SHARING EXPERIENCES OF SYSTEMIC INEQUITY: USING VIRTUAL TIME TRAVEL TO DISRUPT WHITENESS AND PROMOTE ENVIRONMENTAL JUSTICE

by

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(Under the Direction of Sun Joo (Grace) Ahn)

ABSTRACT

Individuals are fundamentally motivated to construct shared understandings with others, or shared realities. Virtual environments show promise in constructing shared experiences that reflect everyday interactions. However, when shared knowledge is influenced by Whiteness—a deeply ingrained racist system—such *realities* can be distorted. This multi-method dissertation explores the intersection of Whiteness, systemic racism, and virtual reality (VR) as a tool for promoting environmental justice. The first study involves semi-structured interviews to co-design a VR time travel narrative about environmental racism. A pilot test examines the correlation between source credibility and the construction of shared reality with a virtual agent. The final study, a laboratory experiment, uses the co-designed VR narrative to investigate underlying mechanisms of shared reality. Guided by shared reality theory and critical Whiteness studies, this dissertation demonstrates the potential of VR to disrupt entrenched systemic racism by fostering new understandings and motivating support for environmental justice efforts.

INDEX WORDS: Virtual Reality, Shared Reality, Whiteness, Source Credibility, Systematic Representative Design, Community-Participatory Research Framework

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DEDICATION

To Michelle, mahal ko.

Your unwavering support and love has been my greatest strength.

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CHAPTER 1

INTRODUCTION AND STUDY OVERVIEW

Understanding systemic inequities, particularly those rooted in environmental racism—or the disproportionate hazardous exposure that many communities of color must endure (Bullard, 1996; Swope et al., 2022)—is complicated by the pervasive influence of Whiteness. Whiteness is a racist oppressive system of power born out of the legacies of colonization that prioritizes those racialized as white (Haney Lopez, 2006; Rabaka, 2007). This racist system manifests through laws, policies, and practices, which is (re)produced through media forms, normalizing and legitimizing hierarchical social structures at individual and structural levels (Haney Lopez, 2006). This influence distorts shared knowledge and reality, making it difficult for people to fully grasp the present-day implications of historical injustices. Whiteness shapes perceptions, interactions, and even research methodologies, often sidelining the experiences and perspectives of historically excluded and marginalized communities (Bonilla-Silva, 2006; hooks, 2001). This results in a fragmented understanding of environmental racism, where different groups live in disparate realities informed by their socio-cultural backgrounds.

Immersive virtual environments, like virtual reality (VR), offer a novel way to bridge these disparate realities by providing first-hand experiences that transcend traditional learning methods. By simulating real-life scenarios, VR can vividly depict the long-term impacts of systemic racism, such as the lingering effects of past discriminatory policies on health disparities in communities of color (Swope et al., 2022). However, the design and implementation of these VR narratives must actively disrupt practices rooted in Whiteness to be effective. This

dissertation employs a critical Whiteness framework and integrates community-based participatory research (CBPR) to co-create VR narratives grounded in lived experiences. These narratives aim to foster a shared reality, shifting worldviews not distorted by Whiteness to enhance understanding of systemic inequities and motivating action toward environmental justice. The theoretical backgrounds of Whiteness, shared realities, and virtual environments are provided in Chapters 2, 3, and 4, respectively. While Chapter 5 dives into disrupting Whiteness within VR narrative development and research methodologies.

Chapter 6 begins by detailing the first study of this dissertation featuring semi-structured interviews with ten content experts to gain insight into constructing a shared reality about environmental racism with a virtual agent. Following a community-based participatory research (CBPR) approach, the semi-structured interviews leverage the content experts' feedback to co-design and improve an initial interactive virtual time travel narrative prototype. Experts were selected based on their prior experience and knowledge of environmental health and with having direct involvement working with community members on addressing environmental racism. Five experts work for community-centered non-profit health organizations that provide services to underserved families and five experts work in federally-funded environmental health facilities conducting community-based research. Chapter 7 reports the interview results through conducting a Latent Dirichlet Allocation (LDA) topic modeling technique on transcribed interview data, central themes were revealed and further examined through a critical thematic analysis. Based on the topic modeling and thematic analysis, Chapter 8 details a discussion and the improvements that were made to the final virtual time travel narrative that was tested in the preceding pilot test and laboratory experiment.

Chapter 9 describes the pilot test conducted on a cohort of first-year medical students attending an environmental justice workshop at Emory University. Over 60 students viewed the updated co-designed virtual time travel prototype and answered a brief post-experience questionnaire with measurements of source credibility perceptions and generating shared reality with the virtual agent. Results indicated a positive linear relationship between source credibility and shared reality. Limitations of the single sample pilot test are discussed and addressed in the subsequent laboratory experiment.

Based on the findings of the interviews and pilot test, Chapter 10 provides additional theoretical motivation and hypotheses behind the laboratory experiment. Chapter 11 details a three-condition between-subjects experiment was conducted to test the effects of virtual time travel in influencing perceptions of speaker source credibility, likability, and media presence in constructing a shared reality between user and virtual agent. Participants viewed either the environmental racism narrative with or without the virtual time travel technique, or read a narrative text (e.g., Wikipedia article) detailing the same information as the VR story. Exploratory analyses on counterarguing perceptions and willingness to support environmental justice efforts are also presented. Results and discussion of the laboratory experiment are provided in Chapter 12 and Chapter 13, followed by a more in-depth discussion of all three experiments within the context of a critical Whiteness framework in Chapter 14.

CHAPTER 2

WHITENESS, ENVIRONMENTAL RACISM, AND MEDIA'S ROLE

Whiteness is a pervasive oppressive system with roots in historical colonization and ongoing racist practices. This system prioritizes and grants privileges upon Anglo-European descendants or those racialized as "white" over those who do not *qualify* as white (i.e., white supremacy)(Bonilla-Silva, 2017; hooks, 2001; Rabaka, 2007). Emerging from the global colonizing influence of the European empire, Whiteness acts as an ingrained normative center, valuing and perpetuating itself, often remaining invisible to those benefiting from its privileges (Bonilla-Silva, 2017; Rabaka, 2007). This global phenomenon is observed largely in the colonized regions of Australia, South Africa, and the United States (Coleman et al., 2021), where Whiteness manifests as a taken-for-granted standard to compare all else to, clinging to the desire to maintain and (re)produce its systems (Bonilla-Silva, 1997; Painter, 2011). Whiteness creates ingrained favorability in white-dominant societies, making it challenging to disrupt the structural power systems that maintain it (Bonilla-Silva, 2017; Rabaka, 2007).

In the United States, Whiteness intertwines with the settler colonialism genocide of Native and Indigenous populations (Cook-Lynn, 1997) and the enslavement of African Americans and peoples from Africa (Painter, 2011; Roediger, 2007). These racist and dehumanizing practices shaped the societal and economic foundations of the U.S., relying heavily on the socioeconomic power gained from the exploitation and exclusion of those deemed *not white* (Bonilla-Silva, 2017). Those in power justified racial hierarchies with racist pseudo-scientific practices (e.g., skull size and IQ) and religious doctrine (e.g., Christianity) where white

people are deemed superior and all others inferior (Davis, 2018). Such laws and policies served—and continue to serve—as efforts to rationalize colonialism, genocide, imperialism, capitalism, slavery, and the continued exclusionary practices of people of color in educational and career opportunities (Davis, 2018; Hill Collins, 2009). Ultimately, Whiteness legitimizes a system of racial hierarchies that perpetuate the superiority of white individuals while marginalizing and delegitimizing historically oppressed groups (i.e., people racialized as Black, Indigenous, Latine, Asian, and other people of color)(Bonilla-Silva, 2017; Hill Collins, 2009; Mullings, 2005).

Years of overtly racist laws and practices (e.g., Jim Crow) have helped create and shape a white identity in the U.S. (Haney Lopez, 2006). Through an extensive examination of court cases, Haney Lopez (2006) reveals how race was legally constructed in the U.S. on a foundation of "common knowledge" (p. 5) or public community opinion (Davis, 2018). Rather than simply relying on physical characteristics, language, or ancestry, individuals were assigned racial categories on a white versus non-white basis at the discretion of those in control (Haney Lopez, 2006). Sometimes, those immigrating to the U.S. would petition courts to be legally recognized as white because they saw the value of belonging to Whiteness (Haney Lopez, 2006). For example, around the late 19th and early 20th centuries, immigrants from countries like Ireland or Italy were once recognized as non-white, even those with lighter skin complexion (Jacobson, 1998). During the Jim Crow era, these immigrants witnessed (and often took part in, due to the advantages of Whiteness) the discriminatory and racist policies and practices against Black citizens and other people with darker complexions (Jacobson, 1998). As U.S. society became more diverse, those of lighter skin tones labeled non-white could assimilate into Whiteness and be granted an "honorary white" status (Bonilla-Silva, 1997; Haney Lopez, 2006). After many

discussions about classifying people, courts in the South and West during Jim Crow emphasized that anyone not legally "black" was, therefore, legally "white" (Jacobson, 1998, p. 232). In other words, to achieve the advantages of Whiteness is to distance oneself from Blackness.

Environmental Racism

State and local Jim Crow laws remained legal and enforced until the mid-20th century (i.e., 1930s-1960s), institutionalizing racial segregation in schools, transportation, housing, and other public facilities (Swope et al., 2022). These laws led to the creation of segregated neighborhoods and communities, reinforcing historical inequities that persist today. One significant practice during this era was *redlining*, a racist housing policy used by the newly formed federal Home Owners' Loan Corporation (HOLC) in the 1930s. Across the U.S., the HOLC marked areas on maps as either desirable and rated A for "best," outlined in green, B for "still desirable" and outlined in blue, C for "definitely declining" and outlined in yellow, or undesirable and rated D for "hazardous," outlined in red—hence, *redlining* (Swope et al., 2022).

Areas were rated based on their racial makeup, with areas rated A being almost exclusively white and enforcing barriers to prevent non-white people from buying homes there. Areas rated D were predominantly Black communities and were typically excluded from federal home lending, like the FHA (i.e., Federal Housing Administration)(Coates, 2014). Because D-rated areas were considered undesirable and, therefore, dispensable, cities chose these sites as locations for industrial plants, landfills, and freeways (Swope et al., 2022). These racist practices resulted in many communities of color—predominantly African American and Black communities, as well as Latine, Filipino, and immigrant communities—being confined to resource-deprived areas and disproportionately exposed to environmental hazards, such as dirtier

air, water, and soil, also referred to as *environmental racism* (Lee et al., 2022; Nelson et al., 2023; Swope et al., 2022).

Although the practice of redlining was outlawed in 1968 (Swope et al., 2022), recent studies found that these racist practices reinforced existing segregation and Jim Crow laws (Aaronson et al., 2021; Faber, 2020; Heard-Garris et al., 2021), and contributed to long-term underinvestment in these communities (Rothstein, 2018; Woods et al., 2014). Some of the detrimental effects of historic redlining are linked to disproportionately higher poverty rates (Aaronson et al., 2021), food insecurities (Alkon et al., 2020; Raja, 2020; Shaker et al., 2023), housing loan lending discrimination (Faber, 2020; Park & Quercia, 2020; Rutan & Glass, 2018), police brutality and carceral systems (Baker et al., 2021), and health-related issues such as preterm births (Hollenbach et al., 2021; Nardone et al., 2020), cancer (Beyer et al., 2019; Krieger et al., 2020), asthma (Schuyler & Wenzel, 2022), cardiovascular diseases (Churchwell et al., 2020), diabetes, poor mental health, and COVID-19 occurrence and mortality (Lee et al., 2022; Lynch et al., 2021; O'Hara & Toussaint, 2021; Richardson et al., 2020).

Research linking past discriminatory practices to present-day health disparities has influenced public health sciences to recognize the role that social determinants of health, such as race and environmental conditions, play in health outcomes (Hahn, 2021). Specifically, over the last few decades, this research has increasingly acknowledged that health consequences are fundamentally predicated on societal *systems* (i.e., Whiteness) that control the distribution, allocation, and withholding of harms or resources (Hahn, 2021). These systems of power ensure that the discriminatory, racist policies and practices of the past are not just problems of the past but persistent injustices that continue to widen the health gap between prioritized white and wealthy communities at the expense of the lives of those who are not.

Redlining, while a significant factor, is just one element within a larger, interconnected system that maintains racism and Whiteness, including over-policing and gentrification (Swope et al., 2022). This perpetuation further exacerbates and reinforces societal inequities through the influence of laws, social norms, economic policies, and cultural practices (Lund, 2022). Understanding environmental racism within this dynamic and complex system proves challenging without extensive knowledge and lived experiences. Addressing the fundamental systemic change required to disrupt persisting inequities demands a comprehensive and multifaceted approach, especially when such patterns are replicated and reinforced within media.

Media's Role in Whiteness

In the multifaceted landscape of systemic oppression, media often functions as a perpetuator of existing power structures. Operating at individual, cultural, and structural levels, the media plays a pivotal role in shaping narratives that can either reinforce or challenge the norms dictated by Whiteness (Lund, 2022). At the individual level, thoughts, attitudes, and behaviors often stem from stereotypes and favorability of one's racial group. On a cultural level, dominant groups justify practices through shared social values and norms, influencing literature, entertainment, media, and other popular culture expressions that shape perceptions of other groups (Davis, 2018). Structural or institutional oppression manifests through large organizations, such as government, education, and legal systems, prioritizing the interests and perspectives of dominant social groups at the expense of others (Davis, 2018; Haney Lopez, 2006).

Despite media representations becoming more diverse, white dominant norms persist across various formats—from traditional outlets like magazines and television to emerging technologies like virtual reality and artificial intelligence. A study examining thirty *Time*

magazine covers between 1996 and 1999 found that illustrations depicting the "prototypical American" exclusively featured white individuals (Entman & Rojecki, 2001, p. 53). There were other covers published during this time, however, the only Black individuals featured were well-known celebrities like Oprah Winfrey and Michael Jordan. Entman & Rojecki (2001) suggest patterns such as this indicate that when thinking of the "average American," editors (who are presumably white) tend to think of a white person, reinforcing a prevailing association between Whiteness and Americanness.

In a more recent examination of children's literature from 2018, half of all characters represented are white, with the next greatest proportion (27%) being animals and nonhuman characters (i.e., robots, aliens)(Lund, 2022). Characters depicted as "African American (10%), Asian Pacific Islander/Asian Pacific American (7%), Latinx (5%), and American Indian/First Nations (1%)," made up the remaining 23% (Lund, 2022, p. 137). When examining the authors of these stories, only 3 out of 42 books including Indigenous characters were written by Indigenous authors (Lund, 2022). The other 39 books included several stereotypes, biases, and factual errors (Lund, 2022). Put differently, white children grow up seeing themselves portrayed in various contexts (e.g., superheroes, astronauts, scientists). The already limited representation of characters for children of color is riddled with instances that maintain Whiteness and offer very limited authentic representation (Lund, 2022). Ultimately, these experiences can contribute to shaping worldviews and perceptions of others at very early ages.

Similar patterns are also found in other media narrative formats such as television sitcoms (Lund, 2022). For example, popular white sitcoms such as *Friends* present the viewer with a sanitized, raceless version of the world. In the rare circumstances where people of color or queer characters make an appearance, they often became subjects of racist and homophobic

jokes, reinforcing white dominance in media (Lund, 2022). Storylines in television, film, and more recently in immersive virtual reality experiences often center on Whiteness to maintain the status quo, reinforce racial boundaries, or present a utopian view of racial affairs. The pervasive "white savior trope" frequently seen in historical narratives involving people of color positions white individuals as the solution to racism, further entrenching racial hierarchies (Lund, 2022; Nakamura, 2020).

Early depictions of environmental racism coverage began attracting attention in the early 1980s when civil rights groups in Warren County, North Carolina, protested dumping millions of pounds of cancer-causing toxins in a landfill site in the county with the highest percentage of Black Americans in the state (Mohai et al., 2009; Moore & Lanthorn, 2017). Although the government still allowed the toxic dumping despite widespread disapproval, the media coverage from these demonstrations helped spark investigations into establishing the link between race, racism, and toxic waste sites (Bullard, 1983; Mohai et al., 2009). However, despite the attention gained from these earlier protests, many environmental disasters receive little news attention unless they impact a white and wealthy population (Mohai et al., 2009). Moreover, when the media does cover such events, coverage of the problems are often sensationalized, or the communities of color dealing with environmental racism are stereotyped (Moore & Lanthorn, 2017). For instance, citizen complaints are often overshadowed by statements from official sources, leading to residents being portrayed as desperate and demoralized despite months of proactive efforts before gaining mainstream attention. Furthermore, the narratives rarely include Black activists as the leaders of these demonstrations, a pattern especially evident during the Flint, Michigan water crisis (Jackson, 2017).

Some scholars argue that it wasn't until Flints' human-made water crisis that the city became known for environmental racism, as commenters quickly noted the majority Black population of the city (Bullard, 1996; Pauli, 2019). The Flint water crisis gained national attention around the same time as several high-profile police murders of Black men, sparking national racial injustice discourse and continued support for the Black Lives Matter movement (Pauli, 2019). This situation forced many to recognize the overlapping systems of power that disproportionately affect the lives of Black communities. However, Jackson (2017) details that the national news coverage of Flint came much too late. Nearly a year before making national headlines, local community members and outlets had been tirelessly reporting on and protesting the issues, prompting questions about whether the crisis's significance could have been mitigated with earlier intervention. Jackson (2017) suggests that this delay of media attention is due to a lack of diversity in newsrooms and the likelihood to respond only *after* harm has been confirmed by doctors and scientists, rather than addressing the widespread concerns of citizens.

Exploring the role of media in perpetuating Whiteness and shaping societal narratives reveals that media reflects and reinforces the desires and perspectives of those in power. This dynamic media relationship within social structures and cultural norms establishes a foundation for understanding the shared reality constructed through mediated communication, a concept explored in the subsequent section.

CHAPTER 3

SHARED REALITIES

The interplay between Whiteness and media holds significant relevance as individuals navigate and perceive the world through two interconnected avenues of social information: lived experience (e.g., education, socialization, conversation) and mediated communication (e.g., television, video games, social media)(Entman & Rojecki, 2001). Amidst the backdrop of a U.S. education system that often whitewashes history and the enduring effects of segregation and redlining, individuals frequently find themselves in environments that predominantly foster interactions with similar others (Coleman et al., 2021). Additionally, media narratives can either reinforce or disrupt Whiteness to construct shared worldviews (Lund, 2022), together with lived experiences, help to shape what can be termed as *shared reality* (Echterhoff & Higgins, 2021), or "the product of the motivated process of experiencing a commonality of inner states about the world" (Echterhoff et al., 2009, p. 498).

Shared reality theory suggests that within any social group, individuals collaboratively construct a shared understanding of reality through communication, shared experiences, and mutual agreement on thoughts, feelings, beliefs, and values (Echterhoff & Higgins, 2021; Rossignac-Milon et al., 2021). Humans, driven by an innate desire to share experiences with others, actively seek to create shared truths about the world, especially within close relationships (Higgins, 2019). People tune and adapt their interactions to match friends' feelings and thoughts to experience a shared reality (Higgins, 2019). For example, when certain life moments are spent

apart from a loved one, there is often a wish to share that experience with them because it would make that moment even more meaningful (Higgins, 2019).

Shared reality is a foundation for interpersonal relationships and group cohesion, establishing a common worldview (Higgins, 2019). Individuals seek validation from others, aiming to confirm that their perception of the world aligns with the "correct" view. In other words, people possess a *motivated connection* to share certainty about the world with others and a *motivated cognition* to perceive a similar reality about the world with others (Echterhoff & Higgins, 2021). The two motivations fundamentally work together to produce shared understandings or perceptions of reality: motivated *connection* is satisfied by the desire to have common experiences with others, and motivated *cognition* is satisfied by having those experiences verified or co-constructed. For example, individuals driven by a concern for environmental injustice by protesting a toxic dumping site alongside others who share the same concerns creates a strong *motivated connection*, strengthening community and solidarity while reinforcing their collective identity. Additionally, individuals can seek additional information to validate their worldview by choosing to watch or support organizations that uphold environmentally friendly practices, illustrating *motivated cognition*. Sharing one's understanding of the world and having it co-constructed with others enhances interpersonal connections, transforming subjective experiences into shared, objective *truths*—or what individuals *believe* is real about the world (Echterhoff & Higgins, 2021; Higgins, 2019).

The motivation to create shared realities offers benefits such as strengthening collaborations, coordination, and relationships (Higgins, 2019). While typically easier to create with close others, recent research has also found that constructing a shared reality is possible even with strangers or new acquaintances (Rossignac-Milon et al., 2021). This is because, at its

core, the desire to create a shared reality allows individuals to learn from others, providing a basic sense of belonging and connection. However, this intrinsic motivation to build connections with like-minded individuals also comes with consequences, particularly when shared realities reinforce homogeneity (Echterhoff & Higgins, 2021). Such shared truths, driven by limited exposure to diverse social information, can lead to attitudes, feelings, and beliefs that create distrust, fear, and conflicts with groups holding different perspectives (Higgins, 2019).

Many of these consequences can be attributed to Whiteness, where biased educational content and media representations limit exposure to diverse perspectives and cultivate a distorted view of racial realities. Because of Whiteness, the U.S. education system has often prioritized white stories and justified racist acts as necessary for the country's good, as told from a white perspective. White people are often centered as heroes and leaders who are always morally good (Lund, 2022). When these historical perspectives are taught to many generations, it can be difficult to disrupt shared understandings of white superiority and motivate white people to unlearn such history (Coleman et al., 2019). Notably, while highly educated individuals may hold less overt and implicit racist attitudes, the foundation of race education in the U.S. allows white people to understand that overt racism is wrong but fail to fully grasp the seriousness of ignoring, denying, or misunderstanding why racism is much more than individual biases (Coleman et al., 2019). Being socialized as white in the U.S. means being part of a "collective forgetting about the deeply-rooted history of racism underlying the nation's structures and institutions" (Coleman et al., 2019, p. 2), making many white individuals' (and potentially those subscribing to Whiteness) resistant to acknowledging and addressing white privilege, ignoring racial inequities, and *systemic racism* as a whole.

At individual and structural levels, Whiteness reinforces itself through educational systems, media portrayals, and limited intergroup interactions, promoting worldviews that sustain and legitimize dominant social hierarchies (e.g., white supremacy)(Coleman et al., 2021). Individual worldviews skewed in favor of Whiteness that are then consistently reinforced exert a profound influence on forming institutions, organizations, laws, and policies, normalizing a particular perspective within society. Challenging these shared worldviews becomes crucial for initiating systemic change on a grand scale. Without such challenges, the persistence of Whiteness remains entrenched, impeding efforts to evoke transformative change.

Shared reality theory is essential for understanding environmental racism because it emphasizes the importance of common experiences and mutual agreement in forming perceptions of reality (Echterhoff & Higgins, 2021). For instance, the structural inequities of redlining are difficult to grasp without a shared reality that includes the historical and systemic nature of these practices. Without a shared understanding of how past racist policies continue to impact present-day disparities, efforts to address environmental racism remain fragmented (Bullard, 1996). Recognizing the importance of shared realities can help bridge the disparate experiences shaped by segregation and whitewashed history and media, fostering a more comprehensive and accurate understanding of environmental injustices.

Interpersonal Interventions to Construct Alternative Shared Realities

Earlier research highlights that individuals are naturally more inclined to align attitudes and views with those who share similar perspectives and backgrounds, reinforcing the creation of shared realities among people who are likable and share status (Echterhoff et al., 2009; Hardin & Higgins, 1996; Higgins, 1992; Pierucci et al., 2013). Although creating shared realities with individuals holding differing *truths* can be difficult, interventions that challenge shared

worldviews, particularly those rooted in Whiteness, offer valuable insights for deconstructing the complexities of shared reality and work towards co-constructing alternative, antiracist worldviews.

Traditional approaches to constructing shared reality involve the saying-is-believing paradigm (Echterhoff et al., 2009). In this setup, participants receive ambiguous behavioral information about a target person that could be viewed as positive or negative. This ambiguity triggers a need to reduce uncertainty, which is achieved by creating a shared reality (Pierucci et al., 2014). Participants then describe the target to an audience with a known positive or negative opinion of the target. Participants' descriptions are tuned to match the audience's attitude—positive for a liked target and negative for a disliked one. Subsequent recall of the target's behaviors is biased to align with the evaluative tone of their audience tuning description, illustrating the creation of a shared reality through communication (Echterhoff et al., 2009; Higgins, 1992). However, this may not always be the case when communication occurs between those of different racial or cultural backgrounds.

Echterhoff et al. (2017) conducted several experiments using the traditional setup to explore shared reality formation in intergroup interactions between communication partners of either German or Turkish backgrounds. In one study, when discussing attitudes about a German target, German participants struggled to align with a Turkish partner and preferred developing a shared reality with a German partner. Implicit biases measured by the Implicit Association Test (IAT)(Greenwald et al., 1998) negatively correlated with this effect, suggesting greater difficulty in forming shared realities with outgroup members when biases are prevalent (Echterhoff et al., 2017). A follow-up experiment tested this effect on Turkish participants about attitudes of a Turkish target with both Turkish and German partners (Echterhoff et al., 2017). Results mirrored

the initial experiment to find a comparable shared reality ingroup favorability regardless of group majority or minority status (Echterhoff et al., 2017).

Another experiment sought to counteract the ingroup bias by enhancing an outgroup's epistemic authority, or the perceived expertise of the outgroup partner about a specific communication topic (Echterhoff et al., 2017). German participants discussed judgments about ingroup (German) or outgroup (Turkish) targets with only a Turkish partner. Shared reality occurred when the Turkish partner had expertise about the Turkish target, demonstrating shared reality creation across cultural lines by elevating outgroups' authority and expertise about a topic (Echterhoff et al., 2017). Echterhoff et al. (2017) suggest that when communication topics and communication partners share a same-group membership, epistemic authority is enhanced, and shared reality is more likely to take place.

A final experiment tested whether the outgroup shared reality facilitation occurred because of intergroup threat (i.e., fear or anxiety-driven)(Lutterbach & Beelmann, 2020) rather than epistemic authority (i.e., credibility or expertise). Following a similar design as the previous experiment with German participants and Turkish partners, Echterhoff et al. (2017) increased the number of outgroup discussion partners from one partner to three partners to indicate a group majority consensus about an ingroup or outgroup topic. Results replicated shared reality occurring when outgroup partners had greater epistemic authority, regardless of topic membership. Specifically, intergroup threat did not negate shared reality, and the outgroup majority even altered participants' memory for ingroup focused topics, contrary to what might be expected. These findings indicate that threat is not the primary factor between ingroup and outgroup shared reality (Echterhoff et al., 2017), and intergroup threat is not likely because more

outgroup members (Turkish) still garnered a shared reality for ingroup (German) topics rather than rejecting the partners' viewpoints altogether (Echterhoff et al., 2017).

The studies by Echterhoff et al. (2017) help establish baseline conditions for shared reality via intergroup communication, notably by enhancing perceived epistemic authority to counteract inherent biases. These findings are crucial when addressing systemic racism, where the challenge is to recognize the biases and actively work to dismantle them. Additionally, when discussing topics explicitly related to racism or antiracism, white individuals may exhibit additional resistance due to societal norms that reinforce biased perspectives (i.e., Whiteness). Echterhoff et al., (2017) demonstrated that shared realities across diverse groups are possible under specific conditions, which are critical for challenging worldviews ingrained in Whiteness and forming new understandings about the world.

Mediated Interventions to Construct Alternative Shared Realities

Traditional shared reality interventions, like the saying-is-believing paradigm (Echterhoff et al., 2017), rely on face-to-face interactions and direct communication to align worldviews among individuals. Mediated communication interventions, on the other hand, utilize various forms of media to influence perceptions and knowledge (Burgoon et al., 2000). These interventions leverage the power of media clips, videos, and other mediated formats to present information from credible sources. Unlike traditional methods that depend on interpersonal communication, mediated interventions can reach broader audiences and present multifaceted information in an engaging and accessible manner.

The study by Bonam et al. (2019) demonstrates this approach. By using media clips featuring experts discussing systemic racism, the intervention aimed to enhance critical historical knowledge among white individuals. The method was particularly effective in challenging

dominant narratives of Whiteness and fostering a deeper understanding of systemic racism. For instance, given white individuals' (vs. Black individuals) greater lack of knowledge of past racism (i.e., critical historical knowledge) and more significant denial of systemic racism, Bonam et al. (2019) had white individuals listen to a renowned historian discussing past racist housing policies and the government's role in developing Black U.S. ghettos, versus a control group that listened to a journalist discussing research that is irrelevant to systemic racism (e.g., pig intelligence)(Bonam et al., 2019). Those exposed to the historian experienced a new outlook on racism perceptions about Black ghettos with an enhanced understanding of systemic racism compared to those in the control condition. Bonam et al. (2019) suggested that mediated interventions with highly credible sources can disrupt dominant worldviews and that learning about *systemic* racism at the macro level through a critical historical lens helps resist ignorance and denial of Whiteness.

Coleman et al. (2019) further analyzed the open-ended responses from participants in Bonam et al.'s (2019) critical historical knowledge intervention. Using thematic analysis, Coleman et al. (2019) uncovered complex layers of knowledge, emotional responses, skepticism, and a drive to address systemic racism. Responses varied from never being taught about the topic to expressions of disgust or sadness about historical injustices. Some felt that it had justified the behaviors of protesters during the Ferguson and Baltimore reactions to the deaths of Michael Brown and Freddie Gray, two Black men whom police officers murdered. Coleman et al. (2019) state that many of these responses adhere to feelings of white fragility and help to absolve white people from focusing on systemic injustice to instead focus on their guilty feelings about being white.

Some individuals responded with skepticism toward the historian's credibility, stating they would want to do more research themselves or flat-out denied what they had heard. Others expressed that the historian must hold extremely politically left viewpoints to think that white people have more opportunities than people of color. A few responded with overtly racist responses and relied on stereotypes to justify their opinions, reflecting entrenched views and resistance to new perspectives (Coleman et al., 2019). However, some recognized the importance of understanding systemic racism, expressing a desire for broader consciousness-raising and action. Coleman et al. (2019) suggested that this shows evidence that when white individuals are exposed to critical historical knowledge detailing the symptoms of systemic racism, they demonstrate awareness of the systems and structures maintaining oppression beyond an individual level.

The studies by Coleman et al. (2019) and Bonam et al. (2019) provide additional evidence of the more nuanced reactions associated with dominant group threats and anxieties that the previous experiments by Echterhoff et al. (2017) seemed to disrupt, evincing the challenges and difficulties of truly disrupting Whiteness. Nevertheless, the role of source credibility, tied intrinsically to epistemic authority (Appelman & Sundar, 2016; McCroskey & Young, 1981; Metzger et al., 2010; Sundar, 2008; Szumowska et al., 2022; Whitehead, 1968), emerges as a crucial mechanism in the shared reality process. Source credibility stems from recognizing a communicator's expertise and reliability, which are critical for accepting new information—especially when contradicting long-held beliefs (Hovland & Weiss, 1951; Kruglanski et al., 2005). In the case of Bonam et al. (2019), high source credibility was established by selecting a reputable historian with significant expertise in their field. This strategic choice ensured that the information provided was reliable and authoritative enough to

challenge existing narratives and prompt a reevaluation of some individuals' worldviews. In other words, when individuals communicate with credible partners who hold expertise on the message topic, a shared reality becomes more likely, offering a potential avenue for disrupting worldviews shaped by Whiteness—even when a message is mediated (Bonam et al., 2019; Echterhoff & Higgins, 2021; Higgins, 2019; Kruglanski et al., 2005; Sundar, 2008).

Understanding the dynamics of shared reality interventions and recognizing the critical role of source credibility is essential for addressing the systemic challenges rooted in Whiteness. As examined earlier, traditional shared reality interventions often rely on face-to-face communication. These methods require individuals to align their descriptions with the attitudes of their audience, fostering shared realities through validation and reinforcement of mutual perspectives (Echterhoff et al., 2009).

However, traditional means of building shared reality have limitations. Face-to-face interactions often struggle to overcome entrenched biases and require high levels of personal engagement. This can be challenging when attempting to shift deeply ingrained worldviews, particularly those rooted in Whiteness. Furthermore, these interactions are typically limited in scope, reaching only those directly involved. Conversely, mediated communication interventions offer promising alternatives for disseminating critical historical knowledge to a broader audience, facilitating shifts in beliefs and attitudes without direct interpersonal communication (Bonam et al., 2019; Coleman et al., 2019).

As technology continues to evolve, virtual environments emerge as promising tools for exploring and influencing the motivations behind shared realities. These environments, through the creation of carefully designed three-dimensional worlds, offer significant opportunities to construct and maintain shared realities within highly controlled and realistic settings (Bailenson,

2018). Virtual environments can simulate real-life scenarios with virtual humans, coming close to face-to-face interventions (Miller et al., 2019). By immersing users in these scenarios, virtual environments have the potential to challenge and reshape worldviews entrenched in Whiteness and reinforce and expand existing antiracist worldviews.

The forthcoming chapter delves into how virtual environments can effectively create shared realities that challenge entrenched worldviews and promote antiracist education. This exploration underscores the unique potential of virtual environments as tools for dismantling Whiteness, providing strategies for engaging with and transforming deeply ingrained societal structures.

CHAPTER 4

VIRTUAL ENVIRONMENTS AND CREDIBILITY PERCEPTIONS

Immersive virtual environments, such as virtual reality (VR), are computer generated systems (i.e., hardware and software) that engage multiple senses (Biocca, 1997; Slater & Wilbur, 1997). By engaging multiple sensory channels, such as sight, sound, and touch through headsets or head-mounted displays (HMDs) and hand-held controllers (Ahn et al., 2022a), users are immersed in more natural human-computer interfaces (Miller et al., 2019a). Literature defines *immersion* as additive "layers of sensorimotor information to users" (Ahn et al., 2022b, p. 592; Biocca, 1992; Biocca & Levy, 2013; Steuer, 1992). Immersion attempts to mimic realism between virtual and physical environments by robust computing systems to achieve a degree of high fidelity (Ahn et al., 2022b). VR aims to replicate corporeal sensory information with artificial computer-generated materials, often made up of three-dimensional visuals, spatialized audio, haptic feedback, and positional tracking (Bowman & McMahan, 2007; Cummings & Bailenson, 2016). Depending on the number of sensorimotor layers a virtual environment can imitate, the greater level of immersion one typically feels (Biocca, 1997; Bowman & McMahan, 2007; Slater & Wilbur, 1997). In other words, VR relies on rendering software and display technologies (e.g., head-mounted displays; HMDs) to immerse the user in a mediated space designed to feel real.

Immersion fidelity consists of two components: display and interaction. Together, display fidelity and interaction fidelity can transform traditional two-dimensional media (i.e., computer screen) into three-dimensional environments that closely mirror real-world face-to-face

interactions, strengthening objective states of immersion (Bowman & McMahan, 2007; Ahn et al., 2022a). Display technologies offering stereoscopic vision, higher display resolutions, refresh rates, and spatialized audio help reproduce the same sensory experiences as the real world—creating high display fidelity (Ahn et al., 2022b). The differences between more and less immersion may depend on the "vividness" a display offers. The range of sensory cues offered by media (i.e., breadth) and the resolution and quality of each sensory cue (i.e., depth) contribute to the overall vividness of an immersive virtual environment (Steuer et al., 1992; Ahn et al., 2022a). For example, radio only offers one sensory cue (i.e., sound), while immersive VR can offer multiple cues simultaneously (i.e., sight, sound, and touch), which strengthens immersion capabilities (Ahn et al., 2022b). Furthermore, the concept of medium richness, which refers to the amount of social information conveyed through various communication channels (Burgoon et al., 2000), can influence individuals to trust dynamic visual media like television footage more than static written sources, such as newspaper articles (Burgoon et al., 2000; Rubin & McHugh, 1987). VR can provide great vividness and richness as a medium to leverage display fidelity and enhance realism.

Interaction fidelity relies on engaging users in various ways with the virtual environment, such as grabbing objects with real-time hand tracking or physically moving bodies to look around. Sophisticated hand- and head-tracking systems offer high interaction fidelity because users can use their physical body movements to look at, grab, and pick up objects in the virtual environment, which introduces more naturalistic mapping between motor movements and input mechanisms compared to lower interaction fidelity formats like using a computer mouse and keyboard to control movements (Ahn et al., 2022b). Previous research shows that greater interaction fidelity can increase the realism of VR experiences even in situations that are not

humanly possible, such as shrinking down to the size of a human cell (Nowak et al., 2020) or traveling through time (Ahn & Fox, 2017; Ahn et al., 2022a). Greater interaction fidelity creates higher immersion and makes the virtual experience more convincing. Lee et al. (2023) demonstrated that when individuals virtually contracted the flu and subsequently exposed vulnerable populations to the virus, traveling back in time to see how prior vaccination could have prevented the spread significantly enhanced perceived vaccination efficacy for self- and other-protection. The *virtual time travel technique* (Ahn, 2021) allows users to experience narratives with shifting "tempos and sequence of events in the mediated environment" (Lee et al., 2023, p. 1), providing additional layers of information and context to the viewer.

Higher immersion through interaction fidelity in VEs also depends on how the sensorimotor layers are mapped to a user's physical world actions (Cummings & Bailenson, 2016; Ahn et al., 2022b). The connection of a user's corporeal body to the mediated environment can affect interaction fidelity and immersion overall. Three operational categories help describe the different forms of interaction fidelity: natural mapping, spatial mapping, and contextual mapping (Ahn et al., 2022a). For example, a joystick controller offers much lower natural mapping than movements requiring arm and hand actions to control and change objects in VEs (Steuer et al., 1992; Ahn et al., 2022b). When the 3D computer-generated world behaves like the physical, unmediated world (i.e., placing an object onto a table), this is known as spatial mapping (Ahn et al., 2022a; Pietschmann & Ohler, 2015). The interaction context (i.e., contextual mapping) depends on how the virtual world is designed with the users' real world (e.g., virtual environment mirrors in-person laboratory space; Ahn et al., 2022b). The more natural, spatial, and contextual interactions in VE's, the more immersive a user feels. High fidelity helps to build feelings of realism and *presence*.

Presence

Presence holds significant importance in VEs and is commonly defined as the feeling of "being there" in the mediated environment (Biocca, 1997; Ahn et al., 2022a). Greater immersion, achieved through providing multiple simultaneous sensory channels, enhances the sense of presence. However, it is noteworthy that presence can also be felt with fewer sensory cues, such as reading a book or watching a movie (Gerrig, 1993; Lee, 2004). Presence encompasses both non-sensory and sensory experiences, facilitating behaviors like perception, manipulation, and interaction (Lee, 2004).

Presence is often conceptualized across three dimensions: spatial presence, social presence, and self-presence (Lee, 2004). Spatial presence refers to feeling physically located in a virtual or mediated environment (Biocca, 1997; Lee, 2004). Users experience a psychological state where they can interact in mediated spaces with virtual or artificial objects as actual objects in less mediated environments (Lee, 2004; Ahn et al., 2022b). In other words, greater spatial presence means users forget technology mediates their surroundings and perceive it as true, even when the objects are virtual and are only perceivable by overriding sensory cues with technologies (i.e., HMD). Wirth et al. (2007) argue that for spatial presence to occur, users must first go through mental-model prerequisites that allow users to allocate attention within the virtual environment to construct and interpret their surroundings. For example, spatial cues such as visual and auditory inputs help build and maintain the mental representation of the surrounding space, allowing users to momentarily forget their corporeal world and immerse themselves in the virtual environment (Wirth et al., 2007).

Social presence is characterized by "the sense of another through a medium," wherein users interact with virtual social actors and perceive (non)human intelligence (Biocca et al.,

2003, p. 456). This psychological state occurs when users forget the technological mediation between themselves and other social actors, fostering a sense of connection (Lee, 2004). Copresence and social presence are often used simultaneously to mean similar feelings. However, Lee (2004) distinguishes copresence as the sense of being in a mediated environment with other people. Copresence focuses more on a shared mutual awareness in a virtual space with another. At the same time, social presence does not require a mutual awareness between social actors and can be experienced even in one-way communication, such as when reading a letter or listening to a voice recording (Lee, 2004). The perception of social presence is valuable when developing virtual simulations where users must interact and engage with a virtual character that is controlled by computer programming (i.e., agent) rather than another human user (i.e., avatar) within virtual environments (Nowak & Fox, 2018).

Self-presence occurs when users feel as if their virtual selves are their corporeal selves. Similar to spatial and social presence, feeling self-presence means that users forget there is technology mediating their virtual bodies (Lee, 2004). More immersive technologies, such as VR, provide naturalistic head-movement controls and can strengthen self-presence because the virtual self is experienced as the real self. Greater self-presence allows users to react and behave similarly in unmediated environments. This concept is sometimes used interchangeably with embodiment and body transfer. However, embodiment focuses more on avatar body ownership from a first-person perspective (Peck & Gonzalez-Franco, 2021) and has been found to strengthen feelings of self-presence.

While self-presence and embodiment are important, this study focuses on spatial and social presence due to their critical roles in feeling *there* and *with* others, which are important for sharing experiences. Spatial presence immerses users in the virtual space, while social presence

enables meaningful social interactions with virtual agents. These two dimensions of presence have been shown to play a role in shaping individuals' various perceptions of their experience, such as the credibility of an information source, something that earlier research has found to be crucial in shaping shared realities (Echterhoff et al., 2017; Sundar et al., 2017).

Credibility Perceptions in Virtual Environments

Credibility in virtual environments is distinct from realism or presence. While realism pertains to the accuracy and believability of the virtual world (i.e., how well it mirrors the real-world), and presence refers to the feeling of "being there," credibility involves the trustworthiness and expertise (i.e., epistemic authority) perceived within the virtual environment (Sundar et al., 2017). Research demonstrates that the credibility perceived within virtual environments can be significantly influenced by the design (e.g., agent appearance) and features of the environment (e.g., interactive tasks), ranging from the information source to the contextual backdrop of the message (Burgoon et al., 2000; Tan & Liew, 2020; Sundar et al., 2017). These features, or heuristic cues (i.e., elements that guide judgments and influences, (Gilovich et al., 2002), play a crucial role in how individuals evaluate information and make decisions (Tan & Liew, 2020). Understanding these heuristics is essential for designing VR environments that can challenge and reshape deeply ingrained worldviews.

For instance, digital representations of computer-programed agent partners have been scrutinized for their role in shaping credibility assessments compared to human partners. Burgoon et al. (2000) tested differences in an interactive decision-making task with either human or computer partners and whether the richness (i.e., dynamic vs. static) and anthropomorphistic (i.e., human-like) qualities (e.g., voice recognition, animated facial expressions) of the computer interface design played a role. Results showed that human partners were rated more credible as

social communicators when individuals participated in a face-to-face interaction compared to a mediated interaction. However, agents, despite being less human-like, significantly influenced decision outcomes, demonstrating that the persuasiveness of computer-generated arguments can outweigh the social credibility typically associated with human partners. Burgoon et al. (2000) propose that although individuals often employ human-like heuristics in their interactions with computers and evaluate computer partners similar to humans, they may also perceive the computer's arguments as being more informed and objective than their own, thus increasing the influence of computer agents on decision-making tasks.

This paradox, where individuals can be more influenced by mediated information than by humans, aligns with findings from Tan & Liew (2020), who examined whether simple surface cue manipulations could influence virtual agents' credibility and expertise perceptions. In an e-commerce setting, virtual agents were depicted as either product specialists with labels (i.e., surface cues) such as, "camera product specialist" or "health product specialist," compared with product generalists (i.e., no labels). Results indicated that surface cue evaluations were consistent with previous source credibility findings in that, just by having a simple label presented next to the agent, agents depicted as specialists garnered higher credibility than those positioned as generalists. Notably, perceptions of expertise, message trustworthiness, and social presence, increased for agents labeled as specialists (Tan & Liew, 2020). Furthermore, perceived agent expertise and trustworthiness of the message mediated the specialists' influence on product purchase intentions (Tan & Liew, 2020). These results suggest that source credibility in virtual environments can be manipulated through surface-level cues, impacting subsequent user decisions and highlighting the potential for virtual environments to influence perceptions and behaviors through carefully designed heuristics.

However, some studies have found conflicting results when individuals rely on heuristics. For example, Sundar et al. (2017) examined how immersive technological affordances, like modality and interactivity, affect credibility across different mediums (e.g., VR, 360-degree video, and text). Two emotionally different (i.e., sad vs. happy) news stories with a written version and a 360-degree video version were either read or watched on a computer screen or with a VR headset. Sundar et al. (2017) investigated *presence*-related cognitive heuristics of immersive affordances (spatial presence, interaction, and realism) and their impact on credibility perceptions and story-sharing intentions. Spatial presence measured feelings of "being there" in the 360-degree environment (Lee, 2004), while interaction measured the level an individual could directly affect the environment. Realism represented the degree to which the stories mirrored physical reality (Sundar et al., 2017).

Their studies found that 360-degree videos enhanced spatial presence, interaction, and realism, improving credibility perceptions, memory recall, and sharing intentions more effectively than text-only formats. However, Sundar et al. (2017) cautioned that excessive realism and emotional intensity could override the immersive technological affordances. Notably, greater presence negatively affected news organization trust, emphasizing the delicate balance between presence and credibility in virtual environments (Sundar et al., 2017). Sundar et al. (2017) suggest that when credibility is the goal in a virtual environment, presence and realism must work together to create a more believable setting for the user.

Similar studies have found comparable results with VR evoking greater presence; however, credibility evaluations of mediated experiences in virtual environments are not always statistically different from less immersive mediums (Greussing, 2020; Kang et al., 2019). For example, virtual environments delivering news content or immersive journalism (Shin & Biocca,

2018), have explored how to potentially manage viewer overstimulation and enhance credibility assessments (Greussing, 2020; Pjesivac et al., 2021). Greussing (2020) examined knowledge acquisition and perceived message credibility in climate change news across four different modalities: written text, photograph, video, and 360-degree photograph. Unexpectedly, message credibility did not differ across all mediums and the inclusion of a 360-degree photo hindered participants' knowledge acquisition, suggesting that immersive content may act as a distractor rather than an amplifier.

A study by Pjesivac et al. (2021) attempted to mitigate these distractor effects by adding directional cues to limit overstimulating viewers when processing information in VR and examined viewers' attitudes toward message credibility and feelings of spatial presence. Individuals wore a VR headset and watched a 360-degree immersive news story with either no directional cues, visual cues (i.e., graphical arrows), or visual and verbal cues (i.e., audio directions and graphical arrows). Results indicated that while verbal and visual directional cues had significantly higher message credibility evaluations than the other two conditions, the overall recall of verbal information was low for all three groups (Pjesivac et al., 2021). Pjesivac et al. (2021) proposed that directional cues may add additional layers to message credibility, but did not necessarily decrease the cognitive load during information encoding, indicating a complex interaction between presence and credibility perceptions within information processing in immersive settings.

In one of the only VR studies to examine race and environment biases in connection with credibility perceptions, Marino et al., (2020) manipulated the scenery and speaker race in a 360-degree news video report. Participants watched either a white or Hispanic eyewitness give a suspect description of a recent home break-in that occurred in an environment created to

represent a suburban white, urban white, suburban Hispanic, or urban Hispanic neighborhood (Marino et al., 2020). Results revealed that when individuals hold negative attitudes toward particular neighborhoods (i.e., urban Hispanic), they also hold unfavorable attitudes about the people in those neighborhoods—finding them less credible and less truthful as sources. Additionally, Hispanic sources were viewed as significantly less credible by non-Hispanic individuals compared to Hispanic individuals, though Marino et al. (2020) cautioned that these results might have limited generalizability due to the relatively small number of non-Hispanic participants in their sample. This research indicates that preexisting biases toward certain cues emphasizing race or cultural backgrounds can harm credibility perceptions. These findings highlight that surface-level cues, like race and scenery, can trigger biases and stereotypical heuristics about environments and people, affecting the trust and credibility perceptions in virtual environments similarly to offline settings (Hatfield et al., 2022).

Collectively, these studies underscore that while virtual environments can offer promising avenues for enhancing credibility perceptions, their effectiveness is heavily contingent on thoughtful design that minimizes sensory overload and considers the psychological impact the content may have, especially regarding racial and cultural representations. For virtual environments designed to challenge ingrained ideologies such as Whiteness, it is crucial to leverage these technologies in a way that engages users effectively without compromising the accuracy and integrity of the information presented. Virtual narratives can enhance perceived expertise, strengthen presence, and foster a more compelling shared reality by integrating human-like agents, directional cues, and maintaining a neutral emotional tone.

Although many studies mentioned tested 360-degree videos, employing 3D computer-generated imagery (CGI) may offer greater flexibility in crafting narratives that mirror lived

experiences. Additionally, VR narratives can leverage *virtual time travel techniques* to demonstrate an extended period (i.e., 60 years) within a brief 10-minute intervention. Individuals could feel immersed in an environment and witness first-hand how racist policies of the past, such as redlining, have directly impacted health disparities of communities of color over time.

These design choices may help mitigate the potential negative impacts of virtual environments on credibility evaluations. However, these environments must also navigate the complex reliance of surface-level cues, like race and environments emphasizing cultural backgrounds, which, as Marino et al. (2020) have shown, can perpetuate racial biases. The forthcoming chapter explores mitigating racial biases in virtual environments in greater depth and discusses how to strategically create immersive narratives to challenge Whiteness and promote systemic racism understanding toward environmental justice.

CHAPTER 5

CONFRONTING AND ADDRESSING WHITENESS IN VR DEVELOPMENT FOR SYSTEMIC CHANGE

Virtual environment studies examining racial bias typically adopt two approaches: embodiment (e.g., a white individual completing a task *as* a Black avatar) and interracial contact (e.g., a white individual completing a task *with* a Black avatar or agent). Both methods have determined that racial biases transcend into virtual environments, but very few have successfully reduced bias following a virtual intervention (Hatfield et al., 2022). Recent scholarship suggests that interracial contact may be preferred over embodiment because it accurately mirrors real-life situations (Taylor et al., 2020).

A critical examination through a Whiteness lens of the last two decades of research using virtual environments to reduce racial bias revealed major criticisms of each method (Hatfield et al., 2022). One major critique of embodiment studies is that they often replicate a phenomenon referred to as "virtual Blackface," where white individuals take *ownership* of Black avatars. This practice treats virtual bodies of color as costumes, inadvertently commodifying racialized bodies without confronting the individuals' own privileged statuses (Hatfield et al., 2022, p. 6). This approach can perpetuate harmful power dynamics and fail to address underlying biases.

On the other hand, studies employing interracial contact in virtual environments are criticized for perpetuating harmful stereotypes and often focusing solely on whether bias exists without actively working to disrupt those biases (Hatfield et al., 2022). These studies can mirror the pitfalls found in more traditional media representations, such as stereotyping and insensitive

design, which fail to foster genuine shared experiences. Despite these shortcomings, interracial contact is seen as having the potential to reflect real-life interactions better, thus providing a more authentic basis for exploring and addressing racial biases (Hatfield et al., 2022).

VR is often framed as a moral machine that can create connection, compassion, and empathy for others, sparking several perspective-taking "empathy machine" experiences designed by white creators about the plight of marginalized and oppressed people and communities (Nakamura, 2020, p. 48). Rightly termed 'virtuous VR," Nakamura (2020) emphasized how these experiences attempt to reduce racial violence by reproducing the violence through an immersive experience as a *cure* for racism—and misogyny, sexism, homophobia, and other -isms and -phobias. This so-called remedy perpetuates racism by exploiting the pain of marginalized communities as a tool for self-reflection for the intended audience (most often white individuals), who feel the need to experience the pain for themselves through a VR headset rather than trusting the words of a marginalized person's lived experiences (Nakamura, 2020). This approach distracts from the necessary real-world action required to confront and dismantle structural racism by creating imitation empathy or surface level feelings rather than fostering genuine understanding and change (Nakamura, 2020). Nakamura (2020) argues that while including women of color in the VR development process—rather than as "empathetic workers and sites of identification" (p. 58), or what Hatfield et al. (2022) describe as exploiting oppressive experiences for white people's self-transformation—is a step in the right direction. True decolonization of VR requires significant investment in these communities, and the communities involved in these narratives deserve equitable partnership in power and resources over the production and representation of the experience.

The critiques brought forth by Hatfield et al. (2022) and Nakamura (2020) necessitate a shift in research focus from individual biases to a broader focus on systemic inequities. Specifically, Hatfield et al. (2022) argue for research using interventions to expose "Whiteness and racialized hierarchies to understand *why* racial biases exist and *how* to reduce them, rather than to only confirm *whether* biases exist" (p. 7). For example, advocating for authentic simulations of intergroup and interracial contact that reflect the multifaceted dynamics of the real world (Taylor et al., 2020) may foster a deeper understanding of *systemic* racism and help collectively shift worldviews away from those distorted by Whiteness. Instead of brief exposures to brief episodes of racism while embodied in different skinned-tone avatars or replicating harmful, virtuous, toxic empathy scenarios, virtual environment technologies have advanced enough to craft thoughtfully designed narratives that contextualize or situate social interactions (Miller et al., 2019a). For example, a VR experience could guide users through sharing an experience with an individual facing *systemic* environmental racism, highlighting interactions in various contexts, such as the persisting consequences of discriminatory practices like redlining. This approach provides a comprehensive understanding of the pervasive impact of racism on daily life and demonstrates that these consequences were never about any one *individual* choice, but rather a larger oppressive system—Whiteness—that dictates how harms and resources are distributed and allocated (Hahn, 2021).

Systematic Representative Design

Miller et al., (2019a) propose applying a *Systematic Representative Design* (SRD) in virtual environments to increase the causal inference and generalizability of research outcomes. SRD challenges traditional notions of experimental control by aiming to replicate *generalizability to everyday life*, or GEL (Miller et al., 2019a). GEL is achieved through creating

virtual scenarios that closely mirror real-world contexts based on input from individuals' everyday lives who are the intended population of interest. It is possible that following SRD could begin to address past criticisms of research that predominantly represents WEIRD (Western, Educated, Industrialized, Rich, and Democratic) samples, which often fail to generalize across broader populations (Henrich et al., 2010; Miller et al., 2019).

SRD involves the development of a default control group that simulates real-life conditions as a base environment (Miller et al., 2019a, 2019b). Researchers can then introduce systematic manipulations in experimental conditions to study different behaviors or interventions. The advantage of this method lies in its ability to model complex day-to-day situations and examine psychological and behavioral mechanisms within precisely designed contexts (Miller et al., 2019b). Such an approach is similar to recent shifts in biological sciences where studies conducted in more naturalistic settings with wild mice, as opposed to the historical white lab rat, have yielded insights that are dramatically different from traditional findings (Miller et al., 2019a).

The key to SRD is the *context*, or the situation in which individuals construct social meaning of the world around them (Miller et al., 2019a). Miller et al. (2019a) suggest that interactive narratives in VR "allow users to take a role in a narrative story and interact with character agents in an environment" (Miller et al., 2019a, p. 185). Interactive narratives with built-in cues, tasks, and goals can help users structure situations to understand and engage with the underlying social dynamics, resulting in more authentic interactions. Interactive narratives applying GEL in VR enables researchers to focus on specific contexts within a condensed time period that is not always practical or possible in the real world or a laboratory setting. Additionally, pairing embodied interactive narratives simulations with presence and real-world

corporeal rules (e.g., gravity), make VR particularly effective in modifying long-standing behaviors, even after leaving the virtual environment (Ahn et al., 2016; Miller et al., 2019a; Riva et al., 2019). For example, clinical psychology research has used VR simulations successfully when mitigating post-traumatic stress disorder (PTSD) effects with audio and visual cues to experience triggering narratives to manage and treat trauma (Rizzo & Koenig, 2017).

Adding computer-programmable social actors, or "intelligent agents," into interactive narratives can also play a key role in effective interventions (Miller et al., 2019b, p. 8). Programming social agents to have a specific set of parameters (e.g., characteristics, beliefs, goals) can aid in the process of understanding how individuals may respond or behave in a real-world social interaction. For example, Miller et al. (2019) crafted intelligent agent partners to have specific tendencies that were representative of their target population's identified attachment style (e.g., avoidant/dismissive) to examine specific risky sexual behaviors of interest. Moreover, it is possible to manipulate a social agent to have different sets of parameters for different conditions to examine specific social interactions between agents and humans (Miller et al., 2019b; Feng et al., 2017; Jeong et al., 2017). Virtual environments in this context allow for a highly controlled setting across individual, social, and environmental conditions, a feature Miller et al. (2019b) argue, may have a higher capacity to produce generalizable results and increase external validity for conclusions about causality.

To effectively implement SRD, Miller et al. (2019a; 2019b) recommend several steps: 1) identifying target populations (e.g., those with limited environmental racism knowledge) and behaviors of interest (e.g., shared reality), 2) identifying and developing scripts of recurrent situations related to behaviors of interest (e.g., environmental health hazards), 3) formulate details and specific cues needed to mimic entry/exit-based scenarios, 4) replicate common

situations in a virtual environment and correlate to real-world, 5) conduct initial tests to identify effective behavior change strategies, 6) integrate strategies as interventions and compare as experimental groups, and 7) conduct randomized control trials. While SRD demands significant initial investment in design and preparation, its potential to transform the understanding and impact of VR interventions in social sciences justifies the effort (see Miller et al., 2019a for a comprehensive review of SRD).

Applying SRD to Address Whiteness Contexts

Systematic Representative Design (SRD) offers a structured framework for enhancing the generalizability of experimental findings in virtual environments, however, its application in contexts addressing Whiteness and environmental racism warrants careful consideration of potential challenges. Given the previous criticisms of Whiteness and racism in VEs (Hatfield et al., 2022; Nakamura, 2020), one primary concern with employing SRD to address Whiteness is the potential replications of real-world scenarios that contain inherent racial biases and systemic inequities. Previous research on racial biases indicates that individuals often transfer their real-world prejudices into virtual environments (Hatfield et al., 2022), which can also manifest a behavioral carry-over effect from virtual scenarios back into real-world settings (Ahn et al., 2016; Miller et al., 2019b). Creating VR situations mirroring these conditions risks re-traumatizing individuals who experience these biases in their daily lives and normalizing these conditions for others (Hatfield et al., 2022). This approach could inadvertently reinforce the stereotypes and systemic issues it aims to explore, especially if participants are not adequately debriefed or the implications of these scenarios are not critically analyzed with the research (Hatfield et al., 2022).

SRD's emphasis on crafting environments that reflect "real-world" scenarios poses the risk of perpetuating systemic inequities, particularly when these environments are designed without a comprehensive understanding of Whiteness and racial dynamics (Hatfield et al., 2022; Taylor et al., 2020). The challenge becomes even more pronounced when addressing environmental racism, which often involves both geographical and cultural specificities. While using targeted representative sampling based on demographic data (e.g., U.S. Census) can begin to identify relevant contextual cues and scripts (Miller et al., 2019a), the cultural contexts and lived experiences of racialized individuals can vary widely. Furthermore, because technology is not inherently free of racism (Benjamin, 2019; Noble, 2018), there is often a lack of respectful and culturally authentic representation of virtual humans of color available for use as social agents in virtual environments unless there is the ability for custom creations (Dietrich, 2013, 2023). This issue is exacerbated by the fact that those working in these technologies and related industries are predominantly white and male, leading to biases in the creation and availability of virtual avatars (Dietrich, 2023). For instance, Hatfield et al. (2022) found that many of the virtual humans of color used in racial bias interventions were often default white avatars with their skin tone shader changed to the darkest option available. This superficial approach to representation highlights the systemic problems within the industry and underscores the need for more inclusive and diverse development practices to create genuinely representative and respectful virtual humans of color.

SRD must navigate these complexities, which may not always be adequately captured by online surveys or addressed in later interviews, creating a risk that VR narratives and interactions designed to disrupt Whiteness might not fully capture the subjective experiences of marginalized

groups, leading to oversimplified and racially colorblind (Bonilla-Silva, 2018) portrayals that fail to challenge the underlying structures of Whiteness.

To improve the design of virtual interactions challenging systemic inequities and continue working towards decolonizing VR experiences (Nakamura, 2020), researchers—especially researchers like myself (i.e., racialized as white)—must incorporate a critical awareness of Whiteness and culturally informed perspectives throughout the design and implementation process. For example, Taylor et al. (2020) recommend addressing racial/ethnic representations in virtual spaces by actively seeking feedback from racial/ethnic minorities. By increasing racial and ethnic minority representation among VR developers and researchers, simulations can better address misrepresentations and minimize biases in virtual content, thereby enhancing the credibility and effectiveness of these environments (Taylor et al., 2020; Marino et al., 2020). This approach goes "beyond mere tokenism" in considering the influence of race and ethnicity in VR development and research (Taylor et al., 2020, p. 134), and may lead to constructing shared realities grounded in perspectives that Whiteness typically excludes.

Implementing Community-Based Participatory Research

To effectively apply SRD in contexts addressing Whiteness and environmental racism, implementing a Community-Based Participatory Research (CBPR) framework is crucial. This approach, grounded in social justice principles (Freire, 1970, 2018), ensures that the development of VR experiences authentically reflects community insights and experiences, thereby avoiding the perpetuation of stereotypes (Duke, 2020). By involving community members and relevant stakeholders throughout the research process, CBPR fosters a collaborative environment that respects and centers the voices and perspectives of those most impacted by Whiteness and environmental inequities.

CBPR transforms underrepresented and marginalized communities from passive subjects into active co-creators of research (Taylor et al., 2020). This shift is critical to dismantling oppressive structures and effectively addressing the nuanced challenges of environmental racism. For example, Teng et al. (2019) demonstrated the significance of this approach in a project where incarcerated women collaboratively designed therapeutic VR simulations. These simulations were carefully crafted to reduce uncertainties about reentry situations while avoiding re-traumatizing or reproducing harmful, oppressive dynamics. Participatory projects like this illustrate the importance of CBPR in addressing real-world issues and highlight how VR can serve as a tool for social rehabilitation and empowerment (Teng et al., 2019).

The most substantial difference between traditional research and CBPR is the collaboration with community members. Traditional methodologies often see researchers setting the agenda and using convenience sampling to validate hypotheses (O'Fallen et al., 2002). In contrast, CBPR involves community members early in the research pipeline, ensuring that their needs and perspectives shape the research objectives and methods from the outset.

Developing a VR interactive narrative that effectively communicates the realities of environmental racism requires an *iterative prototyping process* with community members, public health experts, and environmental scientists. Prototyping is a preliminary version, or a 'proof of concept' of an idea or product, commonly used in engineering (Marks & Chase, 2019) and design (Smith et al., 2021). Working with a prototype involves refining the initial idea through making continuous or iterative progressions based on feedback to become closer to a finalized version. Having an initial starting point enables the process to show a progressive evolution from start to finish, which is critical for confronting and addressing potential biases and ensuring the narrative's authenticity.

The interdisciplinary nature of CBPR fosters equitable partnerships between researchers and community members, enabling public health experts and environmental scientists to contribute to evidence-based insights, while community experts provide essential guidance to creating culturally relevant and authentic narratives of those who have firsthand experience with the challenges associated with environmental racism. The development of the VR interactive narrative used in this research, underpinned by SRD guidelines, was informed through semi-structured interviews with experts in environmental racism. These interviews were part of an iterative feedback and adaptation process to refine an initial VR prototype to ensure its relevance and effectiveness.

Based on the literature above, through an iterative prototyping process with content experts, this process was designed to gain an understanding of how a VR interactive narrative can leverage source perceptions (i.e., credibility and likability) of a virtual social agent to construct a shared reality about environmental racism in the U.S. The following research questions were posed to guide this process:

RQ1: How do community and environmental health experts describe their experience of "shared reality" with a virtual agent in the VR environment, and what factors influence these perceptions?

RQ2: In what ways do different VR affordances (immersion, presence, interactivity) shape community and environmental health experts' experiences and perceptions of "shared reality"?

RQ3: How do community and environmental health experts describe the cultural accuracy and authenticity of the VR environment?

These questions explore how various elements of the VR narrative—such as credibility perceptions, likability, social presence, and spatial presence—affect the construction of shared reality. By understanding these dynamics, the VR narrative can be continuously improved based on feedback to elucidate potential mechanisms to foster a genuine connection with a virtual agent and gain a deeper understanding of environmental racism.

The insights gained from this collaborative research process are instrumental in creating a VR experience that educates users about environmental racism and encourages a shared understanding rooted in historically excluded perspectives. The final version of the co-designed VR prototype will inform a series of empirical tests investigating the impact of the VR narrative on constructing a shared reality between participants and those directly impacted by environmental racism. By integrating CBPR in the SRD process, this dissertation aims to challenge traditional research and VR development to re-imagine standards for how virtual technologies can be leveraged to address systemic issues while actively addressing Whiteness and promoting environmental justice.

CHAPTER 6

SEMI-STRUCTURED INTERVIEWS

In addressing the shortcomings identified in prior VR interventions and storytelling experiences (Nakamura, 2020; Hatfield et al., 2022), this chapter outlines the use of semi-structured interviews to co-design a prototype with content experts within the Systematic Representative Design (SRD) framework. The primary aim was to gather insightful feedback on an initial VR prototype that tackles issues of environmental racism. This feedback facilitated an iterative development process using a Community-Based Participatory Research (CBPR) process, refining the prototype for subsequent testing in controlled experiments.

Participants and Recruitment

Participants comprised of two groups of content experts: community members actively engaged in local environmental health organizations and environmental health researchers specializing in community-engaged environmental health. Many of the community members were associated with local non-profit wellness centers and grassroots organizations, bringing a rich understanding of how environmental and structural racism affects their communities. Public and environmental health experts from state and federal organizations (e.g., NIH-funded university research center) contributed their academic and field expertise.

These interviews are categorized as informant/expert interviews, given that participants possess critical knowledge and experiences directly relevant to the research goals (Lindlof & Taylor, 2017). These experts hold extensive social networks and a deep understanding of

environmental and public health systems, allowing them to offer nuanced, firsthand insights into the dynamics of environmental racism (Lindlof & Taylor, 2017).

Content experts were recruited using purposive sampling through community organizations and research networks. Snowball sampling was then used to identify additional key informants. The inclusion criteria required participants to be: (1) at least 18 years of age, and (2) part of an organization focused on environmental justice and/or environmental health. Participants were contacted through email or phone calls and were provided with the necessary information about the study's objectives and their potential role. A total of ten (N = 10; M_{age} = 37.9, SD_{age} = 12.98; 90% women; 70% Black, 30% white) content experts, five community experts (n = 5) and five environmental health experts (n = 5) participated in the study. All participants signed an informed consent form outlining the study's purpose, procedures, and ethical considerations. One participant declined the incentive, while the nine other participants were compensated with a $100 Amazon gift card for their time and expertise. Table 1 lists the demographics and organization characteristics of each expert interviewed.

Table 1

Demographics and organization characteristics of the participants.

ID	Gender	Age	Race	Organizational Focus/Professional Setting:
P1	Woman	31	Black	University research in Public Health
P2	Woman	26	white	Government Agency
P3	Woman	25	Black	Non-profit (e.g., Health Care)
P4	Woman	56	Black	Non-profit (e.g., Health Care)
P5	Woman	34	Black	Non-profit (e.g., Health Care)
P6	Woman	37	white	Federally funded Research Center
P7	Woman	63	Black	Non-profit (e.g., Environmental Justice)
P8	Woman	40	Black	Non-profit (e.g., Environmental Justice)
P9	Man	46	white	Federally funded Research Center
P10	Woman	21	Black	University research in Environmental Health

Stimulus Prototype

Creation and Ideation of Default Control Narrative

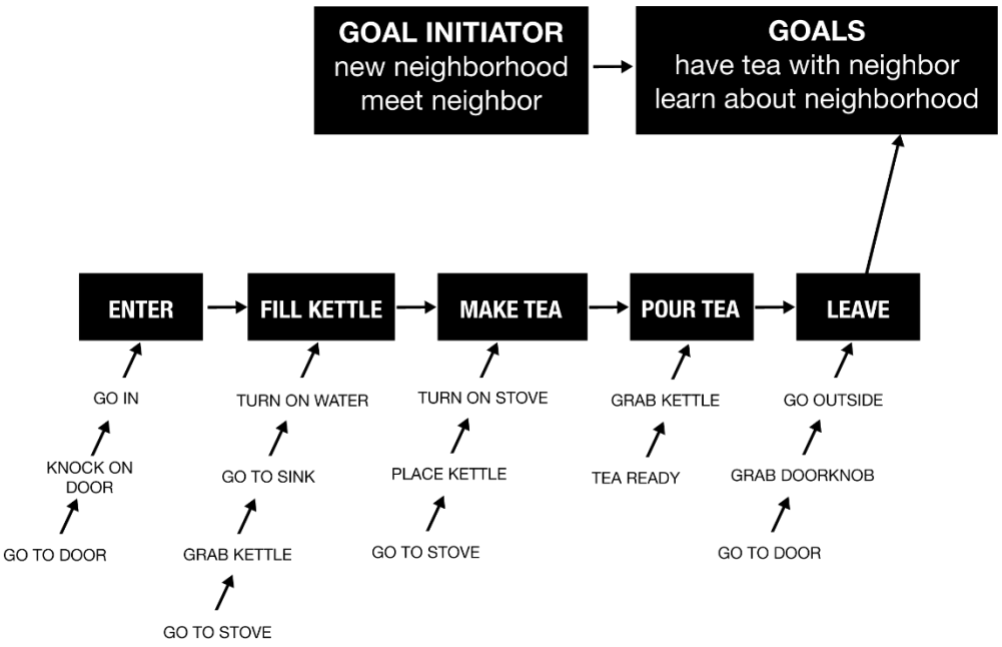
During a span of about six to eight months, an initial VR narrative prototype was developed with the help of undergraduate computer science students. The prototype drew on extensive preliminary research into the historical and ongoing impacts of Whiteness and redlining on health disparities. The overall goal for the VR interactive narrative was meant to demonstrate *structural* racism by highlighting how racist policies of the past have impacted the air, soil, and water quality of communities of color which, over time, have exacerbated and widened health disparities between white and more advantaged communities.

Critical source materials ranged from Black Feminist Thought leaders' insights such as hooks (2001), Davis (1981), and Hill Collins (2009) to Fiere (1970, 2018) and Benjamin's work on race and technology (2019). Additional source materials were specific to environmental racism and justice, such as the work by Bullard (1983, 1996), who is often considered the "father of environmental justice" and Pellow's (2005) work on *critical environmental justice* that engages with the historical shaping of socio-ecological relationships (e.g., intersections of race, carceral systems, and environmental impacts). Government websites like the U.S. Environmental Protection Agency (EPA) and National Institute of Health (NIH) provided additional background information on when production of toxic materials were banned and the exacerbated impacts to communities' health because of environmental racism.

Based on the critical formative research, an initial interactive script for the VR default control narrative was created following the SRD process outlined by Miller et al. (2019a). Because narratives help structure understanding of social interaction over time, Miller et al. (2019a) suggests crafting context-specific scripts with a set beginning and end made up of hierarchically ordered goals and subgoals along the way. Therefore, to contextualize or situate the script, a home in a neighborhood with a history of redlining was selected as the setting of the interactive narrative with the goal of meeting a new neighbor and learning about the neighborhood. To add *generalizability to everyday* (GEL) and fidelity, goals and subgoals were shaped by ordinary or mundane tasks that most individuals could do around a typical home (e.g., prepare a cup of tea) that also adhered to real-world physics (e.g., dropping a tea kettle in VR resulted in the kettle falling to the floor). Figure 1 illustrates the initial interactive narrative script adapted from Miller et al., (2019b).

Figure 1

First draft of the interactive narrative script about environmental racism



The act of preparing tea was chosen because it is a communal activity easily shared with others, especially new acquaintances, and therefore, a virtual social agent was required to help facilitate the sharing, or *motivated connection* of shared reality. A virtual character by the name of Linda, a 70-year-old Black woman, was created as the homeowner and spokesperson for the interactive narrative. Linda was named after Linda Mckeever Bullard, a lawyer and spouse of Robert D. Bullard (i.e., father of the environmental justice movement), who helped ignite some of the first environmental justice research from a 1979 class-action lawsuit she was working on about a proposed landfill being placed near a Houston middle-class Black community (1994).

A verbal conversational script pertaining to environmental racism was drafted for Linda to narrate key information about her experiences growing up and living in the neighborhood. The script first introduces redlining, then the enduring effects of such policies leading to impacts of present-day gentrification and health disparities. For example, when the user goes to the sink to

fill the kettle, there is a factory polluting the air outside the kitchen window. The tone of the conversation was kept friendly and "neutral" so as not to reinforce potential stereotyping that often befall Black women who confront racism, such as the "angry Black woman" trope (Bailey, 2021). A local voice acting studio was contacted to hire an experienced voice actor who identified as a Black woman to audio record the conversational scripts varying in sound depending on the age of Linda (e.g., more child-like sounding when Linda is 10 years old).

Interactive journalistic materials, such as newspapers and video news coverage, were embedded to complement the plot and incorporate historical evidence to demonstrate the *systemic* nature of environmental racism. For example, while waiting on the kettle to heat up, the user interacts with newspaper clippings based on selected EPA historical press releases between 1975 and 1980. Headlines were edited to shorten word length and reworded in layman's terms for understandability. For example, a press release from May 31, 1977 titled "EPA Bans PCB Manufacture; Phases Out Uses" was changed to "EPA Bans Toxic Cancer-Causing Materials," because some users may not know what PCBs are (i.e., Polychlorinated biphenyl) or why it is bad (EPA, 1979). Additionally, users watch a news clip from the 1982 Warren County, North Carolina protest of a state-sanctioned PCB disposal site which leaked toxins into the water supply of predominantly Black communities. This protest is often noted as one of the origins of the environmental justice movement (NRDC, 2022). The entire experience was kept to about 10-minutes in length to prevent fatigue.

Building the Treatment Narrative

Vital to SRD process is creating a default control group that additive changes can be implemented to manipulate the VR narrative for treatment conditions (Miller et al., 2019a). Based on the formative research and control narrative development, it was determined that the

virtual time travel technique (Ahn, 2016) could aid in the understanding of structural racism and how past racist policies influence present-day inequities. Therefore, unlike the default control narrative where the virtual social agent Linda remains a 70-year-old woman throughout the interactive narrative, the addition of a time travel effect manipulates the year and age of Linda to align with the story timeline.

To demonstrate time traveling, a dynamic animated calendar was designed to float within the user's point of view showing the current year of 2024. Once the time travel effect initiates, the calendar flips back in time 60 years to 1965 and then continuously flips forward by one year each second (e.g., 1965, 1966, 1967, 1969, etc.). At the same time, the social agent Linda shrinks down to a 10-year-old version and then gradually grows back year-by-year into the older Linda version as the calendar advances. The dates and ages correlate with the information of the storyline (e.g., when watching the 1982 protest footage, the floating calendar displays 1982, and Linda looks to be about 40-years-old).

Software, Hardware, and User Controls

The entire experience was created using the Unity® cross-platform game engine or a Meta Quest 2 headset. Three-dimensional assets, such as the home, factory, calendar, furniture, the model for Linda, were obtained from the Unity Asset Store and other online asset repository sites (e.g., TurboSquid, CGTrader). Directional and navigational cues were integrated to help guide the user throughout the narrative via text instructions and highlighted interactive elements (e.g., instructions stating to knock on the door and glowing yellow indicator pointing at the newspapers to pick up)(see Pjesivac et al., 2021 for an example).

To limit the learning curve with using the technology, only one hand-held controller was required to operate the experience and could be set to a user's dominant hand. The experience

was mapped to use two primary buttons on the controller: the “grip” and “trigger” buttons. The grip button is used by squeezing the middle finger down on the button to simulate a grip or grab action (e.g., grabbing a tea kettle) and the trigger button served as a primary selector tool to move around the home via virtual teleportation locomotion. To use virtual teleportation, users aim a virtual laser pointer projected from their controller at a yellow circle on the ground indicating where to move next. When the trigger button is pressed while aiming the laser pointer at the next location indicator, the user’s view jumps—or *teleports*—to that location within the world. Teleportation is one of the most common VR locomotion techniques and has been shown to reduce feelings of motion sickness, but may cause disorientation (Bond & Nyblom, 2019). However, teleportation is relatively easy to learn to use and allows the user to navigate the world without needing a large physical space to experience the VR narrative, which can be a barrier for some users.

A brief tutorial was designed to help users familiarize with the Meta Quest 2 controllers and locomotion technique. Users were guided with the same navigational and directional cues as in the interactive narrative. For example, users complete similar tasks using the grip and teleportation functions, such as gripping a doorknob to open a door or grabbing a clock from a shelf and teleporting to place the clock on another shelf.

Detailed Interactive Narrative Walkthrough

The VR Default Control narrative and VR Treatment narrative begin with the user on the front porch of Linda’s home. While on the porch, a text prompt reads that the user has just moved into an “up and coming area” and their new neighbor Linda has invited them over for tea. Instructions then say to knock on the door. Users knock on the door and are greeted by Linda at

the present-day age of 70. Linda welcomes them into her home, leading them into the kitchen area, and begins to share past experiences of her life growing up in this neighborhood.

In the Default environment, there are no added manipulations and Linda reflects on her past to share how her neighborhood had been affected by previous redlining policies. She then requests assistance with getting the tea started by asking the user to fill the kettle from the sink. Linda walks over to the sink area as users teleport to the stove, grab the kettle, and then teleport to the sink. Once the user places the kettle in the sink, Linda begins speaking about how because of the policies, factories were built near her neighborhood which led to polluting the air with harmful toxins. She explains how the dirty air impacted her ability to play outside as a child. Next, she describes how the factory impacted the neighborhood's water supply and explains how she had to boil the water for it to be safe. Here, the user is guided to turn on the faucet where at first, they see brown-colored water coming from the spout before it turns into a clearer and cleaner water. Users then grab the kettle and hold it under the running water until it fills. They then teleport to the stove and place the kettle down on one of the burners before reaching to turn the knob above the stove to start heating the kettle.

Linda walks over to the doorway of the living room area and asks the user to please come join her. The user teleports into the living room and Linda shares that she still has old newspaper clippings about when researchers found cancer-causing chemicals coming from the factory and that eventually the factory was shut down. Users are then guided to pick up each newspaper clipping that is on a coffee table in the middle of the room. After they've picked up both newspapers, the directional cue indicates to turn on the TV. When the user activates the TV, a 30-second news clip of the Warren County protest plays. When the clip ends, a tea whistling

sound can be heard coming from the kitchen. Linda asks if they can grab the kettle while she prepares the cups.

The user teleports to the stove, grabs the kettle, and then proceeds to the center kitchen island where Linda is waiting with two cups. The user is instructed to pour the tea into the cups. The kettle must be raised above the cup and then tilted to see and hear water pour from the kettle into the cups. The user pours the kettle into each cup before Linda begins speaking again. Linda continues her story, recounting how the city was very slow to clean up the area. She explains that once soil levels were finally deemed safe again, the city took several steps to revitalize the area, such as building a grocery store and hospital nearby. However, she also emphasizes how these improvements often come at the expense of those who have lived there for many years through city rezoning to build less multi-unit and affordable housing. Linda shares how many of her long-time neighbors have been pushed out of the community and it is clear gentrification is occurring. She coughs slightly as she makes a remark about how all these years have caught up to her, she then thanks the user for their visit and expresses her enjoyment in sharing this time with them. Linda then proceeds to the entry hallway to lead the user to the exit. She mentions how she is glad she can grow flowers now after all these years and offers the users to take one on their way out. The user teleports to the front door where it is optional to grab a flower from a vase next to the door before grabbing the doorknob to leave Linda's home, thus ending the experience.

The Treatment narrative is the exact same as the Default narrative except with virtual time travel added. For example, the moment when Linda begins reflecting on her past, a floating calendar appears indicating the year is 2024 and flips back to 1965. At the same time, Linda's virtual model shrinks into a smaller version of herself to appear about 10 years old. Sounds of a

ticking clock and flipping paper are used to heighten the effect. By the time the user finishes the conversation over tea, the year has changed back to 2024 and Linda has aged and grown to look the same as her 70-year-old version at the beginning of the narrative.

Data Collection and Procedure

Alternative from the typical SRD process of first reviewing the Default experience, receiving feedback on the Treatment (i.e., time travel) narrative is vital because there are many modifications happening to the social agent Linda throughout the experience (e.g., going from child to adult). To ensure that all representations of Linda are culturally authentic and whether the time travel technique can be useful for constructing a shared reality about lived experiences, co-designing the Treatment experience with community partners made the most sense. Given that both the Default and Treatment narrative experiences are primarily the same and both see Linda at the oldest age, input from community experts on the Treatment experience would still provide valuable feedback for necessary changes and improvements that would also apply to the Default narrative.

Data collection for the study occurred from October 2023 through February 2024. Initially, twenty experts were invited via email to participate, followed by a reminder email one week later if no response was received. Eight in-depth interviews typically suffice for qualitative data collection (Guest et al., 2020). However, recruiting efforts and the goal of reaching data saturation led to conducting 10 individual in-depth interviews with community members and public health researchers working in environmental health-related organizations.

Interview dates and times were scheduled at locations convenient for the interviewees to minimize their costs and logistical burdens. These locations included local university library meeting spaces, conference rooms at their organizations, or personal offices at research facilities

within the metro Atlanta area. Whenever a participant needed to visit a local university site, parking validation was provided at no cost to them. Each interview was scheduled for a 60-minute session and received approval from the University of Georgia Institutional Review Board (IRB ID: VERSION00002756).

Semi-structured interviews were chosen as the primary data collection method to allow a flexible yet systematic approach to gathering information. Interview guides were crafted based on the three research questions (RQ1, RQ2, and RQ3) to explore "shared reality" with the virtual agent Linda and underlying factors (i.e., source credibility), modalities of VR (i.e., immersion, presence, interactivity) that contribute to "shared reality," and the cultural authenticity of the time travel experience (see Appendix A for Interview Guide). Participants also provided brief demographic information, including age, gender, race, and occupation.

Each session began with the interviewees providing consent, followed by a 10–15-minute session where they engaged with the VR tutorial and prototype using a Meta Quest 2 headset. This headset was chosen because of the flexibility it has as a standalone headset and does not require additional hardware to power it. Post-VR experience, participants answered the interview questions, with sessions averaging 32.5 minutes. Afterwards, they answered a brief demographics questionnaire in a Qualtrics survey format. All interviews were audio-recorded with participants' consent and transcribed using transcription software (Otter.ai) for further analysis.

Data Analyses

Topic Modeling

After transcription, a Latent Dirichlet allocation (LDA) topic modeling analysis was conducted to aid in the thematic analysis process because it more closely aligns with human

interpretation than alternative methods (Albalawi et al., 2020). An LDA assesses semantic structures in textual documents through generative probabilistic modeling (Blei et al., 2009). LDA examines the distribution of terms through a mixture of latent topics within each document and is more useful for long- and short-text datasets when compared to other unsupervised learning methods (Albalawi et al., 2020). This analysis helps reveal the importance of topics throughout the dataset and evaluate the proportion of the topic overall (see Bastani et al., 2019). Therefore, I divided the interview data by individual responses to each question into 1-3 sentence segments. The preprocessed dataset consisted of 326 rows of interview transcriptions with individual responses ranging from 1 word to 341 words as some participants gave more lengthy answers. Within all ten interview responses, each participant averaged 32.6 rows of data.

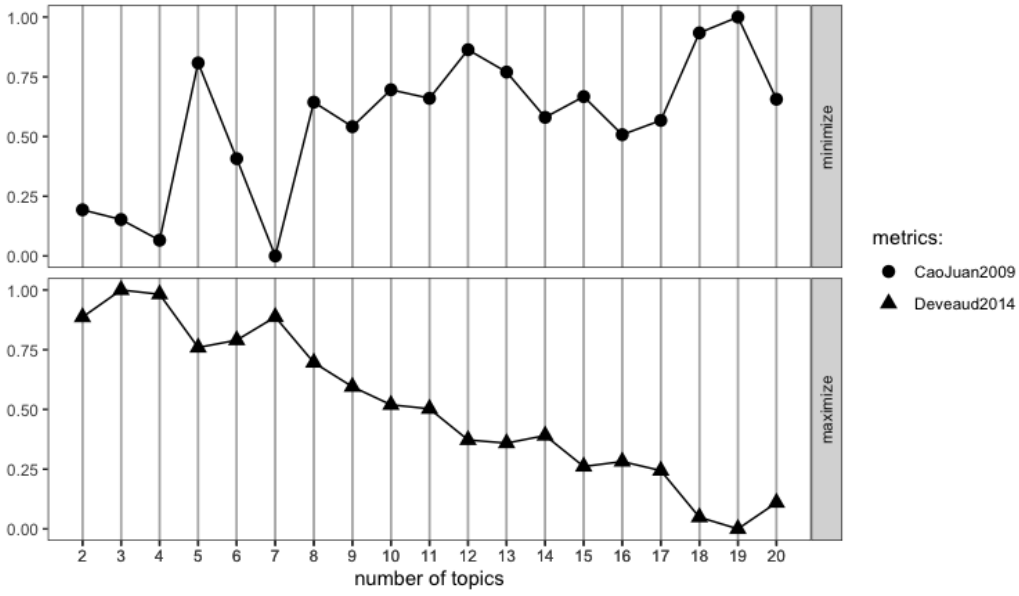
Data preprocessing was completed using R Studio, a statistical computing and graphics environment that uses R programming language (RStudio Team, 2020), following instructions provided by Schweinberger (2023). The dataset went through 5 separate tasks to prepare for data analysis: (1) replace characters not in {A-Za-z} (e.g., numbers and punctuation like !&?',.;) with a single space, (2) convert all text to lower case characters, (3) remove contractions (i.e., "don't," "can't," "I've"), (4) remove stop words, or generic common English words (i.e., "the," "an," "is") and lastly, (5) stemming all root words (e.g., "running" and "runs" becomes "run"). These steps follow the best practices recommended by Bastani et al. (2019). Once complete, a final task to construct a term-document matrix is required to run the LDA analysis (Deerwester et al., 1990; Blei et al., 2003). A term-document formats individual responses as documents and each word within each response as a term (Bastani et al., 2019). The final term-document matrix dataset contained n=322 documents and n=250 terms in rows and columns, respectively. This

matrix allows LDA analysis to assess words with a minimum frequency of 10 and determine common topics to inform the thematic analysis.

Deciding the number of topics (K) to analyze is essential for the LDA unsupervised machine learning to be useful (Schweinberger, 2023). If K is set too small or large prior to running the LDA, then the dataset will be divided into too few or too many topics, making the dataset difficult to interpret. Schweinberger (2023) recommends running CaoJuan2009 and Deveaud2014 using a range of number of topics to determine the optimal K. The optimal number of topics shows low values for CaoJuan2009 and high values for Deveaud2014 approaches. Visual inspection of resulting data plots indicate where the number of topics align in the peaks and dips suggest an optimal number of topics (see Figure 2). The matrix runs through a collapsed Gibbs sampling parameter estimation (Schweinberger, 2023). Gibbs sampling creates a Markov chain to define latent structures and estimates which terms are important to form a topic (Schweinberger, 2023; Silge & Robinson, 2017). This sampling-based algorithm allows the LDA to form topics of words that are related to one another and the proportion of which the term shows up in each document based on the optimal number of topics. This approach is useful when following the LDA analysis with a qualitative inspection of the data (Schweinberger, 2023), such as thematic analysis.

Figure 2

Estimation Plot used to Determine Optimal Number of K-means Clustering



According to the visual inspection of the plot, an optimal number of topics for this dataset is either K = 4 or 7, because that is where the dips of the CaoJuan2009 estimates closely meet the peaks of the Deveaud2014 estimates. After running the LDA with K = 4 and K = 7, it was determined that 4 topics was the optimal number because the results of the analysis produced more concurrent themes. Additional probability analysis—similar to a term frequency-inverse document frequency (TF-IDF)—were conducted to re-rank topics and produce more meaningful top terms (Chang et al., 2009; Schweinberger, 2023).

Thematic Analysis

In addition to the LDA analysis, this study employed thematic analysis as a distinct method to interpret the qualitative data (Braun & Clarke, 2013). Thematic analysis is "the process of identifying patterns or themes within qualitative data" (Maguire & Delahunt, 2017, p. 3352). This technique does not adhere strictly to any singular epistemological or theoretical framework, allowing flexibility for broad interpretation of data and accommodating a top-down

analytical approach (Braun & Clarke, 2013) informed by Whiteness and CBPR frameworks that align closely with the specific research questions.

Following the structured six-step guide by Braun & Clarke (2013), the analysis proceeded as follows:

1. *Data familiarization*: This includes repeated readings and gaining a deep understanding of the contents.
2. *Initial code generation*: Systematically coding data in an initial pass to organize into meaningful groups.
3. *Combine into themes*: Identifying broader patterns of meaning across different codes.
4. *Review themes*: Check themes against the dataset to ensure they accurately represent the data and refine them as necessary.
5. *Define and name themes*: Delineating and naming the themes for interpretation.
6. *Report findings*: Integrating and synthesizing the themes into an insightful narrative of the findings.

The thematic analysis coding began by printing out the list of interview transcriptions used in the topic modeling analysis. By hand, responses relevant to the research questions were highlighted and color-coded based on similarities (i.e., specific mentions of interactivity or relating the story to the real world). Each response was cut out individually and grouped based on the color-coded system. Commonalities within and between each grouping were examined more in-depth until set definitions could be created for each grouping. Each group was then analyzed along with the four topics from the LDA analysis to develop higher-order themes using Microsoft Excel. The entire process incorporated thoughtful reflexivity, engaging with the data to uncover meaningful

patterns and overlaps, and progressive refinement of themes to capture the data's essence comprehensively (Braun & Clarke, 2013) and aid in the VR co-creation process

CHAPTER 7

RESULTS FROM INTERVIEWS

Topic Modeling

The Latent Dirichlet Allocation (LDA) analysis of interview transcriptions identified four distinct topics that capture the primary themes by content experts regarding the virtual reality (VR) narrative on environmental racism. Each topic is characterized by a set of keywords that emerged frequently in the discussions, helping to elucidate the different aspects of shared reality construction as perceived by the experts. Topic 1 included top words that focused on community and personal experience (e.g., “people,” “community”); Topic 2 focused on environmental settings and realism (e.g., “house,” “real”); Topic 3 included terms related to emotional and sensory engagement (e.g., “feel,” “thought”); and Topic 4 pertained to the narrative and storytelling (e.g., “story,” “time”). Table 2 lists the top 10 words for each topic according to their probability (*P*) within the entire dataset.

Table 2

Top 10 ranked words from 4 K-means topic clusters

Topic 1, *P(.25)*	**Topic 2,** *P(.25)*	**Topic 3,** *P(.25)*	**Topic 4,** *P(.25)*
peopl	house	feel	stori
yeah	felt	back	part
communiti	guess	thought	neighborhood
hard	real	yeah	feel
experi	thing	tea	hous
air	health	good	kind
water	kind	make	show
import	kettl	thing	move
clean	bit	cloth	time
environment	child	benefit	stuff

Thematic Analysis

Given that earlier shared reality research suggests that increasing epistemic authority, or source credibility (see Chapter 3), is crucial when it comes to shifting differing worldviews, incorporating feedback from content experts with lived experiences of environmental racism is pertinent to constructing a shared reality based on shared truths and cultural authenticity. Grounding the narrative in lived experiences also contributes to creating a more realistic experience that is generalizable to everyday life, which is key to the systematic representative design (SRD) process (Miller et al., 2019a). The integration of community experts' feedback helps align the virtual experiences with real-world perceptions and experiences of those most affected by and knowledgeable about the issues, thereby increasing the authenticity and relevance of the narrative. The analysis of the semi-structured interviews revealed three primary themes that elucidate how content experts perceive the construction of a "shared reality" about environmental racism with a virtual agent in a VR interactive narrative. These themes are essential for addressing the research questions and are characterized as: *Building Credibility and Epistemic Authority through Lived Realities, Co-Constructing Virtual Lived Realities,* and *Distractions and Barriers to Engagement*. For each theme, key categories are emphasized in italics, and notable excerpts from participant responses are included to provide depth and context to the discussion.

Building Credibility and Epistemic Authority through Lived Realities

RQ1 asked how community and environmental health experts described their experience of "shared reality" with a virtual agent in the VR narrative, and what factors influence these perceptions. This theme explores how the CBPR framework enhances the credibility of the VR narrative by grounding it in the lived experiences of content experts. By incorporating firsthand

accounts of those who have experienced environmental racism, the narrative gains a level of authenticity and trustworthiness, crucial for constructing shared grounds based on a reality not distorted by Whiteness.

In this theme, many participants expressed the storyline and visual representations *reminded them of real-world experiences*, such as actual people or places they knew. Others noted the integration of time traveling and tangible historical journalistic elements (e.g., newspapers) *represented real-world* complexities and visualized longitudinal impacts of environmental racism. Experts also provided recommendations for refinement to co-design a more precise worldview. This theme highlights how these elements collectively strengthen the narrative's authority, complementing Linda's personal story and enhancing user engagement through a deeper, more realistic connection to the content. Thus, aiding in the construction of a shared reality.

When participants were asked whether the virtual narrative presented an accurate portrayal of events related to environmental racism, many expressed how the virtual home looked familiar to them, Linda even reminding them of someone they knew or that what took place in the virtual narrative aligned with their own experiences. For instance:

> "The first thing that stood out was that it actually looks like one of the community leaders' houses that we actually know and work with. So, that was like a very relatable experience." (P8)

> "She remind me of my great grandmother neighbor. Her name is Miss Annie…older lady staying in the same house for at least before I was born, at minimum." (P5)

> "I think it all aligned with what I experienced in my neighborhood…and we couldn't stop it in our neighborhood." (P1)

These responses underscore the importance of real-world accuracies and how the sense of familiarity helps validate the narrative, making the virtual experience more relatable and trusted. Participants also frequently drew *comparisons to real-world locations* known for environmental injustice, such as the "toxic donut" in Chicago, superfund sites in Georgia, or "cancer alley" in Louisiana. For example:

> "I think like her story resonated with me like thinking about…the toxic donut or whatever, where I was, like, we spent a lot of time there when I was in Chicago and it was like one of the few like housing projects that remained. So, I saw the parallel to like Linda talking about how there weren't like bigger buildings anymore. But, now like more single-family homes and things were changing and the affordable housing was gone." (P2)

These comparisons help to acknowledge that Linda's story is not necessarily unique to any one place, but rather, these *issues are ongoing* and have occurred in many places around the U.S. Such contextual accuracy helps to reinforce the structural aspect of the narrative. However, some participants shared firsthand accounts of experiences that were not currently present in the storyline. For instance:

> "Rent goes up first. So, then the people who can't afford to pay rend end up having to leave. And then in my experiences, what happens is the elders are targeted by investors. So like, I know an elder who had a home and she was talking to an investor about purchasing it, he was giving her a really low price. And so, she said, well, I'm not going to sell it. He like came over, put trash in her yard, and then called code enforcement. And so, she had to go downtown. And she was like, it's nothing but elderly people in here. And those fines are $700." (P1)

Someone unfamiliar with environmental racism may not know specific details like the targeting of elderly folks in many of these communities unless one has actual experience or knows someone to whom these predatory practices happened to. Integrating firsthand accounts of what happens in neighborhoods actively going through discriminatory and predatory practices,

such as the one described above, is an example of context that can be added to Linda's dialogue during the iterative design process to further ground the narrative in accurate lived experiences.

Additionally, many experts expressed that the time travel effect of witnessing the virtual agent Linda as a child *personalized* her experience and *contextualized* the information, allowing them to connect emotionally to the narrative. Some participants used words like "upset" or "disappointment" when describing her story, and others stated:

> "I think it felt *genuine* because of one thing, being able to see her age made it seem more realistic, like especially when she was a kid. It *put the story in more context* because I could actually see her...I feel like seeing her as a child did put things in perspective, that she's not just an old lady that somehow just gives most of her life advice." (P10)

> "I feel like when she was the child version of her, and it could have been like the voice change occurred just because I'm a softy, but it just kind of like made you kind of pull at the heartstrings a little bit because she was like, well, yeah, we have to boil the water. And because X, Y, Z, or how when she started trying to explain, like, the neighborhood was undesirable, and she had these discriminatory practices, but she was like, obviously, in her child-like voice trying to say it, and it's like, hey, well, don't you know, kids really pay attention." (P5)

These comments imply that even those most knowledgeable in this topic area can be impacted by the virtual time travel effect and recognize the enduring impact of environmental injustice through Linda's life course exposure from childhood into adulthood. The voice changes used to make Linda more childlike (i.e., more human-like) also appeared to strengthen the perceived realism of the narrative, enhancing the emotional engagement and credibility of Linda's experiences.

When probing specifically about the perceived credibility of the virtual agent Linda, the inclusion of tangible journalistic elements such as newspapers, news footage, and the realistic

depiction of environmental changes over time was frequently mentioned as key in complementing the narrative's credibility. Participants often felt these elements helped bridge the gap between VR and real-life experiences. For example:

> "I think *she had credibility*, I think it was just more that it just like added to it, right? I think, like if you were just given those pieces of information, I think that's where they would have like, sounded credible, but they would have lacked, like some, like an ability to like internalize it, right? Whereas, like, if you're hearing from a person, about their experience in it, I think it goes back to what I said before about how I came to understand structural racism." (P9).

This comment highlights the unique capability of VR narratives to incorporate multiple elements in a linear narrative to enhance a speaker's epistemic authority on a given topic, blending both lived experiences and historical evidence. Integrating layered information in this way might be more challenging using more traditional media forms, such as only physical newspapers or archival news footage.

By taking the likely heightened epistemic authority into account through the accurate lived experiences and historical evidence, participants stated that sharing an experience like this might help people think of environmental racism and injustice in much broader ways and be able to connect it to their own lived experiences afterward. One participant stated:

> "In my experience, all the times people think of like pollution, they're not thinking of nearby neighborhoods. And I feel like a lot of the times, people only think of pollution, and like the ocean or pollution in the air. I know when she talks about like our soil was polluted, I don't think most people think about that. So, I feel like if they heard it, and also saw, like the news clip of people protesting, maybe it will change their minds a little bit. Because I just don't think a lot of the things she said are things that people consider as being hazardous. And also, like I said, I don't think most people think that it *hits close to home*." (P10)

Additionally, several participants spoke about the value of a platform like this in helping to explain the complex and intricate layers that go into understanding the structures of environmental racism. Specifically, the information laid out in a narrative like this made the information "approachable" and digestible for someone unfamiliar with the content. For instance, two participants shared:

> "I think this is a great format to educate people on these matters. Especially when they are pretty complex to understand, you know, unless you work in the field, or you know, you have a class about it, or something. A lot of people don't know about this. When they think of environmentalism, they think of like recycling plastic, but you know, like being able to be in someone's home and see dirty water coming out of the faucet. Or in seeing how, like how much you use water, like from a cup of tea to showering to boiling eggs, like it's drinking, obviously, water is everything. You know, it makes a greater impact." (P3)

> "…I think it's more of the personal side to it, so that you know, one, this isn't a historical artifact. This is a today situation and that people are living with that history. So as much as like, new people would be coming into areas and overtly places look, you know, environmentally clean, safe, whatever, that in fact there's a history there and that there are people still in those areas that are living that history. I think that's like the big message I got out of that, and it really hit at the end." (P9)

By embedding these lived experiences and historical elements into the VR narrative, the CBPR framework helps co-create a more truthful and relatable shared reality to potentially increase the epistemic authority of the narrative. These comments imply that enhancing the epistemic authority of a narrative can be helpful when emphasizing the various ways that environmental concerns can impact an individual and their community. In other words, incorporating personal stories with historical evidence and accurate visual cues may alleviate

some of the uncertainty non-experts may have when addressing environmental concerns, making understanding environmental racism and constructing a shared reality more feasible.

Interestingly, when asked who a target audience might be for something like this, the combination of layered personal and historical information provided several avenues to expand upon. One participant had specific examples that would be helpful for communities more susceptible to environmental injustice:

> "It makes me wonder how would this be incorporated into practice or to community practice? Is this something that like, you know, providers or staff like healthcare staff, program staff…we could implement it in our classes? …I'm curious to see what it could grow into, like, even could I be at my doctor's visit and they're like, oh, well, we see you live in zip code 30318, or 30312. Here, if you have a few moments, you know, you can look at this simulation thing and talk about the soil. And we have resources if you want to get your soil tested or something like that." (P5)

Another participant mentioned that because it uses both personal and historical elements, it could be helpful when taking a more policy-driven approach:

> "It gives you that personalized piece to it that I think you don't get from just reading stuff. And I think that that makes a big difference in it…I've gotten like some trainings and stuff about how to interact with Congress people or you know, people in legislature, and it's all about personal stories, not about data. And, and this is feeling like I know I get it, like sitting here and having a personal it just helps to connect to the materials better." (P9)

Both suggestions indicate the potential of demonstrating shared truths in a virtual narrative like this one and who it could impact. However, their comments also allude to the fact that there is room to strengthen and refine the narrative in order to create a narrative for such purposes. One participant stated that while it's obvious Linda is a Black woman, it's important to add to the dialogue to be more explicit about how race is essential to the story:

> "If Linda said, this neighborhood was mostly Black, it *might be more what I see in real life*, you know, Black folks being pushed out of these neighborhoods, and becoming minorities in these neighborhoods that they were born or raised in…yeah, race and also economic status and things like that." (P3)

An additional suggestion included integrating the health impacts of environmental racism more explicitly into the narrative, potentially making these issues more *central to the story* for greater understanding:

> "And she did a small moment when she coughed, so, I was like, okay, that probably could have, that could be a health sign or issue…so something like that will be more being able to build a better relationship with her and more sympathy toward her as well to that will help…overall more health, information about health." (P8)

The recommendation to explicitly address the role of race throughout the narrative is essential in the CBPR process as it highlights potential biases researchers may have when designing an initial prototype. Furthermore, emphasizing the health impacts alongside environmental issues underscores that discriminatory policies do not merely affect the environment but also directly harm the people living in those communities. These insights are valuable for refining the prototype to accurately represent the lived experiences of community experts.

Overall, in this theme, the CBPR framework significantly enhances the epistemic authority of the VR narrative by ensuring that the story is deeply rooted in the lived experiences of those most affected by and knowledgeable about environmental racism. Integrating their feedback and incorporating tangible historical elements and personal stories enables the VR narrative to present a more authentic and credible account. This approach ultimately implies that it can foster a stronger shared reality for its users.

Co-Constructing Virtual Lived Realities

RQ2 asked in what ways do different VR modalities (e.g., immersion, presence, interactivity) shape community and environmental health experts' experiences and perceptions of "shared reality." This theme explores the unique affordances of VR that enhance the user's sense of spatial and social presence within the immersive interactive narrative. Given that previous research shows that greater spatial presence, interactivity, and realism can positively influence credibility perceptions (Sundar et al., 2017), it is crucial to understand how experts respond to the different affordances of VR when interacting with the narrative. Because presence (social and spatial) and realism must work together to not overwhelm the user, feedback from content experts is critical to developing a balanced experience. These elements are also integral to the systematic representative design of virtual environments, ensuring they are generalizable to everyday life (Miller et al., 2019a).

To better understand spatial presence perceptions, participants were asked whether they felt immersed in the space to the point where they forgot they were in a simulated environment. Many participants expressed surprise that even though the graphics weren't necessarily realistic and felt "robotic and computerized," they still felt like they had left the physical space they were in. For example:

> "I'm happy I didn't hit a table. But it was so interesting how it really did feel like I was in someone's house. But I was in this, just for the recording, this space is what, like, seven by ten feet maybe? Not that much room, but I felt like I was in a whole house." (P3)

This comment highlights how immersion fidelity in virtual environments, comprising display and interaction fidelity, does not require the most human-realistic rendering display

quality to enable users to feel as if they are in the virtual space. Instead, interaction fidelity can make virtual environments feel more convincing, as another participant expressed:

> I feel like when we get to like the living room, and there were like, all those things I could like, see, and like, the newspapers and the TV, and I was like watching TV and reading the newspapers, kind of like felt most realistically, like I was like, *in her living room with her*." (P2)

Here, the participant notes that the additional interactive journalistic materials enhanced their sense of realism in the environment, which in turn influenced feelings of being *there* in Linda's living room (i.e., spatial presence) and *with* Linda (i.e., social presence). These interactions with the VR world, such as seeing the tangible effects of environmental hazards and performing realistic changes to the virtual world, contributed to a heightened sense of presence.

Many participants also expressed how they felt the need to take a step back when they got too close to Linda. These comments imply that participants felt Linda's presence in the space with them enough that they would go out of their way to avoid bumping into her, despite her being virtual. Other comments about *feeling with her* (social presence) and *feeling in her home* (spatial presence) emerged from the virtual situation. For example:

> "After I went in, and she said, "Come on, come on in, would you mind putting some water in my kettle?" To me, that's why it felt like real life. I mean, *being in somebody's home* and they asked me to help them do something." (P4)

> "Yeah*, I felt like I was in Linda's house*, you know, like she invited me in and then we walked through the kitchen and like, I was making like this tea, like, *it felt like I was having an interaction with a human*." (P2)

These comments suggest that not only does the virtual representation of the home and Linda's human-likeness help foster feelings of social and spatial presence, but the realistic

actions that took place also played a significant role. Sharing tea with Linda provided a realistic and relatable activity that deepened the connection between participants and the narrative. One participant noted:

> "Being able to like, share a cup of tea together, that's very, you know, as simple as it is, you know, communing over a cup of tea is so significant, you know, and bonding. It's very friendly. So, I think, for the folks who aren't used to interacting with Black folks day to day, let alone being welcomed into their home, I think maybe they can experience this." (P3)

This participant implies that people who may not typically have intimate and friendly experiences with older Black women could benefit from experiencing something like this due to the shared nature of the tea-sharing environment. It is likely that creating virtual environments that represent common everyday settings can facilitate bonding experiences, even when one participant is virtual.

Additionally, several participants spoke to the value of being able to visually confirm the proximity to environmental hazards, adding a layer of thought-provocation to the experience:

> "I think like being able to, like open up the curtain and literally see the factory was kind of thought provoking. Because sometimes you think about that you're like, oh, like, there's a dump, like, down the road, or like, we can smell the trash, but like, you certainly can't see it. But like, she was very close to that factory, she could literally see it. So, I thought that was, like, provoking." (P2)

This comment emphasizes the multifaceted layers of environmental racism that communities of color endure and the need for the interactive narrative to incorporate each of those layers to capture a full picture. Conversely, this comment also alludes to the potential emotional intensity of the narrative and the importance of finding a balance between presence and realism. Moreover, while some still expressed that it "felt virtual," the integration of the interactive tasks and sounds seemed to help make it feel *more natural*:

> "Not really realistic. Like the setting and the house and the décor and stuff. Like it felt like I was in a video game, just the graphics and things like that. But I guess some of the interactions like being able to pick up the kettle and fill the water, or picking up the newspaper felt realistic, like those, I turned it over, and was able to look like on both sides. That felt realistic." (P8)

> "…when I like dropped the kettle on the floor, like that was so cool. How, you know, how real that would be." (P3)

These comments shed light into the SRD process aimed to make the VR environment respond realistically, where incorporating real-world physics like gravity and everyday tasks that are straightforward and intuitive for users. This design choice is crucial, as it may ensure that users are not overwhelmed by complex tasks while learning complex information about environmental racism. However, sometimes the interactive tasks took away from the *social* presence of Linda because participants weren't *talking back*. Specifically, the integration of eye-gaze tracking (i.e., human-like qualities) appeared to make participants feel as though they were expected to respond during the conversation—but remembered they were in VR. For instance:

> "There are times where I was like, oh, I should maybe respond. And I'm like, this is a VR." (P1)

> "Maybe that's where the mundane tasks make sense. I mean, it almost makes that, like, I guess I'm not talking back to her, but at the same time, it felt like she thought I was." (P9)

These suggestions highlight the importance of incorporating static yet informative elements, like newspapers and television footage, to enrich the story without requiring direct interaction with the virtual agent. A curated linear narrative with built-in interactive tasks can provide a more engaging experience than merely reading an article.

A couple participants made additional suggestions to enhance the connection with Linda and her home such as having people actually drink the tea:

> "…like I know from my experience, like boiling the water, being on a boil advisory, and being in a position where you actually don't even want to drink the water, you're just like, well even just even use the water is still like, you're very hesitant about it. So, for to have a part in there where you're encouraged to actually drink it will kind of give like a real experience of like dealing with that kind of situation." (P8)

And adding more *homey touches* to the virtual environment:

> "Like if I go to my aunt's home, I know there's gonna be plants there. I know she's gonna have some kind of food on the table somewhere. Something prepared, food, something's going to be out. Yeah, and if I come in, I'm gonna get more than tea. It's gonna be like cookies or…I just made this, you want some? Take a peach cobbler back. Make it feel like more welcome into the space." (P8)

Based on the following responses, the unique affordances of VR, such as spatial presence, social presence, interactivity, and immersion, play a crucial role in enhancing the user experience within the immersive interactive narrative. By incorporating these elements, the VR narrative fosters a strong sense of being "there" in the virtual environment and facilitates meaningful interactions with the virtual agent, Linda, feeling there "with" her. The experts' feedback underscores the importance of balancing realism and simplicity to avoid overwhelming users while ensuring an engaging and relatable experience. The CBPR framework, combined with SRD, ensures these virtual environments are grounded in everyday life.

Distractions and Barriers to Engagement

Despite the supportive evidence of enhanced epistemic authority and the unique affordances of VR in the VR prototype, the third theme explores some of the distractions and barriers mentioned by the experts. Though critical to the immersive experience, these aspects present challenges that need to be addressed to fully realize the potential of interactive VR narratives in constructing shared realities about environmental racism. This theme also includes specific suggestions for refinement that experts gave to mitigate some of these challenges.

One of the most notable distractions mentioned was the floating calendar object used to visualize the time travel effect, which flipped through the years throughout the experience while Linda changed ages. Some participants found this effect distracting and suggested ways to improve it with additional environmental cues. For instance, one participant noted:

> "[The calendar] was distracting because the numbers were changing like really fast…I feel like if it could just be like one year or something. I think that would help to show because I thought it was like, there's just this one brief time where she's a little kid and she goes back to being the same woman…" (P6)

Others recommended incorporating more noticeable changes in Linda's surroundings to better illustrate the passage of time:

> "The calendar did help. But maybe like seeing like, maybe some changes to the home? Well, I'm sure she didn't keep the house the same since 1960…Or like, even outdoors, maybe seeing like, time changed…small décor changes in her home will be helpful." (P8)

These suggestions emphasize the need for a more intuitive and gradual representation of time changes, which could help users connect emotionally with each phase of Linda's life and enhance the narrative. Additionally, participants recommended modifications to Linda's appearance to better reflect her age changes during the time travel sequences, enhancing her realism. These changes would help users perceive her not just as small adult but as a genuinely younger version of herself and enhance the user's emotional engagement and believability of the shared reality experience. For example:

> "If she had a doll in her hands that emphasize that she's not just a small adult, she's a child, or an outfit change or something to like a little simple dress…with pigtails on the side or something." (P3)

> "I would just try to make Linda more realistic. I felt like I was talking to a video game, like an old old video game…and then her walk was like, the walk was funny." (P8)

These comments highlight the importance of detailed and authentic representations of Linda's life course. Although the initial prototype's time traveling effect was largely positive, improving the child-like appearance and animations can significantly enhance the narrative's credibility and user engagement.

Moreover, participants expressed the need for a slower narrative introduction to allow users to acclimate to the environment and Linda's story. A more gradual approach could help users better understand and emotionally connect with the narrative:

> "Maybe something at the beginning, when you first walk into the house where it doesn't just dive right into that conversation, you know, like more of a typical, like, if your neighbor invites you over to meet them for the first time. Like, you know, maybe they're going to talk a little about themselves first, or something like their background. Yeah, and that might help somewhat with the age thing of like, showing her at different ages or something like that." (P6)

> "I do recommend like her speaking about the experience with brown water, maybe kind of just adding to that a little bit like it was very brief. And it was like not really like a full like being able to connect with her and really understand what she's going through with that…" (P8)

These comments also speak to the more technical barriers that some participants expressed when learning the controls:

> "Once I got a little bit used to it, it was a little bit easier. But it still felt virtual, but it got more relaxed once I got used to the controls." (P7)
>
> "Maybe it's just because I'm not used to VR, but sometimes I was distracted. I don't know if you noticed, I could not pick up that newspaper. When I was doing a lot in this house, sometimes I was getting distracted. But like, again, like some tasks, which I was drinking the tea, I was still able to focus on her. So, it just depended on how hard the task was, but I still felt like I was interacting with her." (P10)

These insights underscore the importance of pacing in narrative delivery, emphasizing that allowing time for users to absorb and reflect on the visuals and dialogue can significantly deepen their understanding and emotional connection to the issues presented. Additionally, giving the participants adequate time to become familiar with the controls through a longer tutorial could mitigate such distractions when new users learn how to use VR. These responses underscore some of the potential enhancements that can be made to the VR experience in the process of constructing a shared reality with a virtual agent in a VR narrative.

Further, while some participants appreciated the realistic aspect of multitasking—engaging with a task while simultaneously listening to the narrative—others reported challenges that detracted from their ability to fully engage with the content. The distractions primarily arose from the demands of interacting with the environment, which sometimes caused the narrative elements, particularly Linda's dialogue, to become "background noise."

> "I know you try to make it as realistic as possible because my grandma, even in real life, people are going to talk to you while you're doing things. But it's like I guess you kind of still have like the mindset of this is virtual reality. I'm trying to figure out how to…my main focus is most of my attention is really trying to focus on how to pick up this thing with the controls. And so…at that point, she just became background noise." (P8)

> "I could see her standing or walking, but like, when I was focusing on stuff like I wasn't aware of like my surroundings, or what she was doing in the background." (P1)

> "Definitely I could tell I was like paying more attention because I was in that setting, you know, than like reading something, right? But there were times where I was like, I did not catch anything she just said because I was like looking for like where the yellow pointer was or something." (P6)

Participants clearly stated the need to *find a balance* between interactive tasks and narrative absorption within the 10-minute time limit because these comments suggest that too much

interaction while also trying to intake information can potentially negatively impact social presence perceptions of feeling there *with* Linda. However, previous research suggests that too much presence can lead to lower trust evaluations, so again, the challenge with interactive narratives is finding a balance where presence and interactivity do not hinder the narrative's overall shared reality.

Although several participants stated understanding the information "doesn't take an environmental scientist, we're not talking about lead and carbon and, you know, chemical terms, it's just simply clean water, clean air, and clean soil" (P3), but because of the imbalance of the interactive tasks, one participant posed a pertinent question:

> "Do you want us to look at her tell the story, or you just want people to see the imagery of what she is saying?" (P1).

In response to some of these challenges, participants suggested potential ways to enhance narrative integration without overwhelming the user with too much interaction. For example:

> "she can tell the story…you wouldn't even have to have all that movement and center the story…Linda goes to show outside, that used be [where a factory was], then a point…You might have the magazine…give a little story there. And, you know, you might have something [playing on TV] in the background and be like, 'Oh, there's a guy that's coming over on the archive from whoever fake journalist name…', then turn it up." (P7)

These reflections underscore the importance of creating a narrative that mirrors real-life experiences while avoiding overloading users with interactive tasks. When the virtual environment focuses on constructing a shared reality about environmental racism, this feedback highlights the need for a careful balance between interactive elements and narrative coherence to enhance user engagement and understanding.

Lastly, the representation of Linda at different ages, particularly her hairstyles and movements, was another area of concern. Participants emphasized the need for historically accurate and culturally respectful representations, as these details significantly impact the narrative's authenticity and user connection:

> "…So, if you're really going back in history, if you're going back to her [when she's young], and she's 70 years old [now], they didn't have no stuff like that for Black folks back then. So, go and really look at some history." (P7)

This feedback underscores the importance of CBPR frameworks in VR narrative design, ensuring the representation is accurate and respectful of cultural and historical contexts. This feedback also highlights structural issues within current technologies, where there is an ongoing lack of accurately crafted assets for Black avatars and Black hair unless developer teams can customize their own (Hatfield et al., 2022).

Additionally, one participant pointed out a concern with the default virtual house asset used for the narrative:

> "They had some sweet rabbit cereal that is unhealthy and we talked about environmental justice, that bothered me a lot. And it seemed very, I can't even, I'm just gonna say it, really racism about Black people, they don't eat healthy. Something to show healthiness." (P7)

Feedback such as this aids in confronting potential biases by researchers and demonstrates the importance of refining VR narratives to avoid perpetuating harmful stereotypes and systemic inequities. By addressing these distractions and barriers, the VR experience may become more engaging, accurate, and impactful in sharing the lived realities of environmental racism.

Summary

The Latent Dirichlet Allocation (LD) analysis of the interview transcriptions identified four distinct topics that encapsulate the primary themes by content experts regarding the VR

narrative on environmental racism. These topics include community and personal experiences (Topic 1), environmental settings and realism (Topic 2), emotional and sensory engagement (Topic 3), and narrative and storytelling (Topic 4). The topics align closely with the three main themes that emerged from the thematic analysis of the interviews: *Building Credibility and Epistemic Authority through Lived Experiences*, *Co-Constructing Virtual Lived Realities*, and *Distractions and Barriers to Engagement*. Each theme reveals critical insights into how the VR narrative can effectively construct a shared reality by incorporating lived experiences to enhance epistemic authority, leverage immersive realism and feelings of presence, while also addressing potential challenges.

The first theme, *Building Credibility and Epistemic Authority through Lived Experiences*, highlights how grounding the narrative in lived experiences of content experts enhances its authenticity and trustworthiness. This aligns with Topic 1, emphasizing personal and community experiences, and Topic 2, which focuses on environmental settings and realism. The second theme, *Co-Constructing Virtual Lived Realities*, delves into the unique affordances of VR, such a spatial presence, interactivity, and immersion, reflecting Topic 3's emphasis on emotional and sensory engagement. Lastly, the third theme, *Distractions and Barriers to Engagement*, addresses the challenges and potential solutions for enhancing the VR experience, resonating with Topic 4's focus on narrative and storytelling. Together, these themes and topics provide a comprehensive understanding of the elements necessary to create an effective and impactful VR narrative on environmental racism. The specific findings of each research question will be discussed in more detail in the next chapter.

CHAPTER 8

DISCUSSION FOR INTERVIEW RESULTS

The integration of community and environmental health experts' feedback into the iterative design process of a VR narrative on environmental racism is crucial for creating credible experiences and fostering a deeper understanding and connection with the content. The time and commitment to this approach is required to disrupt prior criticisms on empathy-provoking and "virtuous VR" focused VR narratives (Hatfield et al., 2022; Nakamura, 2020). This chapter synthesizes the key findings from integrating a Community-Based Participatory Research (CBPR) framework with the Systematic Representative Design (SRD) process to develop a virtual interactive narrative with generalizability to everyday life (see Miller et al., 2019a).

The findings from the interviews highlight underlying factors influencing the construction of a shared reality with a virtual agent employing a virtual time travel technique. The research questions explored (1) how experts describe their shared reality experience with a virtual agent and what factors influenced those perceptions, (2) how different VR affordances shape those experiences and perceptions, and (3) how experts describe the cultural acceptability and authenticity of the VR narrative. Drawing on the results from Latent Dirichlet Allocation (LDA) topic modeling and thematic analyses, this chapter discusses how feedback from content experts has been instrumental in refining the interactive VR narrative. By weaving in the two principles of shared reality—motivated connection and motivated cognition—this process

emphasizes the construction of a shared reality for future users through centering lived experiences and balancing VR affordances.

Constructing a Shared Reality through Virtual Lived Experiences

The interview analyses with ten community and environmental health experts revealed how an iterative co-design process can significantly enhance the SRD process by identifying various factors ranging from building epistemic authority (i.e., source credibility) to leveraging VR affordances for constructing a shared reality with Linda. Particularly, the analysis illustrated the importance of realism, not necessarily in the sense of rendered display quality, but in terms of deriving the virtual narrative from *real* representations—whether through the virtual agent, storyline, physical interactions, or the environment itself.

Experts frequently described their experience of "shared reality" with the virtual agent Linda as deeply rooted in the authenticity of the narrative and how the virtual environment and storyline resonated with their real-world experiences of environmental racism. By integrating firsthand accounts, the VR narrative gained significant credibility and trustworthiness, prompting discussions for how such narrative could be used to help other audiences better understand the enduring impacts of environmental injustice.

The VR affordances of immersion, presence, and interactivity were also critical in shaping the experts' experiences and perceptions of shared reality. Immersive elements, such as the time travel effect, allowed users to experience the historical context of environmental racism firsthand, *sharing* Linda's personal experiences and making the narrative more impactful by being active participants in the story. Additionally, feelings of presence were enhanced through the realistic interactions with the virtual environment and Linda, fostering a strong sense of being in the same space and time.

Since the events mirrored experts' lived realities, this helped validate the narrative and the use of the virtual time travel technique in personalizing the experience. Seeing Linda as a child and growing into an adult likely enabled experts to connect emotionally with her story, acknowledging Linda as the most authoritative viewpoint throughout her life. With the illusion of time traveling, Linda visibly demonstrated the enduring effects of environmental racism over a 60-year period. Although this study did not compare the time traveling technique with the default control group (i.e., no time traveling), it suggests that a dynamically aging Linda may be more credible than an elder Linda recalling the events as if from memory. In other words, the virtual time travel technique provides a unique method to directly test the seeing-is-believing aspect of shared reality (Echterhoff et al., 2009) when applied to more critical historical contexts.

Interactivity, facilitated by the user's ability to perform tasks like filling the kettle or picking up newspaper clippings, made the experience more engaging and personal. These interactions increased the narrative's realism and allowed users to explore the content actively, enhancing their shared understanding. However, there is a caution that too much realism and interactivity can overwhelm the user which can result in lowered credibility perceptions (see Sundar, 2008). For example, many experts noted they missed what Linda had said or could not recall seeing the factory outside because they were too focused on multitasking. Feedback highlighted the cognitive load required to manipulate VR control, which can overshadow the narrative, reducing immersive affordances and the potential impact of the experience. This suggests that combinations of static and dynamic aspects of the narrative must be strategically balanced to adjust the delivery of the information and avoid overwhelming the user for a more impactful experience.

These findings support shared reality theory, which posits that shared *truths* are constructed through motivated connection and motivated cognition. The two principles work synergistically: motivated connection is fulfilled through common experiences with others, and motivated cognition is achieved when those experiences are verified or co-constructed by others (Echterhoff & Higgins, 2021). Replicated *authentic*—and rather ordinary—shared experiences, such as making and drinking tea with another, innately apply SRD's generalizability to everyday life model. It is within that shared everyday experience that it becomes possible to weave in additional lived experiences that may differ from those of the user, creating new shared experiences. Therefore, it can be argued that the shared experience of communing over tea and the co-construction of lived experiences with Linda fulfill the motivated connection principle of shared reality.

Furthermore, the addition of tangible aids like newspapers and historical footage provides the user with supplementary information from external sources, verifying the shared truths delivered by the virtual agent. Thus, fulfilling the motivated cognition principle of shared reality. These elements collectively enhanced the narrative's epistemic authority, making the experience more relatable and believable through a combination of lived experiences, realistic interactions, accurate depictions of environmental hazards, and journalistic materials derived from historical evidence that could be shared for other use cases. The findings underscore the potential of VR narratives to inform users about critical social issues, such as environmental racism, through immersive and interactive experiences that resonate with real-world experiences.

Incorporating SRD and CBPR into VR Narrative

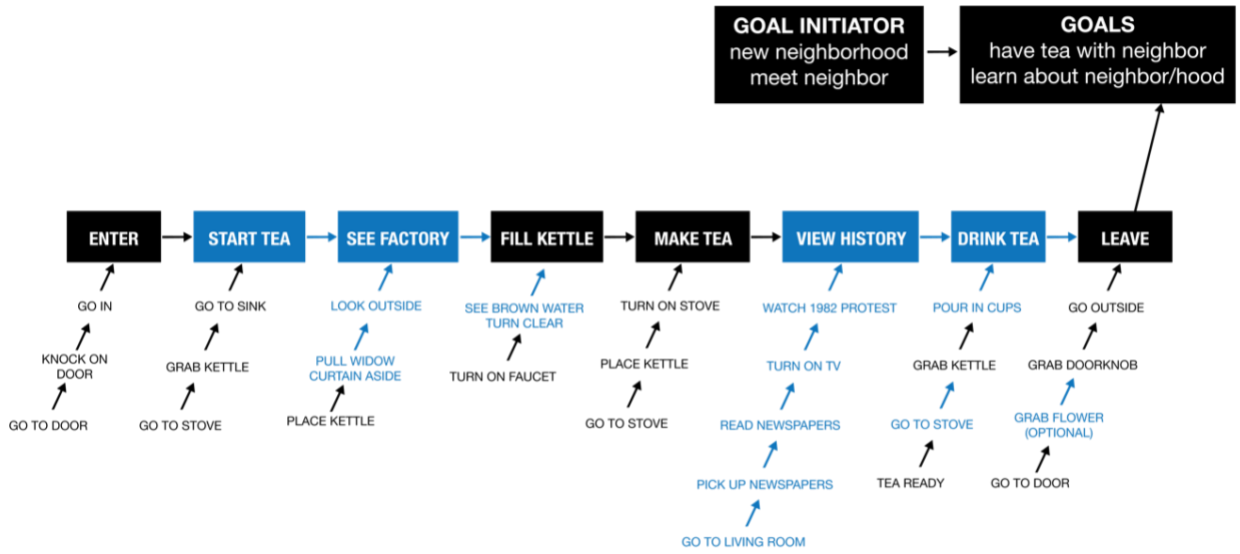
Using SRD with a CBPR framework throughout the iterative prototyping process was instrumental in integrating real-world elements to ensure that each iteration is well aligned with

actual community experiences and cultural contexts. Notably, having an initial prototype developed helped jumpstart the process in order to create a starting point that can be developed further along. By involving community experts in the design process, the narrative was enriched with authentic lived experiences and culturally meaningful details. This collaborative approach aligns with SRD's emphasis on creating credible narratives reflective of everyday life (Miller et al., 2019a). The iterative feedback loop allowed for continuous refinement, addressing potential oversights, and enhancing the overall narrative fidelity.

Moreover, the SRD process ensured that the VR environment was not just a high-fidelity simulation, but a meaningful representation of real-world issues. The use of everyday activities, like preparing tea, as a backdrop for discussing complex issues like environmental racism, demonstrated how mundane tasks could be leveraged to construct a shared reality. This approach made the narrative accessible and engaging, facilitating a deeper connection between the user and the virtual agent. To demonstrate the various interactions that take place throughout the refined narrative, an updated tasks and goals flowchart was created (Figure 3). This study helped establish the importance and relevance of the tangible journalistic materials within the storyline goal, which was not initially realized in the first draft (see Figure 1 in Chapter 6).

Figure 3

Final VR narrative walkthrough tasks and goals script



Note. Enhancements are shown in blue.

Based on the suggestions received to refine the virtual representation in the world (e.g., Linda's childlike appearance) and balancing the multitasking nature of the narrative, some of the major changes that were made to the initial prototype included:

- Changing hair and clothing to create 4 different age-stages for Linda from child (10-12 years of age), to young adult (25-35 years of age), middle-aged (45-55 years of age), and elder (70 years of age).
- Cutting all awkward walking animations and using cut scenes to change Linda's position instead.
- Changing floating calendar to fade-to-black cut scenes with a rolodex-like text feature of the date snapping to another date (e.g., 2024 to 1965, 1965 to 1982, 1982 to 2005, and 2005-2024) and Linda's age (e.g., Linda is now X years old).
- Adding a window curtain interaction to prioritize looking at the factory outside.

- Pacing talking and interactive tasks to go one-after-the-other rather than overlapping or requiring multitasking (i.e., doing tasks while listening to dialogue).
- Adding an interactive task to grab the cup and drink the tea.
- Replacing sugary cereal on the counter with a bowl of fruit.
- Adding plants, home décor, and a plate of biscuits to go with the tea.
- Changing environment to reflect time periods (e.g., removing dishwasher in 1965, updating living with a modern couch and TV in 2000's).
- Adding dialogue to be more specific about how race is important to redlining and example of predatory tactics elderly often face (e.g., someone throwing trash in their yard and reporting it to the city).
- Slowing down the overall narrative pacing (e.g., making the water stay brown for a couple seconds longer before turning clear).

Additionally, to visualize an example of the multiple changes that were made throughout the iterative design process, Figure 4 notates specific modifications addressed in the resulting refined narrative and Figure 5 captures screenshots of the most current version of the interactive narrative.

Figure 4

Example of enhancements made during iterative feedback process

Note. This scene is a first prototype of the time travel effect where the year is 1965. a) removed dishwasher and replaced with countertop, b) added interactive curtain to emphasize factory outside, c) replaced sugary cereal with bowl of fruit, d) changed to an older fridge model, e) replaced sit down table with a bar top island to allow users to stand with Linda, f) child Linda updated to not look like a shrunken version of older Linda.

Figure 5

Screenshots of Refined VR Time Travel Narrative

Note. Image a.) Linda is about 70 years old; b.) Linda as a child in 1965; c.) interactive curtain on window; d.) TV model from 80s with protest footage; e.) table for tea drinking

The changes made to the virtual environment based on expert feedback are expected to improve the construction of a shared reality for future users. Many of the changes addressed the comments of either being overwhelmed by multitasking and learning how to use the VR technology or the overall visual representation of Linda and her home during different years.

These changes were important because before the iterative design process, less attention was spent on the explicit changes to the virtual environment to reflect a specific year. It was assumed that a dynamic calendar that changed through the different years and seeing the Linda character shrink and grow would suffice for the time traveling effect. However, it was clear that giving more attention to environmental details and cultural accuracy is what aids in making it *feel* like time has changed.

Due to timeframe and budgetary restrictions, not every modification was feasible. Nonetheless, the current version progress demonstrates the success of integrating CBPR with the SRD process in developing more culturally authentic and credible VR narratives that represent lived experiences to inform users about systemic inequities. This study provides a potential solution for addressing Hatfield et al.'s (2022) call to rethink existing approaches to racial bias research using virtual environments and develop research methods and virtual interventions that expose and decenter Whiteness.

Practical Implications

Integrating the CBPR framework with the SRD process demonstrated the importance of engaging community experts and individuals with lived experiences to incorporate reliable feedback and make refinements that researchers and developers may overlook. This collaboration ensures that the VR narratives are more accurate, capturing the nuances of the community's experiences to enhance the narrative's realism and credibility.

This study also highlighted the necessity of creating culturally accurate representations in VR narratives, particularly when depicting systemic inequities that impact the communities researchers aim to represent. Features such as skin tones, hairstyles, and clothing require extra care and attention to detail to ensure cultural accuracy. Even the most well-intentioned researchers can fail to catch culturally insensitive designs because they are focused on the science behind the narrative. Taking the needed time through iterative design processes emphasized the value of continuous feedback and refinement in developing VR narratives.

Lastly, the use of a collaborative approach in this study revealed practical applications for a VR narrative that had yet to be considered. Although only some community responses could be included, notable suggestions emerged on utilizing this VR environment as a steppingstone for

other projects. For example, standalone VR headsets could be brought to local neighborhood council meetings to raise awareness about the historical context of rezoning laws and their potential harm. Additionally, after informing about historical contexts, VR environments can be crafted to virtually guide community members on *using* resources like testing soil for lead and then transfer those skills to real-world resources for their own homes. These applications underscore the versatility of standalone VR headsets in various community settings, highlighting their potential to impact public awareness and inform on environmental racism or other critical issues.

Limitations

While the semi-structured interviews conducted in this study provided valuable insights into the experiences and perceptions of community and environmental health experts regarding the VR narrative on environmental racism, several limitations must be acknowledged. These limitations pertain to the generalizability of the findings, resource constraints, and the technical challenges associated with creating culturally accurate representation in VR.

The study involved only ten interviews, which, while sufficient for a qualitative exploration (Guest et al., 2020), may not fully represent all possible experiences and perspectives. Although the sample was carefully selected to include experts with relevant lived experiences and expertise in environmental racism, the small sample size limits the generalizability of these findings, particularly to areas outside of the Southeast. While best practices were followed throughout, including ensuring diverse representation and thematic saturation, caution should be exercised when extrapolating these results to broader populations or other systemic inequities.

Resource limitations posed significant challenges in the creation of the VR narrative. A substantial hurdle in the iterative design process was collaborating with creators and developers who critically understood Whiteness and the importance of cultural nuances. For instance, when first contacting a local studio for voice actors, it was explicitly stated that a Black woman was required for the speaking role. However, the studio initially provided sample clips from two white women based in Europe and one Black woman locally based. Although the Black woman was employed for the role, this incident highlights either a lack of understanding behind the intentional request or a potential scarcity of Black voice actors despite the studio being in a large Southeastern city with a nearly 50% Black population. Similar hurdles were encountered when requesting specific lighting changes in the virtual environment, such as balancing skin tones and adding hair textures to different hairstyles.

Developing high-quality, culturally accurate avatars and animations requires substantial time, funding, and technical expertise. Developing customized, high-quality assets for the VR narrative would have required collaboration with specialized developers and animators, which was not feasible within the study's budget and timeframe. Consequently, the VR narrative may not have achieved the desired level of visual and interactive fidelity at its current stage. Specifically, limited access to skilled animators and advanced modeling tools hindered the creation of 'respectable' Black avatars and hairstyles, which are critical for authenticity and cultural accuracy.

These limitations underscore the broader issue of inadequate representation and resources in developing culturally sensitive and diverse VR content (Dietrich, 2023). Many of the design technologies and software have historically not been designed for darker skin tones or created with people of color in mind, partly due to the gaming industry being historically monopolized

by white men (Dietrich, 2023). The current state of VR technology and the lack of specialized assets for Black characters necessitated compromises that may have affected the overall user experience and the perceived authenticity of the narrative. This limitation highlights a significant gap in the availability of culturally appropriate resources for VR development, particularly for narratives focusing on historically excluded and underrepresented communities.

Future Directions

The process of achieving SRD demands substantial upfront effort, yet as Miller et al. (2019a) asserts, "the potential payoff is worth it" (p. 186). Establishing a controlled VR environment enables future research to systematically assess the impact of these narratives on various user groups. Specifically, as the VR narrative is refined, pilot testing and laboratory experiments can begin to explore its efficacy in fostering shared realities and perceptions of credibility among broader audiences. Empirical evaluations of these virtual environments will elucidate the mechanisms underlying the construction of shared reality with a virtual agent within a highly developed and controlled interactive narrative.

Additionally, since the virtual time travel technique has found success in vaccine-related simulations, the potential in other contexts, such as integrating it with lived experiences and historical evidence, requires future research to examine the effectiveness in promoting critical engagement with multifaceted social issues like environmental injustice. By doing so, researchers can better understand how immersive social interactions in VR can influence users' cognitive and emotional processing of real-world derived narratives and how processes transfer to non-virtual situations.

Addressing the limitations identified in this study is crucial for enhancing the credibility and impact of VR narratives in constructing shared realities about critical topics. Therefore,

additional interviews and other qualitative methods like focus groups and case studies are necessary to continue the iterative design process. Building larger and more diverse participant groups will improve the generalizability of findings and refine the VR narrative. These ongoing discussions and improvements could uncover new avenues and underexplored aspects of the narrative that can be integrated into the default control environment for subsequent testing. Increased funding and technical support are imperative for developing high-fidelity, culturally accurate VR content. Collaborations with experts in animation and those with a deep understanding of cultural nuances and Whiteness are essential for enhancing the narrative's authenticity and effectiveness. The advancement of artificial intelligence (AI) programs offers opportunities for creating more human-like audio scripts, yet ethical considerations must be addressed (Benjamin, 2021). Using AI in place of human actors, especially those from marginalized and precariously employed backgrounds raises significant ethical concerns. Moreover, AI systems often replicate the biases of their human creators, potentially perpetuating systemic issues. Therefore, the critical examination of AI tools is necessary before their implementation in VR narratives.

Lastly, integrating the CBPR framework into VR narrative development normalizes collaborative design processes and ensures that the narratives are rooted in the lived experiences of the communities they represent. As researchers, being willing to be vulnerable to confront biases, address oversights, and learning from one another guarantees the success of this collaboration. This approach enhances the epistemic authority of the narratives and fosters a more inclusive, participatory research environment. By continuously engaging with community experts and stakeholders, the iterative design process becomes a dynamic tool for co-creating culturally resonant and critically impactful narratives.

Future research should continue to prioritize iterative, systematic, community-driven design processes, secure necessary resources, and critically assess the use of emerging technologies. These steps are vital for advancing VR narrative development and creating immersive experiences that disrupt and address Whiteness.

CHAPTER 9

PILOT TEST

This chapter details a pilot test conducted in November 2023 with first-year School of Medicine students at Emory University. The goal was to examine correlations between source credibility and shared reality toward a virtual agent in the updated VR experience that was co-designed using feedback from the semi-structured interviews (see Chapters 6-8). Previous shared reality research has used various techniques to enhance epistemic authority, such as creating a majority consensus and cultural alignment with topics of interest during face-to-face interactions (Echterhoff et al., 2017) or using media clips of renowned experts discussing their research (Bonam et al., 2019). This study, however, leveraged a community-based participatory research framework with topic experts to ground a VR narrative in lived experiences. While past interventions have successfully enhanced epistemic authority, they have not directly measured source credibility as a mechanism of shared reality. Conducting this pilot was essential to evaluate the updated VR narrative, gather preliminary data, and demonstrate the feasibility of using VR to explore and understand multifaceted social issues like environmental racism.

Pilot Test

Specific Aims and Hypotheses

This initial pilot test sought to investigate how source credibility might be associated with the construction of a shared reality between participants and the virtual agent, Linda. Based on previous shared reality research, when users feel uncertain about an unfamiliar topic, it is anticipated that participants will be motivated to create a shared reality with Linda if she is

perceived to be someone with experience about the topic, high in *source credibility* (Echterhoff & Higgins, 2021). Specifically, although the virtual agent Linda's story is based on historical events and real-world experiences, participants may not perceive her as credible because she is virtual. Therefore, it is necessary to first examine how people perceive her as a source and if the VR narrative can construct a shared reality for other audiences. Furthermore, based on previous literature, source credibility should be a significant motivator of shared reality (Bonam et al., 2019; Echterhoff & Higgins, 2021; Echterhoff et al., 2017). Therefore, the following hypothesis is proposed for the pilot test:

H1: Source credibility will be positively correlated with shared reality.

Participants, Procedures, and Measures

Participants were first-year medical students at Emory University (N = 65). Data collection took place during a 2-hour Climate Justice Workshop. During four 30-minute rotations with about 20 students in each rotation, students viewed the VR narrative experience and then answered a brief questionnaire. The questionnaire contained 12-items for *credibility of the source* (Cronbach's alpha = .92; adapted from McCroskey & Teven, 1999) and 8-items for *shared reality* (Cronbach's alpha = .92; adapted from Rossignac-Milon et al., 2020). Example items of credibility of the source were bipolar word opposites such as, "Not an Expert…Expert" and "Incompetent…Competent," ranked from 1 to 7. Example items of shared reality were based on participants thinking about their experience with Linda and answer questions such as, "We thought of things at the exact same time" and "We shared the same thoughts and feelings about things," ranked on a 7-point Likert scale (1=Not at all, 7=Very much). Demographic data was unable to be collected due to the time limit of the workshop. See Appendix B for pilot test measurements.

Data Analysis and Results

Seven participants were excluded due to incomplete data, resulting in a final dataset of *N*=58 for the pilot test. Mean statistics revealed that participants exhibited a strong perception of Linda's credibility. Furthermore, a moderately positive correlation was observed between source credibility and shared reality, suggesting a linear relationship. Detailed descriptive statistics and the results of two-tailed Pearson Correlations can be found in Table 3.

Table 3

Descriptive statistics and Pearson Correlations for Pilot Test

Measure	**1**	**2**	***M***	***SD***
1. Source Credibility	--	.451**	6.03	.927
2. Shared Reality	.451**	--	3.97	1.28

** Correlation is significant at the .001 level (2-tailed).

Discussion and Implications for Lab Experiment

The results of the pilot test yielded valuable insights into participants' perceptions of the virtual agent, Linda, suggesting that she is perceived as a credible source when conveying a narrative rooted in lived experiences and historical events. The strong perception of Linda's credibility observed by the participants aligns with the intended design of the VR experience. Importantly, the pilot test indicated a positive correlation between participants' experience of shared reality and the credibility of the information source, emphasizing the potential of VR as a medium for building epistemic authority of the virtual agent delivering the narrative to generate a shared reality with it.

While these findings contribute to understanding the initial dynamics among virtual agents, source credibility, and shared reality, there are likely additional, unexplored motivations

influencing participants' responses. Therefore, a more comprehensive investigation through a controlled laboratory experiment is warranted. Based on the findings from the interview study and the pilot test, the next chapter details a conceptual model to examine the underlying mechanisms of individual differences, source credibility, and VR affordances for constructing a shared reality. Furthermore, it provides a first look at testing the impact of virtual time travel by comparing the treatment group (i.e., virtual time travel) with the default group (i.e., non-time travel), as suggested by the SRD process (Miller et al., 2019a).

The laboratory experiment enables the manipulation and systematic variation of certain conditions, allowing for a rigorous examination of the causal relationships between virtual agent credibility, shared reality, and other relevant variables. This approach enhances the internal validity of the study and contributes to developing compelling VR narratives that authentically engage users to foster meaningful experiences related to environmental racism. The pilot test laid the groundwork for a more comprehensive exploration of the factors influencing shared reality in VR narratives and the potential impact of shared reality on participants' concerns related to environmental racism.

CHAPTER 10

UNDERSTANDING SYSTEMIC RACISM THROUGH VIRTUAL TIME TRAVEL

This chapter synthesizes the theoretical insights and empirical findings from the preceding chapters to guide the design and execution of a laboratory experiment. Earlier chapters established a comprehensive and multifaceted foundation for understanding the interplay between systemic racism, environmental racism, and the potential of VR as a transformative tool for creating shared social realities between users and the virtual human agent delivering the message. Using a critical Whiteness perceptive, the problem of systemic racism and environmental racism was introduced, with VR proposed as a medium to foster a deeper understanding of these issues. Traditional approaches to research and VR content development can often inadvertently reinforce Whiteness, necessitating alternative methods (Hatfield et al., 2022).

By integrating Community-Based Participatory Research (CBPR) with Systematic Representative Design (SRD), an iterative co-design process with community members and environmental health researchers ensured the cultural appropriateness and authenticity of the VR narrative. This process highlighted how a carefully crafted VR narrative that leverages media affordances like presence and incorporates lived experiences and historical content can enhance the credibility and epistemic authority of a virtual agent during a shared social interaction. Additionally, findings from the pilot test with medical students demonstrated a positive relationship between source credibility and shared reality, providing guidance for further VR refinements. By integrating critical Whiteness perspectives, leveraging immersive VR

technologies, and employing participatory research methodologies, this experiment continues the process of developing a VR narrative that can transform users' understanding of environmental racism and foster worldviews based on realities not distorted by Whiteness.

Shared Reality and the Impact of Virtual Time Travel

Following the SRD process (Miller et al., 2019a), this experiment initiates the testing phase to begin evaluating the effectiveness of the virtual time travel technique and examines whether the virtual time travel effect in VR aided or hindered in constructing shared reality. The refined virtual time travel narrative used in the interviews and pilot test served as the treatment group, while the no time travel narrative is the same VR narrative without the additive effects of time travel. Previous research has shown credibility perceptions (Sundar et al., 2017) and information seeking (Pjesivac et al., 2021) to differ between media modalities (i.e., immersion), while others have not (Burgoon et al., 2000). Therefore, to compare the underlying mechanisms of the VR narrative against a pure narrative delivery and to maintain ecological validity (Pjesivac et al., 2022), a traditional text narrative about a nondescript resident was read on a digital tablet and served as an additional control condition.

Previous research demonstrated that a virtual time travel could help individuals understand the long-term consequences of their present day actions by allowing them to experience future outcomes (Lee et al., 2023). The findings from the expert interviews and pilot test discussed earlier suggested that virtual time travel impacts attitudes and behaviors differently compared to no time travel. When users experience an accelerated pace during the VR narrative, wherein they observe a virtual agent age dynamically throughout the virtual interaction, it can reduce the psychological distance that users have for temporally distal past and future events. Virtual time travel thereby helps participants concretely experience the impact of time on

structural racism and the long-term consequences occurring during the course of the virtual agent's life. This aging effect enhances the agent's credibility by making the narrative more realistic and contextually grounded. Conversely, a virtual agent describing past and future events without virtual time travel may be perceived instead as recalled memory, requiring individuals to take the agent's word for it, making it presumably more challenging to conceptualize the significance of structural racism over decades.

Comparing virtual time traveling and no virtual time travel VR narratives directly test the shared reality mechanisms described by Higgins et al. (2021) as "sharing-is-believing" (p. 104). The interview responses analyzed in the earlier chapters underscored how certain media characteristics (social presence and spatial presence) and speaker characteristics (credibility and liking) played crucial roles in influencing the underlying principles of shared reality—motivated connection and motivated cognition (Echterhoff & Higgins, 2021). Motivated connection was primarily facilitated from the interactive shared tea experience with Linda (i.e., the *sharing*), while motivated cognition was enhanced through supplementary journalistic materials and historical evidence that verified her experiences (i.e., the *believing*). Together, motivated connection and motivated cognition of the virtual time travel, influenced by media and speaker characteristics, contributed to making Linda and her story feel more credible, likable, and realistic.

Applying SRD's concept of generalizability to everyday life through high-fidelity interactive tasks and mundane situations (e.g., having tea) helped the virtual world closely mirror the real world. Virtual environments that replicate realistic spaces and enable users to look around and directly interact with virtual objects can increase feelings of spatial presence, or the sense of "being there" in the virtual narrative (Biocca, 1997; Lombard & Ditton, 1997; Slater &

Wilbur, 1997). Additionally, integrating a programmed virtual agent with human-like characteristics in a high-fidelity situation can produce feelings of social presence, or the sense that the social interaction taking place with a virtual entity is authentic (Miller et al., 2019a). Feedback from the expert interviews noted that seeing Linda as a child evoked an emotional response, which has been linked to higher feelings of presence (Ahn et al., 2022a; Barreda-Ángeles et al., 2021; Sundar et al., 2017). Therefore, the need to test the impact of the virtual time travel on social presence and spatial presence informs the following hypothesis:

> **H2:** Participants in the virtual time travel condition will experience higher (a) *social presence* and (b) *spatial presence* than participants in the no virtual time travel and text control conditions.

Speaker characteristics, such as source credibility and liking, are intrinsically linked to epistemic authority (Appelman & Sundar, 2016; McCroskey & Young, 1981; Metzger et al., 2010; Sundar, 2008), which has been shown to be impactful in aligning worldviews among individuals from different backgrounds (Echterhoff et al., 2017, Coleman et al., 2019). Source credibility, defined as the perceived speaker qualities, such as expertise and trustworthiness (Appelman & Sundar, 2016), of the virtual agent delivering the narrative, was positively correlated with shared reality in the pilot test. Although the pilot test focused on the narrative of the VR experience, findings suggested that virtual time travel can enhance credibility when audiences experience Linda's life from childhood to adulthood. High source credibility enhances the persuasive power of a message, encouraging audiences to be more likely to accept and internalize the presented information (Heesacker et al., 1983; Tan & Liew, 2020). Additionally, liking the source, which involves an affective response to the virtual agent, can lead to greater engagement and receptiveness to the message (Flanagin & Metzger, 2000; Miriam et al., 2010).

Therefore, the need to test the impact of virtual time travel on source credibility and liking of the virtual agent informs the following hypothesis:

> **H3:** Participants in the virtual time travel condition will perceive greater (a) *source credibility* and (b) *liking* of the virtual agent than participants in the no virtual time travel and text control conditions.

Shared reality, a concept central to this study, involves the alignment of perceptions and attitudes among individuals through shared experiences and information (Echterhoff & Higgins, 2021). It is essential for fostering a deep understanding of multifaceted social issues like environmental racism. In the context of this study, shared reality is constructed through both the immersive qualities of the VR environment (media characteristics) and the credibility and likability of the virtual agent (speaker characteristics).

The VR narrative with time travel was designed to provide users with an immersive and contextually rich experience. Previous shared reality research shows that shared reality construction is easier among those familiar or similar with one another, but it is still possible between strangers or those of different backgrounds if epistemic authority is enhanced (Coleman et al., 2019; Echterhoff et al., 2017; Echterhoff & Higgins, 2021). Taking this into account, the virtual time travel VR narrative was designed to replicate both similarities and epistemic authority through the dynamic aging process. Simply put, every adult was once a child, and every adult is the product of lived experiences from childhood to adulthood. Furthermore, the narrative is not a fabricated reality. Although time travel is not feasible in real life, incorporating it in VR provides a unique opportunity to explore different historical and lived experiences. This method does not present a false reality; instead, it offers a way to experience a historical context

that users might have only seen in movies or read about in history books—some of which may have been distorted by Whiteness (Coleman et al., 2019; Lund, 2022).

By sharing Linda's life moments as if in real-time, the world participants share with Linda reflects the world they already know. While participants' exact lived experiences may differ from those of Linda, people tend to take the opinions, beliefs, and judgements of others into account when considering their positions and understanding of the world (Echterhoff & Higgins, 2021). The shared-*ness* of the virtual experience and "growing up" in this same world may provide users with new information, transforming subjective or unfamiliar experiences into more objective truths about the same world they are living in.

Moreover, research suggests that individuals are often more persuaded by mediated communication than traditional face-to-face interactions. This phenomenon occurs because mediated formats can provide a sense of detachment that allows individuals to process information more objectively, reducing biases that may arise in direct interpersonal interactions (Burgoon et al., 2000). Although it is still important to consider that biases toward virtual humans of color persist in virtual environments (Hatfield et al., 2022), especially when the virtual interaction closely mirrors that of face-to-face interactions.

The "sharing-is-believing" notion of shared reality (Higgins et al., 2021) builds from earlier "seeing-is-believing" aspects (Echterhoff et al., 2009) and may be particularly powerful in the context of virtual time travel. The dynamic aging process and temporal shifts in the narrative allow participants to directly witness and participate in the long-term consequences of systemic racism, which may foster a deeper and more immediate connection to the material than a static narrative could provide. This aspect of virtual time travel directly engages participants' desire to share and cultivate new experiences, which is a fundamental principle of shared reality.

VR, as a form of mediated communication, has the potential to combine the persuasive power of mediated experiences with the immersive and interactive qualities that closely mirror face-to-face interactions (Burgoon et al., 2000). This unique combination can create a compelling environment for constructing shared realities, as users can engage with the virtual agent in a way that feels both *real* and mediated. The dynamic and interactive nature of VR narratives allows for a more engaging and persuasive presentation of lived experiences, making it an effective tool for challenging deeply ingrained worldviews and fostering new understandings. Therefore, the following hypothesis is proposed to test the impact of the VR time travel narrative on constructing a shared reality:

H4: Participants in the virtual time travel condition will generate a greater perceived shared reality than participants in the (a) no time travel and (b) text control conditions.

To further understand the mechanisms through which virtual time travel in VR influences shared reality, this study also examined the mediating roles of media characteristics (social presence and spatial presence) and speaker characteristics (source credibility and liking). Social presence makes interactions with virtual agents feel authentic, fostering emotional and cognitive bonds (Biocca et al., 2003; Lee, 2004), which is essential for motivated connection in constructing shared reality (Echterhoff & Higgins, 2021). Spatial presence immerses participants in the narrative, making the story context more tangible and likely leading to enhanced motivated cognition (Echterhoff & Higgins, 2021). Together, these media characteristics help create a compelling environment for constructing shared realities by providing a sense of "being there" and "being with" the virtual agent to influence genuine engagement with realistic content and connections.

Source credibility and liking perceptions as speaker characteristics influence engagement with the virtual agent and narrative, driving motivated connection and motivated cognition. Source credibility, encompassing perceived expertise and trustworthiness, facilitates the acceptance and internalization of information from the speaker (Appelman & Sundar, 2016). Additionally, given that enhanced epistemic authority has been shown to help construct shared realities (Echterhoff et al., 2017), source credibility is likely to be a mechanism of shared reality. Liking the source enhances emotional connection, making participants more receptive to aligning their views with the presented narrative to construct shared reality (Flanagin & Metzger, 2000; Miriam et al., 2010).

By examining these characteristics as mediators, this study aims to uncover how VR narratives can effectively influence shared reality about environmental racism; thus, the following hypotheses are proposed:

H5: Media characteristics, (a) *social presence* and (b) *spatial presence*, will mediate the relationship between experimental conditions and shared reality.

H6: Speaker characteristics, (a) *source credibility* and (b) *liking*, will mediate the relationship between experimental conditions and shared reality.

The experiment aims to assess individual differences in the underlying mechanisms that work to construct a shared reality about environmental injustice. *Pre-existing environmental injustice concerns* can significantly influence how individuals perceive the credibility of the virtual agent. Individuals with high pre-existing concern might be more likely to scrutinize the source more critically, evaluating the accuracy and relevance of the content based on their existing knowledge (Flanagin & Metzger, 2000). This heightened scrutiny can lead to either enhanced credibility if the information aligns with their expectations, or skepticism if it does not

(Flanagin & Metzger, 2000). When the information provided by the virtual agent aligns with their existing beliefs, these individuals are more likely to trust and accept the information, enhancing the perceived credibility of the source (Burgoon et al., 2000).

Individuals with low pre-existing concern are more likely to rely on heuristic cues because they have less background knowledge and motivation to engage in deeper cognitive processing. Heuristic cues, such as the perceived credibility and likability of the source (Burgoon et al., 2000), serve as mental shortcuts that allow individuals to make quick judgments without expending significant cognitive effort (Tan & Liew, 2020). This is particularly relevant in situations where individuals are not personally invested or knowledgeable about the topic, as they may default to these cues to guide their understanding and acceptance of information (Ahn et al., 2022a). These individuals may lack the background knowledge to critically evaluate the content, so the source's lived experiences guide their perceptions. Additionally, credible sources are generally more persuasive to these individuals, leading to higher acceptance of the information provided (Burgoon et al., 2000). On the other hand, individuals with high pre-existing knowledge or interest in content tend to allocate more attention and are shown to experience increased spatial presence (Ahn et al., 2022a; Wirth et al., 2007). Therefore, it is likely that individuals with high pre-existing concern would have increased spatial presence, suggesting higher attention allocation in the condition.

Furthermore, previous research has indicated that greater emotional experiences may override the technological affordances of VR (Sundar et al., 2017). For individuals with high pre-existing concern about environmental injustice, the virtual time travel might evoke strong emotional responses because Linda's lived experiences aligns closely with their existing beliefs and knowledge (Sundar et al., 2017). These heightened emotional responses could diminish the

effects of social presence and spatial presence, as the intensity of their emotions takes precedence over the immersive qualities of the VR experience (Sundar et al., 2017). In contrast, individuals with low pre-existing concern might not have the same depth of emotional engagement. Instead, they may rely more on the realism and immersive qualities of the VR narrative to feel "there," which moderates their perceptions of social presence and spatial presence (Ahn et al., 2022a).

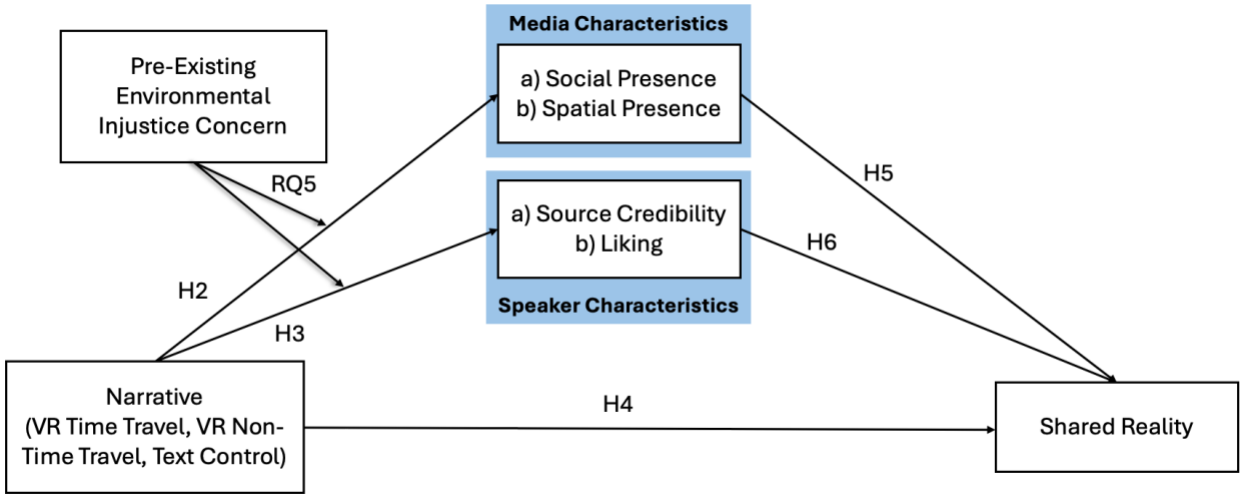
To investigate how individual differences in pre-existing environmental injustice concern may moderate the relationship from experimental conditions to perceived media and speaker characteristics, the following research question is proposed:

> **RQ5:** How does pre-existing environmental injustice concern moderate the relationship between perceived (a) *social presence*, (b) *spatial presence*, (c) *source credibility*, and (d) *liking* for each condition, ultimately mediating a sense of *shared reality* between the participants and the virtual agent?

Figure 6 displays a conceptual model of the proposed experimental design.

Figure 6

Conceptual model of laboratory experiment



CHAPTER 11

EXPERIMENT

This chapter details the materials and methods for conducting the laboratory experiment aimed at evaluating the effectiveness of virtual time travel in constructing shared reality. The chapter begins with an overview of the experimental design, followed by a description of participant recruitment and demographics. The different stimuli used in the study are then presented, along with a detailed account of the procedure followed. Lastly, the chapter outlines the measures employed to assess the outcomes of the study.

Materials and Method

Design

A 3 (time travel: present, not present, text control) group between-subjects experiment was conducted in a controlled laboratory. In the VR conditions, participants experienced a VR narrative with a head-mounted display (HMD; Meta Quest 2) and hand controllers. In the text control condition, participants read an article with similar information on a digital tablet.

Participants

Participants were students recruited from a large Southeastern university and the surrounding community in the United States. Enrolled students received course credit and community members received a $20 Amazon gift card as compensation. Targeted sample size was estimated via an a priori power analysis using G*Power (Faul et al., 2007). An estimated sample size of at least $N = 159$ participants is needed to detect a small effect size ($d_z = 0.25$) for the difference between conditions, given $\alpha = 0.05$ and $1\text{-}\beta = 0.80$. A total of 161 participants

were recruited. Three participants were excluded for technical issues and one had to end the study early due to motion sickness. Data analyses were conducted on the remaining participants (N = 157).

Participant ages ranged from 18 to 43 (M = 21.94; SD = 4.28). Of the final sample, 54.1% identified as white (n = 85), 29.3% as Asian (n = 46), 5.7% as Black or African American (n = 9), 4.5% as Hispanic, Latine, or of Spanish origin (n = 7), 5.1% identified with two or more racial identities (n = 8), and 1.3% preferred not to say (n = 2). 75.2% of the sample identified as women (n = 118) and 24.8% as men (n = 39). Politically on average, 44.6% (n = 70) of participants identified as more liberal, 26.8% (n = 42) as moderate, 28% (n = 44) as more conservative, and 0.6% (n = 1) preferred not to say. Participants recruited from the surrounding community made up 31% of the final sample (n = 49) and students recruited from the participant pool made up the remaining 69% (n = 108).

Stimuli

The updated VR narrative co-designed with community experts (see Chapter 8 for semi-structured interview discussion) was used for this experiment. The *virtual time travel* condition employed accelerated pacing of time, allowing participants to witness Linda aging from child to adult and move through time concurrent with the historical events of Linda's life. The *no virtual time travel* condition is the same simulation except Linda remains 70-years-old and there is no virtual time travel effect. Specifically, the beginning and ends of the simulations are the same with participants meeting a 70-year-old Linda, however, as participants move into the kitchen and Linda reflects on her past, Linda remains the same age in the *no virtual time travel* version whereas in the *virtual time travel* version the world fades out to show the year going back in time and Linda becomes a child. For the traditional text control condition, participants read a similar

narrative about a nondescript "resident" on a tablet without a named spokesperson, such as "Linda." See Appendix C for the VR and text stimuli details.

Procedure

The study was approved in accordance with requirements of the University of Georgia's Institutional Review Board (IRB ID: VERSION00002756). Participants indicated interest in participating in the study through an online university participant pool or flyers placed on community bulletins. Once first contact was established, interested participants were sent an online link containing information about the study and the informed consent form. Participants had an incomplete disclosure of the entire purpose of the study to avoid bias in responses and ensure the external validity of the study. The informed consent included a clause stating that some information was being withheld until they are debriefed at the end of their participation. The debriefing is an important step to emphasize that the VR narrative does not represent an exclusive experience of individual and structural racism.

Participants provided consent by clicking "Yes, I agree to participate" after reading the form online. After consent was granted, they were directed to an online pre-survey that included the measure for *pre-existing environmental injustice concern*. The term injustice was used instead of *racism* to avoid priming participants. Filler questions about VR and immersive media use were also asked. After completing the pre-survey, participants scheduled a 30-minute session to come in-person to the lab.

For the in-person session, participants arrived at their scheduled in-person lab sessions and were randomly assigned to one of the three conditions: time travel in VR (n = 54), no time travel in VR (n = 52) and text control (n = 51). For those in the VR conditions, trained researcher assistants provided a brief overview of how to use the Meta Quest 2 VR headset and controls

before fitting the headset on the participant. Once in the headset, participants completed a brief 5-minute tutorial on the basic controls used in the VR experience.

When the VR experimental conditions were completed, participants removed the headset and then sat at a survey station to complete the post-experience survey on an iPad. Those in the control condition were automatically advanced to the post-survey after they read the story. The post-survey asked questions related to *source credibility, liking, social presence, spatial presence*, and *shared reality*. Two exploratory measures were also included for *counterarguing* and *willingness to support environmental justice efforts*. At the end of the post-survey, participants provided demographic information which included age, ethnicity and race, gender identity, educational attainment, student status, religion, and political views. Once the in-lab session and post-survey was completed, participants were debriefed about the different conditions, asked any remaining questions, and then compensated for their participation. See Appendix B for experiment measurements.

Measures: Pre-Survey

Pre-existing Environmental Injustice Concern. To capture pre-existing concerns related to the message content for environmental injustice issues (Ahn et al., 2022a), 7-items (1=not at all, 7= extremely) adapted from the Maibach et al (2011) Six Americas Screening Tool was used. Examples include items that have replaced the words "global warming" with "environmental injustice," such as, "How worried are you about environmental injustice," "How much do you think environmental injustice will harm you personally," and "How much do you think environmental injustice will harm future generations of people?" (Cronbach's $\alpha = .90$).

Measures: Post-Survey

Social Presence. To assess social presence, the 5-item scale by Bailenson et al.'s (2004) was used to capture the sense of another in the narratives. Examples of items include: "I perceived that I was in the presence of [Linda/the resident] in the room with me" and "the thought that [Linda/the resident] is not a real person crosses my mind often (reverse coded)." Items were measured on a 7-point scale (1=strongly disagree, 7=strongly agree) on the extent individuals agree or disagree with each statement (Cronbach's α= .52).

Spatial Presence. To assess spatial presence, the Spatial Presence Experience Scale (SPES) from Hartmann et al., (2015) was used. The SPES consists of two factors made up of 4-items each: Self-Location (Cronbach's α= .94) and Possible Action (Cronbach's α= .90). An example item of Self-Location (SL) is "I felt like I was actually there in the virtual environment." An example item of Possible Action (PA) is "The objects in the virtual environment gave me the feeling that I could do things with them." Each item was answered on a 7-point Likert scale (1=strongly disagree, 7=strongly agree) (Cronbach's α= .94).

Credibility of source information. An 18-item bipolar scale adapted from McCroskey and Teven (1999) was used to assess perceptions of credibility of source information. Items were rated on a 7-point Likert-type scale with opposite terms at each end (e.g., Intelligent… Unintelligent; Untrustworthy…Trustworthy; Self-centered…Not self-centered) and asked individuals' opinions toward Linda/the resident (Cronbach's α= .92).

Liking. An adapted 11-item 7-point (1 = *Very strongly disagree*, 7 = *Very strongly agree*) Reysen Likability Scale was used to capture the degree of likability for a target individual (Reysen, 2005). Sample items included, "[Linda/the resident] is friendly," "I would like to be

friends with [Linda/the resident]," and "[Linda/the resident] is knowledgeable" (Cronbach's α= .90).

Shared Reality. To measure shared reality, two combined scales adapted from Elnakouri et al (2023) were used: generalized and goal-relevant shared reality. All items were rated on a 7-point Likert scale (1=not at all, 7=very much). For generalized shared reality, participants answered an 8-item scale developed by Rossignac-Milon et al. (2021). This measure "captures the subjective experience of sharing a common set of feelings, beliefs, or concerns" (Elnakouri et al., 2023; p. 1076) with a virtual other about the world. Examples include: "We developed a joint perspective," and "We shared the same thoughts and feelings about things." (Cronbach's α= .87).

For goal-relevant shared reality, participants answered 4 adapted items from Elnakouri et al. (2023) that begin with "[name] and I tend to have the same thoughts and feelings about:" followed by specific goal-relevant items pertaining to the study. For example, an academic success item might include "the best study tactics," or "the number of hours needed to put toward studying to achieve success" (see Elnakouri et al., 2023). For this study, goal-relevant shared reality focused on environmental injustice concerns. The adapted items (Cronbach's α= .91) included, "Linda/the resident and I tend to have the same thoughts and feelings about:" "the causes of environmental injustice," "the impact of environmental injustice on marginalized communities," "the need for addressing environmental injustice in society," and "the importance of raising awareness about environmental injustice compared to other societal goals." Both measures were averaged to form the shared reality composite (Cronbach's α= .88).

Demographic Information. Participants' demographic information was measured based on recommendations by Hughes et al. (2022) for the categories of age, gender identity, ethnicity and race, and religion. Political affiliation was measured using three 5-point Likert-type items

adapted from Brown & Mourão (2021) for participants to place themselves on a scale (strongly liberal = 1, strongly conservative = 5) based on "social issues," "economic issues," and "in general." The 3-items were averaged for a composite political affiliation score (Cronbach's α= .91).

Exploratory Post-Measures

Counterarguing. Four 5-point Likert-type items (1= strongly disagree, 5 = strongly agree) were used to capture participants' counterarguing. Specifically, counterarguing measures an individuals' persuasive resistance to a media message (Ma, 2020; Slater & Rouner, 2006). This measure was included because counterarguing has previously been used to examine cognitive reactance to a message (Clayton et al., 2019), such that individuals with prior experience of the message content are least liking persuaded by source credibility regardless of expertise and more likely to engage in counterarguing (Pornpitakpan, 2004). Conversely, VR messages may produce cognitive load where an individual cannot critically process the message because they are more focused on following the storyline, thus resulting in *less* counterarguing (Groenendyk & Krupnikov, 2021; Nabi et al., 2007). Adapted items from Ma (2020) included: "I found myself actively agreeing with [Linda/the resident] (reverse coded)," "I was looking for flaws in [Linda's/the resident's] arguments," "I found myself actively disagreeing with [Linda/the resident]," and "It was easy to agree with the arguments made by [Linda/the resident]" (Cronbach's α= .65).

Willingness to Support Environmental Justice Efforts. Five 7-point Likert-type items (1= extremely unlikely, 7 = extremely likely) were used to measure individual's willingness to support environmental justice efforts adapted from previous research (Ma, 2020; Peng et al., 2010). This measure could be an indicator of a successful shared reality. Sample items include:

"How likely is it that you would donate money to help fund crucial awareness and advocate programs needed for environmental justice" and "How likely is it that you would sign a petition to build the political pressure needed for policy reform for environmental justice." (Cronbach's α= .85).

Table 4

Descriptive Statistics of Main Variables

	Mean	Median	Mode	SD	Range (Min, Max)
EIC[a]	4.56	4.80	5.00	1.22	6.00 (1.00, 7.00)
SoP[b]	4.25	4.20	4.20	1.03	5.00 (1.60, 6.60)
SpP[c]	4.86	5.25	6.00	1.50	6.00 (1.00, 7.00)
CS[d]	5.52	5.44	4.78	0.86	3.83 (3.17, 7.00)
L[e]	4.78	4.73	4.27	0.80	4.36 (2.64, 7.00)
SR[f]	4.87	4.92	4.67	0.96	5.75 (1.25, 7.00)
CTA[g]	1.90	1.75	1.75	0.65	2.75 (1.00, 3.75)
WSE[h]	4.75	4.80	4.00	1.32	6.00 (1.00, 7.00)

[a] Environmental Injustice Concern
[b] Social Presence
[c] Spatial Presence
[d] Credibility of the Source
[e] Liking
[f] Shared Reality (composite)
[g] Counterarguing
[h] Willingness to Support Environmental Justice Efforts

Table 5

Pearson Correlations

	EIC	SoP	SpP	CS	L	SR	CTA	WSE
EIC[a]	-							
SoP[b]	-.074	-						
SpP[c]	.047	.428**	-					
CS[d]	.042	.331**	.259**	-				
Lik[e]	.168*	.410**	.338**	.585**	-			
SR[f]	.234**	.385**	.167*	.463**	.555**	-		
CTA[g]	-.037	-.224**	.117	-.463**	-.442**	-.432**	-	
WSE[h]	.379**	.236**	.114	.284**	.252**	.518**	-.173*	-

** Correlation is significant at 0.01 level (2-tailed).

* Correlation is significant at 0.05 level (2-tailed).

[a] Environmental Injustice Concern

[b] Social Presence

[c] Spatial Presence

[d] Credibility of the Source

[e] Liking

[f] Shared Reality (composite)

[g] Counterarguing

[h] Willingness to Support Environmental Justice Efforts

CHAPTER 12

EXPERIMENTAL RESULTS

This chapter presents the results of statistical tests of the proposed hypotheses and research questions. Data was analyzed with descriptive analyses, a multiple analysis of variance (MANOVA), analysis of variance (ANOVA), and moderated mediation regression analyses using Process Macro Model 7 (Hayes, 2017) on IBM's SPSS Statistics Version 29 software. All means and standard deviations are reported in Table 6.

To investigate the effect of the experimental condition (Time Travel VR, No Time Travel VR, and Text Control) on multiple dependent variables—social presence, spatial presence, source credibility, liking, and shared reality—a Multiple Analysis of Variance (MANOVA) was first conducted. Given the previously reported Pearson correlation observations among the variables (see Table 5 in the previous chapter), a MANOVA was chosen to determine whether the combination of dependent variables significantly differed across the three experimental groups (Meyers et al., 2006). This approach is recommended to control for Type 1 error when performing multiple univariate analyses of variance (ANOVA)(Cramer & Bock, 1966; Leary & Altmaier, n.d.). Furthermore, the Box's Test of Equality of Covariance Matrices yielded a Box's M value of 65.86 ($p < .001$) and, based on recommendations by Huberty and Petoskey (2000), was interpreted as non-significant. Therefore, it was assumed that the covariance matrices between groups were equal for the MANOVA.

Table 6

Means, Standard Deviations, MANOVA, and ANOVAs Statistics for Study Variables

Variable	Time Travel VR (n = 54)		No Time Travel VR (n = 52)		Text Control (n = 51)		ANOVA		
	M	*SD*	*M*	*SD*	*M*	*SD*	*F*	*df*	*Partial* η^2
Social Presence	4.27	.957	4.21	1.15	4.27	.993	.056	2,154	.001
Spatial Presence[ab]	5.49	.803	5.38	.994	3.20	1.60	54.59***	2,140[a]	.438
Source Credibility	5.61	.844	5.61	.897	5.33	.809	1.815	2,154	.023
Liking[b]	4.90	.934	4.85	.810	4.59	.590	2.33	2,154	.029
Shared Reality	4.86	1.04	4.79	.997	4.97	.843	.419	2,154	.005
MANOVA	Pillai's Trace = .591, F(10,274)=11.49, p <.001								.295
	Wilks' Lambda = .410, F(10,272)=15.26, p <.001								.359

Note. N=157. [a]Missing data. [b]Levene's Test for Equality of Error Variances was violated. *p<.05. **p<.01. ***p<.001.

The one-way MANOVA testing the differences between experimental conditions and dependent variables yielded a statistically significant result, Pillais' Trace = .591, F(10, 274) = 11.49, p < .001 and Wilks' Lambda = .410, F(10,272)=15.26, p < .001. The multivariate effect size was estimated at .30 and .36, indicating that 30% to 36% of the variance in the combined dependent variables was accounted for by experimental condition.

Before conducting follow-up ANOVAs, the homogeneity of variance assumption was tested for all five variables. Based on the mean in a series of Levene's F tests, although two of the five Levene's F tests were statistically significant (p < .05), the homogeneity of variance assumption was satisfied. Despite the Levene's F test suggesting that variances associated with

spatial presence and liking were not homogenous, examining standard deviations (see Table 4) revealed that none of the largest deviations exceeded four times the size of the corresponding smallest deviations, indicating that the ANOVA should be robust in this instance (Howell, 2009). Several one-way ANOVAs on each of the five dependent variables were conducted as follow-up tests to the MANOVA.

Two one-way ANOVAs were performed to test the effects of narrative conditions on the perceived media characteristics (a) social presence and (b) spatial presence (H2). The results indicated no significant effect of condition on social presence, $F(2,154)= .056$, $p = .96$, $\eta^2 = .001$, suggesting that the mean scores did not significantly differ across narrative groups. For (b) spatial presence, there was missing data, and Levene's test indicated that the assumption of equal variances was violated $F(2,140)= 18.16$, $p < .001$. There was a significant effect of condition on spatial presence, $F(2,143) = 54.59$, $p < .001$, $\eta^2 = .438$, indicating that at least one narrative condition differed significantly from the others. A Tukey HSD posthoc test showed that spatial presence was significantly lower for participants in the Text Control ($M = 3.20$, $SD = 1.60$) than for those in the Time Travel VR ($M = 5.49$, $SD = .803$), $p < .001$, and the No Time Travel VR ($M = 5.38$, $SD = .994$), $p < .001$. The findings indicated a greater spatial presence in the VR conditions than in the text condition. No other pairwise groups were significant. H2a was not supported, but H2b was partially supported.

Two one-way ANOVAs were performed to test the impact of conditions on the spokesperson characteristics (a) source credibility and (b) liking (H3). The results indicated that there was no significant effect of condition on source credibility, $F(2,154)= 1.82$, $p = .17$, $\eta^2 = .023$, suggesting that the mean scores did not significantly differ across narrative groups. For (b) liking, Levene's test indicated that the assumption of equal variances was violated $F(2,154)=$

5.45, p = .005. The results indicated that there was no significant effect of condition on liking, $F(2,154)= 2.33$, p = .10, η^2 = .029, suggesting that the mean scores did not significantly differ across narrative groups. H3 was not supported.

A one-way ANOVA was performed to test the impact of conditions on shared reality (H4). The results indicated that there was no significant effect of condition on shared reality, $F(2,154)= .419$, p = .66, η^2 = .005. Exposure to different experimental conditions did not meaningfully shift participant perceptions of shared reality. H4 was not supported.

Moderated Parallel Mediation Analyses

To test the validity of the proposed moderated parallel mediations, the PROCESS path-analysis macro Model 7 for SPSS (Hayes, 2017) was used to test the underlying mechanisms in H5 (media characteristic mediators: social presence and spatial presence), H6 (speaker characteristic mediators: source credibility and liking), RQ5 (individual differences moderator: pre-existing environmental injustice concern), and how they impact constructing a shared reality between participants and the spokesperson. First, experimental conditions were entered as the independent variable using a multicategorical indicator coding system because there are at least three groups (Hayes, 2017). Text Control was used as the reference group to compare with Time Travel and No Time Travel VR (see Table 7 for Indicator Coding). Pre-existing environmental injustice concern was entered as the moderator, social presence and spatial presence as the mediators, and shared reality as the dependent variable. Bootstrapping methods were used (5000 samples; Preacher & Hayes, 2008). A second mediation analysis was conducted with the same independent variable and moderator, with source credibility and liking as the mediators, and shared reality as the dependent variable. Results of the direct and indirect effects are reported in Table 8.

Table 7

Multicategorical Indicator Coding

	Text Control	Non Time Travel	Time Travel
X_1	0	1	0
X_2	0	0	1

The first model analysis investigated individual differences in pre-existing environmental injustice concerns moderating role on mediated media characteristics, (a) social presence and (b) spatial presence (H5). The overall model fit for shared reality was significant F (4,138) = 6.86, p < .001, R^2 = .17. There were no significant direct effects on social presence, revealing social presence was not affected by experimental conditions or moderator. However, findings indicated that high pre-existing environmental injustice concern positively correlated with spatial presence (b = .424, bSE = .15, 95% CI [.129, .720], p =.005). There were significant positive direct effects on spatial presence for No Time Travel (b = 4.56, bSE = .86, 95% CI [2.85, 6.26], p < .001) and Time Travel (b = 4.45, bSE = .97, 95% CI [2.54, 6.37], p < .001). The interaction between No Time Travel and pre-existing environmental injustice concern was negatively significant (b = -.53, bSE = .19, 95% CI [-.90, -.16], p = .005), as was the interaction between Time Travel and pre-existing environmental injustice concern (b = -.48, bSE = .20, 95% CI [-.87, -.08], p = .02). The direct effect on shared reality was significant for social presence (b = .30, bSE = .09, 95% CI [.12, .48], p = .001), but not for Time Travel (p = .172), No Time Travel (p = .132), and spatial presence (p = .261). No other direct or indirect effects were significant. Spatial presence (RQ5b), but not social presence (RQ5a), was moderated by pre-existing environmental injustice concerns. Social presence and spatial presence do not significantly mediate the relationship between

conditions and shared reality. However, social presence alone significantly influenced shared reality (see Figures 7 & 8). H5a and H5b were not supported.

Figure 7

Moderated Mediation comparing Text Condition to No Time Travel VR (X_1) on Media Characteristics

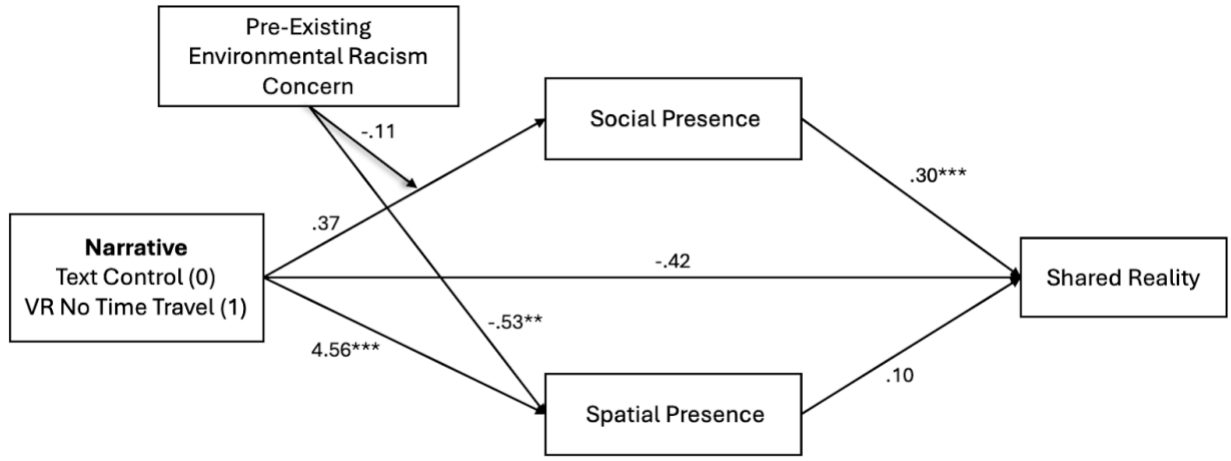
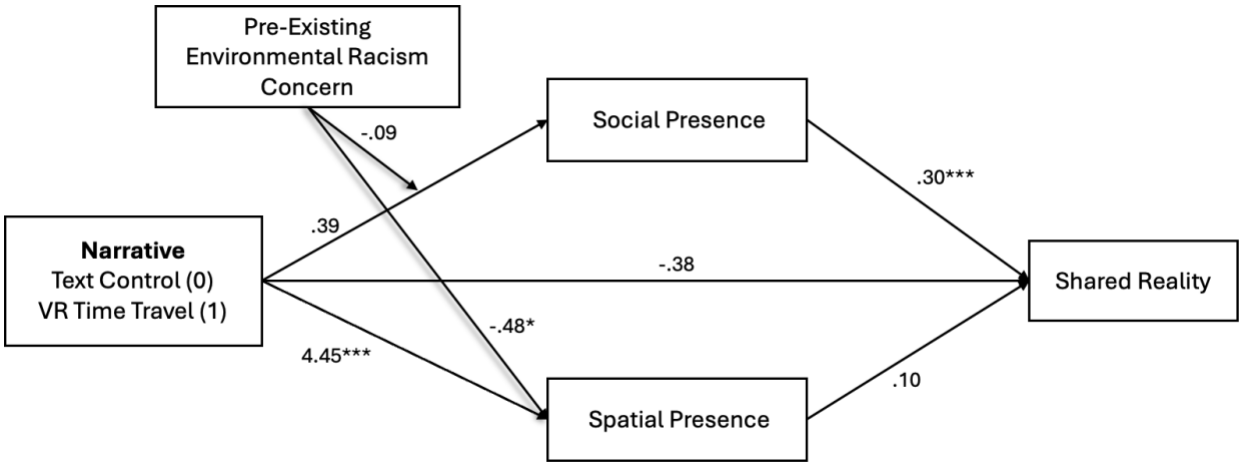


Figure 8

Moderated Mediation comparing Text Condition to Time Travel VR (X_2) on Media Characteristics



The second model analysis investigated individual differences of pre-existing environmental injustice concerns' moderating role (RQ5) on mediated spokesperson characteristics, (H6a) source credibility and (H6b) liking. The overall model fit for shared reality was significant F (4,152) = 22.21, $p < .001$, $R^2 = .37$. There were no significant direct effects on source credibility or liking, revealing that spokesperson characteristics were not influenced by the conditions or the moderator. However, there were significant negative direct effects on shared reality for Time Travel (b = -.385, bSE = .154, 95% CI [-.69, -.08], p = .014) and No Time Travel (b = -.350, bSE = .153, 95% CI [-.65, -.05], p =.024). There were significant positive direct effects on shared reality for source credibility (b = .254, bSE = .090, 95% CI [.08, .43], p = .005) and liking (b = .544, bSE = .096, 95% CI [.36, .73], p <.001). For No Time Travel, a significant positive indirect effect was found for the pre-existing environmental injustice concern moderator at the 50th percentile (M = 4.80) through liking on shared reality (b =.17, bSE = .09, 95% CI [.008, .361]. No other direct or indirect effects were significant. This indicates that shared reality is partially mediated by liking, particularly for No Time Travel at the mid-range level of the moderator. Source credibility and liking alone directly correlated with shared reality (see Figures 9 & 10). H6a was not supported and H6b was partially supported.

Figure 9

Moderated Mediation comparing Text Condition to VR No Time Travel (X_1) on Speaker Characteristics

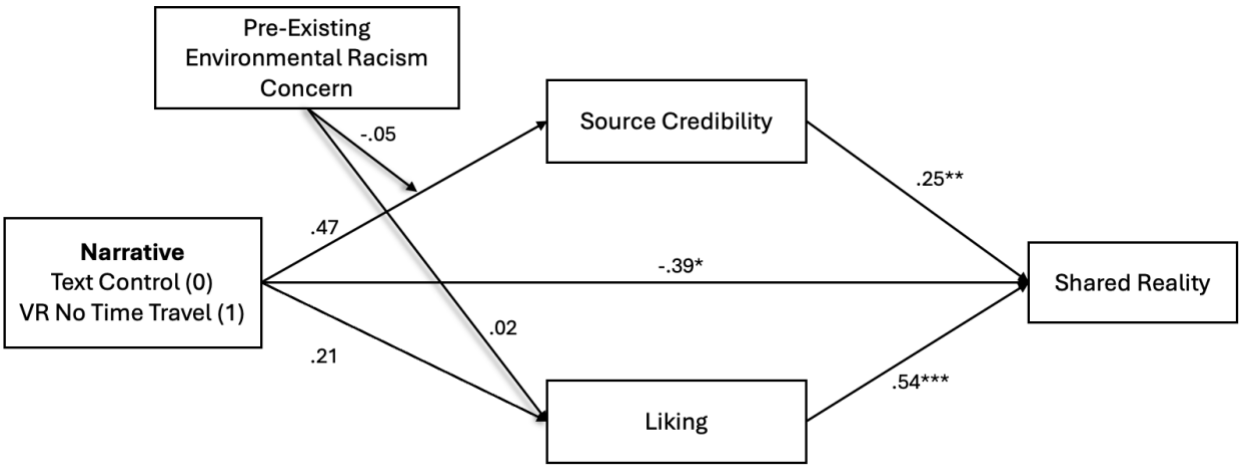


Figure 10

Moderated Mediation comparing Text Condition to VR Time Travel (X_2) on Speaker Characteristics

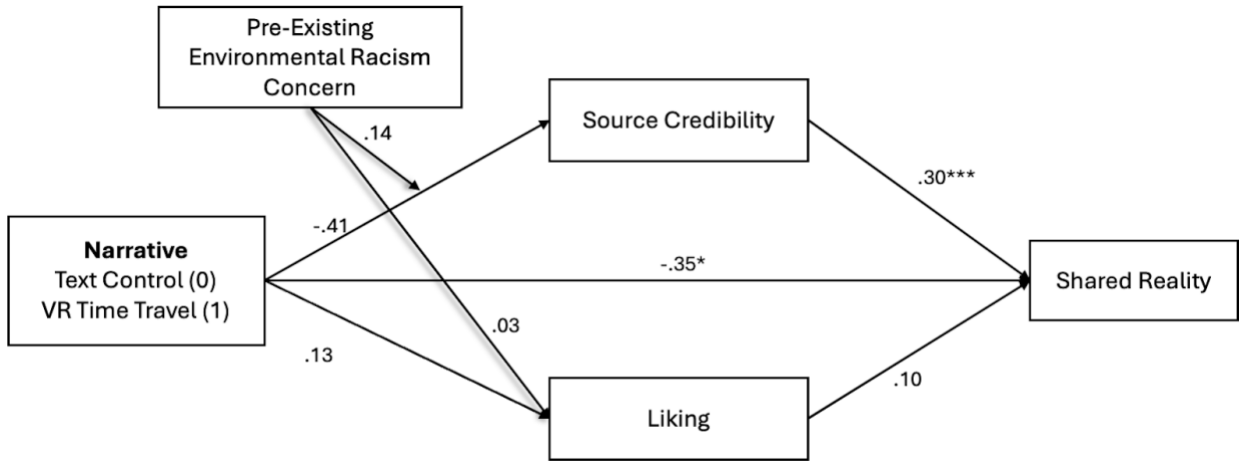


Table 8

Regression weights, indirect effects showing moderated mediation, bootstrap 95% confidence interval, lower and upper bounds on main model

			Bootstrap 95% CI	
	Coefficient	*SE*	Lower	Upper
Media Characteristics				
Social Presence				
X_1 → Social Presence	.37	.84	-1.28	2.02
X_2 → Social Presence	.39	.94	-1.47	2.25
Pre-Existing Concern → Social Presence	.03	.14	-.25	.32
Int_1 → Social Presence	-.11	.18	-.47	.25
Int_2 → Social Presence	-.09	.20	-.48	.30
Social Presence → Shared Reality***	.30	.09	.12	.48
Spatial Presence				
X_1 → Spatial Presence***	4.56	.86	2.85	6.26
X_2 → Spatial Presence***	4.45	.97	2.54	6.37
Pre-Existing Concern → Spatial Presence**	.43	.15	.13	.72
Int_1 → Spatial Presence**	-.53	.19	-.90	-.16
Int_2 → Spatial Presence*	-.48	.20	-.87	-.08
Spatial Presence → Shared Reality	.10	.09	-.07	.27
Shared Reality				
X_1 → Shared Reality	-.42	.27	-.96	.13
X_2 → Shared Reality	-.38	.28	-.93	.17

Speaker Characteristics				
Source Credibility				
X_1 → Source Credibility	.47	.64	-.79	1.73
X_2 → Source Credibility	-.41	.73	-1.85	1.02
Pre-Existing Concern → Source Credibility	.01	.11	-.20	.22
Int_1 → Source Credibility	-.05	.14	-.32	.23
Int_2 → Source Credibility	.14	.15	-.32	.23
Source Credibility → Shared Reality**	.25	.09	.08	.43
Liking				
X_1 → Liking	.21	.59	-.96	1.37
X_2 → Liking	.13	.67	-1.20	1.46
Pre-Existing Concern → Liking	.10	.10	-.10	.29
Int_1 → Liking	.02	.13	-.23	.27
Int_2 → Liking	.03	.14	-.24	.31
Liking → Shared Reality***	.54	.10	.36	.73
Conditional effects at moderator level				
Pre-Existing Concern → Liking → Shared Reality	Effect Size	*bSE*	BootLLCI	BootULCI
X_1 3.40 (16th percentile)	.15	.09	-.02	.34
X_1 4.80 (50th percentile)*	.17	.09	.00	.36
X_1 5.60 (84th percentile)	.18	.12	-.04	.43
Shared Reality				
X_1 → Shared Reality*	-.39	.15	-.69	-.08
X_2 → Shared Reality*	-.35	.15	-.65	-.05

Notes: X_1 = Control vs. No Time Travel; X_2 = Control vs. Time Travel*; SE* = standard error; CI = confidence interval. Bootstrap resampling = 1000. *** $p < .001$ ** $p < .01$ $^{*}p < .05$

Post Hoc Exploratory Analyses

To investigate the differences between the two VR groups in more detail (No Time Travel = 1; Time Travel = 2), the same Model 7 moderated parallel mediation analyses were run after dropping the text control group from the dataset (n = 106). The first model investigated individual differences of pre-existing environmental injustice concerns' moderating role (RQ5) on mediated media characteristics, (H5a) social presence and (H5b) spatial presence, on shared reality. The overall model fit for shared reality was significant F (3,102) = 4.96, p = .003, R^2 = .13. There were no significant direct effects on social presence or spatial presence, revealing media characteristics were not affected by either VR experimental group or the moderator. There was a significant positive direct effect of social presence on shared reality (b = .287, bSE = .106, 95% CI [.076, .498], p = .008). No other direct or indirect effects were significant.

The second model analysis investigated individual differences of pre-existing environmental injustice concerns' moderating role (RQ5) on mediated spokesperson characteristics, (H6a) source credibility and (H6b) liking on shared reality. The overall model fit for shared reality was significant F(3,102) = 29.72, p < .001, R^2 = .47. There were no significant direct effects on source credibility or liking, revealing spokesperson characteristics were not associated with either VR experimental group or the moderator. There was a significant positive direct effect of source credibility (b = .326, bSE = .123, 95% CI [.103, .549], p = .005) and liking (b = .543, bSE = .112, 95% CI [.321, .765], p < .001) on shared reality. No other direct or indirect effects were significant.

To investigate the exploratory measures of *counterarguing* and *willingness to support environmental justice efforts*, two one-way ANOVAs were performed (see Table 9). There was a significant effect of condition on counterarguing, F(2,154) = 3.01, p = .05, partial η2 = .038,

indicating that at least one narrative condition differed significantly from the others. A Tukey HSD post hoc test showed that counterarguing was significantly lower for participants in Text Control (M = 1.73, SD = .598), compared to VR Time Travel (M = 2.02, SD = .605), p = .05. The findings indicated there was greater counterarguing in the Time Travel narrative compared to the Text Control. No other pairwise groups were significant.

For willingness to support environmental justice efforts, there was a significant effect of condition on willingness to support, $F(2,154) = 4.17$, p = .017, partial η^2 = .051. A Tukey HSD post hoc test showed that willingness to support was significantly lower for participants in No Time Travel (M = 4.33, SD = 1.38) compared to Text Control (M = 5.02, SD = 1.11), p = .022, and moderately significantly lower compared to Time Travel (M = 4.91, SD = 1.35), p = .061. This result indicated that participants were more likely to support environmental justice efforts after reading the Text Control or experiencing the Time Travel VR narratives over the No Time Travel narrative.

Table 9

Means, Standard Deviations, and ANOVAs Statistics for Exploratory Measures

	Time Travel (n = 54)		Non-Time Travel (n = 52)		Text Control (n = 51)		ANOVA		
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*	*F*	*df*	*Partial* η^2
Counterarguing	2.02	.605	1.95	.720	1.73	.598	3.01*	2,154	.58
Willingness to Support	4.91	1.38	4.33	1.38	5.02	1.11	4.17**	2,154	.73

Note. N=157. *p<.05. **p<.01. ***p<.001.

A Model 7 moderated mediation was run with experimental conditions (Text Control, Time Travel VR, No Time Travel VR) as the independent variable, pre-existing environmental injustice concern as the moderator, counterarguing as the mediator, and shared reality as the

dependent variable (see Figures 11 & 12). The Text Control was used as the reference group. The overall model fit for shared reality was significant, F (3,153) = 11.28, $p < .001$, $R^2 = .18$. There were no significant direct effects on counterarguing and so was not affected by either experimental groups or the moderator. There was a significant negative direct effect of counterarguing on shared reality (b = -.631, bSE = .110, 95% CI [-.849, -.414], $p < .001$). For No Time Travel, a significant negative indirect effect was found for the pre-existing environmental injustice concern moderator at the 16th percentile (M = 3.40) through counterarguing on shared reality (b = -.225, bSE = .112, 95% CI [-.469, -.035]). For Time Travel, a significant negative indirect effect was found for the pre-existing environmental injustice concern moderator at the 16th percentile (M = 3.40) through counterarguing on shared reality (b = -.285, bSE = .157, 95% CI [-.640, -.038]) and the 50th percentile (M = 4.80) through counterarguing on shared reality (b = -.181, bSE = .094, 95% CI [-.389, -.024]). No other direct or indirect effects were found. Results of the direct and indirect effects are reported in Table 10.

Figure 11

Moderated Mediation comparing Text Condition to No Time Travel VR (X_1) on Counterarguing

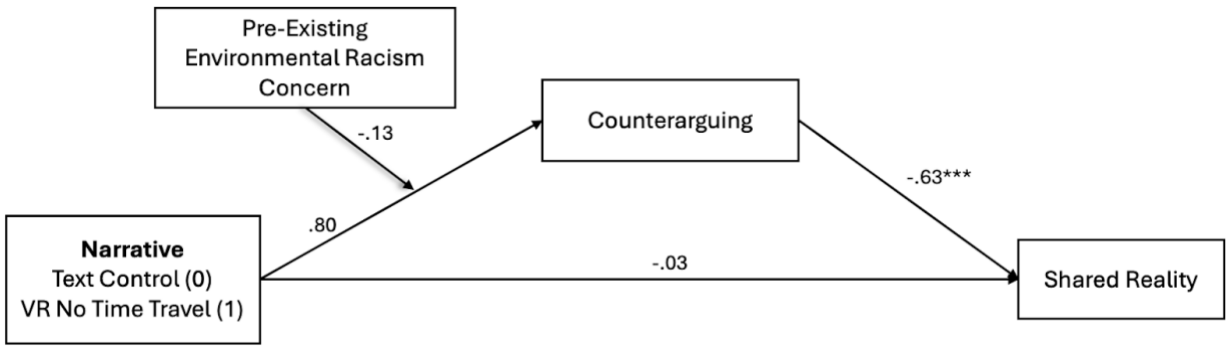


Figure 12

Moderated Mediation comparing Text Condition to Time Travel VR (X_2) on Counterarguing

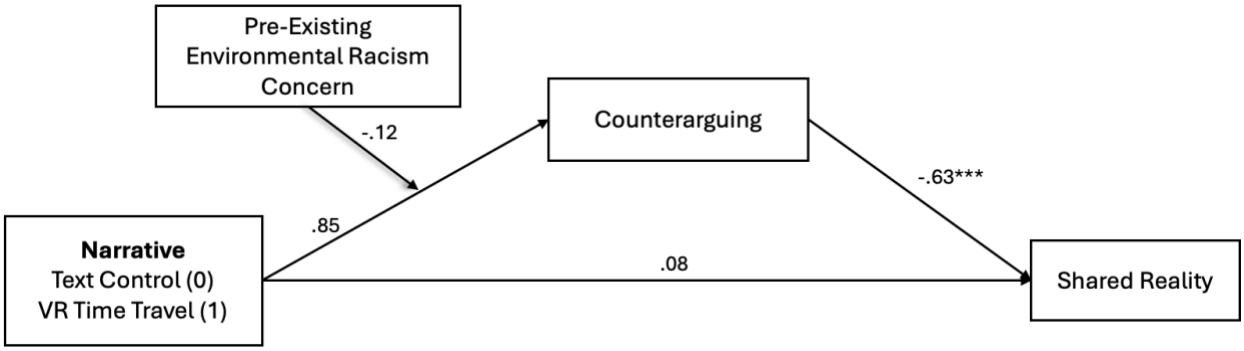


Table 10

Regression weights, indirect effects showing moderated mediation, bootstrap 95% confidence interval, lower and upper bounds on Counterarguing

			Bootstrap 95% CI	
	Coefficient	*SE*	Lower	Upper
Counterarguing				
X_1 → Counterarguing	.80	.48	-.16	1.75
X_2 → Counterarguing	.85	.55	-.23	1.94
Pre-Existing Concern → Counterarguing	.07	.08	-.09	.22
Int_1 → Counterarguing	-.13	.10	-.34	.08
Int_2 → Counterarguing	-.12	.11	-.34	.11
Counterarguing → Shared Reality***	-.63	.11	-.85	-.41
Conditional effects at moderator level				
Pre-Existing Concern → Counterarguing → Shared Reality	Effect Size	*bSE*	BootLLCI	BootULCI
X_1 3.40 (16th percentile)*	-.22	.11	-.47	-.03
X_1 4.80 (50th percentile)	-.11	.10	-.32	.06

X_1 5.60 (84th percentile)	-.04	.12	-.29	.18
X_2 3.40 (16th percentile)*	-.29	.16	-.64	-.03
X_2 4.80 (50th percentile)*	-.18	.09	-.38	-.02
X_2 5.60 (84th percentile)	-.12	.10	-.34	.07
Shared Reality				
X_1 → Shared Reality	-.03	.18	-.38	.31
X_2 → Shared Reality	.08	.17	-.27	.42

Notes: X_1 = Control vs. No Time Travel; X_2 = Control vs. Time Travel*; SE* = standard error; CI = confidence interval. Bootstrap resampling = 1000. $^{***}p < .001$ $^{**}p < .01$ $^{*}p < .05$

A multiple linear regression was used to test whether willingness to support environmental justice efforts was predicted by pre-existing environmental injustice concern, social presence, spatial presence, source credibility, liking, counterarguing, and shared reality. The results of the regression indicated the seven predictors explained 36% of the variance (R^2=.36, $F(7,135)=10.82$, $p < .001$). Two predictors were found to significantly predict willingness to support, which were pre-existing environmental injustice concern ($\beta = .291$, $p < .001$) and shared reality ($\beta = .692$, $p < .001$). Liking was moderately negatively significant ($\beta = -.305$, $p = .068$). This finding demonstrates that individual differences of pre-existing environmental injustice concern is an important characteristic in creating shared reality. Moreover, having a stronger shared reality can predict more willingness to support environmental justice efforts. Results of the regression are reported in Table 11.

Table 11

Results from linear regression analysis predicting Willingness to Support Environmental Justice Efforts

Variable	Unstandardized B	Coefficients SE	Standardized Coefficients Beta (B)	*t*	*p*
Pre-Existing Concern	.359	.077	.332	-.486	<.001
Social Presence	.124	.106	.096	1.17	.245
Spatial Presence	.000	.075	.000	-.005	.996
Source Credibility	.223	.142	.143	1.57	.119
Liking	-.308	.161	-.187	-1.92	.058
Counterarguing	.110	.178	.054	.622	.535
Shared Reality	.637	.123	.464	516	<.001

Note. Constant= -.494, $F(7,135)=12.43^{***}$, $p <.001$, $R^2 = 39$

CHAPTER 13

DISCUSSION FOR THE EXPERIMENTAL RESULTS

This experimental study began the initial steps at evaluating the effectiveness of a co-designed VR narrative informing audiences about environmental racism. It used virtual time travel to elucidate the underlying mechanisms and the role of individual differences, particular pre-existing environmental injustice concerns, in the process of constructing a shared reality. While the VR and time travel effect alone did not significantly construct a shared reality, the findings provide nuanced insights into the underlying roles of media and speaker characteristics in generating a deeper understanding and engagement with multifaceted, critical societal issues like environmental racism.

Findings

The findings revealed no significant differences in social presence perceptions between the VR conditions, and surprisingly, also between the text narrative. This result suggests that the immersive qualities of VR alone, without the additive time travel effect, are sufficient to maintain social presence across different VR conditions. Although social presence did not mediate the relationship between experimental conditions and shared reality, it was still significantly related to the construction of shared reality and implies that feelings of social presence may help fulfill the motivated connection principle of shared reality, as individuals feel a sense of connection and engagement with the content (Echterhoff & Higgins, 2021).

Interestingly, participants in the text narrative condition also reported feelings of social presence despite lacking a specific “resident” character. This finding could be due to the ability

of individuals to imagine a more personalized version of the resident, a phenomenon similar to narrative transportation (Ma, 2020), where individuals become engrossed in the story and its character, whether it is a text story or a video game. Additionally, reading a text narrative may allow for more focused engagement with the content than a highly interactive immersive experience, facilitating a deeper connection with a story. However, these results should be interpreted cautiously given the relatively low Cronbach's alpha (.52) for the social presence measure, suggesting potential issues with the scale times.

As expected, spatial presence was significantly greater for the VR conditions compared to the text narrative. Unexpectedly, the time travel effect did not significantly affect feelings of spatial presence. This finding aligns with previous literature suggesting that the immersive nature of VR enhances users' sense of "being there" compared to less immersive media forms (Sundar et al., 2017). High pre-existing concern was positively associated with spatial presence, indicating that individuals concerned about environmental injustice are more likely to feel "there" in the VR environment. However, this effect was negatively moderated by the interaction between the experimental conditions and pre-existing concern, suggesting that the combination of high concern and VR realism can cancel out VR affordances, impacting spatial presence. This is consistent with research showing that strong emotional connections to VR content can negatively impact spatial presence perceptions (Sundar et al., 2017) but conflicts with research showing pre-existing interest in content increased spatial presence (Ahn et al., 2022b). Ahn et al. (2022b) had participants embody coral to witness the deteriorating effects of climate change on marine systems. Although both VR narratives were related to environmental concerns, the conflicting results may be attributed to embodiment or the differences in seeing impacts on human life compared to marine life, warranting further investigation.

The spatial presence results are noteworthy, given the lack of difference in social presence between conditions. This may suggest that a compelling story can evoke feelings of connection with the character in VR and text formats, but the added sensory inputs of an immersive VR headset significantly impact feelings of being in the narrative. Although spatial presence did not mediate the relationship between experimental conditions and shared reality, it may not play as significant a role in constructing shared reality as social presence does. This may suggest that establishing a deeper connection with the virtual agent should take priority over environmental changes, as the modality of VR is enough to elevate the sense of spatial presence.

For speaker characteristics, source credibility and liking are significantly related to shared reality regardless of experimental conditions. This finding indicates that neither the time travel effect nor the VR narrative impacted the perceived expertise and trustworthiness of the virtual agent or the emotional engagement. However, these characteristics still played a direct role in constructing a shared reality. Source credibility, defined as the perceived expertise and trustworthiness of the virtual agent, is a crucial element in enhancing the persuasive power of the message and encouraging alignment of perceptions (Heesacker et al., 1983; Tan & Liew, 2020). The moderated mediation analysis revealed that liking the virtual agent mediated the relationship between the non-time travel VR condition and shared reality for individuals with moderate levels of pre-existing concern. This suggests that liking the virtual agent can enhance shared reality, especially for those with moderate levels of pre-existing concern in environmental injustice, aligning with previous research that individuals with lower pre-existing knowledge or concern may be more persuaded by a source they have positive attitudes towards (Heesacker et al., 1983).

Post hoc exploratory analyses

The post hoc exploratory analyses provided additional insights into the relationships between the VR conditions and other variables. Counterarguing, or the extent to which individuals look for flaws in a source's message (Ma, 2020), was significantly lower for the text condition compared to the VR time travel condition. This suggests that individuals may have been more critical when seeing Linda grow from childhood to adulthood. In contrast, the text condition presented a story about a nondescript resident, reducing the opportunity for counterarguing. However, counterarguing is also associated with higher levels of attention (Clayton et al., 2019), indicating that individuals in the VR time travel condition were more cognitively engaged with the narrative.

Counterarguing had a significant negative effect on shared reality. Significant negative indirect effects were found at lower levels of pre-existing environmental injustice concern on shared reality through counterarguing for the VR non-time travel and time travel groups. This suggests that individuals with lower pre-existing concerns may engage in more counterarguing in VR rather than for text, which negatively impacts the construction of shared reality. This negative effect may indicate resistance to the message when beliefs do not align (Clayton et al., 2019).

Lastly, willingness to support environmental justice efforts was explored to assess whether shared reality formation could be verified through behavioral intentions. The findings indicated that individuals in the VR non-time travel condition were significantly less willing to support the message than those in the text and VR time travel conditions. This suggests that the time travel effect in VR narratives may enhance participants' willingness to support environmental justice efforts, although the text narrative was equally effective. Additionally, pre-

existing environmental injustice concerns and shared reality were found to significantly predict willingness to support environmental justice efforts, while liking was moderately negatively significant. This emphasizes the importance of individual differences and the role of shared reality in motivating support for environmental justice.

Implications for VR Narrative Design and Future Research

The findings from this laboratory experiment underscore the complexity of designing compelling VR narratives to address systemic issues like environmental racism. First, tailoring VR experiences to account for varying levels of pre-existing knowledge and concern is crucial. Individuals concerned about environmental injustice may require more nuanced and contextually rich narratives to engage critically with the content. These narratives could provide deeper historical context and more complex interactions that can further enhance their existing beliefs and knowledge. Conversely, individuals with lower concern may benefit from heuristic cues that emphasize the likability of the virtual agent to mitigate potential counterarguing perceptions while in VR.

Balancing emotional engagement and realism is another critical consideration. The immersive qualities of VR are effective in enhancing spatial presence, but the additive effect of time travel did not significantly impact social presence or shared reality. Future VR narrative designs should consider balancing emotional engagement with the narrative's realism. While time travel is a novel technique, it may not have been sufficiently distinct from the non-time travel narrative to make a significant impact since all the interactive tasks were the same. Exploring film and movie techniques for showing the passage of time, such as lighting and atmosphere effects, could enhance the effectiveness of time travel narratives, helping to convey the long-term impacts of systemic racism more compellingly. Future developments of the VR

narrative should continue to build on the additional suggestions made by the earlier expert interviews.

Addressing racial bias and salience is also essential. Racial bias was not measured in this study, a limitation that future research should address. The VR environments were explicitly designed to highlight race, whereas the text narrative was racially colorblind, although it did go into detail about what redlining was. This difference could have impacted the results, as the salience of race in the VR conditions heightened participants' awareness and reactions to racial issues. The results from the experiment may indicate that individuals preferred a less direct confrontation of racism through the text narrative. Future VR designs should consider how racial salience affects user engagement and the construction of shared realities. Including measures of racial bias could provide deeper insights into how different audiences perceive and react to racially charged narratives.

The complexity and interactivity of VR environments can impose a higher cognitive load on users, potentially hindering their ability to fully construct a shared reality. Navigating the VR space, interacting with virtual objects, and simultaneously processing visual and auditory information may lead to cognitive overload (Ahn et al., 2022b). In contrast, reading text narrative allows for more focused engagement with the content, facilitating a deeper connection with the story. Future VR narrative designs should reduce cognitive load by streamlining interactions and minimizing distractions, allowing users to focus more on the narrative.

Another critical aspect is reducing counterarguments and enhancing engagement. The findings suggest counterarguing can negatively impact the construction of shared reality in VR, particularly for individuals with lower pre-existing concerns. To reduce counterarguing and enhance engagement, VR narratives should anticipate and address potential objections within the

story. Clear, credible information can help preempt counterarguments and foster a more immersive and believable experience.

These implications highlight the complexity and potential of VR narrative design in addressing systemic social issues. By considering individual differences, balancing emotional engagement with realism, addressing racial bias, managing cognitive load, and enhancing narrative techniques, VR can be a powerful tool for fostering understanding and motivating action toward supporting social justice. This underscores the impact of the research and encourages future research and design efforts to continue exploring these areas to create more effective and impactful VR experiences.

CHAPTER 14

CONCLUSION

This dissertation has delved into the complex ways in which Whiteness manifests, influences, and distorts shared realities, particularly in the context of environmental racism. Utilizing VR as a transformative tool, this research aimed to challenge these deeply entrenched oppressive systems of power and foster a more comprehensive understanding of systemic inequities. Throughout this work, I adopted a critical Whiteness perspective, emphasizing the necessity of recognizing and confronting the pervasive impact of Whiteness at both individual and structural levels. This perspective was integral to guiding research practices, the VR narrative development process, and framing the overall purpose and intent of the research outcomes. Additionally, I critically considered my positionality, acknowledging the role of my personal and professional biases, and strived for reflexivity throughout the research process. By critically examining and addressing these factors, this dissertation contributes to the field by offering multifaceted methodologies and insights to strive to disrupt Whiteness and promote environmental justice.

Integrating the Interviews, Pilot Test, and Experiment Findings

The semi-structured expert interviews with community members and environmental health researchers specializing in environmental racism were foundational in co-designing the VR narrative. These interviews ensured the VR experience was culturally authentic and grounded in lived experiences. Insights from the interviews emphasized the importance of

realistic scenarios and deep emotional connections with the virtual agent, Linda, which informed the narrative's development.

The pilot test with first-year School of Medicine students further validated the significance of source credibility in constructing shared realities with virtual agents within VR environments. Findings indicated a positive correlation between source credibility and the generation of shared reality, highlighting the potential of VR to enhance the credibility of virtual agents and foster a shared reality. This step was crucial in establishing the foundational role of source credibility before proceeding to more complex experimental manipulations.

The subsequent experimental study built on these findings by testing the effects of virtual time travel on perceptions of source credibility, likability, and social and spatial presence. While the results showed that all media characteristics (social and spatial presence) and speaker characteristics (source credibility and liking) were significant within the tested model, it became evident that social presence, source credibility, and liking were particularly influential in the shared reality process. However, these factors were not significantly affected by the immersive qualities of VR or the time travel technique. This result suggests that while VR can create engaging environments, the critical factor in constructing shared reality lies in the virtual agent's perceived credibility and relational qualities.

These findings resonate with the earlier comments from community members about the importance of feeling a connection with Linda and building strong emotional ties through realistic interactions. Despite several updates to the VR narratives, prioritizing changes to the dialogue and direct interactions with Linda might have been more impactful than altering the environment's aesthetics to reflect different historical periods. This insight underscores the

importance of focusing on relational dynamics within VR narratives to enhance user engagement and shared reality.

The experiment's results on individual differences in pre-existing environmental racism concerns provided further insights into the potential audiences that experts mentioned during the interviews. For example, community members had suggested eventually incorporating more practical implications following interactions with Linda, such as learning how to test soil for toxins. The experimental results indicated that individuals with high pre-existing concern for environmental injustice were less likely to look for flaws in Linda's arguments. In contrast, those with low pre-existing concerns were more critical. Furthermore, the VR affordance of spatial presence had adverse effects on those with high pre-existing concerns, potentially due to their familiarity with the topic, which may have impacted their ability to construct a shared reality since they did not gain new information. On the other hand, participants with lower pre-existing concerns had more favorable attitudes toward Linda in the non-time travel narrative and successfully formed a shared reality.

These differences suggest that tailoring VR experiences to address specific audience concerns can enhance the intervention's engagement and effectiveness. Individuals with higher levels of concern might benefit more from practical implications and additional content since they may already be well aware of the information presented. Conversely, those with lower pre-existing concerns may not require advanced VR manipulations like time travel to construct a shared reality about new information. This nuanced approach to designing VR interventions can better meet the diverse needs of different audience segments, ultimately fostering a more inclusive and practical educational experience.

Additionally, the differences between conditions for the willingness to support environmental justice efforts in the exploratory analysis were noteworthy. The fact that willingness to support environmental justice efforts was significantly lower for the VR non-time travel narrative than the text and VR time travel narratives is curious. Although speculative at this point, this result could indicate that the time travel effect may help individuals grasp the *structural* aspect of environmental racism, thus enhancing the willingness to support these efforts over the non-time travel narrative. When considering that counterarguing was greater for the time travel compared with text, whether this was due to paying more attention or being more critical of the time travel effect should be explored further.

Considering that those with lower pre-existing concerns liked Linda best in the VR non-time travel narrative but had greater counterarguing in the VR narratives overall, it may suggest that individual differences play a significant role in how the structural aspects of the time travel narrative are understood. The time travel technique may have more adverse effects for those with lower pre-existing concerns than simply seeing Linda as an elder reflecting on her past experiences. These findings indicate a complex interplay between narrative design, user background, and the effectiveness of VR as an educational tool. Whether counterarguing reflects greater attention allocation, cognitive load, or more critical attitudes toward Linda is yet to be determined. Future research should continue to explore these dynamics to refine VR interventions for various audiences.

Ultimately, these insights underscore the importance of community input and expert feedback in the iterative design process. The alignment between the interviews and experimental findings highlights the value of co-designing VR experiences with the target community to ensure cultural authenticity and relevance. By continually integrating feedback from community

members, VR interventions can be more effectively tailored to address various audiences' specific needs and concerns, thereby enhancing their potential to foster shared realities and promote understanding of systemic issues like environmental racism.

Reflecting on Whiteness in Research and VR Processes

This dissertation has aimed to unravel the intricate layers of Whiteness and systemic racism, using VR as a transformative tool for promoting environmental justice. The journey through the research and VR development process has illuminated the pervasive challenges and limitations of tackling such profound social issues. This concluding reflection ties together these experiences, emphasizing the importance of critically addressing Whiteness in the research and development phases.

Significant hurdles were encountered throughout this project, particularly in ensuring cultural authenticity and sensitivity in the VR narrative. For instance, securing a Black voice actor for the virtual agent, Linda, proved challenging (see Chapter 8 limitations). After specific requests, a Black woman voice actor was hired for the role. Nonetheless, the process with the studio was disjointed and lacked transparency compared to previous collaborations. The studio, voice actor, and researchers would typically meet over Zoom to review the recordings. However, in this instance, the lack of transparency resulted in inconsistencies that compromised the overall narrative quality—later requests for updated dialogue recordings sounded different than the original actor. These clips were edited using audio software to match tones and pitches as much as possible, but many could not be used in the final version. This challenge hindered making several community-requested edits, such as making race more salient within the dialogue.

Moreover, the VR development process was not without its unique challenges. Many of the assets, from character models to environmental textures, did not meet the desired standards.

In the initial version, community members pointed out the awkward animations of Linda walking around the home, which detracted from the immersive experience, often disrupting the narrative flow and diminishing the story's impact. Some even felt that the robotic nature of her movements could be seen as dehumanizing, potentially leading to stereotyping. As a result, the animations were removed and replaced with cut scenes to move Linda throughout the world. Furthermore, requests to developers for changes to the environment were often met with minimal enthusiasm. For instance, when requesting assets such as slices of pie, biscuits, cookies, and other snacks to be on the table with the tea, the request was only partially fulfilled with a single plate of scattered cookies. Similar requests to make Linda's hair even and textured, and her skin tone consistent had to be addressed through many repeated requests.

These experiences underscored the need for improved communication between researchers and developers, a crucial aspect of the VR development process. The lack of readily available, culturally authentic resources that can accurately convey the experiences of underrepresented communities and the substantial time, money, and resources required to create VR experiences that do justice to the complexities of environmental and systemic racism were also highlighted. To effectively carry out this work, everyone involved must be committed to the larger goal. Developers must be motivated to create culturally authentic and respectful representations of people of color. This may necessitate better communication between researchers and developers, with researchers needing to be familiar with the VR development process and developers understanding the research process. Otherwise, compromises along the way can significantly hinder the final product.

Reflecting on these experiences raises a critical question: Can this work be genuinely effective without adequate resources, or does it risk falling into the trap of "virtuous VR"?

Virtuous VR, as Nakamura (2020) describes, often exploits the pain of marginalized communities for self-reflection of privileged audiences without driving meaningful change. While this project took a community-based participatory research approach to help mitigate some of these pitfalls, the challenges faced throughout the process highlight the pervasive nature of systemic racism in all facets of industry, academia, and available resources. The lack of readily available Black voice actors, the scarcity of culturally authentic digital assets, fully rigged avatars of color to animate, the difficulty in accurately representing Black hair textures and dark skin tones in virtual worlds—all underscore the depth to which Whiteness seeps into these domains. Despite its intentions, this project faced moments where it risked replicating such dynamics. The question remains: Is making the story three-dimensional and interactive in VR significantly better than previous 360-video versions, or does it still reduce Linda's experience to mere spectacle?

Through this experience, it has become evident that merely showcasing racism is insufficient, even when trying to demonstrate individual and structural levels. For VR to be truly just, it must go beyond representation to provide actionable insights and resources that empower individuals and communities. Environmental injustice, while disproportionately impacting communities of color, poses a threat to everyone. The narrative must, therefore, not only inform users of these deeply historical systemic racist practices but also convey the urgency of collective action without leaving users feeling helpless. Rather than knowledge for knowledge's sake, VR can be designed to inform users with anti-Whiteness worldviews *and* demonstrate specific steps they can take to protect themselves and advocate for environmental justice, such as getting their soil and water tested or understanding the benefit of air purifiers in their homes. Moving forward, it is crucial to continue refining VR as a medium for equitable social change, focusing

on practical applications that drive real-world impact and empower all communities to address environmental racism effectively.

Strengths and Limitations

One of the strengths of this dissertation is its interdisciplinary approach, integrating critical race theory, environmental justice, and VR technology. The use of a CBPR framework with an SRD process ensured that the research was grounded in community insights and aimed at producing tangible benefits for those most affected by environmental racism. Additionally, the experimental design allowed for a rigorous examination of the effects of VR on perceptions of source credibility and shared reality.

However, limitations include the relatively small and specific sample sizes, which may affect the generalizability of the findings. Additionally, the text control article used in the study did not undergo pilot testing, which ultimately could have provided similar, but still different information between conditions. The challenges in achieving culturally authentic design also highlight the need for greater diversity and inclusion within VR development teams. Future research should continue to address these limitations by expanding sample sizes and further refining the VR narratives through ongoing community collaboration.

Practical Implications and Future Directions

The findings of this dissertation have significant implications for the use of VR in antiracist education and environmental justice advocacy. VR's immersive capabilities offer a unique opportunity to educate individuals about systemic racism and motivate action toward social change. Future research should continue to explore VR's potential to disrupt Whiteness and promote systemic change. Research can include conducting longitudinal studies to assess the long-term impact of VR interventions on attitudes and behaviors related to systemic racism

(Hatfield et al., 2022). Additionally, exploring the use of VR in other contexts, such as education and healthcare, can help address various forms of systemic inequities. Developing and testing new VR narratives incorporating intersectional perspectives is crucial, highlighting the interconnectedness of different forms of oppression (Davis, 1981; Hill Collins, 2009), such as sexism and queerphobia (Hatfield, *in press*).

Expanding research and VR development teams to include a wider range of perspectives, with a particular focus on critical Whiteness, will enhance the cultural authenticity and effectiveness of these interventions. By integrating critical Whiteness perspectives, leveraging community-based participatory research, and employing systematic representative design, this work contributes to the broader field of VR narratives and environmental justice. The journey to create more inclusive, equitable, and effective VR experiences is ongoing, necessitating a steadfast commitment to authenticity, collaboration, and innovation. As Miller et al. (2019a) aptly point out, this work takes time, but the ultimate goal is worth the effort. Researchers and developers must persist in pushing the boundaries of VR and other emerging technologies to challenge dominant norms and create rich tools for fostering shared realities that promote understanding, reflexivity, and action toward a more just and equitable world.

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APPENDIX A

SEMI-STRUCTURED INTERVIEW GUIDE

After VR Experience

1. What are some initial thoughts you had about the VR experience you just saw?
    a. Did anything in particular stand out? About Linda/the story she told/environment you were in?

VR Affordances

Social Presence

1. Did you feel like Linda was there with you in the virtual environment? Could you explain or describe what might have contributed to that feeling?
    a. At any point, did you feel as though you and Lidna were coexisting within the same virtual space at the same time?
    b. Did you ever forget I was actually here with you and instead you were with Linda? Please describe.
    c. How aware were you to Linda's actions and interactions throughout the VR experience? Do you think her presence influenced the narrative as it unfolded in any way?
2. In what ways were you able to engage and communicate with Linda within the virtual world?
    a. Please describe any interactions or exchanges you had with her character and how they impacted your sense of social presence and connection to the narrative.
3. Were you able to communicate with Linda in the virtual world? If so, in what ways?

Spatial Presence

1. When did you feel most like you were actually there immersed, or present, in the virtual environment?
2. Were there moments during your experience where you became so engrossed in the virtual environment that you momentarily forgot you were in a simulated space?
    a. If so, please describe those instances and what contributed to that sense of presence.

Interactivity & Realism

1. Did you feel that the environment was realistic?

    a. Why or why not?
2. Were there any moments during your interaction where you felt a strong sense of agency and freedom to explore the VE, similar to how you navigate the real world?
    a. Please provide examples of these experiences.
3. In what ways were you able to interact with objects and surroundings in the virtual world that mirrored your actions in the real world?

4. Were there any specific interactions that stood out to you as particularly immersive or believable?
5. Reflecting on the visual presentation of the environment and graphics, did you find them to be convincing and lifelike, resembling scenarios you might encounter in reality?
    a. Could you give specific examples of what is done well and what might need more work?

Shared Reality

1. Reflecting on your conversation with Linda, did the interaction feel genuine or authentic?
    a. What aspects of the conversation contributed to this sense of realism?
    b. What made it feel that way?
2. After your interaction with Linda, in what ways did you feel like you saw the "real" world in a similar way as her once you left the house?
3. Can you explain how these interactions facilitated understanding or did not?
4. Would you say that interacting with the objects in Linda's house helped build a connection with her or gained insights to her situation?
    a. Are they more distracting rather than actually collaborative? Please explain.
5. From your perspective, what elements or changes could be implemented to strengthen your relationship between you and Linda?
    a. How do you believe enhancing this relationship could contribute to a deeper shared reality or worldview with Linda's narrative?

Time Travel

1. To what extent did you feel like you traveled back in time with Linda?
    a. What made you feel like that?
    b. And what did not?
2. What would you like to see added to the experience to enhance that feeling?
3. How did you feel about seeing Linda as a child and aging back into an older adult?

Story accuracy

1. Would you say the events that took place, make sense, and represent an accurate portrayal of disparities related to structural racism?
    a. Is there anything you would like to see presented differently to help the overall message?
2. Would you say the world or time travel effect can help in demonstrating structural racism?
    a. Could you please describe what makes you think that? And if not, why?
3. In 1-2 sentences, could you tell me what you think the overall message or takeaway is?
    a. What parts of the narrative were thought-provoking to you and why?
    b. Can you describe moments when you felt specific emotions during the narrative?
        i. What kind of emotion?

Cultural authenticity

1. If you had to describe Linda to your closest friends using 5 words. How would you describe her personality?

2. How do you feel about the way Linda shared her experiences?
    a. Did she seem positive or negative in the way she shared?
3. Does Linda remind you of anyone you know? Can you please explain?
    a. Do you think Linda, the avatar, was presented in a respectable and acceptable way?
    b. Did you think her appearance from child to older woman gave a respectable and acceptable appearance?
4. Were her experiences presented in a respectable and acceptable way?
5. Is there anything you think that could enhance her appearance?

Interviewee Expertise

1. Could you describe your expertise or personal experiences related to environmental justice and/or racism?
2. How did you become involved in this area?

Wrapping up

1. What are things that you would like to talk about that we didn't get to talk about yet?
2. Who comes to mind that you think we should reach out to for an interview about this project?
3. Do you have any remaining comments or questions?

APPENDIX B

MEASUREMENTS FOR PILOT TEST AND EXPERIMENT STUDY

Pilot Test

Credibility of source information

What is your opinion toward Linda after your experience?

1. Intelligent	1 2 3 4 5 6 7	Unintelligent
2. Untrained	1 2 3 4 5 6 7	Trained
3. Cares about me	1 2 3 4 5 6 7	Doesn't care about me
4. Honest	1 2 3 4 5 6 7	Dishonest
5. Has my interests at heart	1 2 3 4 5 6 7	Doesn't have my interests at heart
6. Untrustworthy	1 2 3 4 5 6 7	Trustworthy
7. Not an expert	1 2 3 4 5 6 7	Expert
8. Self-centered	1 2 3 4 5 6 7	Not self-centered
9. Concerned with me	1 2 3 4 5 6 7	Not concerned with me
10. Honorable	1 2 3 4 5 6 7	Dishonorable
11. Informed	1 2 3 4 5 6 7	Uninformed
12. Moral	1 2 3 4 5 6 7	Immoral
13. Incompetent	1 2 3 4 5 6 7	Competent
14. Unethical	1 2 3 4 5 6 7	Ethical
15. Insensitive	1 2 3 4 5 6 7	Sensitive
16. Bright	1 2 3 4 5 6 7	Stupid
17. Phony	1 2 3 4 5 6 7	Genuine
18. Not understanding	1 2 3 4 5 6 7	Understanding

General Shared Reality (7-point Likert scale: 1=Not at all, 7=Very much)

Think back on your media experience with the speaker and answer the following

1. We thought of things at the exact same time.
2. We developed a joint perspective.
3. We shared the same thoughts and feelings about things.
4. Our conversation felt very real.
5. The way we thought became more similar.
6. We often anticipated what the other was about to say.
7. We became more certain of the way we perceived things.
8. We saw the world in the same way.

Experiment

Pre-existing Environmental Racism Concern (7-point Likert scale: 1=Not at all, 7=An extreme amount)

1. How worried are you about environmental injustice.
2. How much do you think environmental injustice will harm you personally.
3. How much do you think environmental injustice will harm future generations of people?
4. How much had you thought about environmental injustice before today?
5. How important is the issue of environmental injustice to you personally?

Social Presence (7-point Likert scale: 1=Strongly disagree, 7=Strongly agree)

1. I perceived that I was in the presence of [Linda/the resident] in the room with me.
2. I felt that [Linda/the resident] was watching me and was aware of my presence.
3. The thought that [Linda/the resident] is not a real person crosses my mind often. (R)
4. [Linda/the resident] appears to be sentient, conscious, and alive to me.
5. I perceive the [Linda/the resident] as being only a computerized image/narrative story, not as a real person. (R)

Spatial Presence (7-point Likert scale: 1=Strongly disagree, 7=Strongly agree)

Self Location

1. I felt like I was actually there in the virtual environment/story.
2. It seemed as though I actually took part in the action in the virtual environment/story.
3. It was as though my true location had shifted into the virtual environment/story.
4. I felt as though I was physically present in the virtual environment/story.

Possible Action

5. The objects in the virtual environment/story gave me the feeling that I could do things with them.
6. I had the impression that I could be active in the virtual environment/story.
7. I felt like I could move around among the objects in the virtual environment/story.
8. It seemed to me that I could do whatever I wanted in the virtual environment/story.

Credibility of source information

What is your opinion toward Linda/the resident after your experience?

19. Intelligent	1 2 3 4 5 6 7	Unintelligent
20. Untrained	1 2 3 4 5 6 7	Trained (R)
21. Cares about me	1 2 3 4 5 6 7	Doesn't care about me
22. Honest	1 2 3 4 5 6 7	Dishonest
23. Has my interests at heart	1 2 3 4 5 6 7	Doesn't have my interests at heart
24. Untrustworthy	1 2 3 4 5 6 7	Trustworthy (R)
25. Not an expert	1 2 3 4 5 6 7	Expert (R)
26. Self-centered	1 2 3 4 5 6 7	Not self-centered (R)
27. Concerned with me	1 2 3 4 5 6 7	Not concerned with me
28. Honorable	1 2 3 4 5 6 7	Dishonorable
29. Informed	1 2 3 4 5 6 7	Uninformed
30. Moral	1 2 3 4 5 6 7	Immoral
31. Incompetent	1 2 3 4 5 6 7	Competent (R)
32. Unethical	1 2 3 4 5 6 7	Ethical (R)

33. Insensitive	1 2 3 4 5 6 7	Sensitive (R)
34. Bright	1 2 3 4 5 6 7	Stupid
35. Phony	1 2 3 4 5 6 7	Genuine (R)
36. Not understanding	1 2 3 4 5 6 7	Understanding (R)

Liking of the person (7-point Likert scale: 1=Strongly disagree, 7=Strongly agree)
Think about the person you just heard[read about] in the virtual experience/story. Select how strongly you agree with each statement.

1. This person is friendly
2. This person is likable
3. This person is warm
4. This person is approachable
5. I would ask this person for advice
6. I would like this person as a coworker
7. I would like this person as a roommate
8. I would like to be friends with this person
9. This person is physically attractive
10. This person is similar to me
11. This person is knowledgeable

Shared Reality General (7-point Likert scale: 1=Strongly disagree, 7=Strongly agree)
Think back on your media experience with [Linda/the resident] and answer the following

9. We thought of things at the exact same time.
10. We developed a joint perspective.
11. We shared the same thoughts and feelings about things.
12. Our conversation felt very real.
13. The way we thought became more similar.
14. We often anticipated what the other was about to say.
15. We became more certain of the way we perceived things.
16. We saw the world in the same way.

Shared Reality Goal (7-point Likert scale: 1=Not at all, 7=Very much)
[Linda/the resident] and I tend to have the same thoughts and feelings about…

1. the causes of environmental injustice.
2. the impact of environmental injustice on marginalized communities.
3. the need for addressing environmental injustice in society.
4. the importance of raising awareness about environmental injustice compared to other societal goals.

Counterarguing (5-point Likert scale: 1=Strongly disagree, 5=Strongly agree)
The following ask about your attitudes toward the video:

1. I found myself actively agreeing with the speaker. (R)
2. I found myself actively disagreeing with the speaker.

3. I was looking for flaws in the speakers arguments.
4. It was easy to agree with the arguments made by the speaker. (R)

Willingness to Support Environmental Justice Efforts (7-point Likert scale: 1=Extremely unlikely disagree, 7=Extremely likely)
How likely is it that you would…

1. volunteer your time to help build crucial awareness and advocacy programs needed for environmental justice
2. donate money to help fund crucial awareness and advocacy programs needed for environmental justice.sign a petition to build the political pressure needed for policy reform for environmental justice
3. discuss the resident's story with your friends and family
4. forward the link of the resident's story to your friends to disseminate the message

Demographic information
What gender do you most closely identify to? (select all the apply**)**

- Woman
- Man
- Non-binary or third gender
- Transgender
- A gender not listed
- Prefer to self-describe [text entry]
- Prefer not to say

What is your racial identity? (select all that apply**)**

- American Indian or Alaskan Native
- Asian
- Black or African American
- Native Hawaiian or Other Pacific Islander
- White
- Hispanic, Latine/x, or Spanish origin
- Middle Eastern or North African
- Some other race, ethnicity, or origin
- Prefer to self-describe [text entry]
- Prefer not to say

If applicable, describe your religion
[text entry]

What is your current age? (e.g., 25)
[text entry]

Political affiliation (5-point Likert scale: 1=Strongly liberal unlikely disagree, 3=Moderate, 5=Strongly conservative)

Where would you place yourself on the scales below? On social issues

1. On economic issues
2. In general

APPENDIX C

EXPERIMENTAL STIMULI

VR Narrative Dialogue and Actions
Linda's dialogue is blue. *Denotes dialogue added from the first draft.*
Interactive tasks are green.
Additional instructions are orange.

Scene 1
Setting: Start on the porch of the house

Pop-up Prompt:

You've just moved into an "up and coming" neighborhood and you're stopping by to meet your neighbor, Linda. She has lived here for some time and has invited you over.
[*Knock on the door to go inside*.]
Linda (audio through the door) : *One second, I'll be right there!*

Scene 2
Setting: in front entry hallway | Linda is about 70 years old

You must be the new neighbor! You got here just as things have started to improve. You know, I was raised right here in this home. But come, come. Let's go to the kitchen, and have some tea.
[participant follows Linda inside and down the hallway]

So many new people are moving here...but I've seen how this neighborhood has changed in the last 60 years.

Scene fades to kitchen
You know, when I was about 10 years old …

Time Travel: Linda is about 10 years old, the calendar year shows 1965
No Time Travel: Linda remains 70 years old, the calendar year shows 2024

My dad would talk about this neighborhood being called "undesirable." Some discriminatory housing policy called redlining.

And because of our race, we weren't really allowed to buy homes in certain neighborhoods that were labeled as more desirable. Redlining made it so that families like mine could only buy homes next to landfills and industrial areas since these areas were seen as undesirable.

They made it seem like just because there were families living here like mine, no one else would want to live in this part of town

Would you help me fill the kettle from the faucet?
[participant grabs kettle from stove and goes in front of sink, places kettle in sink]

Do you see that big factory right outside the window? The dirty air made it hard to play outside as a kid
[pull curtain aside]

Because people thought my home was undesirable, the city rezoned this area to build landfills and chemical plants across the street.

a year or so after that, the water in our pipes turned brown and we couldn't drink it without boiling it first
[turn on faucet, fill up kettle, put on stove and turn on]

thank you, can you put the kettle on the stove and heat up the water
[put on stove and turn on]

Scene 3
Setting: in living room

Time Travel: Linda is about 30 years old, the calendar year shows 1980
No Time Travel: Linda remains 70 years old, the calendar year shows 2024

I want to show you something over here
[participant follows Linda to living room]

I still have the newspapers. Researchers found evidence of cancer-causing chemicals coming from these factories. It took a few years, but eventually the EPA banned it. Unfortunately, that wasn't the end of it…
[participant picks up and reads 2 newspapers]

lots of us even tried protesting the dumping of toxic chemicals near our neighborhoods. I have some of the old news footage from that day on the TV behind you.
[participant clicks TV on]

oh! That'll be the tea. Would you please help me pour the water at the table? I'll get the cups ready.
[participant goes back into kitchen]

Scene 4
Setting: in kitchen

Time Travel: Linda is about 50 years old, the calendar year shows 2000
No Time Travel: Linda remains 70 years old, the calendar year shows 2024

Turns out the soil was toxic too. We pleaded to city zoning councils about our health, we had higher cancer rates and kids always had asthma.
[participant grabs kettle off stove, turns to pour in cups on table]

Eventually that factory was shut down and the city took years before they finally got the soil back to safe levels.

I guess this area seemed more desirable without the toxic air and soil…but most of the affordable apartment buildings were torn down.

So many people I grew up with had to leave the area because rent kept going up. I guess I was one of the lucky ones and got this house from my parents.

Oh please don't let your tea get cold. Go ahead and try it.*
[participant picks up tea to mouth, gulping noise and tea lessens in cup]

the city rezoned the area to have more family-type homes like the one you just moved into. There's even a hospital and grocery store being built nearby now..

But these recent changes means property taxes keep going up and predatory home buyers are trying to push us out now. One neighbor was fined because she didn't want to sell her childhood home and so they dumped trash in her yard and called the city…

After all these years, it sure would be nice to finally enjoy our homes without the extra worry of toxic air, soil, and water….

Scene fades to black and back in
Time Travel: Linda is about 30 years old, the calendar year shows 1980
No Time Travel: Linda remains 70 years old, the calendar year shows 2024

Oh my, look at the time! I didn't realize we were talking for so long, I guess it's time for you to get going

[Linda coughs] Excuse me, sorry. It seems those earlier days have caught up to me.

*I do enjoy meeting my new neighbors. I hope they'll appreciate this neighborhood as much as I do *and understand what some of us have endured for it to look like it does now.* I've enjoyed sharing this time with you…*

Scene fades to Linda in front hallway
Please, come over here

I'm so glad I can finally grow flowers after all these years. Please take one on your way out and thank you so much for stopping by. I do hope to see you again soon.
[participant grabs flower, then doorknob to leave home]

Text Control Narrative

For the next few minutes, you will read a story about a resident who has lived their entire life in a neighborhood shaped by past discriminatory housing policies.

Please read carefully. A button to advance to the survey questions will automatically appear after some time has elapsed to read the story.

This resident grew up in a neighborhood deeply impacted by historical redlining practices, where, at times, they faced significant challenges accessing basic amenities and contended with environmental injustices. Redlining, a legal discriminatory housing policy in the 1930s, segregated communities based on racial and economic factors. This policy earned its name because federal home lenders drew red lines on maps to mark neighborhoods as "undesirable."

Due to redlining, this resident and their community were confined to specific parts of town, resulting in limited access to clean water and quality healthcare. Meanwhile, nearby industries, including factories and landfills, emitted toxic pollutants unchecked, exacerbating environmental hazards. The effects of redlining lingered, shaping the collective experiences of all residents in this community for generations.

A pivotal moment in this particular residents' history occurred when county authorities approved the establishment of a hazardous waste landfill within its borders. Despite passionate opposition

from the resident, community members, and environmental activists, the decision intensified existing environmental challenges and disregarded the health and well-being of those affected.

Eventually, intervention came when the EPA shut down nearby factories upon discovering that the chemicals emitted were toxic and cancer-causing pollutants. After several years, the city was forced to clean up the area and restore the soil to safe levels.

Without the toxic air and soil, the resident's neighborhood became more desirable, leading to city rezoning efforts to build more family-type units. Additional infrastructure, including a hospital and grocery store, was built nearby. However, the affordable apartment buildings were torn down, and many of the resident's long-time neighbors were forced to move away due to rising rent and property taxes.

The enduring impact of environmental injustice is evident in the prevalence of health issues in this resident's life and the surrounding community, including respiratory problems and heart diseases. These health disparities reflect years of exposure to polluted air, soil, and contaminated water sources.

Many residents from communities such as the one in this story seek to raise awareness of the ongoing struggles faced by neighborhoods affected by historical redlining practices by retelling their experiences.