	119	52	55.5% White, 23.5% Asian, 21% Black, 3.4% Hispanic	26.3	between-subjects	Reading an article unrelated to weight	People with obesity	virtual agent	use of stigmatizing language; responsiveness to patient information needs; communication length; lifestyle counseling; lifestyle assumptions	N/A	N/A	Physician trainees were more likely to talk about weight with and provide lifestyle counselling to virtual patients with obesity when they had just read articles about behavioural or genetic influences on weight relative to a control

Title	Authors	Year	Country of data collection	Total N	Percent female	Ethnic composition	Sample age	Type of design	Control condition	Prejudice target	Kind of interaction	Prejudice-related measures	Examined mediators	Examined moderators	Main results
															condition. In the behavioural condition, they also used more stigmatizing language and made more assumptions about patients' lifestyle.
Using virtual reality to induce gratitude through virtual social interaction	Collange, J., & Guegan, J.	2020	France	80	61	N/A	21	between-subjects	Interaction with an ingroup avatar	black people (Study 1)	avatar	social support intentions	gratitude; impression formation (warmth and competence)	N/A	Receiving help from a virtual outgroup avatar increased participants' willingness to offer social support to benefactors and this effect was mediated by perceived warmth.
Prosocial Virtual Reality, Empathy, and EEG Measures: A Pilot Study Aimed at Monitoring Emotional Processes in Intergroup Helping Behaviors	D'Errico, F., Leone, G., Schmid, M., & D'Anna, C.	2020	Italy	40	47.5	100% White	23.8	between-subjects	Interaction with an ingroup member	black people	3D video	empathy	EEG-measured calmness, engagement, alertness	social appearance	White participants showed stronger self-reported and neurophysiological stress reactions as well as empathy when interacting in a helping situation with a White

Title	Authors	Year	Country of data collection	Total N	Percent female	Ethnic composition	Sample age	Type of design	Control condition	Prejudice target	Kind of interaction	Prejudice-related measures	Examined mediators	Examined moderators	Main results
															person with beggars' clothes or a Black person in business attire than in the other conditions.
Reducing the schizophrenia stigma: A new approach based on augmented reality.	de C. Silva, R. D., Albuquerque, S. G. C., de V. Muniz, A., Reboucas Filho, P. P., Ribeiro, S., Pinheiro, P. R., & Albuquerque, V. H. C.	2017	Brazil	N/A	N/A	N/A	N/A	no control group	N/A	schizophrenia patients	augmented reality	Questionnaire about stigma	N/A	N/A	Medical students showed increased empathy, pity, fear, stigma, and willingness to help towards patients with schizophrenia after using an augmented reality tool to simulate schizophrenia symptoms.
Virtual prejudice	Dotsch, R., & Wigboldus, D. H. J.	2008	Netherlands	33	63.6	100% white	21.4	within-subjects	Interaction with an ingroup avatar	Moroccans (in the Netherlands)	virtual agent (but not explicitly stated; remains passive)	single-target IAT with Moroccan names; explicit prejudice; distance from outgroup avatar	skin conductance	N/A	Participants kept more distance from a virtual agent with Moroccan vs White features, which was predicted by implicit attitudes towards Moroccans. The

Title	Authors	Year	Country of data collection	Total N	Percent female	Ethnic composition	Sample age	Type of design	Control condition	Prejudice target	Kind of interaction	Prejudice-related measures	Examined mediators	Examined moderators	Main results
															effect was mediated by skin conductance levels.
The behavioral dynamics of shooter bias in virtual reality: The role of race, armed status, and distance on threat perception and shooting dynamics	Eiler, B. A.	2017	USA	61	N/A	N/A	N/A	within-subjects	Interaction with an ingroup avatar	Black people	virtual agent (but not explicitly stated; remains passive)	race-weapon IAT; shooter bias	heart rate; perceived threat	distance from outgroup member and armed status (gun, phone, no object)	Black virtual agents were perceived as more threatening and shot at more often than White virtual agents in a shooter bias paradigm.
Virtual Virgins and Vamps: The Effects of Exposure to Female Characters' Sexualized Appearance and Gaze in an Immersive Virtual Environment	Fox, J. & Bailenson, J.	2009	USA	83	48	38.6% White; 24.1% Asian/Asian-American; 13.3% Black/African/African-American; 10.8% Latino/Latina/Hispanic; 13.3% multiracial	20.82 (sd = 3.17; range = 18-34)	between	N/A	Women	virtual agent	Ambivalent Sexism Inventory	N/A	N/A	Participants self-reported stronger sexism after perceiving stereotypical vs counter-stereotypical female virtual avatars.
The Effect of Embodying a Woman Scientist in Virtual Reality on Men's	Freedman, G., Green, M.C., Seidman, M., Flanagan, M.	2021	USA	96	0	.3% African American or Black, 1.0% Arab/Middle Eastern, 31.3% Asian, Asian American, or Asian	19.79 (sd = 1.63)	between/mixed	embodying a male virtual body	women	embodiment	Gender-Science IAT; explicit attitudes towards women in STEM	N/A	N/A	Participants didn't show any improvement in implicit or explicit bias when

Title	Authors	Year	Country of data collection	Total N	Percent female	Ethnic composition	Sample age	Type of design	Control condition	Prejudice target	Kind of interaction	Prejudice-related measures	Examined mediators	Examined moderators	Main results
Gender Biases						Canadian, 3.1% Hispanic/Latino, 47.9% White, 7.3% Multiracial, 2.1% other						(perceptions of the climate for women in STEM, stereotype endorsement)			embodying a female scientist avatar, compared to male avatars performing the same tasks. Game enjoyment was also unvaried between condition. There was no interaction between condition and reveal (early vs. late avatar gender reveal) on the main outcomes. Exploratory analyses showed that participants felt more positive emotions after playing.
Psychological response to an emergency in virtual reality: Effects of victim ethnicity and emergency type on helping behavior and	Gamberini, L., Chittaro, L., Spagnolli, A., & Carlesso, C.	2015	Italy	96	50	100% White	24	between-subjects	Interaction with an ingroup avatar	Black people	virtual agent	helping behaviour in an emergency situation	N/A	N/A	In a virtual helping situation, White participants were less likely to help Black than White virtual agents under time

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navigation															pressure, but no differences were found in dangerous situation (fire in a building).
Being the Victim of Intimate Partner Violence in Virtual Reality: First- Versus Third-Person Perspective	Gonzalez-Liencres, C., Zapata, L. E., Iruretagoyena, G., Seinfeld, S., Perez-Mendez, L., Arroyo-Palacios, J., Borland, D., Slater, M., & Sanchez-Vives, M. V	2020	Spain	32	0	N/A	32	between-subjects	N/A	women	embodiment	gender IAT	N/A	N/A	Men who experienced a situation of intimate partner violence while embodied in a female avatar showed stronger physiological and behavioural reactions and reported stronger feelings of identification with the victim, and of taking the scene personally than a third-person perspective control group.
The influence of racial embodiment on racial bias in immersive virtual environments	Groom, V., Bailenson, J. N., & Nass, C.	2009	USA	98	60	45.1 White, 21 Asian, 15.6 Black, 6.9 Hispanic, 7.8 Other	N/A	between-subjects	Perspective-taking exercise (imagining a day in the life of Black person)	Black people	embodiment	black-white IAT; interpersonal distance; Racial Argument Scale; Modern Racism Scale	N/A	N/A	Participants showed stronger implicit bias against Black people after embodying a Black compared to White avatar.

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Virtual Humans and Persuasion: The Effects of Agency and Behavioral Realism	Guadagno, R. E., Blascovich, J., Bailenson, J. N., & McCall, C.	2007	USA	65 (study 1) + 174 (study 2)	45 (study 1); 51 (study 2)	N/A	N/A	between-subjects	Interaction with male virtual agents	Women	virtual agent	susceptibility to persuasion; dimensions of person perception	N/A	N/A	Participants changed their attitudes more towards a virtual agent's attitude when the virtual agent of the same gender as the participant rather than with a virtual agent of the other gender.
Conceptual knowledge and sensitization on Asperger's syndrome based on the constructivist approach through virtual reality	Hadjipanayi, C., & Michael-Grigoriou, D.	2020	Cyprus	40	50	N/A	N/A	between-subjects	Reading a text about Asperger's syndrome	People with Asperger's syndrome	embodiment	empathy; sensitization towards Asperger's syndrome	N/A	N/A	Participants who used a VR-based simulation of Aspergers gained more knowledge about the syndrome than participants who read about Aspergers.
Virtual race transformation reverses racial ingroup bias	Hasler, B. S., Spanlang, B., & Slater, M.	2016	Spain	32				within-subjects	embodying an ingroup avatar	Black people	embodiment	black-white IAT; liking of the other person; mimicry	N/A	N/A	White participants mimicked virtual agents more if their virtual avatar was of the same skin colour as the virtual agent's than if there was discordance in skin colour,

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															regardless of participants' implicit race bias.
Virtual Peacemakers: Mimicry Increases Empathy in Simulated Contact with Virtual Outgroup Members	Hasler, B. S., Hirschberger, G., Shani-Sherman, T., & Friedman, D. A.	2014	Israel	57	100	100% White	N/A	mixed	counter-mimicking an outgroup virtual agent	Palestinians	virtual agent	empathy; sympathy; self-other overlap; interaction harmony; outgroup affect	N/A	N/A	Conversing with a virtual agent representing a Palestinian led to increased empathy, sympathy, more felt closeness, and to perceptions of a more harmonious interaction when the virtual agent mimicked the participant compared to counter-mimicry.
Virtual Reality-based Conflict Resolution: The Impact of Immersive 360° Video on	Hasler, B., Hasson, Y., Landau, D., Eyal, N. S., Giron, J., Levy, J., Halperin, E., & Friedman, D	2020	Israel	100	0	100% Jewish Israeli	25.4	between-subjects	Watching a video on a desktop computer	Palestinians	3D video	moral justification of soldiers' actions	perspective-taking; empathic emotions; hostile emotions; skin conductance	N/A	Jewish-Israeli participants who watched a 360° video of a conflict scenario between Israeli soldiers and a Palestinian couple judged the soldiers' actions to be less moral and less justified and

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															reported more hostile emotions towards the soldiers relative to a group who watched the video in 2D. These effects were mediated by a higher sense of presence and engagement in the 360° video.
The enemy's gaze: Immersive virtual environments enhance peace promoting attitudes and emotions in violent intergroup conflicts (Study 1)	Hasson, Y., Schori-Eyal, N., Landau, D., Hasler, B. S., Levy, J., Friedman, D., & Halperin, E.	2019	Israel	112	71	100% Jewish Israeli	24.3	between-subjects	Taking the ingroup's perspective in the 360° video	Palestinians	3D video	empathy; fear of the targets; positive appraisals; Attribution of future benign intentions; support for economic compensation	N/A	N/A	Jewish-Israeli participants who watched a 360° video of a conflict scenario between Israeli soldiers and a Palestinian couple from the outgroup's point of view perceived Palestinians more positively than those who watched the scene from the ingroup point of view.
The enemy's gaze: Immersive	Hasson, Y., Schori-Eyal, N., Landau,	2019	Israel	100 (55 at follow	77	100% Jewish Israeli	23.9	between-subjects	Taking the ingroup's perspective	Palestinians	3D video	empathy; fear of the targets; dehumanizatio	N/A	N/A	Jewish-Israeli participants who watched a 360°

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virtual environments enhance peace promoting attitudes and emotions in violent intergroup conflicts (Study 2)	D., Hasler, B. S., Levy, J., Friedman, D., & Halperin, E.			-up 5 months later)					in the 360° video			n; perceived threat; shoot/no-shoot dilemmas			video of a conflict scenario between Israeli soldiers and a Palestinian couple from the outgroup's point of view perceived Palestinians more positively and judged a real-world ingroup transgression five months later more harshly than those who watched the scene from the ingroup point of view.
The effect of gender, religiosity and personality on the interpersonal distance preference: a virtual reality study	Hatami, J., Sharifian, M., Noorollahi, Z., & Fathipour, A.	2020	Iran	46	71	100% Iranian	23.8	between-subjects	N/A	Gender	3D video	preferred distance from the outgroup target member	N/A	N/A	Viewing actors in a 360° video, religious Iranian participants preferred further distances between themselves and opposite gender actors compared to non-religious Iranian participants.

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The Virtual Doppelganger - Effects of a Virtual Reality Simulator on Perceptions of Schizophrenia	Kalyanaraman, S. S., Penn, D. L., Ivory, J. D., & Judge, A.	2010	USA	112	52	N/A	22.2	between-subjects	empathy-inducing instructions without use of VR	People with Schizophrenia	augmented reality	Empathic feelings for people suffering from schizophrenia; social distance scale; attitudes	N/A	N/A	Participants who underwent an augmented reality simulation of schizophrenia with an instruction to empathize with schizophrenia patients showed increases in empathy with and more positive perceptions of people with schizophrenia. Using the augmented reality apparatus without empathy instructions resulted in a stronger desire to keep social distance from people with schizophrenia.
Processing Racial Stereotypes in Virtual Reality: An Exploratory Study Using	Kim, G., Buntain, N., Hirshfield, L., Costa, M. R., & Chock, T. M.	2019	USA	13	47	53.8 White, 23.1 Hispanic, 23.1 Asian	N/A	Within-subjects	racially charged scene vs holiday scene	Black people	3D video	Brain activation in mPFC, right lPFC, left lPFC	N/A	N/A	Viewing a racially-charged animated scene in VR led to stronger activation in the

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Functional Near-Infrared Spectroscopy (fNIRS)															right and left lateral prefrontal cortex than viewing a holiday scene, indicating stronger stereotype activation and suppression in the racially charged scene.
A Virtual Reality Embodiment Technique to Enhance Helping Behavior of Police Towards a Victim of Police Racial Aggression	Kishore, S., Spanlang, B., Iruretagoyena, G., Halan, S., Szostak, D., Slater, M.	2021	USA	38	17	N/A	N/A	within	racially charged scene vs holiday scene	Black people	3D video	behavioral data based on ratings of participant actions and words (helping behaviour towards the victim)	N/A	N/A	After witnessing an abusive questioning of an African American suspect in VR, US police officers were embodied in two different conditions, witness or victim. 3-4 weeks later, they experienced another abusive episode towards an African American person in a cafe, while embodying a White police

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															officer. Participants in the victim condition showed greater support for the victim in the cafe situation.
Testing an Immersive Virtual Environment for Decreasing Intergroup Anxiety among University Students: An Interpersonal Perspective	Kuuluvainen, V., Virtanen, I., Rikkonen, L., Isotalus, P.	2021	Finland	50	78	98% Finnish; 2% Finnish-Russian	27.6 (sd = 7.84; range = 19-49)	between	observer condition (no embodiment)	Middle-Eastern people	embodiment	Intergroup anxiety survey	N/A	N/A	watching a 3D video of a Middle-Eastern man talking about his life and interacting with his family decreases intergroup anxiety in participants, but there is no difference compared to the control group, which was exposed to the same video in 2D.
No Country for Old Men? Reducing Ageism Bias Through Virtual Reality Embodiment	La Rocca, S., Brighenti, A., Tosi, G., & Daini, R.	2019	Italy	24	50	N/A	23.7	Within-subjects	watched 30 years old hand being tapped; anatomical vs non-anatomical arm position	elderly people	3D video	Fraboni Ageism Scale; Age IAT	N/A	N/A	Young adults showed decreased implicit age bias after having embodied a virtually old body whose arm was touched in

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															synchrony with their own physical arm.
How Does Embodying a Transgender Narrative Influence Social Bias? An Explorative Study in an Artistic Context	Lesur, M. R., Lyn, S., & Lenggenhager, B.	2020	Switzerland	114	36	N/A	34.1	between-subjects	VR experience without transgender narrative	Transgender people	3D video	attitudes towards transgender people; IAT (short version)	N/A	N/A	Embodying a Transgender body in 360° video with or without synchronous tactile stimulation did not change implicit transgender bias.
Humans adjust virtual comfort-distance towards an artificial agent depending on their sexual orientation and implicit prejudice against gay men	Lisi, M.P., Fusaro, M., Tieri, G., Aglioti, S.M.	2021	Italy	72	50	N/A	N/A (18-35)	no control	no control	gender	virtual agent	interpersonal distance, explicit sexual prejudice and IAT	N/A	sexual orientation, gender,	Heterosexual Men chose a larger distance toward the male avatar compared to Non-Heterosexual Men; also, among women, the heterosexual participants chose a larger distance toward the female avatar compared to the non-heterosexual ones.

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Investigating Implicit Gender Bias and Embodiment of White Males in Virtual Reality with Full Body Visuomotor Synchrony	Lopez, S., Yang, Y., Beltran, K., Kim, S. J., Hernandez, J. C., Simran, C., Yang, B., & Yuksel, B. F.	2019	USA	24	0	100% White	29.8	mixed	Embodiment in an ingroup avatar	Women	embodiment	gender IAT	N/A	N/A	Male participants who practiced Tai-Chi in a female virtual body showed increases in implicit gender bias while those doing the same exercise with a male virtual body did not show significant changes.
Mitigating Negative Effects of Immersive Virtual Avatars on Racial Bias	Maloney, D.	2018	USA	26	0	100% White	N/A	mixed	Embodiment in an ingroup avatar	Black people	embodiment	IAT	N/A	N/A	White participants who conducted a virtual shooter game showed stronger implicit race bias against Black people when being embodied in a Black relative to White avatar.
Who is Credible (and Where)? Using Virtual Reality to Examine Credibility and Bias of Perceived Race/Ethnicity	Marino, M. I., Bilge, N., Gutsche, R. E., & Holt, L.	2020	USA	248	N/A	66% Hispanic, 15% White, 14% Black, 3% Asian, 2% Native American or other		mixed	Interaction with an ingroup avatar	Hispanics in the US	3D video	attitudes about the neighborhood; opinion of the information source (outgroup member); opinions	N/A	N/A	Participants visited the scene of a break-in in a 360° video, received a description of the robber from an actor, and then judged the

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in Urban/Suburban Environments												of those who disliked the information source (outgroup member); attribution of a crime to the target outgroup member			source's credibility. Ratings of the source were more negative when the source was supposedly from negatively evaluated neighbourhoods.
Proxemic behaviors as predictors of aggression towards Black (but not White) males in an immersive virtual environment	McCall, C., Blascovich, J., Young, A., & Persky, S.	2009	USA	47	26	68% White, 17% Hispanic, 8.5% Asian, 2.1% multiracial, 4.2% no identification	N/A	between-subjects	Interaction with an ingroup avatar	Black people	virtual agent	distance kept from target; shooting game; feelings towards virtual agents	N/A	N/A	Participants' proxemic behaviours (interpersonal distance and head movements) towards virtual agents were predictive of later shooting behaviour against these agents only for Black but not for White agents.
Through Pink and Blue Glasses: Designing a Dispositional Empathy Game Using Gender Stereotypes and Virtual	Muller, D. A., Van Kessel, C. R., & Janssen, S.	2017	Netherlands	19	N/A	N/A	N/A	between-subjects	N/A	Gender	virtual agents	empathy; willingness to act against sexism	N/A	N/A	Experiencing a virtual simulation of sex-discrimination situations from the point of view of both men and women

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Reality															led participants to self-report more dispositional empathy and perspective-taking and willingness to act in future discrimination situations.
Virtually old: Embodied perspective taking and the reduction of ageism under threat. (Study 1)	Oh, S. Y., Bailenson, J., Weisz, E., & Zaki, J.	2016	USA	148	64	43% White, 32% Asian, 11% Latino, 7% Black, 7% other	21)	within-subjects	Perspective taking exercise	elderly people	embodiment	perceived threat; explicit ageism; self-other overlap; future communication intentions	N/A	N/A	When confronted with intergenerational threat, young adult participants reported more self-other overlap with older adults after a perspective-taking exercise, especially when this was supported with the experience of embodying an avatar representing an older person.
Virtually old: Embodied perspective taking and the	Oh, S. Y., Bailenson, J., Weisz, E., & Zaki, J.	2016	USA	84	55	54% White, 12% Asian, 8 % Latino, 13% Black, 13% Other	N/A	between-subjects	Perspective taking exercise	elderly people	embodiment	perceived threat; self-other overlap; future	N/A	N/A	Being socially excluded by older adults in a ball toss game,

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reduction of ageism under threat. (Study 2)												communication intentions; affect misattribution procedure; empathic listening task			young adult participants showed less self-other overlap and more implicit preference for young over older people and this could not be overcome by an empathy task nor by embodying an older adult's virtual avatar.
Evidence of Racial Bias Using Immersive Virtual Reality: Analysis of Head and Hand Motions During Shooting Decisions	Peck, T. C., Good, J. J., & Seitz, K.	2021	USA	99	56	80 White, 9 Asian, 8 Hispanic, 3 Black, 1 multi-racial	23.1	Within-subjects	Interaction with ingroup avatars	Black people	virtual agent	shooter bias (accuracy, latency, motion paths, bias scores)	N/A	Socioeconomic Status	Performing a shooter task in immersive virtual reality, participants showed no racial or socioeconomic bias in terms of latency to shoot but head and hand motion analyses predicted participants' implicit racial bias.
Putting yourself in the skin of a	Peck, T. C., Seinfeld, S.,	2013	Spain	60	100	N/A	N/A	between-subjects	embodying an ingroup	Black people	embodiment	race IAT	N/A	N/A	White participants who

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black avatar reduces implicit racial bias	Aglioti, S. M., & Slater, M								or "alien-skinned" avatar OR seeing a non-embodied black-skinned virtual body						embodied a Black avatar reduced their implicit bias towards Black people more than participants embodying avatars with white or purple skin.
Virtual Reality and Political Outgroup Contact: Can Avatar Customization and Common Ingroup Identity Reduce Social Distance?	Peña, J., Wolff, G., Wojcieszak, M.	2021	USA	149	100	38.2% Asian, 27.2% Latino, 29.9% Caucasian, 2.3% African American, 2.4% other	20.3 (sd = 2.04)	between	embodying an avatar that looked like someone else; priming common ingroup identity (based on gender)	political outgroup	virtual agent	self-reported social distance	female identity salience	N/A	A sample of liberal women were either embodied in an avatar they customized to resemble themselves or someone else, and had their female identity either primed or not. They all met in VR a virtual agent representing a conservative woman. While avatar customization had an influence on social distance towards the political

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															opponent, common ingroup identity priming did not. Female identity salience was found not to mediate the latter relationship.
Medical student bias and care recommendations for an obese versus non-obese virtual patient	Persky, S., & Eccleston, C. P.	2011	USA	76	57	59% White, 32% Asian, 14% Black, 3% Hispanic	26.2	between-subjects	Interaction with ingroup avatar	Obese people	virtual agent	negative stereotyping; belief about patients' health; perceptions of patients' adherence; perception of patients' responsibility; visual contact; clinical recommendations	N/A	N/A	Medical students interacting with an obese (vs non-obese) virtual patient displayed more stereotyping, perceived the patient's health to be worse, attributed more responsibility, anticipated less patient adherence, and made less visual contact with the patient but did their clinical recommendations were unaffected by weight status.
An Investigation	Redmond, D.,	2019	N/A	54	48	N/A	22.06 (sd =	between	vignette not priming	people with depression	virtual agent	personal stigma and perceived	N/A	N/A	Participants met a male virtual

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Into The Impact of Virtual Reality Character Presentation on Participants' Depression Stigma	Hennessey, E., O'Connor, C., Balint, K., Parsons, T.D., Rooney, B.						5.61)		depression; virtual agent trying to make eye contact			stigma towards depression			agent in a cafe after reading a vignette either representing depression or not, while the virtual agent was either seeking eye contact with the participant or avoiding it. Neither experimental condition affected participants' level of stigma towards people with depression.
Cultivating Empathy Through Virtual Reality: Advancing Conversations About Racism, Inequity, and Climate in Medicine	Roswell, R. O., Cogburn, C. D., Tocco, J., Martinez, J., Bangeranye, C., Bailenson, J. N., Wright, M., Mieres, J. H., & Smith, L.	2020	USA	76	N/A	N/A	N/A	Within-subjects	N/A	Black people	3D video	empathy; emotions regarding discrimination; experiences (qualitative data)	N/A	N/A	Participants of professional development sessions for medical school and health system leaders, faculty, and staff experienced three racial discrimination scenarios from the perspective of a Black male. Afterwards they reported more empathy

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															towards minorities and felt that the experience helped them understand the experiences of other people.
The impact of virtual reality on implicit racial bias and mock legal decisions	Salmanowitz, N.	2018	USA	92	50	100% White	28	between-subjects	experiencing the scenario without a virtual body	Black people	embodiment	Race IAT; Explicit attitudes re: race and gender (SRS, MSS); decision in mock crime scenario; follow-up after 5 days: another mock crime scenario and questions re: severity, likelihood of reoffending, an severity of sentence	N/A	N/A	After embodying a Black avatar, participants showed lower implicit racial bias and evaluated an ambiguous legal case more conservatively compared to participants who were immersed in a virtual world but did not embody an avatar.
The Effects of Embodiment in Virtual Reality on Implicit Gender Bias	Schulze, S., Pence, T., Irvine, N., & Guinn, C.	2019	USA	16	31	93.8 White, 6.2 Black	N/A	between-subjects	embodying a male avatar	Women	embodiment	IAT "women and leadership"	N/A	N/A	Male and female participants were embodied in male or female avatars in an environment associated with leadership. Across all

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															conditions there was a trend towards increased implicit bias against women in leadership positions.
Shooter Bias in Virtual Reality: The Effect of Avatar Race and Socioeconomic Status on Shooting Decisions	Seitz, K. R., Good, J. J., & Peck, T. C.	2020	USA	50	N/A	N/A	N/A	between-subjects	Interaction with ingroup members	Black people	virtual agent	shooter bias	N/A	N/A	Participants in an immersive virtual shooter bias paradigm made fewer errors in trials with Black compared to White targets and were faster to shoot at agents that represented low, compared to high, socio-economic status and this was most pronounced for Black agents.
"I'm a Computer Scientist!": Virtual Reality Experience Influences Stereotype Threat and	Starr, C. R., Anderson, B. R., & Green, K. A.	2019	USA	79	100	46% Asian, 32% Latina, 14% White, 4% multiethnic	20.3	within-subjects	embodying a woman working in humanities	Women	embodiment	Self-STEM IAT; Gender-STEM IAT; Stereotype threat; expectancy beliefs; value beliefs	N/A	N/A	Female participants who embodied an avatar who had a successful career in science or technology showed

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STEM Motivation Among Undergraduate Women															(compared to a control condition that showed a career in humanities) higher course motivation, lower anticipated stereotype threat, stronger implicit associations between women and science/technology if they identified with the VR experience.
Can intergroup contact in virtual reality (Vr) reduce stigmatization against people with schizophrenia?	Stelzmann, D., Toth, R., & Schieferdecker, D.	2021	Germany	114	58	N/A	24 (sd = 6.6)	between	watching the same video in 2D; other control condition (not specified)	schizophrenia patients	3D video	anxiety, social proximity, empathy, and benevolence	N/A	N/A	Participants either watched a 3D or 2D video about a male schizophrenic patient describing life with schizophrenia, or were sorted in the control group. VR increased stigmatization of schizophrenic patients compared to the

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															2D condition, while it had no effects compared to the control condition.
Body swapping with a Black person boosts empathy: Using virtual reality to embody another	Thériault, R., Olson, J.A., Krol, S.A., & Raz, A.	2021	Canada	90	71	71% female, 29% male; 87% students; 50% White, 26% Asian, 17% South-Asian, 7% other	22.2 (sd = 3.0)	between	mental perspective-taking exercise; no intergroup contact	Black people	embodiment	explicit measures, IAT, and empathy	N/A	N/A	Participants took the experiment with a Black person (confederate). Those in the experimental condition embodied said confederate's virtual body and saw through their perspective, while in the mental perspective-taking condition they had to imagine a day in the life of the confederate. No intergroup contact took place in the control condition. While the use of VR incresed empathy compared to the

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															control condition, there was no difference between the VR condition and the mental perspective-taking condition.
The design and evaluation of a body-sensing video game to foster empathy towards chronic pain patients	Tong, X., Ulas, S., Jin, W., Gromala, D., & Shaw, C.	2017	Canada	15	27	N/A	24.8	Within-subjects	N/A	Chronic pain patients	embodiment	Pommier Compassion Scale; Willingness to Help Scale	N/A	N/A	Participants showed stronger willingness to help with people living with chronic pain after embodying an avatar that simulated everyday situations from the point of view of people with chronic pain.
HIV-related stigma in social interactions: Approach and avoidance behaviour in a virtual environment	Toppenberg, H. L., Bos, A. E. R., Ruiter, R. A. C., Wigboldus, D. H. J., & Pryor, J. B.	2015	Netherlands	50	74	N/A	22.3	Within-subjects	Interaction with an ingroup avatar	HIV patients and homosexual men	virtual agent	Interpersonal distance; approach and walking away speed; time looking at virtual agent; homosexuality IAT; explicit attitudes towards homosexuals	N/A	N/A	When interacting with virtual agents in a virtual hospital setting, participants kept a larger interpersonal distance and approached the agent faster when the agent

Title	Authors	Year	Country of data collection	Total N	Percent female	Ethnic composition	Sample age	Type of design	Control condition	Prejudice target	Kind of interaction	Prejudice-related measures	Examined mediators	Examined moderators	Main results
															was depicted to have HIV rather than cancer, especially when the agent was depicted as being homosexual. HIV patients were looked at more often and less looked away from than other patients. Effects were unrelated to implicit and explicit attitudes.
HIV status acknowledgment and stigma reduction in virtual reality: The moderating role of perceivers' attitudes.	Toppenberg, H. L., Ruiter, R. A. C., & Bos, A. E. R.	2019	Netherlands	58	52	N/A	22.7	within-subjects	N/A	HIV patients	virtual agent	HIV-IAT; explicit attitudes towards people with HIV	N/A	N/A	In a virtual job interview situation, participants evaluated HIV-positive virtual job applicants as more competent if they acknowledged their disease status and if explicit attitudes towards people living with HIV were positive. Applications were evaluated more highly if

Title	Authors	Year	Country of data collection	Total N	Percent female	Ethnic composition	Sample age	Type of design	Control condition	Prejudice target	Kind of interaction	Prejudice-related measures	Examined mediators	Examined moderators	Main results
															they were not responsible for their infection.
The Effects of Immersive Virtual Reality in Reducing Public Stigma of Mental Illness in the University Population of Hong Kong: Randomized Controlled Trial	Yuen, A. S. Y. & Mak, W. W. S.	2021	Hong Kong	206	55.3	N/A	21.76 (sd = 5.04, range: 18-64)	between/mixed	reading a written text from the perspective of a person with anxiety and depressive disorder; no intergroup contact condition	people with anxiety and depressive disorders	embodiment	public stigma towards people with mental illness (self-report)	sense of embodiment; story transportation	N/A	Embodying a person with anxiety and depressive disorders significantly reduced public stigma compared to the control condition, but not to the text condition. Both the embodied and text conditions have significant effects on public stigma over time (both at post-test and follow-up). Sense of embodiment and story transportation are sequential mediators of the effect of condition on public stigma.
Enfacing a female reduces the gender–	Zhang, X., Hommel, B., & Ma, K.	2021	China	97	100	N/A	21.49 (sd = 1.43,	between/mixed	enfaced avatar with asynchrono	Women in science	embodiment	Gender-Science IAT	N/A	N/A	Participants enfaced in a female virtual

Title	Authors	Year	Country of data collection	Total N	Percent female	Ethnic composition	Sample age	Type of design	Control condition	Prejudice target	Kind of interaction	Prejudice-related measures	Examined mediators	Examined moderators	Main results
science stereotype in males							range: 19-25)		us movements						avatar with synchronous movements showed decreased prejudice towards women in science after the experience compared to participants assigned to the control group (enfaced in female avatars with asynchronous movements).

Table 12 Risk of bias assessment following the Cochrane Collaboration's risk of bias tool (Higgins et al., 2019).

Title	Authors	Selection bias: random sequence generation	Selection bias: allocation concealment	Performance bias: experimenter	Performance bias: participant	Detection bias: rated outcome	rating	Detection bias: rated outcome	rating	Detection bias: rated outcome	rating	Attrition bias (participants)	Attrition bias (outcome)	Reporting bias
Contact in VR: Testing Avatar Customisation and Common Ingroup Identity Cues on Outgroup Bias Reduction	Alvidrez, S. & Peña, J.	unclear	unclear	high	low	self-report	unclear	--	--	--	--	unclear	unclear	low
Verbal Mimicry Predicts Social Distance and Social Attraction to an Outgroup Member in Virtual Reality	Alvidrez, S. & Peña, J.	unclear	unclear	high	low	self-report	unclear	verbal distance	low	--	--	unclear	unclear	low
Virtual body ownership and its consequences for implicit racial bias are dependent on social context	Banakou, D., Beacco, A., Neyret, S., Blasco-Oliver, M., Seinfeld, S., & Slater, M.	high	unclear	unclear	unclear	IAT	low	self-reported prejudice	high	--	--	unclear	unclear	low
Virtual Embodiment of White People in a Black Virtual Body Leads to a Sustained Reduction in Their Implicit Racial Bias	Banakou, D., Hanumanthu, P. D., & Slater, M.	unclear	unclear	unclear	unclear	IAT	low	self-reported prejudice	high	--	--	unclear	unclear	low
Virtually Being Einstein Results in an Improvement in Cognitive Task Performance and a Decrease in Age Bias	Banakou, D., Kishore, S., & Slater, M.	unclear	unclear	unclear	unclear	IAT	low	--	--	--	--	unclear	unclear	low
Racial bias and in-group bias in virtual reality courtrooms.	Bielen, S., Marneffe, W., & Mocan, N.	unclear	unclear	unclear	unclear	judgments	unclear	concern about terrorism	unclear	--	--	unclear	unclear	unclear

Title	Authors	Selection bias: random sequence generation	Selection bias: allocation concealment	Performance bias: experimenter	Performance bias: participant	Detection bias: rated outcome	rating	Detection bias: rated outcome	rating	Detection bias: rated outcome	rating	Attrition bias (participants)	Attrition bias (outcome)	Reporting bias
Presence, what is is good for? Exploring the benefits of virtual reality at evoking empathy towards the marginalized	Boehm, N.	unclear	unclear	high	unclear	self-reports	unclear	--	--	--	--	low	unclear	low
Reducing Outgroup Bias through Intergroup Contact with Non-Playable Video Game Characters in VR	Breves, P.	unclear	low	high	low	IAT	low	--	--	--	--	unclear	unclear	low
Perspective-Taking in Virtual Reality and Reduction of Biases against Minorities (Study 1)	Chen, V., Chan, S. & Tan, Y.	unclear	unclear	unclear	unclear	self-reports	unclear	--	--	--	--	unclear	unclear	low
The Effect of VR Avatar Embodiment on Improving Attitudes and Closeness Toward Immigrants	Chen, V., Ibasco, G., Leow, V., & Lew, J.	unclear	unclear	unclear	unclear	self-reports	unclear	--	--	--	--	low	low	unclear
A Virtual Reality Simulation of Drug Users' Everyday Life: The Effect of Supported Sensorimotor Contingencies on Empathy	Christofi, M., Michael-Grigoriou, D., & Kyrlitsias, C.	unclear	high	high	high	self-reports	unclear	--	--	--	--	low	low	low
VR Disability Simulation Reduces Implicit Bias Towards Persons With Disabilities	Chowdhury, T., Ferdous, S., & Quarles, J.	unclear	unclear	high	unclear	IAT	low	--	--	--	--	low	unclear	unclear
A Wheelchair Locomotion Interface in a VR Disability	Chowdhury, T. &	unclear	unclear	high	unclear	IAT	low	--	--	--	--	low	unclear	unclear

Title	Authors	Selection bias: random sequence generation	Selection bias: allocation concealment	Performance bias: experimenter	Performance bias: participant	Detection bias: rated outcome	rating	Detection bias: rated outcome	rating	Detection bias: rated outcome	rating	Attrition bias (participants)	Attrition bias (outcome)	Reporting bias
Simulation Reduces Implicit Bias	Quarles, J.													
Influence of weight etiology information and trainee characteristics on Physician-trainees' clinical and interpersonal communication.	Cohen, R. W., & Persky, S.	unclear	unclear	unclear	unclear	communication outcomes	low	--	--	--	--	low	low	low
Using virtual reality to induce gratitude through virtual social interaction	Collange, J., & Guegan, J.	unclear	high	high	low	self-reports	unclear	--	--	--	--	low	low	low
Prosocial Virtual Reality, Empathy, and EEG Measures: A Pilot Study Aimed at Monitoring Emotional Processes in Intergroup Helping Behaviors	D'Errico, F., Leone, G., Schmid, M., & D'Anna, C.	unclear	unclear	unclear	unclear	EEG measures	low	--	--	--	--	low	low	low
Reducing the schizophrenia stigma: A new approach based on augmented reality.	de C. Silva, R. D., Albuquerque, S. G. C., de V. Muniz, A., Reboucas Filho, P. P., Ribeiro, S., Pinheiro, P. R., & Albuquerque, V. H. C.	high	high	N/A	N/A	self-reports	high	--	--	--	--	low	low	low
Virtual prejudice	Dotsch, R., & Wigboldus, D. H. J.	unclear	low	low	unclear	distance from avatar in VR	low	skin conductance	low	IAT	low	low	low	low
The behavioral dynamics of shooter bias in virtual reality: The role of race, armed status, and distance on threat	Eiler, B. A.	low	low	low	unclear	shooter bias	low	--	--	--	--	low	low	low

Title	Authors	Selection bias: random sequence generation	Selection bias: allocation concealment	Performance bias: experimenter	Performance bias: participant	Detection bias: rated outcome	rating	Detection bias: rated outcome	rating	Detection bias: rated outcome	rating	Attrition bias (participants)	Attrition bias (outcome)	Reporting bias
perception and shooting dynamics														
Virtual Virgins and Vamps: The Effects of Exposure to Female Characters' Sexualized Appearance and Gaze in an Immersive Virtual Environment	Fox, J. & Bailenson, J.	unclear	unclear	unclear	unclear	self-report	unclear	--	--	--	--	low	low	unclear
The Effect of Embodying a Woman Scientist in Virtual Reality on Men's Gender Biases	Freedman, G., Green, M.C., Seidman, M., & Flanagan, M.	low	low	unclear	low	explicit attitudes	unclear	IAT	low	--	--	low	low	low
Psychological response to an emergency in virtual reality: Effects of victim ethnicity and emergency type on helping behavior and navigation	Gamberini, L., Chittaro, L., Spagnolli, A., & Carlesso, C.	unclear	unclear	unclear	unclear	discrimination	low	--	--	--	--	low	low	low
Being the Victim of Intimate Partner Violence in Virtual Reality: First- Versus Third-Person Perspective	Gonzalez-Liencres, C., Zapata, L. E., Iruretagoyena, G., Seinfeld, S., Perez-Mendez, L., Arroyo-Palacios, J., Borland, D., Slater, M., & Sanchez-Vives, M. V	unclear	high	high	unclear	physiological measures	low	IAT	low	--	--	low	low	low
The influence of racial embodiment on racial bias in immersive virtual environments	Groom, V., Bailenson, J. N., & Nass, C.	unclear	high	high	low	IAT	low	Interpersonal distance	low	MRS and RAS	unclear	low	low	low

Title	Authors	Selection bias: random sequence generation	Selection bias: allocation concealment	Performance bias: experimenter	Performance bias: participant	Detection bias: rated outcome	rating	Detection bias: rated outcome	rating	Detection bias: rated outcome	rating	Attrition bias (participants)	Attrition bias (outcome)	Reporting bias
Virtual Humans and Persuasion: The Effects of Agency and Behavioral Realism	Guadagno, R. E., Blascovich, J., Bailenson, J. N., & McCall, C.	unclear	unclear	unclear	unclear	agreement with agent's argument	unclear	impression of virtual agent	low	--	--	low	low	low
Conceptual knowledge and sensitization on Asperger's syndrome based on the constructivist approach through virtual reality	Hadjipanayi, C., & Michael-Grigoriou, D.	unclear	high	high	unclear	sensitization	unclear	--	--	--	--	low	low	low
Virtual race transformation reverses racial ingroup bias	Hasler, B. S., Spanlang, B., & Slater, M.	unclear	unclear	unclear	unclear	IAT	low	mimicry	low			low	low	low
Virtual Peacemakers: Mimicry Increases Empathy in Simulated Contact with Virtual Outgroup Members	Hasler, B. S., Hirschberger, G., Shani-Sherman, T., & Friedman, D. A.	unclear	high	high	unclear	empathy	unclear	self-other overlap	unclear	outgroup affect	unclear	high	low	low
Virtual Reality-based Conflict Resolution: The Impact of Immersive 360° Video on	Hasler, B., Hasson, Y., Landau, D., Eyal, N. S., Giron, J., Levy, J., Halperin, E., & Friedman, D	unclear	unclear	unclear	unclear	self-reports	unclear	physiological measurements	low	--	--	low	low	unclear
The enemy's gaze: Immersive virtual environments enhance peace promoting attitudes and emotions in violent intergroup conflicts (Study 1)	Hasson, Y., Schori-Eyal, N., Landau, D., Hasler, B. S., Levy, J., Friedman, D., & Halperin, E.	unclear	unclear	unclear	unclear	self-reports	unclear	--	--	--	--	low	low	low

Title	Authors	Selection bias: random sequence generation	Selection bias: allocation concealment	Performance bias: experimenter	Performance bias: participant	Detection bias: rated outcome	rating	Detection bias: rated outcome	rating	Detection bias: rated outcome	rating	Attrition bias (participants)	Attrition bias (outcome)	Reporting bias
The enemy's gaze: Immersive virtual environments enhance peace promoting attitudes and emotions in violent intergroup conflicts (Study 2)	Hasson, Y., Schori-Eyal, N., Landau, D., Hasler, B. S., Levy, J., Friedman, D., & Halperin, E.	unclear	unclear	unclear	unclear	self-reports	unclear	--	--	--	--	low	low	low
The effect of gender, religiosity and personality on the interpersonal distance preference: a virtual reality study	Hatami, J., Sharifian, M., Noorollahi, Z., & Fathipour, A.	low	low	low	unclear	preferred distance	unclear	--	--	--	--	unclear	low	low
The Virtual Doppelganger Effects of a Virtual Reality Simulator on Perceptions of Schizophrenia	Kalyanaraman, S. S., Penn, D. L., Ivory, J. D., & Judge, A.	unclear	high	high	unclear	self-reports	unclear	--	--	--	--	low	low	low
Processing Racial Stereotypes in Virtual Reality: An Exploratory Study Using Functional Near-Infrared Spectroscopy (fNIRS)	Kim, G., Buntain, N., Hirshfield, L., Costa, M. R., & Chock, T. M.	unclear	high	unclear	unclear	brain activation	low	--	--	--	--	low	low	low
A Virtual Reality Embodiment Technique to Enhance Helping Behavior of Police Towards a Victim of Police Racial Aggression	Kishore, S., Spanlang, B., Iruretagoyena, G., Halan, S., Szostak, D., & Slater, M.	low	unclear	low	unclear	helping behavior	low	--	--	--	--	low	low	low
Testing an Immersive Virtual Environment for Decreasing Intergroup Anxiety among University Students: An	Kuuluvainen, V., Virtanen, I., Rikkonen, L., & Isotalus, P.	low	unclear	high	low	intergroup anxiety	high	--	--	--	--	low	low	low

Title	Authors	Selection bias: random sequence generation	Selection bias: allocation concealment	Performance bias: experimenter	Performance bias: participant	Detection bias: rated outcome	rating	Detection bias: rated outcome	rating	Detection bias: rated outcome	rating	Attrition bias (participants)	Attrition bias (outcome)	Reporting bias
Interpersonal Perspective														
No Country for Old Men: Reducing Age Bias through Virtual Reality Embodiment	La Rocca, S., Brighenti, A., Tosi, G., & Daini, R.	unclear	low	low	unclear	IAT	low	Ageism Scale	unclear	--	--	low	unclear	low
How Does Embodying a Transgender Narrative Influence Social Bias? An Explorative Study in an Artistic Context	Lesur, M. R., Lyn, S., & Lenggenhager, B.	high	high	high	low	IAT	low	Explicit attitudes towards transgender	unclear	--	--	low	low	low
Humans adjust virtual comfort-distance towards an artificial agent depending on their sexual orientation and implicit prejudice against gay men	Lisi, M.P., Fusaro, M., Tieri, G., & Aglioti, S.M.	unclear	unclear	unclear	high		low		low		high	low	low	low
Investigating Implicit Gender Bias and Embodiment of White Males in Virtual Reality with Full Body Visuomotor Synchrony	Lopez, S., Yang, Y., Beltran, K., Kim, S. J., Hernandez, J. C., Simran, C., Yang, B., & Yuksel, B. F.	unclear	unclear	unclear	unclear	IAT	low	--	--	--	--	low	low	low
Mitigating Negative Effects of Immersive Virtual Avatars on Racial Bias	Maloney, D.	unclear	unclear	unclear	high	IAT	low	--	--	--	--	high	low	high

Title	Authors	Selection bias: random sequence generation	Selection bias: allocation concealment	Performance bias: experimenter	Performance bias: participant	Detection bias: rated outcome	rating	Detection bias: rated outcome	rating	Detection bias: rated outcome	rating	Attrition bias (participants)	Attrition bias (outcome)	Reporting bias
Who is Credible (and Where)? Using Virtual Reality to Examine Credibility and Bias of Perceived Race/Ethnicity in Urban/Suburban Environments	Marino, M. l., Bilge, N., Gutsche, R. E., & Holt, L.	high	high	high	unclear	self-reports	unclear	--	--	--	--	low	low	low
Proxemic behaviors as predictors of aggression towards Black (but not White) males in an immersive virtual environment	McCall, C., Blascovich, J., Young, A., & Persky, S.	unclear	unclear	unclear	unclear	proximity	low	shooting task data	low	feelings towards the agent	high	low	low	low
Through Pink and Blue Glasses: Designing a Dispositional Empathy Game Using Gender Stereotypes and Virtual Reality	Muller, D. A., Van Kessel, C. R., & Janssen, S.	high	high	unclear	unclear	self-reports	unclear	--	--	--	--	low	low	unclear
Virtually old: Embodied perspective taking and the reduction of ageism under threat. (Study 1)	Oh, S. Y., Bailenson, J., Weisz, E., & Zaki, J.	unclear	high	high	unclear	self-reports	unclear	--	--	--	--	low	low	low
Virtually old: Embodied perspective taking and the reduction of ageism under threat. (Study 2)	Oh, S. Y., Bailenson, J., Weisz, E., & Zaki, J.	unclear	high	high	unclear	self-reports	unclear	affect misattribution procedure	low	Empathic Listening Task	low	high	low	low
Putting yourself in the skin of a black avatar reduces implicit racial bias	Peck, T. C., Good, J. J., & Seitz, K.	unclear	unclear	unclear	unclear	IAT	low	--	--	--	--	low	low	low

Title	Authors	Selection bias: random sequence generation	Selection bias: allocation concealment	Performance bias: experimenter	Performance bias: participant	Detection bias: rated outcome	rating	Detection bias: rated outcome	rating	Detection bias: rated outcome	rating	Attrition bias (participants)	Attrition bias (outcome)	Reporting bias
Evidence of Racial Bias Using Immersive Virtual Reality: Analysis of Head and Hand Motions During Shooting Decisions	Peck, T. C., Seinfeld, S., Aglioti, S. M., & Slater, M	unclear	low	low	low	IAT	low	movement data etc	low	--	--	low	unclear	low
Virtual Reality and Political Outgroup Contact: Can Avatar Customization and Common Ingroup Identity Reduce Social Distance?	Peña, J., Wolff, G., & Wojcieszak, M.	low	unclear	high	low	social distance	high	--	--	--	--	low	low	unclear
Medical student bias and care recommendations for an obese versus non-obese virtual patient	Persky, S., & Eccleston, C. P.	unclear	unclear	unclear	unclear	self-reports	unclear	visual contact	low	--	--	low	low	low
An Investigation Into The Impact of Virtual Reality Character Presentation on Participants' Depression Stigma	Redmond, D., Hennessey, E., O'Connor, C., Balint, K., Parsons, T.D., & Rooney, B.	unclear	unclear	unclear	low		low	--	--	--	--	low	low	high
Cultivating Empathy Through Virtual Reality: Advancing Conversations About Racism, Inequity, and Climate in Medicine	Roswell, R. O., Cogburn, C. D., Tocco, J., Martinez, J., Bangeranye, C., Bailenson, J. N., Wright, M., Mieres, J. H., & Smith, L.	high	high	high	high	self-reports	high	--	--	--	--	high	low	low
The impact of virtual reality on implicit racial bias and mock legal decisions	Salmanowitz, N.	unclear	unclear	unclear	low	mock legal decision	low	IAT	low	explicit attitudes	high	low	low	low

Title	Authors	Selection bias: random sequence generation	Selection bias: allocation concealment	Performance bias: experimenter	Performance bias: participant	Detection bias: rated outcome	rating	Detection bias: rated outcome	rating	Detection bias: rated outcome	rating	Attrition bias (participants)	Attrition bias (outcome)	Reporting bias
The Effects of Embodiment in Virtual Reality on Implicit Gender Bias	Schulze, S., Pence, T., Irvine, N., & Guinn, C.	unclear	unclear	unclear	unclear	IAT	low	--	--	--	--	low	low	low
Shooter Bias in Virtual Reality: The Effect of Avatar Race and Socioeconomic Status on Shooting Decisions	Seitz, K. R., Good, J. J., & Peck, T. C.	unclear	unclear	low	low	shooter bias	low	--	--	--	--	low	low	high
"I'm a Computer Scientist!": Virtual Reality Experience Influences Stereotype Threat and STEM Motivation Among Undergraduate Women	Starr, C. R., Anderson, B. R., & Green, K. A.	unclear	unclear	unclear	low	IATs	low	self-reports	unclear	--	--	low	low	low
Can intergroup contact in virtual reality (Vr) reduce stigmatization against people with schizophrenia?	Stelzmann, D., Toth, R., & Schieferdecker, D.	low	low	high	low	all self reports	high	--	--	--	--	low	low	low
Body swapping with a Black person boosts empathy: Using virtual reality to embody another	Thériault, R., Olson, J.A., Krol, S.A., & Raz, A.	low	high	high	unclear	IAT	low	self reported racial bias	high	empathy	unclear	low	low	low
Designing a Virtual Reality Game for Promoting Empathy Toward Patients With Chronic Pain: Feasibility and Usability Study.	Tong, X., Gromala, D., Kiaei Ziabari, S. P., & Shaw, C. D.	high	high	high	high	all self-report	high	--	--	--	--	low	low	low

Title	Authors	Selection bias: random sequence generation	Selection bias: allocation concealment	Performance bias: experimenter	Performance bias: participant	Detection bias: rated outcome	rating	Detection bias: rated outcome	rating	Detection bias: rated outcome	rating	Attrition bias (participants)	Attrition bias (outcome)	Reporting bias
The design and evaluation of a body-sensing video game to foster empathy towards chronic pain patients	Tong, X., Ulas, S., Jin, W., Gromala, D., & Shaw, C.	high	high	high	high	all self-report	high	--	--	--	--	low	low	low
HIV-related stigma in social interactions: Approach and avoidance behaviour in a virtual environment	Toppenberg, H. L., Bos, A. E. R., Ruiter, R. A. C., Wigboldus, D. H. J., & Pryor, J. B.	unclear	unclear	low	high	distance, speed, head orientation	low	IAT	low	explicit attitudes	high	low	low	low
HIV status acknowledgment and stigma reduction in virtual reality: The moderating role of perceivers' attitudes.	Toppenberg, H. L., Ruiter, R. A. C., & Bos, A. E. R.	unclear	unclear	low	high	IAT	low	explicit attitudes	high	evaluation of job candidate	unclear	low	low	low
The Effects of Immersive Virtual Reality in Reducing Public Stigma of Mental Illness in the University Population of Hong Kong: Randomized Controlled Trial	Yuen, A. S. Y. & Mak, W. W. S.	low	unclear	high	low	Perception of public stigma	low	--	--	--	--	low	low	low
Enfacing a female reduces the gender–science stereotype in males	Zhang, X., Hommel, B. &, Ma, K.	low	unclear	unclear	unclear	IAT	low	--	--	--	--	low	low	low