UNIVERSITY OF CALIFORNIA

Santa Barbara

Cognitive and affective explorations through immersive story worlds: Designing social virtual reality for inclusive attitudes and behaviors

A dissertation submitted in partial satisfaction of the

requirements for the degree Doctor of Philosophy

in Media Arts & Technology

by

Enrica Lovaglio

Committee in charge:

Professor Curtis Roads, Co-Chair

Professor Misha Sra, Co-Chair

Professor Marko Peljhan

Professor Richard Mayer

March, 2024

The dissertation of Enrica Lovaglio is approved.

Richard Mayer

Marko Peljhan

Misha Sra, Committee Co-Chair

Curtis Roads, Committee Co-Chair

March, 2024

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ACKNOWLEDGEMENTS

My gratitude goes to the Media Arts and Technology department, which welcomed me in 2000 for my master's degree and then again in 2018 for my doctorate. In particular, Professor Curtis Roads, who graciously accompanied my journey for a quarter century, and Marko Peljhan, who listened to my plea to bring the cognitive science emphasis to MAT, allowed me to study what I love most. My computer science and psychology advisors—Misha Sra and Richard Mayer—have given my research a deeper breath, focus, and meaning.

Most of all, I thank my family, especially my children, Galileo and Zago, who never made me feel like my studies took time away from them. May Mom's achievement be a testament to the fact that, with determination, you can accomplish quite a feat.

My deepest gratitude and dedication go to my mother, Grazia Ricotta, an immigrant with a middle-school education, who encouraged me to earn a prestigious degree in the U.S.

I miss you, mom.

VITA OF ENRICA LOVAGLIO

EDUCATION

2024 Lovaglio, E. (2024). *Cognitive and affective explorations through immersive story worlds: Designing social virtual reality for inclusive attitudes and behaviors*. Ph.D. in Media Arts and Technology with an emphasis in Cognitive Science, University of California, Santa Barbara.

2023 Lovaglio, E. (2023). *Bridging Worlds for a Social and Restorative Justice Pedagogy: Virtual Reality Activism As Empowerment-driven Bias Training*. Ph.D. in Innovation Design, Department of Architecture, Design, Planning, International School of Advanced Studies, University of Camerino, Italy.

2002-2000 MA in Media Arts and Technology, University of California, Santa Barbara.

2001-2000 Certificate, Maya Game Development & Creation, Alias Wave|Front.

2000-1999 Certificate in Multimedia Studies, San Francisco State University.

1997-1998 Specialization, Design for Exhibition Spaces, IASL CISL Lazio, Rome, Italy.

1997 Professional Licensure in Architecture, Italy.

1996-1991 Laurea (Master's degree equivalent) in Architecture from the University of Genova, Italy

PROFESSIONAL EXPERIENCE

Academic Quarters: F = Fall, W = Winter, S = Spring, M = Summer

Present - 2002 Professor in Digital Media, Art and Design department, California Polytechnic State University (Cal Poly), San Luis Obispo, CA, U.S.

Present - 2020 Professor, Honorary appointment, Computer Science Department, Cal Poly.

2018 - 2002 Architect. Residential in San Luis Obispo, CA, U.S.

F-S-W 2022 Teaching Assistant in the Media Arts & Technology department, UCSB.

S 2020 Teaching Assistant in the Theater & Dance department, UCSB.

F 2019 Teaching Assistant in the Art History department, UCSB.

1999-1998 Architect. Simon Martin-Vegue Winkelstein Moris, San Francisco, CA.

1999-1998 Web Designer, Alfredo Tofanelli Design, San Francisco, CA.

1998-1997 Architect. Robinson, Mills & Williams, Sacramento, CA.

1997-1996 Architect. Studio Barone & Tibald, Bordighera, Italy.

SELECTED PUBLICATIONS

Costello, E.L. (2023). "Reimagining Cognitive Visualizations: Designers' Leading Edge & Innovative Power." In: Villa, D., Zuccoli, F. (eds) Proceedings of the 3rd International and Interdisciplinary Conference on Image and Imagination. IMG 2021. Lecture Notes in Networks and Systems, vol 631. Springer, Cham. https://doi.org10.1007/978-3-031-25906-7_52

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Lovaglio E. (2019) "Social Justice through Art, Immersive Interactive Narratives and Biometrics," Society for Literature, Science, and the Arts (SLSA) Experimental Engage-

ments International Conference and SLSA art exhibit “At the Margins,” University of California, Irvine.

Totten, C. W., & Costello, E. L. (2019). Letter From The Guest Editors. In T. Funk (Ed.), Video Game Art Reader: Volume 3 (pp. 3–4). Amherst College Press. http://www.jstor.org/stable/10.3998/mpub.12471295.3

Lovaglio E., Wood Z. (2019) “Not So Different Games: An exploration of five years of student game designers” IEEE Conference on Games (CoG), London, UK.

Lovaglio E. (2019) “The Inclusive Forest: Measuring discrimination across cultures through immersive and interactive narratives,” MIX2019 Experiential Storytelling International Conference, Bath Spa University, UK.

Lovaglio E., Wood Z. (2019) “New possibilities in Art and Computing: Teaching game design to achieve gender inclusion and diversity,” American Society for Engineering Education (ASEE), Los Angeles.

Lovaglio E., Wood Z. (2014) “Birds of a Feather: Computer Science and Art in academia: collaboration, discussion and hands-on,” Grace Hopper Women in Computing, Phoenix, AZ.

Lovaglio E., Rossi M. (2014) “Two different systems of higher education - U.S. and Italy: Learning from the comparison” Hawaii International Conference on Education - Honolulu, HI, U.S.

Lovaglio E. (2013) “Coast to Coast Workshop” Architectural journal Le Mappe.

Lovaglio E. (2006) “Mythological Utopia and Metaphorical Reality for Visualizing and Accessing Information in 3D Interactive Worlds,” IADIS Conference WWW/Internet, Murcia, Spain.

Lovaglio E., Gillette D. (2004) “Summoning the Ghosts of Globalization: Using Invention & Immersion to Teach About Media, Image, and Culture,” SIGGRAPH 2004 Annual International Conference and Exhibition, Los Angeles, CA, U.S.

FUNDING AWARDS

2021 CLA Summer Research grant, Cal Poly, $6,000.

2021-2020 Interdisciplinary Humanities Center (IHC) Research Focus Group, University of California, Santa Barbara. Project: "Sustainability and the New Human: A Cross-Disciplinary Approach to Mind and Environment." Sowon S Park (Assistant Professor of English), Sangwon Suh (Professor of Environmental Science, Bren School), Rebecca Baker (English), Enrica Costello (MAT), Surojit Kayal (English), Daniel Martini Tybjerg (Comparative Literature), Somak Mukherjee & Aili Pettersson Peeker (English).

2020 College of Engineering, Cal Poly. "CPConnect Enabling Interdisciplinary Project-Based Learning," $4,900

2020-2019 BIG IDEAS Honorable Mention Prize, Art for social change, $2,000.

2019 National Science Foundation (NSF) Travel Grant for the Society for Literature, Science, and the Arts annual meeting UC Irvine, CA, $308.98

2019-2018 Cal Poly Circle of Giving Grant, $2,700.

2012-2011 Coleman Fellowship grant, Center for Innovation and Entrepreneurship, California Polytechnic State University, San Luis Obisspo, $2,000.

2006-2005 Cal Poly Faculty Development Grant. Funding received: 2.3 WTUs equiv.

2005-2004 Cal Poly Internet 2 Grant. Investigators: Enrica Costello (Art & Design), David Gillette (English). Funding received: $5,500.

JUSTICE, EQUITY, DIVERSITY, AND INCLUSION ACTIVITIES

Present - 2023 Italian Kindness Movement U.S.A. Ambassador.

2013 - 2016 Creation of the Computing for the Interactive Arts minor (with Computer Science Prof. Zoe Wood), Cal Poly (52% girls in computing representation)

F 2022- 2014 Funding acquisition for six Italian students from the University of the Camerino to study one quarter in Cal Poly and reside in San Luis Obispo.

Cognitive and affective explorations through immersive story worlds: Designing social virtual reality for inclusive attitudes and behaviors, by Enrica Lovaglio.

ABSTRACT

The present investigation aims to identify best practices to design virtual reality (VR) story-worlds to promote prejudice reduction and foster prosocial attitudes toward under-represented groups. Past research shows that VR, which allows the simulation of scenarios that would otherwise be prohibitively difficult or impossible in real life, can be an effective tool for understanding human cognition and researching perception, decision-making, and behavior (Groom, Bailenson, Nass, 2009). In tightly controlled immersive digital simulations, one can inhabit an avatar's digital body with salient features (different skin color, age, gender, social status) to trigger beliefs, affect, and behaviors different from normal day-to-day life (Bailenson &Yee, 2007). VR perspective-taking experiences focused on imagined intergroup contact with individuals from marginalized groups can increase prosocial behavior toward them (van Loon, Bailenson, Zaki, Bostick, Willer 2018). Intergroup contact theory hypothesizes that reducing anxiety, which is the cause of increased stereotyping against the outgroup, and permeating the social encounter with positive emotions (Miller, Smith, & Mackie, 2004) leads to prejudice mitigation (Pettigrew & Tropp, 2006). Beyond these insights from social psychology, sparse literature has explored how to design immersive story-worlds to instill prosocial attitudes and behaviors, including the effectiveness of employing photorealistic techniques. This research fills this gap and challenges the assumption that human perceptions inside virtual and physical worlds are equal if digital assets are photorealistic. By creating a taxonomy of design strategies for inclusive VR, displaying data gathered during playtesting six state-of-the-art VR experiences, it identifies which affordances and methodologies are significant to inducing compassion and prosocial attitudes in immersive social encounters and contributes a pragmatic approach to the design of VR for bias mitigation while considering the craft, ethical and humanistic dimensions of the medium.

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I. Introduction

Technological progress has provided greater opportunities and tools to advance social change. This research focuses on design strategies for model-based virtual reality (VR) employed to teach inclusive practices and prosocial attitudes and behaviors. To utilize technological affordances to serve a social justice agenda, a transdisciplinary approach, including media art, multimedia learning, and cognitive science, is proposed.

Literature includes extensive research on VR's technological and psychological effects. However, it does not explore how to design art-based VR story worlds—especially those fostering bias awareness and prejudice reduction. This research aims to fill this gap, highlighting the importance of including artists in VR development. For example, the development of an immersive visual design hierarchy is crucial to avoid overwhelming the participant, and innovative methods for human representation are needed to overcome issues like a human depiction that is threatening and eerie, a phenomenon called the "uncanny valley," which can lead to breaking the suspension of disbelief and sense of presence.

Intergroup contact is the empirically supported strategy to reduce prejudice and discrimination (Pettigrew, Tropp, 2008). Research in this field has shown that even imagined intergroup contact, the mental simulation of social interactions between an in-group member and an outgroup member, facilitates the development of inclusive attitudes toward the outgroup (Turner et al., 2007). VR, which allows the simulation of experiences that would otherwise be prohibitively difficult or impossible in real life, can be an effective tool for understanding human cognition and researching perception, decision-making, and behavior (Groom et al., 2009).

Virtual reality (VR) perspective-taking is a type of intergroup contact that can increase prosocial behavior toward others (van Loon, Bailenson, Zaki, Bostick, Willer 2018). Perspective-taking, also called "mentalizing," is attributing mental states to others and reasoning about how situations relate to them. Encouraging participants to mentalize about stigmatized groups increases their prosocial behavior (McLoughlin & Over, 2019), and

mentalizing-related brain activity predicts later prosocial behavior (Majdandžić et al., 2016). Moreover, "Intergroup anxiety and intergroup empathy/perspective-taking represent two pivotal mediators of contact effects" (Vezzali et al., 2013, p.345). In VRPT, participants can be primed to take the role of "Them" while inside an immersive, tightly controlled digital simulation, inhabiting an avatar's digital body, which can have salient features (different skin color, age, gender, social status) to guide beliefs, affect, and prime specific behaviors (Bailenson, Yee, 2007).

Social psychologists have used VR to simulate prejudicial situations in which the perpetrator was placed in the victim's shoes. Even though "intergroup anxiety is with no doubt one of the most disruptive variables for harmonious intergroup relation" (Vezzali et al., 2013, p.349), these experiences often employ fear-arousing strategies. Negative affect renders empathy out of reach because participants instinctively activate self-preservation mechanisms. Moreover, the imagined pain can be so intense that the participant's discomfort turns off the desire to help the stigmatized individual (Sapolsky, 2017).

Artists have used a different strategies when creating VR stories: discrimination unfolds through animation, cinematic effects, and theater techniques. This research presents and compares the social psychologists' and artists' approaches through an action research experiment in which fifteen students assess six state-of-the-art VR experiences aimed at instilling prosocial attitudes and behavior. As shown in chapter four, the results indicate that art-based VR experiences' visuals and sounds directed the students' focus and held their attention more than the photorealistic experiences. Moreover, based on the qualitative data analysis, art-based VR story worlds produces greater cognitive and affective learning, enjoyment, and overall impact.

The research's most significant contribution is emphasizing the importance of conducting systematic studies to define best practices in the design of VR for prejudice mitigation and showing that art-based strategies can achieve a higher level of affective and cognitive engagement and overall impact than photorealistic strategies.

A. Research Background

Bias training, which is mandatory in academic institutions and most Fortune 500 companies, currently includes a series of situational videos followed by questions to test the employee's acquired knowledge. This information deficit model, used in all mandatory training on diversity, inclusion, and equity (DEI), is driven by the assumption that individuals do not have the know-how to become unbiased and that the training will provide the needed information to eradicate stereotypes, even though these belong to the unconscious mind. Indeed, past research shows that the fix-it-all approach of information-deficit-based DEI training models cannot address biases, considering the vast spectrum of diverse human traits and ingrained beliefs and that answering a few questions after watching a video may lead to ephemeral outcomes, if any (Dobbin & Kalev, 2018; Cox, 2021). According to Iris Bohnet, of Harvard Kennedy School, "U.S. companies spend roughly $8 billion a year on DEI training—but accomplish remarkably little" (William & Dolkas, 2022).

Currently, photorealism is the visual representation method most employed for bias training and VR experiences aiming at reducing prejudice, despite research showing a sense of repulsion triggered by characters closely depicted as humans, a phenomenon that roboticist Masahiro Mori in 1970 labeled "the uncanny valley."

Some companies have been seeking alternative bias training methods, and many are producing and selling virtual reality-based bias training customized for particular groups or single individuals. Today (March 1, 2024), a Google search for "bias+training+virtual reality" leads to 11,500,000 results. This investigation may contribute to creating effective VR bias training that can be employed inside private and public institutions to foster a rich culture of diversity and inclusivity.

B. Research Motivation & Rationale

Past research shows that VR can be an ideal tool for understanding human cognition, perception, decision-making, and behavior (Groom et al., 2009).

Through carefully constructed situational experiences, VR can provide insights into how humans react in social situations (Bailenson &Yee, 2007; van Loon, Bailenson, Zaki, Bostick, Willer, 2018), showing the potential to become an effective training tool in a range of industries and fields. Significant results in curing phobias and mental disorders have proven that VR is an effective tool for rehabilitation and assessment. It is widely employed to treat psychological and behavioral conditions such as depression, anxiety (Jingiliet al., 2023), post-traumatic stress (Rizzo & Shilling, 2017), attention-deficit and hyperactivity disorders (Bashiri et al., 2017), fear of heights, and fear of insects (Park et al., 2019), as well as for military purposes (Harris et al., 2023), for education and several kinds of training (Strojny & Dużmańska-Misiarczyk, 2023).

VR experiences aim at communicating meaning through visualization and other sensory stimulation. This research's motivation and rationale are grounded on the need to identify and encode a design language of VR for inclusion. To do so, it analyzes the state-of-the-art of VR for inclusion, focusing on visual elements and other stimuli, their meaning in the realm of human perception, and emotional entanglements. The results are summarized in a taxonomy, a map of VR for inclusion to inform future practitioners in designing VR intended for behavioral training and prejudice mitigation.

In their 2016 paper, Barricelli, Gadia, Rizzi, and Marini compare natural language, made of literary symbols, with VR language, made of visual communication symbols. The meaning, which in natural language is given by words and their context on the communication process, in VR is determined by the visual representation elements and their dynamic interaction with complex technological affordances, such as embodiment, interactivity, presence, and more. (Barricelli et al., 2016). This comparison helps clarify this research's goal of

defining the language of VR applied to bias training and prejudice mitigation, including best practices in the choice of visual representation and technological affordances that interact and contribute to the meaning of such visual signs. The research's scope is limited to the design aspects because a complete study requires a transdisciplinary investigation, spanning across the fields of art and design, social psychology, and multimedia learning, intersecting inside *NeuroDesign Research*, which arose in 2018 from Larry Leifer's pan-disciplinary Stanford program at the intersection of Neuroscience and Design Research.

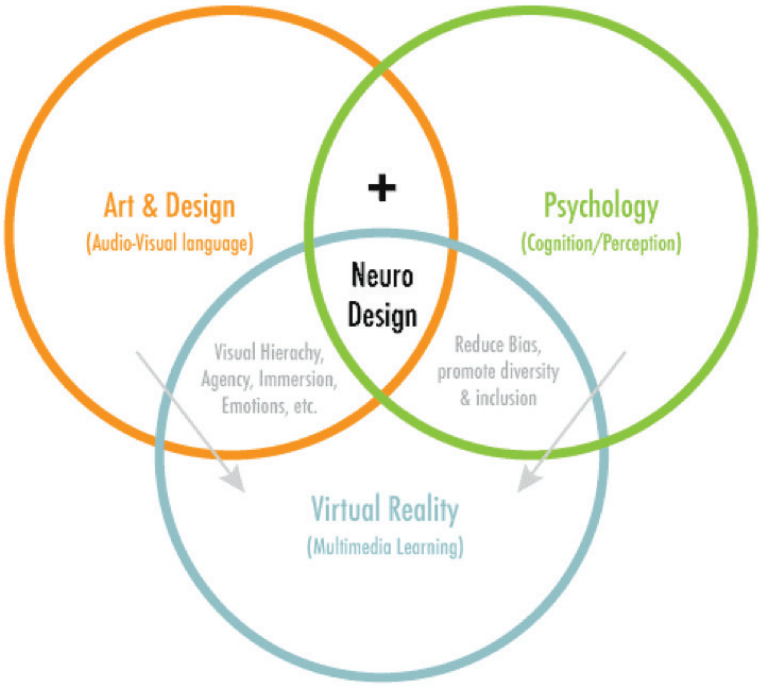


Fig.1. Research fields.

The act of designing always aims to ameliorate human well-being and create artifacts with practical, cultural, and semantic meanings that put humans at the center of the process. People are design makers, users, and receivers, and the ones giving meaning and value to the final product. For example, user-centered design first focused on creating objects with a function to be exploited and evolved with designing the human interactions with artifacts and the meaning to assign to products, with ample consideration of the users' physical and cognitive strengths and limitations.

Design thinking, engineering, and art merge to produce objects, interfaces, and ar-

tifacts informed by how humans perceive, learn, and attempt to alter their surroundings. In interaction and experiential design, which are technologically based and immaterial, the audience is still the human, but the machine becomes a worthy companion, capable of cognition to augment human perception and intelligence.

In 1977, psychologist James J. Gibson, in "The Theory of Affordance" points to the ability of objects to suggest a certain "uso," rendering their purpose straightforward and easy to understand. This term gave broader meaning to the design intent: products had a technical and practical use but could also have subjective and complex dimensions, such as emotional and cultural meanings (Norman, 1999).

Given these new affordances in the field of design, the disciplines involved in creating products and experiences that fulfill human needs in today's society have broadened to include psychology (social and evolutionary), biology, cognitive science, as well as art and engineering. Neurodesign is the discipline that applies research findings from psychological aesthetics and applied neurosciences to the world of design. Its principles focus on how humankind perceives visual information and processes it in making decisions pertaining to designing user-centered assets and interfaces.

C. Problem Statement, Aims, and Significance

Past literature shows that VR is a powerful tool for researching perception, decision-making, cognition, and behavior because it allows the experimental control of scenarios and interactions presented to the study participants. Moreover, it is the only tool that allows us to simulate scenarios that are impossible or challenging to enact in real life.

A proven method to reduce prejudice is intergroup contact. Past VR experiences have emphasized negative stereotypes and focused on the painful and dramatic treatment of individuals from under-represented groups. An early example from 2012 is American journalist Nonny de la Peña's VR documentary *Hunger in Los Angeles*, in which a houseless individual collapses while in line at the food bank. Based on findings from social psychology and

intergroup contact theory by which the mediators for optimal intergroup contact are positive emotions, this research challenges the idea of anxiety-inducing strategies often employed inside VR experiences aimed at instilling prosocial attitudes toward individuals from stigmatized groups. Considering that imagined contact with the life experiences of other groups makes inclusive attitudes more likely (Shamoa-Nir & Razpurker-Apfeld, 2023), this research aims to determine best practices for imagined intergroup contact inside VR as a strategy to combat discriminatory attitudes at the individual level.

A common element of the studies aimed at the exploration of prejudice has been the use of photorealistic assets. This research challenges the assumption that virtual environments must mimic the physical world to have validity in psychology studies. The analysis of data gathered from playtesting VR's state-of-the-art to instill prosocial behaviors shows that artists and designers must join psychologists and engineers in developing virtual environments for behavioral health and cognitive training.

Indeed, until now, psychologists, health practitioners, and computer scientists have been leading the use of VR for learning and mental health. They have employed photorealism rather than artistic design, perhaps assuming that photorealism connects VR participants more effectively to the physical world. This research challenges this assumption and suggests that artistically designed digital worlds engage participants with more depth and less anxiety than hyper-photorealistic digital scenarios. In their book, James Blancovich and Jeremy Bailenson conducted a literature review meta-analysis examining the photographic realism of digital faces to assess its effect on people inside social VR. They discovered that increased photographic realism does not lead to higher persuasion or influence. Some studies even showed the opposite outcome, challenging the need for copying real faces for social VR to be effective (Blascovich & Bailenson, 2011). The main reason for this disconnect between increased facial photorealism and decreased believability is the phenomenon that in the 1978 book by Jasia Reichardt, *Robots: Fact, Fiction, and Prediction*, is called the uncanny valley. The emotional reaction to perceiving a human face that is computer-generated, hence missing

the subtleties of a real face, was first explored in 1970 by Japanese roboticist Masahiro Mori, who guessed that people would feel a sense of eeriness and even revulsion when exposed to a robot with a human-like appearance, calling this phenomenon bukimi no tani in Japanese, translated as uncanny valley in English.

The assumption that VR worlds must be a photorealistic match of the physical world has prevented artists and designers from being included and invited to collaborate with psychologists and computer scientists to design the visual representation of VR environments and experiences. Another contributing factor to preventing collaborations with artists and designers is that current university-level art programs teach art and design as they did a half-century ago, sometimes holding a solid bias against technology as an artistic medium. Fine art curricula often focus mainly on drawing and painting with traditional tools (e.g., pencils, brushes, pastels, oil, acrylic paint) while graphic design curricula focuses on designing for print, such as logos, posters, editorial design, and typography. Photography and video curricula focus on teaching photographic and video content, with an occasional class on video-based VR experiences. Only a few public art graduate-level programs include VR, augmented reality, and other immersive technologies with an emphasis on the technological aspects rather than the design and artistic components. Moreover, these graduate students are engineers interested in specializing in art and entertainment. However, they have no formal training in the arts. Once they graduate, they still need to gain the foundational artistic skills that an undergraduate degree provides. In summary, when making VR experiences for behavioral training, traditional photorealistic representation and the need for more experts in art and design familiar with technological applications prevent designers from systematically entering the field. Through the presentation and empirical analysis of case studies, this research provides evidence of why designers must lead, with psychologists and engineers, in creating virtual environments to study human perceptions and behaviors.

This research's significance is grounded on today's push to achieve social justice by overcoming prejudicial attitudes, which has increased significantly across the last half-cen-

tury, making this effort timely and necessary. In the last two decades, academic and private industries have worked hard to diversify. However, they still struggle to develop a culture of equality and respect encompassing all races, genders, and socio-economic statuses.

Currently, the primary tool to reduce prejudice is multimedia bias training (visual and text-based, VR-based bias training has yet to be widely employed). All Fortune 500 companies and two-thirds of academic institutions in America require diversity and inclusion training for their employees and faculty members. In 2018, the California Budget Act included $1.2 million for a two-year anti-bias training program at the University of California and the California State University for administrators, faculty, staff, and campus student leaders. According to Dobbin F. and Kalev's 2018 paper, "Yet hundreds of studies dating back to the 1930s suggest that current anti-bias training does not reduce bias, alter behavior or change the workplace." (Dobbin & Kalev, 2018, p.48). Several companies are now producing VR-based bias training, and universities are promoting it as the next step to overcome prejudice and achieve equity and inclusion, even though they have yet to identify effective design strategies and best practices for VR experiences aimed at reducing prejudice.

Fig. 2. *Insight Into Diversity* magazine cover. March 2021 issue.

Even though very little research exists on how to design model-based VR for prejudice reduction, including the effectiveness of employing photorealistic techniques, considerable investments are allocated to creating VR experiences for bias training that imitate reality. Given the uncertainty of positive outcomes and the risk of alienating people with ineffective strategies, one of this research's significant contributions is emphasizing the importance of conducting systematic studies that challenge the assumption that human perception inside virtual photo-

realistic worlds and physical worlds are equal.

D. Objectives, Research Questions and Methods

This research is a first step in that direction, as it aims at finding the most effective tools and strategies pertaining to VR storytelling for bias awareness and mitigation to combat structural racism and create a rich culture of diversity and inclusivity.

The research aims are the following:

- Compiling an exhaustive review of the fields involved in this transdisciplinary effort aimed at using VR for bias awareness and mitigation and
- Defining the best design practices through the examination of past research (literature review) and the analysis of empirical design examples (case studies).

The research's primary questions are:

1. How can we design and craft immersive virtual realities that are conducive to conveying group belonging, compassion, and empathy toward specific social identities and awareness of one's prejudicial attitudes?
2. Which VR traits and design features are salient to produce positive emotions and trigger prosocial points of view toward individuals from stigmatized groups?
3. Given that cognitive and psychological explorations of social inequalities and stigma have used photorealistic VR worlds, can art-based VR be used effectively to depict and impact social issues?

The following knowledge acquisition methods were employed to answer these questions:

- Critically examining the existing literature pertaining to VR experiences aimed at instilling compassion created after 2015 when American videographer Chris Milk labeled VR "the empathy machine," and research in this field has flourished.
- Critically examining the state-of-the-art in the field of social VR aimed at instilling empathy and compassion toward marginalized groups.
- Developing a taxonomy of VR design for bias reduction from data collected through playtesting six VR for social inclusion state-of-the-art experiences to identify best design

practices, mindful of the values, ethical and humanistic aspects, and the evolving affordances and limitations of VR technology.

First, this research provides a theoretical overview of the cognitive and design implications that play a crucial role in VR storytelling aimed at prejudice awareness and mitigation, with arguments supported by past research and the literature review of the fields involved. Then, it employs action research inside the classroom to gather data and results.

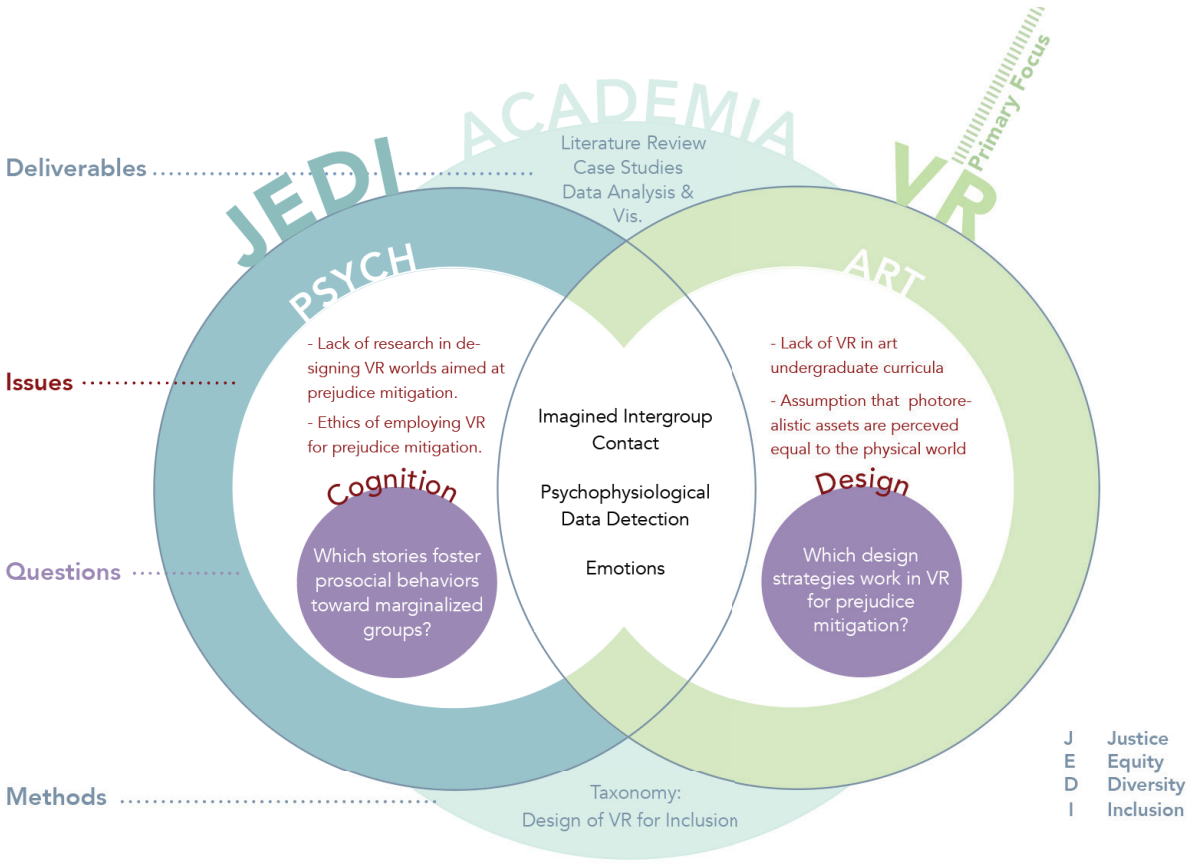


Fig.3. Research somponents.

E. Hypothesis and Limitations

Compared to the physical world, rich in sensory stimuli, VR is visually dominant and lacks the fine details of accurate facial expressions, smells, atmospheric elements, and the emotional arousal derived from actions like embracing others. Rendering a world appealing and believable through VR is a feat of imagination and hard work. Instead of designing and

modeling 3D characters or experimenting with 2D assets, psychology researchers have employed body scanners that are powerful enough to detect skin pores, aiming for photorealism.

This research hypothesizes that, in VR, art-based representation and narrative construction with positive affect may foster prosocial attitudes more effectively than photorealistic representation and fear arousal scenarios because

- just as in cinema, in which we identify with characters both through film and animation, it does not carry false assumptions and
- it employs imagined intergroup contact and perspective-taking inside immersive story worlds, including encounters with marginalized individuals, and
- it employs storytelling, which is one of the most ancient and established forms of social connection and sharing.

To determine if this is true, six state-of-the-art VR storytelling experiences that illustrate discriminatory events on the basis of race, gender, nationality, religion, socio-economic, and immigrant status were assessed during class activity through playtesting and filling out a detailed quantitative and qualitative questionnaire. Four of the experiences, created by artists and not photorealistic, depict a sequence of mostly peaceful events; two, created by psychologists and photorealistic, employ tension and escalate to anxiety and fear.

The literature review guided the selection of the salient elements to assess included in the students' survey, which are twelve categories, some related to physical or sensory perceptions (visuals/sound, point of view, space, scale, and time), some related to more cognitive and affective perceptions (emotion, interactivity, embodiment, narrative flow, cognition, enjoyment, and impact), and created the questionnaire. During the Winter 2024 quarter, the research's author taught a senior-level class focused on computational arts with eighteen students from different majors; each of them assessed the six experiences I selected from the state-of-the-art of VR storytelling aimed at illustrating discriminatory events by completing questionnaires in which they assigned a score to each of the twelve categories. The results are compiled in an interactive taxonomy graphical interface that shows, for each experience, the

scores assigned to each category by the students. As hypothesized, enjoyment, which is a motivator in multimedia learning, is significantly higher in art-based experiences. The taxonomy graph shows which design strategies worked better; surprisingly, the two experiences that induced high levels of fear in participants did not receive the highest scores in the "emotions" category. Chapter four shows the playtesting results.

To strengthen the research's arguments, the author's own experimentation and acquired knowledge is included by presenting the following case studies: *Dreamwalker*, which tests the point at which humans perceive the uncanny valley and trigger emotions, and *Anx Dread*, which employs the participant's psychophysiological input (heart rate variability) to progress through the experience.

A research limitation is a reduced scope due to the sparse employment and literature review pertaining to VR design strategies, such as

1. Manipulating space to induce emotions
2. Testing different character design styles to identify better avatars and agents,
3. Broadening sensory inclusion (smell and touch in addition to sight and sound),
4. Defining the relationship between the virtual world and the physical world,
5. Employing special effects, like cinematographic transitions, that allow for jumping from one scene and space to another
6. Signaling the element that allows agency and interactions inside virtual environments.

Other research limitations include the lack of VR projects to study human perception and cognition in relation to discriminatory bias, which breaks away from a photorealistic representation of the physical world. The perceived need to match the physical world to have consistent results has prevented artists and designers from being included and invited to collaborate with psychologists and computer scientists in designing the visual representation of VR environments.

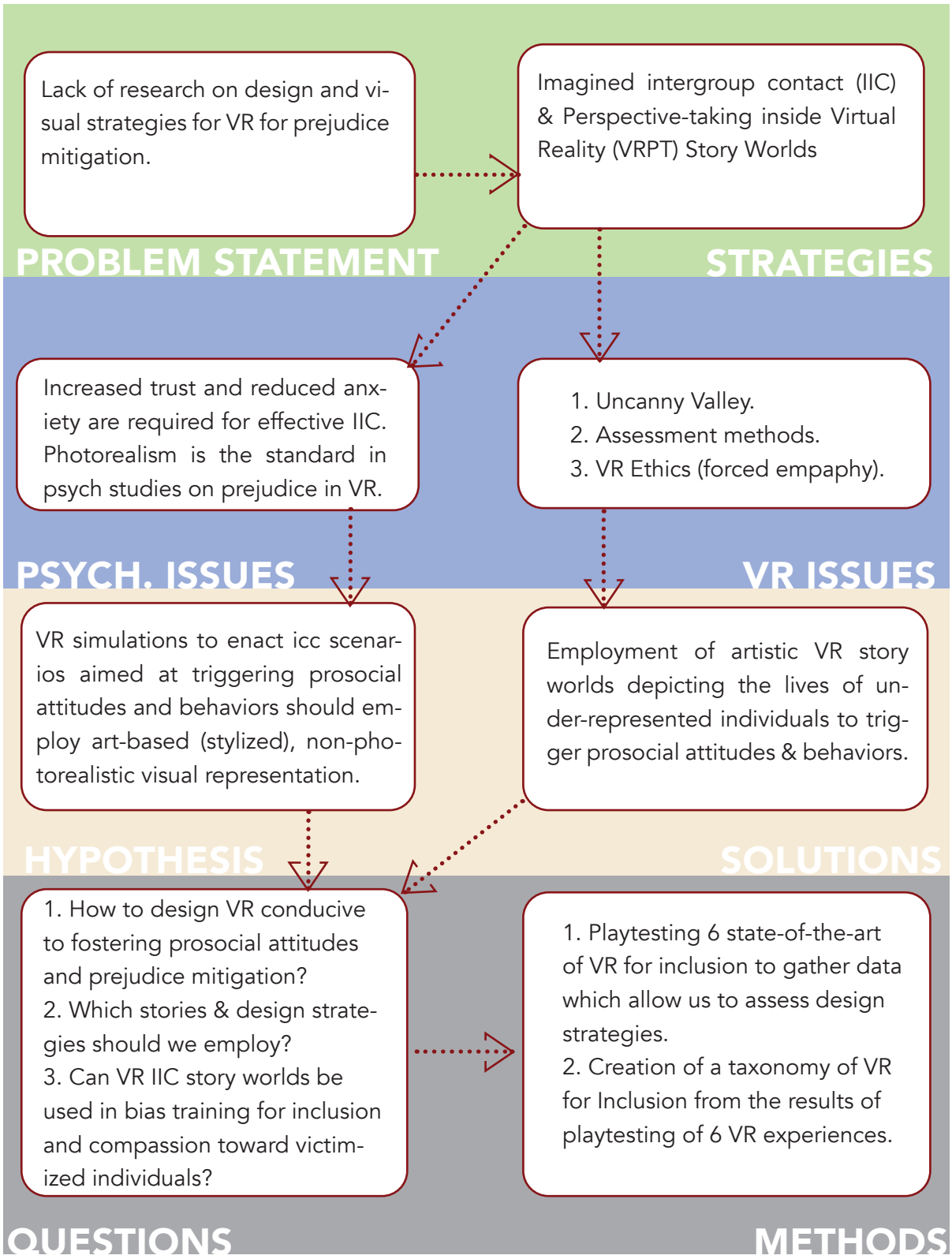
Lastly, the perceptual, cognitive, and emotive components of each experience are evaluated from the design's perspective. Certain design elements contribute to particular

perceptions or emotions, but the emotive and cognitive qualities cannot be fully discussed in this dissertation because that task is beyond my expertise. This narrower scope is essential to limit the main focus on the visual representation, the design elements, and what they trigger in the human mind at a more general level.

Much of the literature review on VR explorations to study human perceptions and cognition does not consider the visual, semantic, and symbolic design of immersive VR. Even when they do, often the papers' authors do not belong to the world of art and design. Due to this limitation, at times, this research borrows from the world of film and entertainment, which is not always concerned with cognitive aspects, and from the fields of psychology and computer science, which often ignore the effects of visual representation.

It delivers the following:

- A comprehensive literature review on research employing VR for prejudice reduction and bias assessment,
- Case studies of VR experiences that subvert realistic representations and employ biofeedback to promote and measure emotional responses,
- Action research inside the classroom to gather data through playtesting of photorealistic and art-based VR experiences,
- A taxonomy summarizing the results of the playtesting and field experiment,
- Data visualization and analysis leading to results on best practices to design VR aimed at promoting prosocial behaviors and attitudes.


Lack of research on design and visual strategies for VR for prejudice mitigation.
Imagined intergroup contact (IIC) & Perspective-taking inside Virtual Reality (VRPT) Story Worlds
PROBLEM STATEMENT
STRATEGIES
Increased trust and reduced anxiety are required for effective IIC. Photorealism is the standard in psych studies on prejudice in VR.
1. Uncanny Valley.
2. Assessment methods.
3. VR Ethics (forced empaphy).
PSYCH. ISSUES
VR ISSUES
VR simulations to enact icc scenarios aimed at triggering prosocial attitudes and behaviors should employ art-based (stylized), non-photorealistic visual representation.
Employment of artistic VR story worlds depicting the lives of under-represented individuals to trigger prosocial attitudes & behaviors.
HYPOTHESIS
SOLUTIONS
1. How to design VR conducive to fostering prosocial attitudes and prejudice mitigation?
2. Which stories & design strategies should we employ?
3. Can VR IIC story worlds be used in bias training for inclusion and compassion toward victimized individuals?
1. Playtesting 6 state-of-the-art of VR for inclusion to gather data which allow us to assess design strategies.
2. Creation of a taxonomy of VR for Inclusion from the results of playtesting of 6 VR experiences.
QUESTIONS
METHODS

II. Context

A. Virtual Reality Affordances

VR's unique characteristics can be employed to trigger heightened social constructs. They include immersion, agency, interactivity, embodiment, and presence or creation belief.

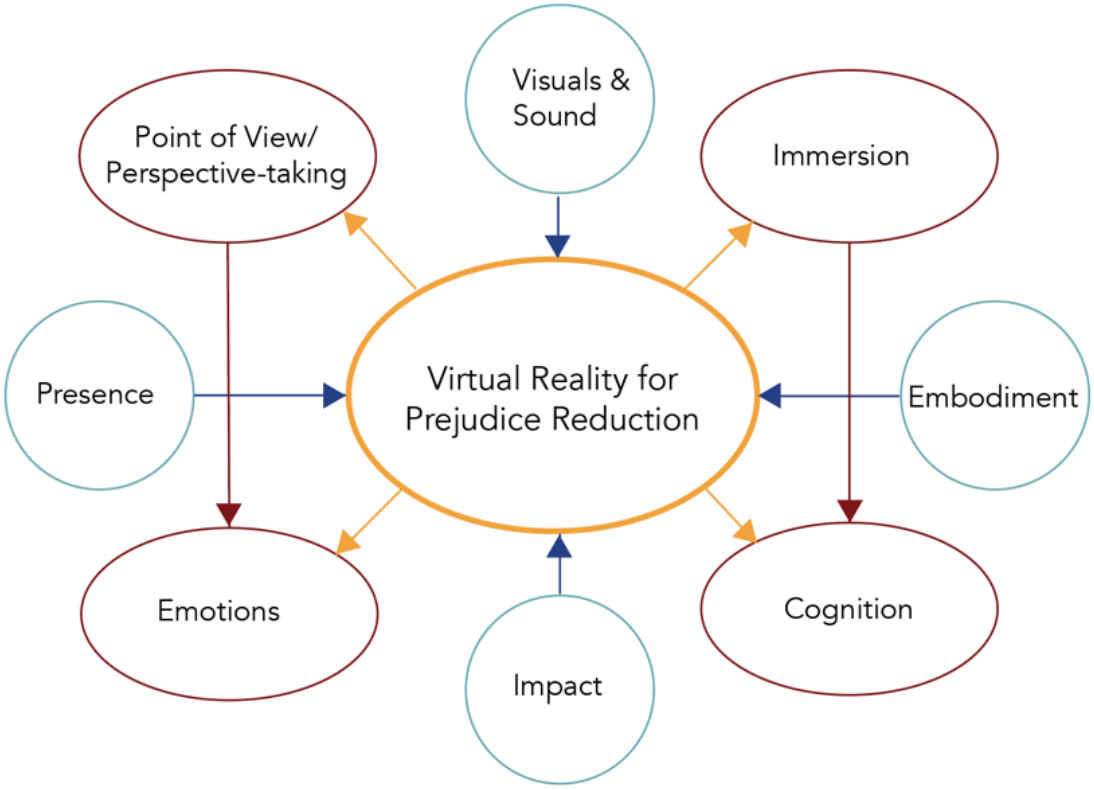


Fig.5. The components of VR for prejudice reduction

Immersion occurs when we are absorbed in a great book, movie, play, music, or performance. In VR, this is achieved by surrounding the participant with the projection of 2D equirectangular images on a 3D digital sphere (for image-based VR) or by the digital 3D models of the virtual space and characters. The participants are placed in the center of the virtual environment, and their senses are saturated by the digitally constructed world's stimuli (visual, aural, and haptic). If immersion depends on the technical quality of the VR setup, with the quality of the hardware directly proportional to the quality of the sense of immersion, presence refers to the experiential quality in virtual environments, which is determined by the overall design, especially the choices of visual language, sound, and VR affordances that contribute to rendering the virtual world believable so that the participants feel that they

belong and exist in the digitally constructed environment or situation.

Agency refers to the participant's ability to choose and change the course of events in the narrative. The desire to act is triggered when the virtual environment is believable and presents choices based on understandable contexts. The sense of agency is connected to interactivity, the participant's ability to move inside the domain by assuming a chosen role in the story. The greater the agency and interactivity, the more the participant can define the meaning of the virtual narrative. The director, the experience maker, determines the level of interactivity given to the characters. The greater the interaction, the more the director loses control in deciding the direction and meaning of the story.

In a virtual experience, humans can be avatars or agents. An avatar is the digital representation of the participant's body; the digital character functions as a costume for the person living the experience through perceptions of the virtual environment's stimuli, choices, actions, and behavior. Avatars mimic the participant's actions, can act independently, and change the story's outcomes. An agent, which in games is called a non-playable character, is a digital character with pre-scripted behavior. It is a virtual actor, not driven by a physical person, with pre-scripted behavior, who interacts socially with the participant's avatar and does not change the course of the story.

Embodiment occurs when the participant "wears" another person's digital body (avatar) and unconsciously assumes the trait of that person. For example, in studies of stigma, the participant often embodies a person of a different race, socio-economic status, or gender. When embodying a stigmatized person, the avatar's hands are the only significant visual clue of the change unless a VR mirror is included.

Believability is a subjective perception that forms unconsciously inside the participant's mind. A significant contributor to the success of a VR world is defined by how strongly the work can trigger an immersive world in the participant's imagination and how much it activates the suspension of disbelief, also thought of as the "create belief" action of the mind. Identifying with a stigmatized person allows participants to see and feel like a different

person entirely. In this case, the visual clues are significantly more pronounced, and we can define new possibilities in social interactions.

B. VR as a Mirror of Sensory Perceptions

Jaron Lanier's book, *Dawn of the New Everything: Encounters with Reality and Virtual Reality*, conveys the spirit of the people who shaped VR in the 70s and 80s, their passion, and frustrations with a technology that, in the beginning, progressed very slowly.
At the beginning of the book, Lanier sketches the origin of VR, from the birth of computer graphics, which he attributes to Ivan Sutherland, to Norbert Wiener, the father of cybernetics. The latter envisioned a society in which machines and humans would be a unitarian system, and one would coexist with the other and be understood in relation to the other. Lanier ties VR to behaviorists' research; in the 1940s, Pavlov, Watson, and Skinner showed how controlled feedback can induce behavior. A Skinner box, also called 'operant conditioning chamber,' is a mechanism to study instrumental conditioning of animals. In it, most often, a rat or a pigeon was isolated and provided with a lever or button to teach it to use it in exchange for a reward, such as food, or to avoid punishment, such as an electric shock. According to Jaron Lanier, "computers might become powerful enough to run fancier Skinner boxes, more effective, harder to detect, and infinitely creepier [. . .] virtual world technology is inherently the ideal apparatus for the ultimate Skinner's box" (Lanier, 2017, p.60).

The very beginnings of Virtual Reality can be traced to 1963 when Ivan Sutherland wrote his Ph.D. thesis, which included a computer program called "Sketchpad," which allowed a person to directly draw on a screen and solve complicated geometric problems in real-time. In 1969, Sutherland built the first head-mounted display to interact with virtual worlds. His device, the Sword of Damocles, included a pole connecting the VR goggles to the ceiling. Before Sutherland, Philco and Mort Heilig developed stereo and film viewing mechanisms, which do not immerse people so that they could interact inside the virtual environments with the compensation for head movement.

Later, in the 1970s and 1980s, the culture that built VR was divided into what Lanier calls "the hackers and the suits." The hackers were the programmers who made VR, and the suits were the business side of corporate America that ran the companies where the hackers worked. When Lanier founded his own company, VPL, with other artists and scientists, they became the first to produce VR for mass dissemination. Lanier's main ideas span from the technical aspects of how VR works and reflects the human body, like a mirror of its sensory and motor organs, to his enthusiasms and disillusions with it. For example, he tells us that, no matter how much we push virtual systems to become a sophisticated mimicry of our senses, VR will never parallel reality's complexity and beauty.

Throughout the book, Lanier repeatedly focuses on encouraging us to pursue the highest possible technological results and innovation without forgetting that, in the end, the virtual experience will always make us appreciate the world outside the head-mounted display and its intricate beauty. He attributes this to the fact that the human system benefits from hundreds of thousands of years of evolution, and it is as fine-tuned as it can be. Indeed, VR trains us to be more critical of the discrepancies between the virtual and real worlds. He concludes: "Encountering top quality VR refines our ability to discern and enjoy physicality. The reason is that human cognition is in motion and will generally outrace progress in VR. [. . .] humans will become even better natural detectives, learning new tricks to distinguish illusion from reality." (Lanier, 2017, p.50)

Lanier's most compelling and convincing arguments are the ones in which he challenges perceptions and predictions. For example, in the studies of non-realistic avatar representation, which he calls "homuncular flexibility," he places participants in distorted or augmented virtual bodies to see if the brain adapts and conforms. In a study with Bailenson and Won, humans are given virtual tails and asked to use them in specific tasks (Won et al., 2015). These experiments teach us about brain plasticity and adaptability and inspire us to use VR to break away from the real world to discover further possibilities of human cognition and perception.

Lanier emphasizes the importance of imitating only part of the physical world. Just as occurs when we go to a magician's performance, VR should trigger a sense of surprise and wonder. This effect might happen when we disrupt our brain's ability to make predictions of the steps ahead because the virtual world is just shy of what the real world would be. In other words, suspense arises because we cannot imagine what is ahead since our virtual surroundings do not match anything we have seen in the real world.

The following timelines trace the steps of VR narratives from the technological and conceptual aspects, and VR for behavioral health and prejudice reduction.

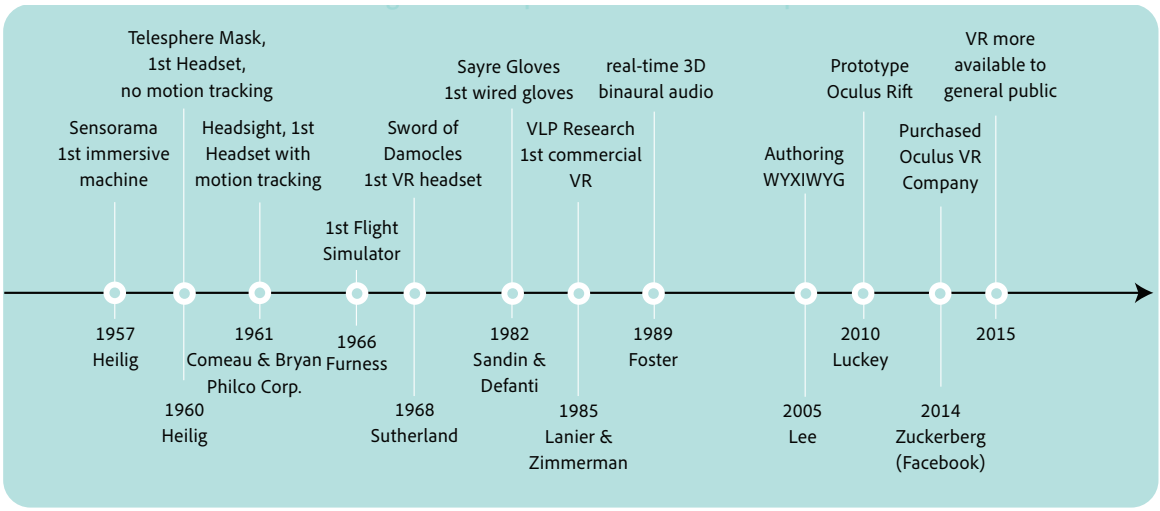


Fig.6. The technological development of interactive narratives.

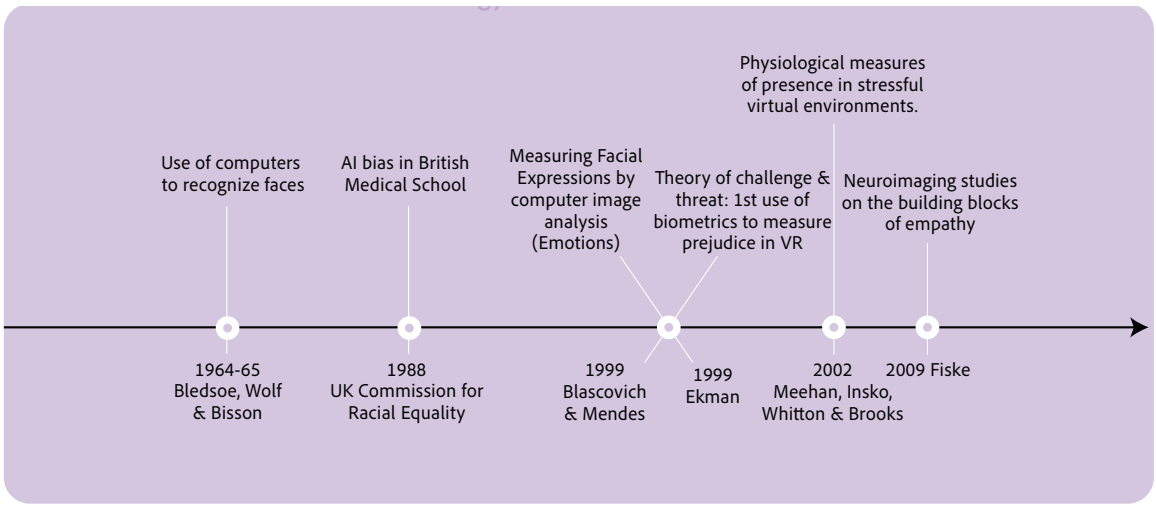


Fig.7. The history of the use of technology to measure emotions.

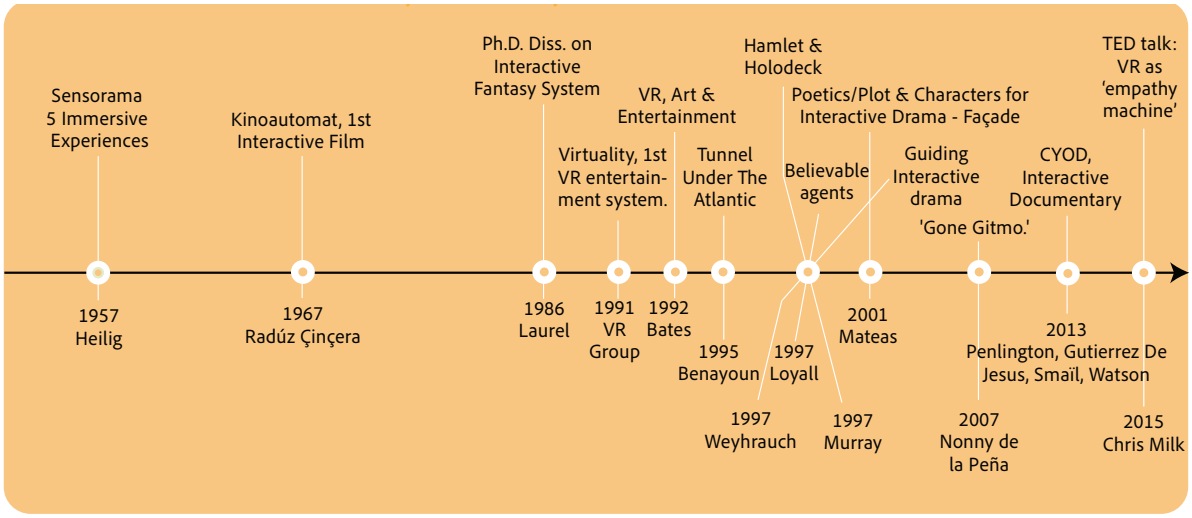


Fig.8. The history of interactive narratives.

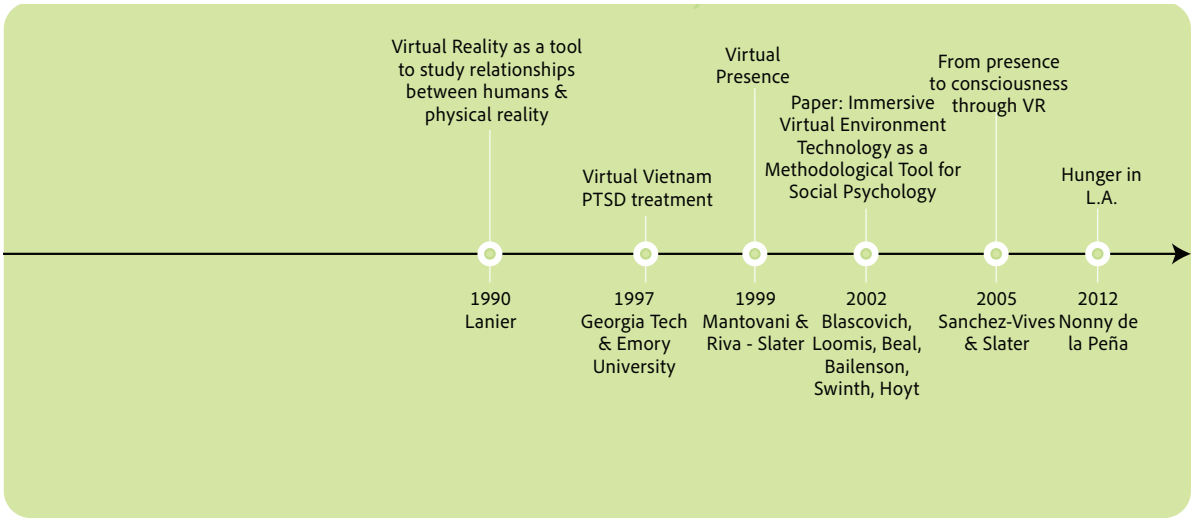


Fig.9. The history of the use of VR for the study of perceptions.

C. Making Virtual Reality Worlds

Nonni de La Peña and Christopher Milk's work has relied on photorealistic representation because their medium is film.

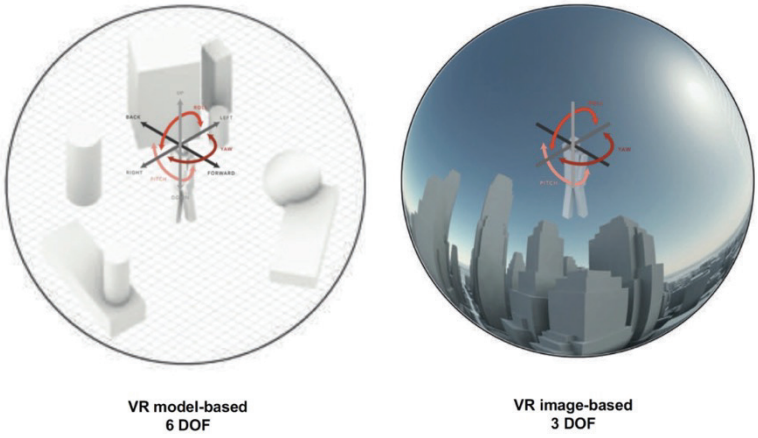


Fig.10. Degrees of motion in model-based VR (left) and image-based VR (right)

In 360° video, a special camera records an image in every direction viewable by the human eye in the scene; those images are stitched through software applications within the camera or after the shoot and projected on a digital sphere to create a panorama so that in VR the viewer can turn around and see the world in all directions as it would occur in the physical world. VR that employs 360° video, in which a two-dimensional equirectangular image (width to height ratio 2:1) is projected on the three-dimensional model of a sphere, is limited by photo-realism and reduced motion (3 directions/degrees of freedom). VR that employs 3D-generated models of characters and environments allows for motion as in the physical world (6 directions/ degrees of freedom). VR holds a set of characteristics that have a unique presence in VR: immersion, agency, interactivity, embodiment, and presence or creates belief.

Immersion, which we know from when we are metaphorically immersed in a great book, movie, play, music, or performance, has a very literal meaning in VR. It points to the fact that, inside virtual worlds, the participant of the experience is fully surrounded by the projection of the 2D equirectangular images on the 3D digital sphere (for image-based VR) or by the digital 3D models of the space and characters. Immersion in VR indicates that the participant is in the center of the virtual space, and the senses are saturated by the stimuli (visual, aural, haptic, etc.) presented by the digitally constructed environment.

D. Building Virtual Narratives

Through stories, we communicate some of our deepest memories and feelings. Through stories, we create deep personal connections with others and emotive bonds that unite us as human beings.

In his 2013 book *Narrative*, American Professor in Language and Media at Middlesex University, Paul Cobley differentiates "story" and "narrative." The first is the succession of events, and the second is the meaning attributed to those events and knowledge earned by understanding them. Traditional film narratives are an unfolding series of pre-scripted events shown to a passive audience. Agency and interactivity have radically changed the audience's role from passive observer to active contributor. The spectator of the traditional film is the actor and the maker, who defines the immersive experience's meaning. One of the reasons for Lanier's neglect to approach interactive narratives is that creating true VR cinema is exceptionally challenging.

VR experiences can take participants into a narrative that touches them at a surface level and at the deepest unconscious level, where they hold mental models of reality and make predictions and judgments that drive behaviors. Recently, VR has made it possible to create immersive experiences where learners live a coherent narrative that allows them to shape the story's events through their actions. In this case, the VR experience's participants decide the events.

In this interactive mode of storytelling, the VR movie director creates situations that demand that the participants and actors influence and complete the story. This process complicates the conception and construction of the story for the maker; on the other hand, it enhances the actor's perception and fruition because the sense of presence and the ability to decide the direction of the events convey power and agency. In terms of implementation, the traditional visual narrative, as in a feature film, is built through scripts and storyboards in which the maker determines how to "see" and frame the scene; the director chooses the characters' actions based on the desired outcomes.

In a VR interactive narrative, the maker has no control over how the scene is viewed and what the actors will decide to do. Several possible outcomes must be constructed, one per each of the potential actions chosen by the participants.

In his paper *Interactive storytelling in V.R.: Coming soon?*, Andy Deck focuses on interactive storytelling in VR and makes clear the crucial difference between video-based and model-based VR: "In true VR, the camera's point of view is identical to the spectator's point of view, and that's not how movies have worked since the 19th century. Letting the spectator aim the camera is a radical change in the orientation of cinematic content." (Deck, 2019, p.429)

A brief history of VR documentary traces its mass consumption back to 2015 when the *New York Times* mailed Google Cardboard VR head-mounted displays to its customers so they could view *The Displaced*, an emotionally charged documentary of children's displacement due to war. Before that event, VR documentaries were created to show reconstructions of ancient historical sites, anatomical explorations of the human body, and astrological voyages.

The difference between VR documentary, always created with 360-degree videography, and "true VR film" is paramount, as highlighted by pioneer and filmmaker James Cameron: "What most people are calling VR right now isn't VR, it's an omnidirectional camera. Moreover, because you don't really have any spatial control – any spatial movement is baked in – you [only] have the ability to look around in an environment, and that's not true VR. [In] true VR, you can move around. And you have a lot of control over where you are spatially in the environment." (Deck, 2019, p.429)

Other prominent VR applications with a high degree of interaction are video games, and immersive social media, and VR cinema. Recent examples of VR films are *Cycle* (Disney, 2019), *Arden's Wake: Tide's Fall* (Penrose Studios, 2018), and *Pearl* (Patrick Osborne, 2016). All of these share the limited ability to move because the omnidirectional camera is a significant challenge in VR film. For example, in *Pearl*, the protagonists are inside a mov-

ing vehicle, and only head movements occur. To overcome this challenge, some directors elect to constrain the participants to an "on the rail" point of view or use other techniques, such as a "shark cage," a box that shows up only in the VR view to indicate the boundaries of the possible motion (Deck, 2017). Another significant issue arises from the fact that VR film requires the creation of all the two-dimensional and three-dimensional assets in the film as computer-generated imaging (CGI). This separation from capturing the physicality of the physical world grants us the ability to fully control the content and immerse the participant in a pre-determined setup with no chances of surprises. Also, it challenges us to figure out the appearance of every detail in that world.

Andy Deck proposes a new way of telling stories, which defines VR artists and designers' boundaries and agency. The VR experiences analyzed in chapter four are examples of this kind of interactive storytelling, in which the VR participant constructs the story's meaning and outcomes:

> Under these circumstances of virtuality, where the camera's point of view becomes the spectator's, the discipline of cinematography disappears. This subtraction represents a loss of control for the storyteller [. . .] The visual language of editing and camera angles is overcome by unknowns. [. . .] Such indeterminate conditions for aiming and framing make it very difficult for a director to anticipate a spectator's visual experience of a story. (Deck, 2017, p.430)

The participant of the VR experience creates a mental schema based on the director's model of the virtual environment. Reality is first perceived, conceived, and produced by the director, then seen and experienced by the participant.

Since the participants can react to the story and choose amongst different outcomes, they can skip entire scenes that were supposed to occur if they responded differently. Two participants might end up experiencing a completely different story even though they went to the same VR movie.

Virtual interactive narratives are a new genre full of possibilities; at the same time, many would wonder how they are different from games. Indeed, body gestures and eye gaze can control the participant's actions in the VR movie, as well as in games. However, they rely on

technological assets, which can distract the viewer from the story, impede acting inside the virtual environment, and affect decisions.

Fig.11. Methodology for the creation of VR narratives, based on the author's experience

E. Virtual Reality for Learning

The most effective VR learning experiences result from a tightly-knit collaboration between psychologists, computer scientists, visual and user experience designers, and educators. Creating VR environments for learning (VRE4L) applications demands significant funding for high-end technological setups and user testing. In which circumstances is VR the most effective tool for learning? When is the massive undertaking of creating a VRE4L worth it?

Through literature review, this research first introduces VR's strengths and challenges for learning. Then, it paints the state-of-the-art through two review articles focused on an in-depth field examination. They reveal a picture of an immature field where the "makers" lack learning theories to support the VR applications, use inadequate methods to evaluate learning outcomes, and forcibly apply VR to existing pedagogical environments and methodologies. Given the medium's affordances and the challenges with force-fitting VR into traditional and established learning strategies, this paper concludes with recommendations to develop new pedagogical paradigms for VR for learning that capitalize on the medium's strengths and the results of current research.

During the October 24, 2016 *mediaX Sensing and Tracking for 3D Narratives Conference* at Stanford University, professor of communication and founding director of the Virtual Human Interaction Lab at Stanford, Jeremy Bailenson, starts by listing VR's downfalls:

- It creates a distraction from the real world.
- It is an addictive medium.
- Its technological apparatus is uncomfortable to wear for extended periods.
- These characteristics make VR ideal for situations that would be extremely dangerous, expensive, counterproductive, or impossible to enact in real life.

Bailenson's ideology is relevant in VR learning. For example, field trips to ancient civilizations to gain historical insights or explorations of extinct natural environments, human populations, animal species, or inaccessible locations are possible only through VR

simulations. For example, in VR, participants can take an insider look into the human body by becoming a blood cell; in military or medical training, in which VR participants can learn to be astronauts by venturing into space discovery or doctors practicing experimental surgery techniques; in mental health treatment, such as post-traumatic stress disorder, where VR simulations can allow participants to revisit the tipping point that triggered the crisis for healing.

A unique trait of VR that supports learning is the ability to acquire knowledge by practicing complex and dangerous tasks through repetition in a safe environment. Another VR characteristic that facilitates learning is how it may affect memory construction. In a 2020 paper on spatial learning in VR, Pollard et al. conducted a rigorous study comparing three levels of immersion (desktop-based for the low, mixed virtual-physical world through NVIS head-mounted display with supra-aural headphones for the medium, and only VR environment with Oculus Rift head-mounted display with circumaural headphones for the high level) to investigate memory retention of objects in space using a within-subject design (each participant was exposed to all levels of immersion). The learning assessments, both post-experiment yes/no quiz questions, and multiple-choice object recognition questions showed significantly better results for the high immersion condition.

In his 2018 thesis, information science and human-computer interaction expert Yeonhee Cho demonstrated that learners remember words more efficiently when the study occurred inside a VR simulation. Huttner and Robra-Bissantz's 2017 study, exploring the use of VR for memory retention, found a 5-7% test score increase for the VR group. Similar results were shown in the 2018 paper by Krokos, Plaisant, and Varshney. Other studies provided further evidence that immersive VR is more effective than other mediums in affecting the long-term memory storage of target words. For example, Tai, Chen, and Todd in their 2020 paper, and Madini and Alshaikhi, in their 2017 paper, compared video delivery versus VR for learning and retention of vocabulary; Alfadil compared the use of traditional best practices against VR; Urueta and Ogi, in their 2020 paper, show that VR effective for teaching English as a foreign language in different task-based distance learning modalities.

When learning includes situations in which physical or emotional risks can occur, VR is the ideal or only medium to avoid such risks. Awareness of the medium's limitations and challenges when VR is used for learning environments and applications can help us determine which learning environment is most appropriate and effective for acquiring knowledge and promoting critical thinking and which learning theory and domain of expertise are best supported by VR applications. In 2020, Pollard et al. identified the level of immersion as a determining factor affecting learning performance, with higher immersion less conducive to learning. Immersion depends on the hardware's quality and the professionals who designed and modeled the visual representation of the virtual worlds. Without high-end technology and expert designers, the illusion of being inside the VR world, also called "sense of presence," is not achieved, which renders learning in VR challenging.

Lack of visual hierarchy or crowded environments can cause cognitive overload and distraction from what should be the primary focus; low-quality graphics (blurred or out of focus) can cause a break in the suspension of disbelief, and excessive or poorly designed ambulation can trigger nausea.

In 2018, Parong and Mayer showed that the complex nature of the medium could generate extraneous cognitive loads and higher processing working memory requirements that impinge on learning performance. They proposed to remedy this issue by breaking the learning process into smaller sessions (scaffolding) with summary tasks between VR learning modules. Parong and Mayer's research emphasizes the importance of calibrating the cognitive demands and learning outcomes in making VR experiences.

Until now, VR has been used inside existing pedagogical environments and methodologies. Given the affordances of the medium and the challenges with force-fitting VR into traditional and established learning strategies, to fulfill its potential, new pedagogical paradigms for VR are needed to capitalize on its unique characteristics (Lege & Bonner, 2020).

Hamilton, McKechnie, Edgerton, and Wilson's 2021 paper "Implementing immersive virtual reality in higher education: A qualitative study of instructor attitudes and

perspectives" shows the results of a systematic literature survey of peer-reviewed journal articles from 2013 to 2019 that included a quantitative assessment of experimental learning experiences comparing HMD-based immersive VR (I-VR) with less immersive pedagogical methods, such as desktop-based applications. Out of the 12,055 papers identified in the initial database search, 29 fulfilled the authors' requirements of

- Including an experimental trial with two subject groups, one exposed to HMD immersive VR (I-VR), one to less immersive or traditional pedagogical tools,
- Including the use of objectively quantifiable learning outcomes (test score, completion time, and knowledge retention were used to assess effectiveness),
- Includinga population sampled from high schools, higher education, or adult and had no developmental or neurological disabilities, and
- VR was not used as a rehabilitation tool.

The authors categorized the learning outcomes across the experiments in the 29 papers as cognitive, which included studies aimed at teaching declarative knowledge; procedural, which included studies aimed at teaching how to perform a specific task or activity; and affective, which included studies aimed at teaching improvement skills in the arena of attitudes and emotional regulation. The cognitive category benefited from using I-VR, which requires a high level of visualization and experiential understanding. I-VR was highly effective when the subject area was abstract, conceptual, or focused on procedural skills. Only one paper was in the affective category, focusing on behavioral training, and the results showed no benefits from using I-VR.

Overall, a significant advantage of using I-VR as a pedagogical method in education surfaced across most papers; a few were neutral, and only two articles gathered detrimental effects from using I-VR. The authors argued that the novelty of using I-VR technology might affect the effectiveness of the learning experience. Indeed, since VR is rarely used in education, it is challenging to assess its comparison to familiar and established traditional methods such as textbooks or lectures, especially when exposure to the medium is limited. The authors

suggested complementing the VR pedagogy with additional teaching methods, promoting a blended and multi-modal learning methodology. Even though the novelty of the technology might impinge on students' knowledge retention, it also triggers positive outcomes, such as an increase in students' intrinsic motivation to learn and excitement (Tai et al., 2020; Cho, 2018; Kaplan-Rakoski & Wojdynski, 2018; Parong & Mayer, 2018; Velev, 2017; Kavanagh et al., 2017), and engagement with the subject matter (Costa & Melotti, 2012).

Hamilton, McKechnie, Edgerton, and Wilson's assessment of the results of each paper's experiment with the Medical Education Research Study Quality Instrument (MERSQI) resulted in the discovery that the methodologies employed across 29 articles are often inadequate. Moreover, they highlighted the need for learning theories to improve the studies' methods and the theoretical framework, which is supposed to guide the design of educational interventions.

Radianti, Majchrzak, Fromm, and Wohlgenannt's 2020 systematic review paper *A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda* points out that the majority of the articles (68%) lacked declared learning theories. In the beginning, the authors perform a literature review of six existing studies selected out of 59 peer-reviewed papers published between 2009 and 2018 gathered from searching "virtual reality" and "systematic review" and linked to "education, training teaching or learning" in the Scopus digital library. Their research questions are detailed and comprehensive:

- Which types of VR technologies are used in higher education?

- Which research designs, data collection, and analysis methods are used to examine and assess the effectiveness of VR in higher education?

- Which learning theories are employed in VR for higher education?

- Which methods and techniques are employed to evaluate the learning outcomes of VR in higher education?

- Which higher education domains and learning contents employ VR?

- Which design elements are included in VR for higher education?
- What is the relationship between application domains and learning versus design elements and learning?

Overall, the authors identified 18 application domains across 38 articles, showing significant interest in using VR as a pedagogical tool in many disciplines. The authors encourage cautiousness because the papers examined illustrated VR applications that are studied for development, not used in the classroom. Even though a few possible "mature" applications surfaced, such as in safety, surgery, nursing, and astronomy training, the state-of-the-art VR for learning is still experimental.

When looking at which design elements support specific learning theories, basic interaction elements, and photorealism were present in the ten papers aimed at teaching procedural or practical knowledge and eight papers aimed at teaching declarative learning through VR applications. Common design elements appeared in VR applications aimed at teaching communication, collaboration, and soft skills (11 elements), procedural or practical knowledge (10 elements), declarative knowledge (9 elements), and analytical and problem-solving skills (7 elements). The authors did not find specific rules on what design elements support specific learning outcomes.

At the end of the paper, Radianti, Majchrzak, Fromm, and Wohlgenannt propose recommendations for the future in line with the idea of inventing a new VR pedagogy:

1. We must advance the field by gathering consensus on terminology. We can mitigate ambiguity and facilitate learning by agreeing to the meaning of keywords like immersion and realism.

2. Researchers must base new experiments on the analysis of prior ones and aim for results that can contribute to the generalization of the design elements and the learning methods. Research papers with declared and explicit learning theories supporting the VR experiments contributed significantly to advancing this experi-

mental field. A robust theoretical background, which uses prior studies' results as foundational, should inform novel VR applications.

3. Researchers must capitalize on results obtained by using VR in other disciplines and facilitate exchanges and collaborations. The field is immature partially because it has been functioning in an isolated modality, without a broad, transdisciplinary approach and learning exchanges.

4. We must invent better evaluation procedures for VR experiences designed for education. Much of the research on VR for learning has focused on the medium and its usability instead of the learning process and assessing the students' knowledge increase. Quantitative and qualitative methods must be employed to verify the transfer and the quality of the experience. When building VR applications for learning, technical feasibility (hardware and software limitations) and learning outcomes must be coordinated, and the users' needs (students and teachers) must be gathered through surveys and group discussions.

These studies inform this research because it help us identify VR's strengths as a pedagogical medium, such as the fact that it is ideal in situations that would be extremely dangerous, expensive, counterproductive, or impossible to enact in real life and for practicing complex and hazardous tasks through repetition in a safe environment. It surpasses other mediums in affecting long-term memory storage (Cho, 2018), and it also increases learning motivation, engagement, and enjoyment Guan & Cai, 2023). To adapt VR for education we must consider:

- the level of immersion and quality of the visual representation affecting the learning
- the complex nature of the medium, which can generate extraneous cognitive loads, and
- higher processing in working memory, which can impinge on learning performance.

Moreover, researchers and educators must still reach a consensus on a shared vocabulary and define learning theories, applications, domains, and assessment methods best

suited to fulfill VR's full potential as a pedagogical tool.

F. Virtual Reality to Reduce Prejudice

In the '90s, Andy Beall was leading the Research Center for Virtual Environments and Behavior with Prof. Jim Blascovich and Prof. Jack Loomis in the psychology department at the University of California in Santa Barbara. As Renaissance man, he used to say he earned superpowers when he learned to code in Python. His experiments focused on testing people's suspension of disbelief by placing participants in challenging VR situations. The most common was the "walk the plank," in which participants had to pace on a narrow bridge suspended high above a gorge, and then they were asked to jump to test their suspension of disbelief. Most people didn't; they stood still, bolted to the flat physical floor, terrified of falling into the virtual abyss. In those years, from 1999 to 2003, another researcher and faculty in psychology, Jeremy Bailenson, joined the UCSB team; he later founded the Virtual Human Interaction Lab in the Department of Communication at Stanford University and became a VR "superstar."

On the other side of the planet, in the Experimental Virtual Environment for Neuroscience and Technology (EVENT) Lab in the psychology department at the University of Barcelona, Spain, Prof. Mel Slater, computer scientist, and his wife Mavi Sanchez-Vives, neuroscientist, were exploring a very different aspect of virtual worlds. Instead of trying to convince people that they were inside an alternate reality, Slater and Sanchez-Vives aimed at convincing them that they were someone else through testing body ownership illusions and the brain representation, our mental models, of the self. In the EVENT lab, their goal is to change people by making them believe they are someone else so that they can experience and understand the other person's perspective. In a *New Yorker* article, Joshua Rothman introduces Slater and Sanchez-Vives's experiments to create simulations, in which participants inhabit a virtual body and undergo meaningful psychological shifts. In one study, a white participant spends ten minutes learning Tai Chi in the body of a virtual black person. Afterward, "Embodiment in the Black body results in a reduction of implicit racial bias, even 1 week

after the end of the experiment" (Banakouet al., 2016, p.7). This phenomenon can be found in other the experiments (Groom et al., 2009).

A German philosopher of mind and consciousness and VR pioneer, Thomas Metzinger, in the 1990s, was excavating the depths of VR to trigger "out-of-body experiences on-demand" by manipulating our mental models of the self. Metzinger believes that reality is our mental image of the physical world, a virtual version of it. He extended this concept by stating that, just like we build a mental picture of the external world, we also create a mental representation of our self, mind, and body. In 2005, along with other cognitive scientists, he devised a VR experiment in which he watched his own body in VR, unable to reach it and inhabit it (Metzinger, 2005). He called this new area of research "virtual embodiment," a field he explored in depth with Mel Slater and Mavi Sanchez-Vive between 2010 and 2015 through a project funded by the European Union called "Virtual Embodiment and Robotic Re-Embodiment."

In 1996, Giuseppe Riva, Professor of Psychology at the Catholic University of Milan, Italy, created the Applied Technology for Neuro-Psychology Laboratory (ATN-P Lab) at the Istituto Auxologico Italiano, Verbania, Italy. His focus initially was the use of VR and internet technologies for improving healthcare, pioneering a new discipline that he called "Cyberpsychology," which aims to understand how we can employ technology to induce clinical change or personal development and wellbeing. Currently, he is studying how to embed technologies for bettering human conditions into physical worlds, creating what he calls "ambient intelligence" or "Tecnologie Positive per il Benessere (Positive Technologies for Human Wellbeing)."

Nonny De la Peña, an American journalist who has been called "the Godmother of VR" and credited for initiating VR journalism, uses photorealistic computer-generated scenarios or 360° video in VR to depict injustice and societal plagues, such as homelessness, jail confinement, environmental degradation, and more.

An American videographer, Chris Milk, advocated that VR is the ultimate "empathy machine" after showing videos of refugees and their personal stories and receiving copious donations from the viewers to improve the victims' life conditions. VR that employs 360° video, in which a two-dimensional equirectangular image (width to height ratio 2:1) is projected on the three-dimensional model of a sphere, is limited by photorealism and reduced motion (3 directions and degrees of freedom).

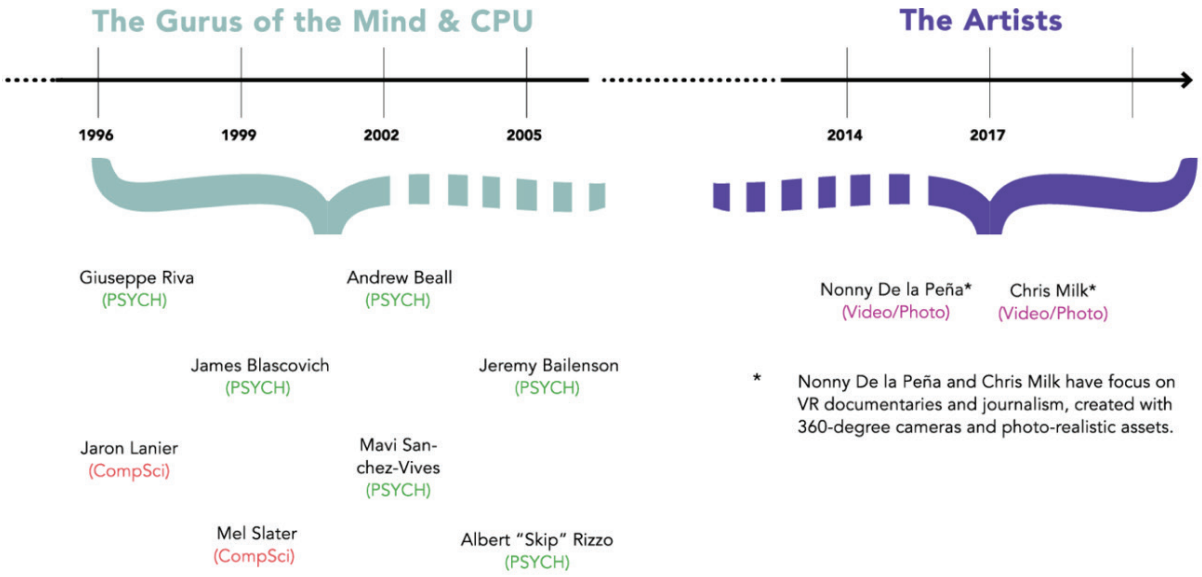


Fig. 12.The lead figures in the history of VR for inclusion.

Several VR researchers claim that, through carefully constructed scenarios, VR can give us insights into how humans create social constructs and become a training tool for behavioral health. Others argue against this theory.

One of these skeptics is Italian psychologist Tiziana Mancini, who just published the book *Psicologia dei Media Digitali* with a pioneer of VR for Wellbeing and Human Health, Professor Giuseppe Riva. Prof. Mancini is an assistant professor in the Humanities, Social

Sciences, and Cultural Industries department at the University of Parma and president of the master's in Social and Clinical Applied Psychology. Her main research topics are the psychology of migratory processes, including identifying individual and social factors that affect the formation and diffusion and analyzing identity processes in virtual contexts with particular reference to the relationships between virtual and offline realities. On October 25, 2023, I interviewed Professor Mancini on topics related to this research, especially VR's potential to be an appropriate medium for bias training and prejudice reduction. I gathered one crucial insight from our conversation. If we want to recreate intergroup contact in VR, we must include inside the immersive experience a strong sense of belonging to a particular group by showing multiple people sharing a common individuality through visuals and actions. Proof of this theory is evident in the field research experiment described in chapters 3 and 4, in which students responded more positively and felt higher levels of compassion when testing the VR experiences that included multiple people of the same group. At the beginning of the interview, the full text of which is in Appendix A, Professor Mancini stated that "Prejudice is a defensive response related to the group we belong to and our social identity. . . to feel like another is difficult in VR because the medium might not allow enough distance from the other to enable you to see that person as part of a group different than yours, as belonging to a different group." She also acknowledged the need and challenge of having a dialog between people from very different fields of expertise and the fact that in current bias training, the choice of story or situation is based on abstract and generalized theory without considering objective, accurate, and concrete contexts.

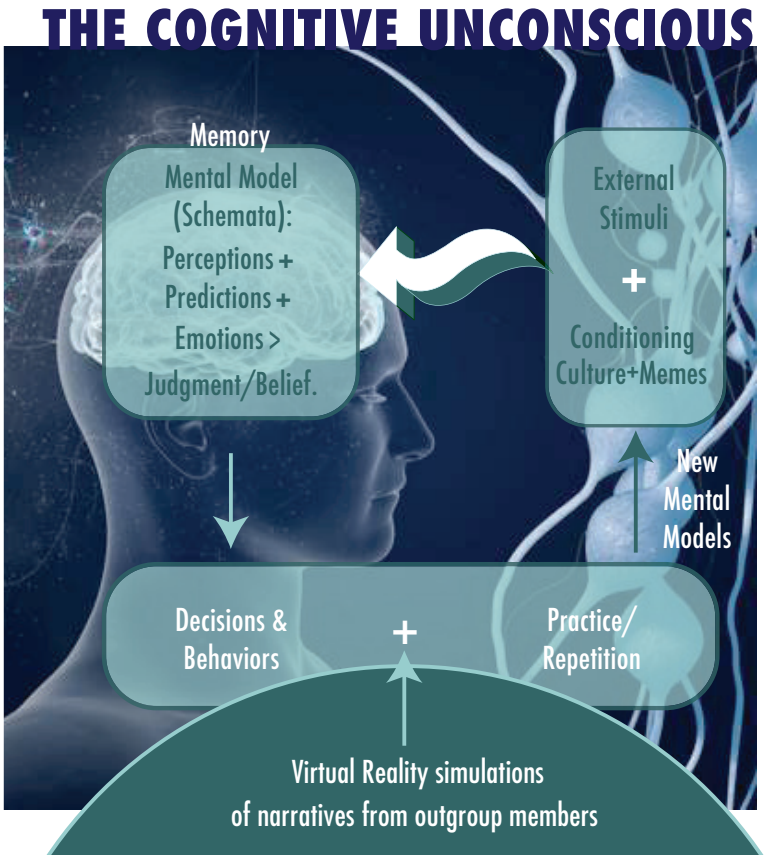


Fig. 13. Employment of VR to alter mental constructs.

G. Virtual Reality Challenges

G1. The Uncanny Valley

The "uncanny valley" points to the uncomfortably strange feeling that arises when a computer-generated character is photorealistic and very close in appearance to a real human but somehow not fully human-like. This effect, which triggers a sense of unease, sometimes repulsion, often contributes to breaking the viewer's suspension of disbelief. This research's hypothesis is that, in social VR, non-photorealistic characters are more conducive to triggering compassion and prosocial behaviors because the risk of experiencing the uncanny valley is minimal.

> [A]nimated characters designed according to a (photo)realist style, rather than stimulating the brain, seem to create further noise and distraction in their immaculate attention to detail. More expressive characters [...], on the other hand, can 'isolate' what is important and focus the viewer's attention on their specific emotional states, making these much more obvious, and therefore easier to engage with.
>
> (van Rooij, 2019, pp.197-198)

In the mirror, a small black child stares back at the viewer. A voice in the background says: "This is Mike Sterling. Wave at him and say hello." The little boy closely mimics the viewer's moves with stiff gestures and no effect. This mimicry is supposed to ignite the sense of body ownership by which the viewer becomes Mike as if the little boy's body becomes a shell for the viewer to inhabit. This psychological phenomenon is called the "proteus effect" (Yee & Bailenson, 2007), by which the user's identity partly blends with one of the avatars they embody. Mike grows into a teenager and then into adulthood. He is victimized, up to an armed encounter with angry coops that pin him down on the sidewalk. This VR experience, *1000 Cut Journey* (Cogburn et al.,2018), conveys little compassion, avatar's body ownership, or sense of presence because Mike Sterling's photorealistic computer-generated model to me has an eerie appearance too far from human to inhabit.

The tech world recognized Masahiro Mori as the originator of the term "bukimi no

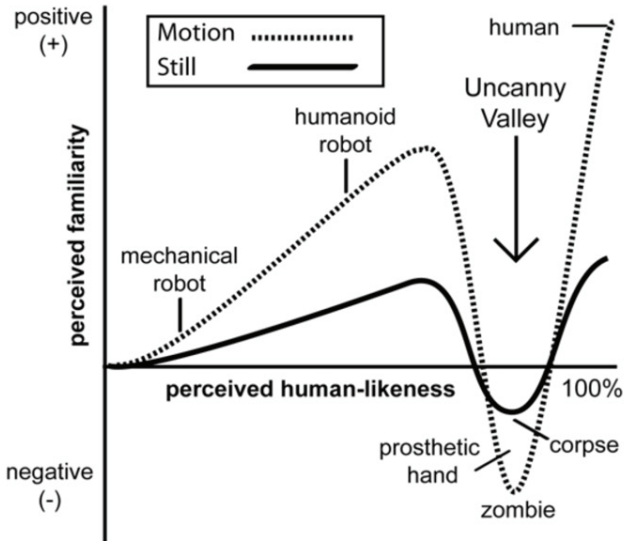


Fig. 14. Graphical representation of the uncanny valley by Masahiro Mori.

tani" which in 1978 was translated by British art critic Jasia Reichardt as the uncanny valley. Two illustrious authors had written about it before Mori. In 1906, the German psychiatrist Ernst Jentsch wrote *On the Psychology of the Uncanny*, in 1919, Sigmund Freud wrote *The Uncanny*. In his essay, Jentsch first blamed the sense of repulsion to uncertainty, which can be characteristic of the world of art. In Jentsch's opinion true art should not replicate nature and living beings because such imitation can cause a sense of uneasiness. (Ernst Jentsch, 1906). Both Freud and Jentsch emphasize the subjective nature of this feeling of unpleasantness, disgust, or repulsion when a digital character is exceedingly human-like, highlighting the difficulty of measuring and defining this phenomenon.

In 2012, the result of a series of studies reported in the paper *Render me real – Investigating the effect of render style on the perception of animated Virtual Humans* confirmed that Cartoon characters were considered highly appealing and rated as friendlier than characters with human appearance when in motion (McDonnell et al., 2012). They were rated as more friendly than realistic styles and therefore might be more appropriate for certain virtual interactions.

While the uncanny valley phenomenon is subjective, with photo-realistic digital worlds, the difficulty of rendering human body language is significant. Unfortunately, artists and designers have refrained from contributing to research in the field, even though an alternative visual representation strategy is needed. Due to a lack of artistic skills, other researchers have made photorealism the standard visual representation method for model-based VR experiences focused on studying prejudicial attitudes and behaviors.

The pioneers of the study of human behavior through VR simulations, Jim Blascovich, Jeremy Bailenson, Andy Beall, Mavi Sanchez-Vives and Giuseppe Riva, all share a background in psychology and cognitive science. Computer scientists, such as Mel Slater, have joined efforts to guide in the technical implementation of the virtual worlds. So far, psychologists and computer scientists have based their work on the assumption that as long as virtual reality mirrors our physical reality, human perception and cognition can be ap-

proached and studied just as they are in the real world. For example, Albert “Skip” Rizzo, the director for Virtual Reality Mental Health (VRPSYCH) lab, part of The Institute for Creative Technologies at the University of Southern California (USC), who has a background in psychiatry and behavioral sciences, has developed a long line of applications for mental health, trauma recovery and education that depict VR worlds and avatars as close to real as possible. Multiple projects at USC are focused on achieving the highest possible fidelity of human faces. *Digital Ira* and *Digital Emily*, for example, are computer-generated perfectly realistic characters. In 2014, the USC Institute for creative technologies developed a suite of technologies and processes, *Rapid Avatar*, to construct a 3D digital character in less than thirty minutes, with no need for artistic or technical expertise. It is increasingly frequent for companies to use apparatuses like Rapid Avatar and opt for photo-realistic characters, that are easy to generate by machines without laborious efforts and risks of human errors.

Even though VR worlds are largely based on visual stimuli, artists and designers have refrained from participating in the experiments, writing papers or searching for solutions in the study of cognition and perceptions. We must design virtual worlds through the experimentation of visual hierarchies and strategies; letting scanners and cameras generate 3D digital characters from real humans in thirty minutes without the need for design experimentation is one possible a solution, but not the only one.

This research is a call for the visual experts to engage in the world of VR, which is still struggling to establish itself as a new medium, sixty years after its invention, possibly due to this absence.

Amongst the hundreds of papers written by psychologists or engineers about the uncanny valley *Expanding the Aesthetic Possibilities for Humanoid Robots*, was written in 2005 by David Handson, one of the few artists invested in searching for solutions. He founded Hanson Robotics in 2002 and has been searching for the best methods for human representation of mechanical creatures. He created a robot called Sophia, who follows her funny and sassy remarks with a delayed smile and a wrinkled nose. Her witty and unexpected assertive-

ness makes us perceive her as endearing and triggers tenderness and affection toward her, despite the clear dome-shaped cover of her mechanical brain. Considering the various disappointing encounters with photo-realistic avatars in VR, I appreciated the fact that Sophia was created by an artist, and Disney Imagineer, who knows the power of wonder, of surprise.

1. In order to avoid the uncanny valley, the level of characters' realism must be matched by the way they move and behave.
2. Avoid "dead eyes." If the hardware used does not include eye-tracking, your avatar's eye will look dead (when looking into a mirror, for example).
3. Stylize your characters: A simplified representation can render the experience more natural and engaging. By stripping back the level of realism we can reach more complexity and sophistication because the realism does not get in the way.
4. Use the uncanny valley effect. Designers of virtual characters can use the uncanny valley to deliberately elicit eerie effects for villains and ambiguous characters. One example of such a villain is Gollum from Lord of the Rings, whose transformation from his former human appearance was even part of the movie's plot.
5. When designing interaction (with non playable characters), proximity and body language are key. We care when others are close to us, the more they are into our personal space the more we react. Body language is a major challenge because mostly occurs at the unconscious level.

VR Character created by the author.

Fig. 15. VR character design guidelines based on the author's experience.
Charater from the author's project titled *Searching for Grace*.

The following case study, DreamWalker, created by the author with a colleague and a group of students, focuses on triggering emotions by experimenting with the uncanny valley effect. The goal is to assess whether users feel repulsed or intrigued by subverted VR worlds. DreamWalker is essential for this research because when the students who playtested the state-of-the-art of VR to foster prosocial attitudes discussed the uncanny valley, they wondered if it could have positive outcomes. DreamWalker is one of the rare and innovative VR experiences in which the uncanny stimulates engagement and enjoyment.

Case Study: DreamWalker: A Surreal Virtual Reality Experience

Authors: Enrica Lovaglio, Gabriella Santiago. Zoe Wood, Zack Ragozzino, Nick Sciaqua, Paula Ledgewood.

This interactive VR experience explores how to trigger emotions in VR by distorting photorealistic familiar environments and the laws of physics, which triggers the uncanny valley effect. DreamWalker is staged inside procedural worlds personalized to each participant, aiming to make participants feel like they are inside a dream while in a lucid state.

The project was built as a part of a two-quarter capstone experience for the Computing for the Interactive Arts minor for the 2018-2019 academic year by a team of four students from artistic and engineering backgrounds and two faculty members, one in the arts, this research's author, and one in the field of computer science. It was developed in the Unity 3D environment using the HTC Vive VR system. Resources used in making the project include free and purchased models found in the Unity store and online, as well as original content developed by the team. Throughout the VR journey, the system generates a series of diverse non-realistic environments to affect the emotional flow of the narrative. As participants delve deeper into a VR environment, they encounter emotions such as fear, surprise, and awe while also confronting unusual ones, such as claustrophobia, arachnophobia, and acrophobia.

The VR worlds are personalized dream states, achieved by populating the three-dimensional assets with photos from the user's Facebook account to simulate unlocking memories from one's past as they would occur within a dream..

DreamWalker is an open-ended experience in which space exploration, narrative creation, and emotions intersect. Inspired by how people might experience dreams, the design aims to balance surrealism and realism. Surrealism seeks to stimulate the unconscious to unlock the power of the imagination, making it the perfect vehicle to develop dream worlds. Unconventional spaces and architectures, such as a forest falling onto the user or an upside-down city, unfold with eye-catching lighting and colors to direct the participant toward points of interest. Game-like tasks, such as collecting items or defeating enemies, are absent

because the motivation for the exploration is the participant's curiosity.

An element that evokes the feeling of dreaming includes a "Follow" script, which causes a creature to follow the participant to trigger anxiety. Flying animals like octopuses, sharks, or butterflies aim to evoke awe or surprise.

Fig. 16. Ocean animals swim inside a forest.

Swarms of insects, such as butterflies or spiders, surround the player, evoking fears like arachnophobia. In dreams, we often experience real-world situations, but combined with elements that do not exist in real life. For example, while exploring DreamWalker's VR worlds, the participant encounters the empty streets of an upside-down city that has been scaled down to make the participant larger, furniture falling like rain on an outdoor open wasteland, and floating doors not attached to buildings that are the portals in between the different dream worlds.

Two components are essential to the final product and drive the VR experience:

- The user explores procedurally generated landscapes, which simulate the visuals people encounter during intense dream states. The participant's choices influence the procedural generation. The interaction with environmental elements triggers changes in the procedural content and emotional tone of the experience.
- Virtual spaces and environments are personalized, which is achieved through populating the

scene with photos from the user's Facebook account. This simulates the idea of unlocking memories from one's past as they would occur within a dream.

DreamWalker was created as an open-ended experience in which space exploration, narrative creation, and emotions blend. For some, it is simply a zen-like walk through surreal environments. For others, it can be a way to confront their feelings or fears. At playtesting, some individuals found the experience terrifying, while others found it exhilarating. The design was driven by observations from the authors' personal experiences with dreams and research about what causes dreams.

The activation-synthesis hypothesis influenced the choice to use procedural generation and randomness. It states that while a person sleeps, their brain fires off electrical signals that randomly pull up old memories. These become the basis for narratives during one's dreams (van der Linden, 2011). This theory encouraged incorporating randomness into the application's generation of the environments so that participants are never entirely in control of how their narrative will unfold.

ARCHITECTURE OF DREAMWALKER

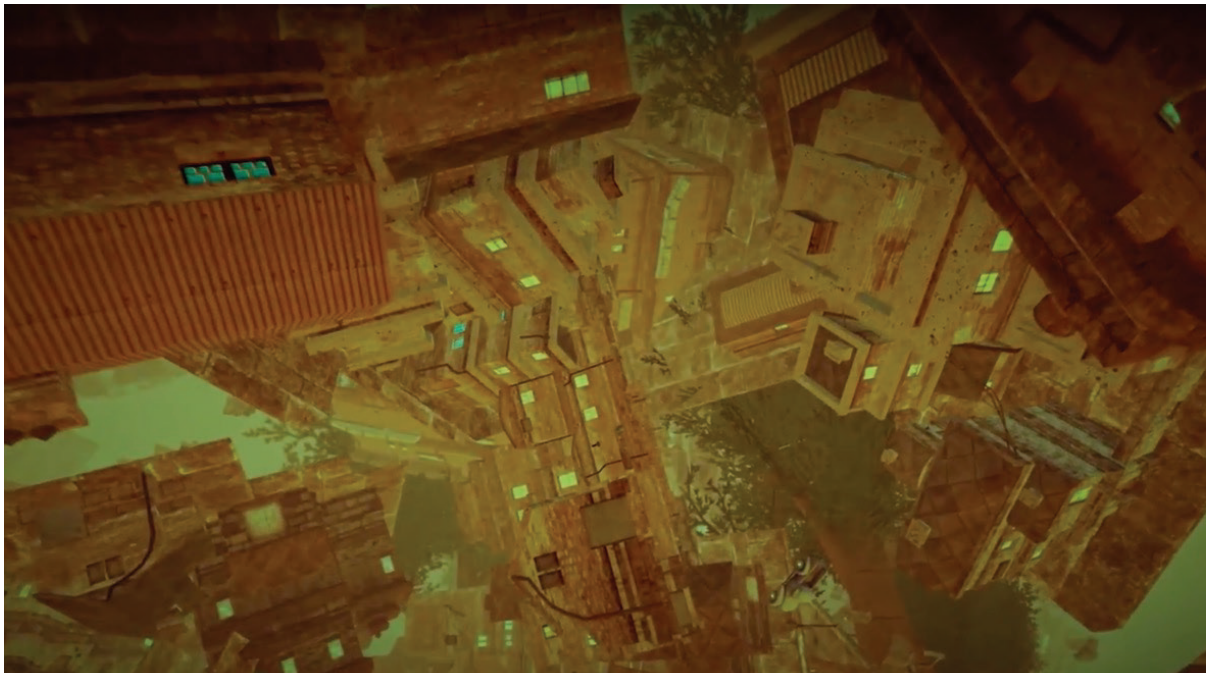


Fig. 17. An upside-down city

The experience starts in an uncluttered and plain room, juxtaposed with the colorful and large-scale visuals that populate the rest of the experience, conveying a sense of safety and easing the participant slowly into the surreal visuals that populate the virtual world later.

The participants can interact with many objects in the room, such as books or furniture. This space gives participants who are new to VR a chance to adjust to the technology without being overwhelmed or distracted by the dream environments and teaches them how to move in virtual space and use the VR controls. After the tutorial is finished, the bedroom walls fall to the ground, and players can have the freedom to explore the world outside as they choose. For each level, portals, in the form of floating doorways, encourage exploration and the making of narratives. When the participants approach one of the doors, it swings open, allowing them to access the next dream space. Every time a doorway is entered, DreamWalker procedurally generates a new environment based on parameters the player is unaware of.

The flow of the narrative changes dynamically: one world might depict a serene forest, while the next is a vast empty desert, an upside-down city, or a landscape with furniture falling from the sky.

Participants were naturally drawn toward the doorways because of the natural associations humans give to such objects, but, differently than doors in the physical world, DreamWalker's doors do not have walls around them and are not attached to any buildings or hallways. Open space is as vital as built environments. These open spaces allow the emphasis on other elements, such as the doorways. Every environment triggers certain emotions. For example, giant redwood trees slowly fall toward the player to instill claustrophobic feelings, and hundreds of animals bounce around erratically like rubber balls for a sense of confusion and disorientation.

While the doors are conducive to transporting the player from one state to the next, the participant can achieve this in other ways. For example, if a bear is encountered, which follows and attacks the player, another dream state is triggered, and a new environment un-

folds. When trees start to fall onto the player, a different environment unfolds again. This act of transporting the player to various worlds is meant to further emulate the fleeting and ephemeral nature of dreams. At the end of the experience, which lasts three minutes, users are automatically transferred to the final stage of the dream: the brightly lit bedroom already encountered at the beginning. The user is dropped into the room, falling for about 5 seconds, and then text appears indicating the end of the dream; from this space, the participant does not have the choice to go into other virtual environments and dream states. This final stage, which connects to the beginning, points to the cyclical process of sleeping, dreaming, and waking up again.

FEATURES OF DREAMWALKER

Elements to evoke emotions include:

- The "Follow" script, which causes a creature to follow the participant and triggers anxiety. This script is attached to several creatures, including a bear that follows and attacks the user.
- Flying animals, such as flying octopuses, sharks, or butterflies, are included to evoke awe or curiosity. It also contributes to rendering the experience surreal.
- Swarms of insects surround the player, such as butterflies or spiders. This particular feature explores fears present in conditions like arachnophobia.

Procedural generation and content creation with random noise are used to ensure that dreams do not repeat throughout the experience. Procedural generation allows randomization and diversification of the content of each dream level by controlling specific parameters. These include properties such as the environment type (e.g., city, forest, flat plains), the density of placement (e.g., how many trees in the forest or buildings in the city), the color palette, and the scale of various elements. Terrain generation and vegetation placement were both based on a literature review of the procedural generation of virtual worlds (Freiknecht & Effelsberg, 2017). Perlin noise is employed to generate grayscale bitmaps randomly (Perlin, 2002). The value of each grayscale pixel directly ties to the elevation of a portion of

the terrain. This same technique is used when attempting to randomly place vegetation and props. A separate grayscale map is generated using Perlin noise, and the data from the map is employed to determine objects' location and type. Instead of using the value of the grayscale texture to control height parameters, the value as an index from a library of assets is selected.

During playtesting, at first, some players had exciting and unique experiences, while others walked through the environments without ever encountering any captivating moments. This is the unfortunate nature of relying on randomness to drive a story. The solution was designing and manually adding a couple of unique and rare environments that a participant might encounter once or twice during a single experience. For example, the buildings in a familiar city environment might appear distorted and rotated in odd directions. The addition of these occasional "directed" moments was important because it allowed for creative control over the flow of the narrative.

Another issue due to the procedural generation was that randomly generated environments of the same kind felt identical. In other words, the algorithm generates a technically unique forest. However, the reuse of 3D assets made distinguishing that forest from a different one generated during another user's experience difficult. This proved that procedural generation only sometimes yields exciting results in making compelling and original spaces. The solution was developing "sweet spots," handcrafted areas of unique and custom assets scattered in the environment for the participants to discover. For example, while exploring the forest, one might encounter a circular clearing of trees with a glowing portal in the center or a large boulder to climb. The incorporation of sweet spots conveys the sense that an artist had crafted each world while still using the power of procedural generation.

PERSONALIZATION OF THE DREAM EXPERIENCE

An essential feature of the experience is the fact that environments are personalized for each user, which was achieved through two different strategies:

- keeping track of the objects the user chooses to interact with. Depending on those objects,

the color of the environment is altered. Each object the participant can interact with is assigned a value, which would either generate a “good” or “bad” dream. For example, if a participant encounters snakes, the tone of the dream turns “bad”, and the world around the player will be tinted red. If a player interacts with a serene clearing in the woods, the dream is “good,” and the level has a greenish tint. As participants traverse each environment, the alternating good versus bad feelings change depending on what the participant chooses to explore or interact with. As participants make decisions throughout the experience, they unknowingly craft their narratives. The flow of the story is completely dependent on the user’s choice in terms of interaction with certain assets in the world.

- provide the feeling of personalized spaces through Facebook integration. Individuals are not required to log into their Facebook accounts, but that option is available. If participants choose to do so, they can experience truly personalized environments where assets show photos of the user’s pets, past events, family, or friends, which are images pulled from their Facebook accounts. Through this method of personalization, the user’s interests and concerns are matched as closely as possible (Lewis, 2014).

Fig. 18. The doors are the portals that allow participants to transition from one environment to the next.

PARTICIPANTS’ FEEDBACK

After refining DreamWalker, playtesting was performed to assess the participants’ likelihood of being nauseous during play, and the duration of the experience, which lasted

three minutes. Fortunately, most of the survey results show agreement with this number.

Playtesting proved crucial because it revealed several issues. The most concerning was the tutorial at the beginning of the experience, which needed to be clarified and revised several times.

People of different age groups responded differently. Younger children, for example, were immediately captivated by the experience and enjoyed it. On the other hand, adults over the age of thirty struggled to maintain interest. This issue was resolved by revising the procedural generation and manually adding custom and interesting "sweet spots" to ensure that there would always be exciting events happening to avoid boredom due to uneventful navigation through the environments.

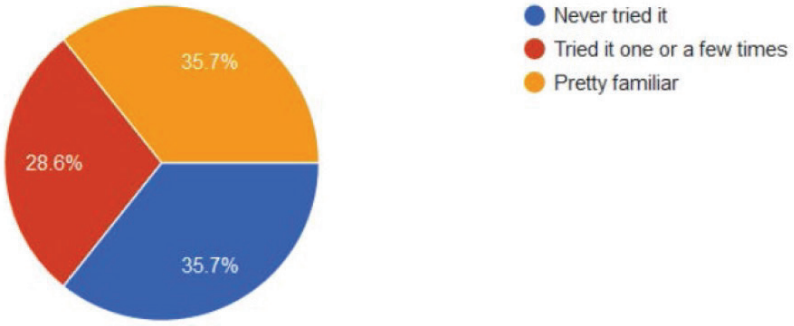


Fig. 19. Playtesting question: "How familiar with VR are you?"

While some slight nausea was experienced among play-testers, most did not find it too debilitating. This was a relief because DreamWalker contained much overwhelming imagery, which could come across as too intense, causing cybersickness. Playtesting surveys showed it was just on the edge of what could be considered a nauseating experience. In the future, testing different ambulation methods would allow for the reduction of motion sickness.

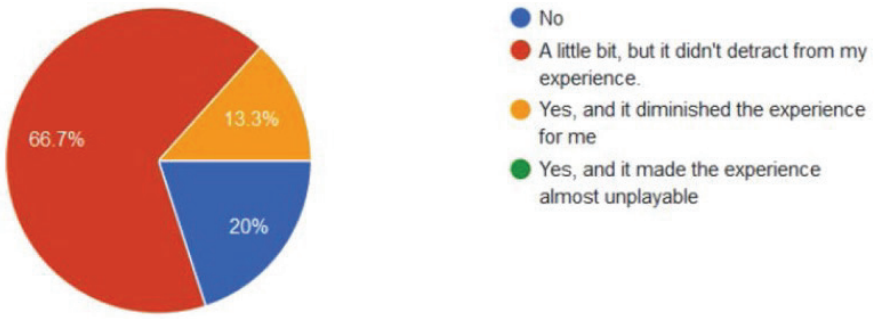


Fig. 20. Playtesting question:"Did you feel sick or nauseated at all during the experience?"

Playtesting involved thirty-eight participants and showed high immersion and engagement during the three-minute VR journey. The post-doc surveys report that nausea was a deterrent for only 13% of the participants, of which 64% never had or rarely experienced VR, and that 100% felt that the personalized dream-like experience was the right length or too short.

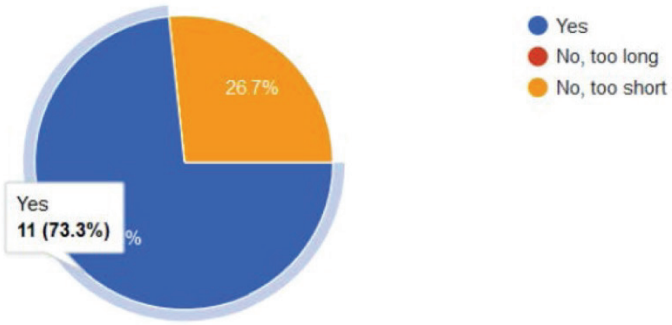


Fig. 21. Playtesting question: Did you feel that the experience was the right length?

CONCLUSIONS AND FUTURE DEVELOPMENTS

DreamWalker explores how VR, procedural generation, and Facebook integration can be combined to create a captivating and personalized experience that people of all backgrounds and ages can enjoy. Future developments include increasing interactivity because,

during playtesting, players try to grab items in the world, expecting interesting things to happen. For example, some would try to pet the animals they encountered and were disappointed to find that the animals did not respond to them. Incorporating interactive elements would encourage participants to explore the environments further and add a playful tone to the experience.

These interactions could also lead to a more personalized procedural generation. By keeping track of which items the participants pick up, the narrative could be customized around what they find interesting. For example, if participants pick up a basketball in the first environment, a basketball court filled with bouncing balls could follow. If they instead pick flowers, the next environment could be a vibrant garden. This would suggest the idea that DreamWalker is a dynamic experience with a "director" working behind the scenes.
The usage of Facebook data was only partially integrated into our final build due to technical issues. Playtester's Facebook photos appeared on cubes that floated in the sky.

Fig. 22. Images from the player's Facebook populate the VR space.

This feature should be integrated more organically in future iterations in the environments. For example, participants could find picture frames on a table with familiar photos from their past when they walk into a house.

G2. Assessement Methods of VR for Inclusion

Initially, the universal assessment method for VR experiments was surveys and questionnaires (in which the study participants produced quantitative subjective data on an ordinal scale based on the comparison of various situations or sensations). It soon became apparent that, in social experiments, it is problematic to employ assessment methods that rely on subjective and qualitative input from the participants, such as questionnaires and surveys. These depend on the accuracy of memories, the subject's awareness of their biases, and willingness to report them. Additionally, they do not accurately capture stress reactions.

In 2004, Mel Slater wrote a paper on this subject, titled "How colorful is your day? Why questionnaires cannot assess presence in virtual environments," which completely changed the status quo regarding the assessment of the experiments. In this paper, he acknowledges that surveys can be used to generate hypotheses before the experiments. Still, he strongly argues against using them as the only post-experiment assessment and as a scientific basis to determine the level of presence in virtual environments. Presence allows for suspending disbelief while inside the VR experience and enables one to perceive the virtual world as if it is real. Slater proves that the simple fact of being asked about the sense of presence is a deterrent that triggers a memory artifact, often leading to a positive response. Slater concludes with "(it's) the use of physiological measures that indirectly capture presence: the argument is that because people experienced measurable anxiety when confronting a virtual precipice, they must have been present (Meehan et al., 2002)" (Slater, 2004, p.492).

Psychophysiological data detection (salivary cortisol reactivity, heart rate, brain waves, and thermal variations) provides a more objective assessment method to identify

human perceptions and reactions on an individual basis (Meehan et al., 2002). Inspired by Richard Dienstbier's 1989 paper "Arousal and physiological toughness: Implications for nental and physical health", in which the author uses psychological responses as markers of challenge and threat, Prof. Jim Blascovich and colleagues pioneered the biopsychosocial model of challenge and threat motivation (BPS-CT), which is a method for evaluating to what extent an individual experiences the psychological states of challenge versus threat in relation to personal resources and situational demands.

Such evaluation is affected by both affective (non-conscious) and cognitive processes. A core tenet of BPS-CT is that the states of challenge and threat result in predictable patterns of physiological changes (Blascovich & Tomaka, 1996; Blascovisch et al., 2001; and Blascovich et al., 2011). In other words, based on this model, the state of "challenge" occurs when performers have the necessary resources, including cognitive ones, to meet the demands of a task; the state of "threat" occurs when they do not have the necessary resources. Full and active engagement is the prerequisite to trigger the psychological states of challenge and threat. Both challenge and threat involve increased heart rate and ventricular contractility. Challenged individuals in this model have increased cardiac output and decreased vascular resistance. Threatened individuals have decreased cardiac output and increased vascular resistance. In simple words, during the challenge state, arteries in the body dilate, facilitating the heart to pump relatively more blood. During threat, arteries constrict, and relatively less blood is pumped despite increased heart activity. In the example of the study of stigma, "challenge" is a positive state in which humans can act pro-socially toward minorities, and "threat" is a negative state because humans are so stressed and in fear that they want to be removed from the situation instead of being prosocial.

Lasana Harris and Susan Fiske's paper, "Dehumanizing the lowest of the low - Neuroimaging responses to extreme out-groups" (Harris & Fiske, 2006), includes another important study of stigma that uses different psychological data as an assessment method. In this paper, new neuroscience data is presented in support of the fact that in extreme cases of prejudice,

we misinterpret or negate the stigmatized person's human traits. These experiments take advantage of subjective assessment methods, such as reporting emotions, and objective methods, such as fMRI scanner measurements.

After defining prejudice as a disliking of a person due to the perceived association with a social group, the authors examine the current stereotype content model (SCM), which differentiates between groups appraised as intending (warmth) or able (competence) to help or harm. SCM includes the definition of emotions toward social groups, which is used to conduct studies to categorize prejudice, especially extreme forms, such as dehumanization. Through examining the prefrontal cortex (PFC) as the locus of social cognition that activates whenever a person is thinking of another person, they conduct experiments to prove that peoples' PFC does not activate when exposed to objects or individuals that they do not consider worthy of being human (dehumanizing effect). During study number One, participants viewed forty-eight photos of people from eight different social groups; in study number Two, eight images of objects were shown. For both studies, one of the assessment methods included the participants rating the emotion triggered by each image between pride, envy, pity, and disgust. Another method was using fMRI scanners for the participants during the performance. The analysis of the brain scans supported the initial dehumanization hypothesis. When participants rated their emotions as disgust for the photos of people from an out-group or the objects, no significant PFC activity was detected.

These examples show that Blascovich and colleagues, as well as Harris and Fiske, devised reliable and successful assessment methods based on the detection of psychophysiological data. The cumbersome equipment and difficulty using it while experiment participants are in motion in VR have prevented us from using these methods. Only very recently have companies developed brain wave detection and eye-tracking devices that can fit and work with head-mounted displays.

One of the emerging themes of recent research is that the brain is malleable and remains modifiable long into adulthood. The neural networks that underlie our behavior pat-

terns can change with experience by modifying the strength of the neural connections. Recent technological advances in biometrics and neuroscience allow accurate hardware to measure human reactions inside immersive experiences. The exploration of human perceptions while immersed in VR experiences has the potential to be a method for a deeper understanding of human behavior and decision-making at the unconscious level. To establish such methodologies, researchers have focused on developing human-machine interfaces that can improve human health, behaviors, cognition, and relations. The emphasis has been on assessing if we can trigger and measure empathic responses to stimuli presented in VR scenarios.

The source of the word "empathy" is Pathos (πάθος), which in ancient Greek means "experience" or "emotion" with the prefix "en" (εν) which means "with." Interestingly, the word "sympathy" also comes from ancient Greek, Pathos (πάθος) combined with "syn" (συν), which also means "with," which might be the reason for the confusion between the two.

Empathy is associated with an awareness of other people's emotional experiences, a lack of having similar experiences in the past, and an attempt to predict how those same emotions affect people and feel the events from their perspective.

Sympathy is associated with the ability to feel commiseration for someone's experience because the person had a similar one in the past and can understand the emotion of the other but does not feel an urge to do something about it. Sympathy stops at the feeling of the shared experience.

Compassion is associated with the desire to take action to help the other person and prosocial behaviors. The more effectively the VR experience conveys the narrative and emotions of the protagonists, the more impactful it is, and the more likely that the VR participant walks away with a desire to do something to better the protagonists' condition.

Empathy can be perceived at affective and cognitive levels. Affective empathy is controversial because it has positive but also adverse outcomes. Fear and distress, for example, can lead to self-centered empathic responses, shutting off the focus on others. Biofeedback

devices can help us assess the quality and magnitudes of affective empathy, allowing us to mitigate negative outcomes by training individuals to control their responses and behaviors.

Biofeedback mechanisms are interactive systems that can measure psychophysiological human responses, record them, and provide real-time feedback to the subject wearing the hardware collecting biodata. These systems have been deployed in serious games, which focus on educational and problem-solving tasks rather than entertainment. Several games have been developed to help people control anxiety by measuring their heart rate and other cardiovascular measures to identify improvement strategies when the real-time feedback system detects it is too high (Azevedo et al., 2017). The case study shown in the next section was developed by the author and a group of students specifically for such a purpose.
In 2010, Blandon et al. created and assessed a game to increase empathy levels in teenage populations. The users, guided by biofeedback, control their stress responses triggered by visual stimuli to cooperate on solving shared challenges.

Brain-computer interfaces (BCI) can also help regulate affect. Neural measures, like brain activation, are converted into computer language and made available to the users to inform them of their attentional, emotional, and cognitive states so that they can strategize to improve those measures once aware of their own empathic arousal and cognitive engagement (Cavazza et al., 2014). The employment of this methodology occurs in the following case study, ANX Dread - A Virtual Reality Experience to Explore Anxiety, which the author created with a colleague and a group of students.

Case Study: ANX Dread – A Virtual Reality Experience to Explore Anxiety

Authors: Enrica Lovaglio, Zoe Wood, Chanelle Mosquera, Ross De Vito, Perry Ting.

This VR experience aims to explore the reactions to stress and anxiety associated with task completion. Participants are in the unfamiliar VR environment of a malfunctioning spaceship with simple puzzle-like tasks to complete. The project was built as a part of a two-quarter capstone experience for the Computing for the Interactive Arts minor for the 2018-19 academic year by a team of five students from artistic and engineering backgrounds

and two faculty members, one in the arts, this research's author, and one in computer science. The experience, built with Unity, includes an integrated heart-rate monitor.

INTRODUCTION

Anxiety is experienced by nearly 40 million people in the United States. Even more concerning, approximately eight percent of young people, children, and teenagers experience anxiety, developing symptoms at a very young age.

Virtual Reality has been shown to be helpful as an assistive technology for users with various physical and mental conditions. Recent work on VR in psychological contexts shows great promise. Rooted in a growing concern surrounding anxiety in young people, this project aims to explore the application of VR in support of furthering studies regarding managing stress and anxiety.

Inspired by projects such as "Injustice," this project follows a similar approach by putting the user in an immersive environment to explore their reactions to anxiety-provoking situations. Specifically, our system was designed to assess users' responses to simple tasks in simulated stressful and fictional settings, namely a malfunctioning spaceship.

THE EXPERIENCE

In this virtual reality experience, the participant must escape a broken spaceship by completing simple tasks. It starts in a dark room where only a large control panel appears with a yellow button, which, once pressed, triggers the control panel to prompt the participant to choose a character to embark on an adventure. When one of the available characters is selected, the ship starts malfunctioning, which is signaled by a stressful series of events: the control room lights turn on, and the only exit door inside the space is broken, as shown by the fact that it loudly moves up and down. A heart rate display (HUD) appears, showing the user's heart rate, and a clock starts counting down from five minutes.

Fig. 23. Soldering task to fix a broken door.

If the clock runs out before the user reaches the end of the experience, it continues to count in negative time, which gives a sense that the experience will never end.

The first task is to fix the broken door. To the right of the door, there is a panel of broken pins with instructions to “Solder the broken pin headers” printed directly beneath it. A spotlight illuminates a soldering iron on the nearby shelf to draw the user’s attention to the tool necessary to solve the puzzle. The user must use the pin’s coloring to trace the correct path of pin headers and fix the door. Once the door has been repaired, the participant enters a labyrinth of long and dark hallways riddled with explosions of sparks and smoke. The explosions are periodic enough to keep the user in a constant state of suspense. Even though the environment does not depict a realistic situation, the participants reach significant levels of immersion and stress, as shown by their assessment during playtesting.

At a certain point, the participant arrives at a fork in the path. Both the left and right options look the same: each a dark hallway leading to a possible exit door lit dimly by a flickering light. Both options lead to the end of the game, but they are presented in this way to give the user the illusion that one unchangeable decision determines the final outcome of the

experience. Before the user can reach the end, the hallway elongates to emulate the “vertigo effect” seen in many movies.

Without instructions, the participant has to discover that every hallway with white lights leads to a dead end, while the ones with a gradient of colors—starting with blue and ending with red—lead to exiting the labyrinth to the outside of the ship, visible through windows, revealing that the ship is floating in space. After the decision is made, the hallway is lit with spinning siren lights, and the user can see a door with a hand scanner at the end. When reached, the hand scanner fails two times before finally letting the user through the door and into the open space outside.

Each failure is followed with a warning that the user must calm down in order to be able to exit the ship. At the end, the door opens, revealing that the user must jump out of the spaceship. Even though the environment does not depict a realistic situation, the participants reached significant levels of immersion and stress, as shown during playtesting.

SYSTEM DEVELOPMENT

ANX Dread was developed in the Unity 3D environment using the HTC Vive VR system. Resources used in making the project include both free and purchased models found in the Unity store and elsewhere online and original content developed by the team. The majority of the assets in the VR environment, including the walls, floors, ceilings, and lights, come from a sci-fi modular pack.

At the beginning of the VR experience, the user can interact with the environment via the in-game “hand,” a 3D model that is mapped to the Vive Controllers. The hands can collide with and grab objects in the environment as the user progresses through the experience. The user navigates the VR environment by holding onto a specific button on both controllers while simultaneously swinging their arms in a walking motion. Collision detection between game elements is used in the soldering puzzle.

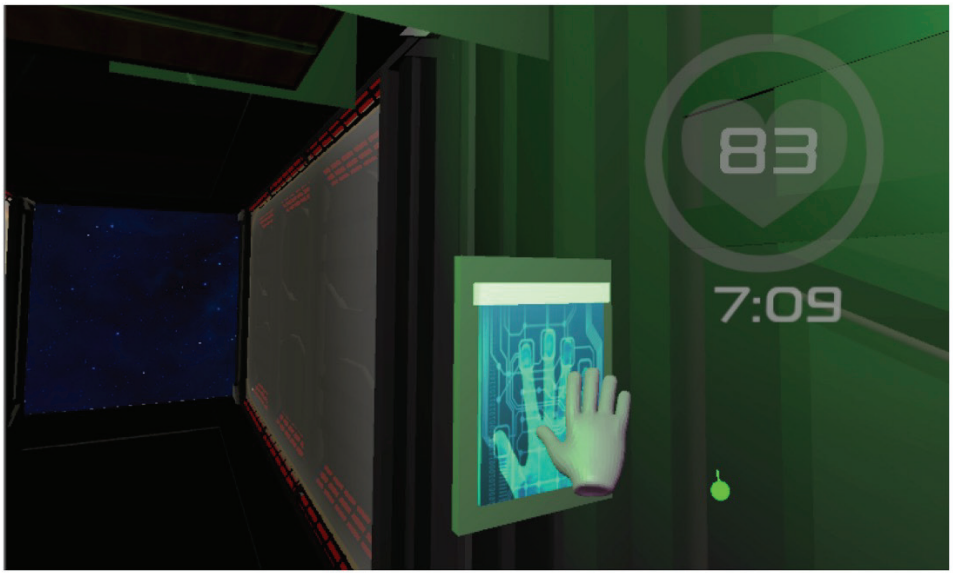


Fig. 24. Heart rate door: Player's heart rate must be below a certain number to progress..

HEART RATE MONITOR

The primary goal of the project was to explore anxiety associated with task completion in VR; thus, a heart rate monitor was incorporated into the experience. The PulseSensor heart rate sensor, developed by Yury Gitman and Joel Murphy, provides biofeedback data to an Arduino Uno. Arduino code was modified for this project to print the current beats per minute (BPM) to the serial port, providing feedback to the Unity VR software. An open-source library called WRMHL enables the system to read data coming in from a specified serial port using Microsoft's .NET Framework 2.0.5.

The VR experience includes a scene change midway through it, the heart rate script needs to be in close communication with the Arduino at the end of the first scene so that it can be reinitiated at the start of the second scene. The Arduino and PulseSensor assembly are harnessed in a fanny pack that is wrapped around the participant's torso during the experience. The PulseSensor, out of the pack, clips onto the ear lobe right underneath the headphones. This setup minimizes extraneous movements that could trigger false readings for PulseSensor. Fig. 24 shows one participant's heart rate recordings throughout the entire VR experience.

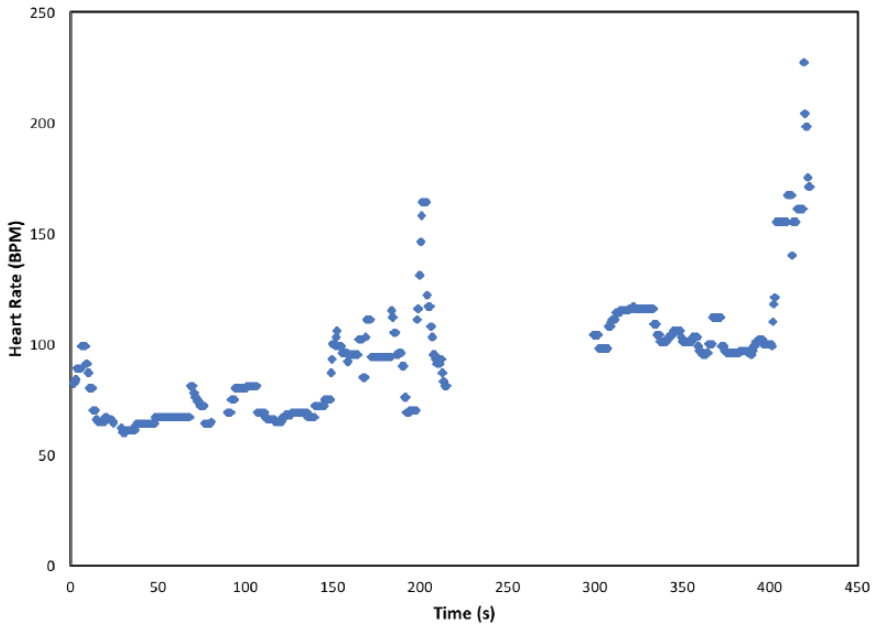


Fig. 25. Heart rate feedback recorded from the PulseSensor for a single participant throughout the entire experience. The momentary break in the flow of data is due to a change of scene when the end of the maze transitions to the extending hallway.

USER STUDY

The study measured the user's speed at completing tasks, heart rate, and self-reported experience via a post-task survey. The main questions in the survey are:

1. Did you experience anxiety while completing the tasks in the experience?
2. Please rate each task/experience from most (5) to least (1) anxiety-inducing:
    a. Spaceship Breakdown
    b. Puzzle
    c. Maze
    d. Extending Hallway
    e. Heart Rate Door
    f. Other
3. Could you imagine this kind of experience helping you practice managing stress?

4. Did you experience any physical sensations during the experience?

    a. Heart Rate Increase

    b. Sweating

    c. Body Tensing

    d. Fatigue

    e. Other

6. Did the heart rate monitor and heartbeat sound cause you any anxiety?

7. Did the countdown cause you any anxiety?

8. Did the sound effects throughout the experience cause you any anxiety?

9. Did the particle effects, the steam clouds, and the sparks, cause you any anxiety?

SUBJECT SELECTION, DATA COLLECTION, AND RESULTS

The pool of subjects included Cal Poly undergraduate and graduate students recruited via in-class announcements and Facebook postings asking for volunteers to participate in a questionnaire/study. No incentives were offered. Investigators observed thirty participants. If participants allowed it, videos of user experience were collected. In addition, a clip-on heart rate monitor was used with participants' permission to record heart rate information throughout the entire experience.

Of the thirty participants in the user study, a little more than half (56.7%) reported that they had used VR prior to the ANX Dread experience. In terms of measuring users' anxiety responses, we found the "Maze" component to be significantly more anxiety-inducing than most other components. Specifically, we conducted a one-way ANOVA between subjects to compare the effects of the VR experience on anxiety for participants' self-rated anxiety levels ($N = 28$). With these metrics, the maze condition stands out in comparison to the various tasks in the experience ($F(4) = 3.69$, $p < 0.01$). There was a significant difference in mean anxiety between the "Maze" condition and the other conditions, specifically: "Spaceship Breakdown" ($p = 0.0184$), "Soldering Puzzle" ($p = 0.0348$), and the final "Heart Rate Door" ($p = 0.0184$).

	Spaceship Break Down	Puzzle	Maze	Extending Hallway	Heart Rate Door
Spaceship Break Down	1	0.9996	**0.0184**	0.4385	1
Puzzle	0.9996	1	**0.0348**	0.5749	0.9996
Maze	**0.0184**	**0.0348**	1	0.6436	**0.0184**
Extending Hallway	0.4385	0.5749	0.6436	1	0.4385
Heart Rate Door	1	0.9996	**0.0184**	0.4385	1

Fig. 26. Results from one-way ANOVA between subjects to compare self-rated anxiety levels in participants (N=28). This chart compares each condition providing the given p-value.

In addition, posthoc comparisons indicate that the mean self-reported anxiety level for the "Maze" condition (M = 3.79, SD = 1.07) was significantly higher than the mean level for "Spaceship Breakdown" (M = 2.75, SD = 1.32), "Puzzle" (M =2.82, SD = 1.28), and "Heart Rate Door" (M = 2.75, SD = 1.40).

	M	SD
Spaceship Break Down	2.75	1.3229
Puzzle	2.8214	1.2781
Maze	3.7857	1.0666
Extending Hallway	3.3214	1.2188
Heart Rate Door	2.75	1.4044

Fig. 27. Mean and standard deviation for level of anxiety in each challenging environment.

Based on the answers in the survey's physical sensations sections, the common side effects of anxiety-inducing components were heart rate increase, body tensing, and sweating.

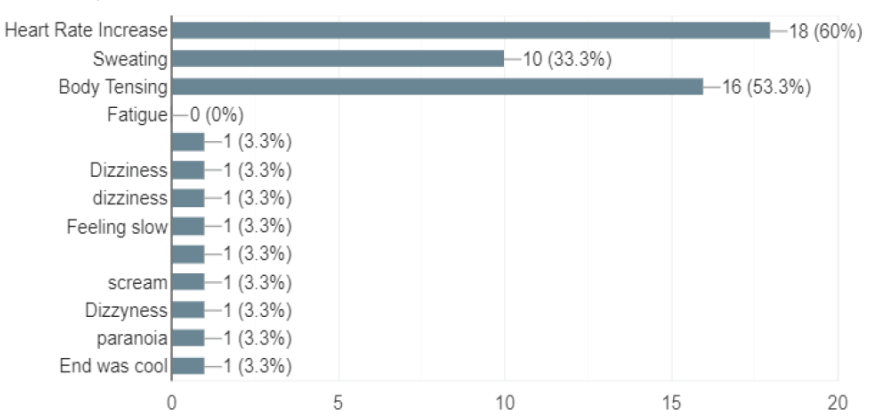


Fig. 28. Physical sensations reported through questionnaire responses.

As shown in Figure 27, 60% of users report feelings of a heart rate increase. Fig. 25 shows one user's heart rate data, collected via Arduino and pulse sensor, displayed over time

as they completed the experience. Data shows an increase in heart rate from the participant's resting heart rate. During the initial "Crash" portion of the experience, users had an average heart rate of 96.67; during the "Puzzle" portion, participants had the lowest average heart rate of 96.39; during the Maze portion, they had an average heart rate of 97.12, and during the "Hallway" portion users had the highest average heart rate of 99.07.

A Fitbit Versa was employed during the initial testing to validate the heart rate data obtained by the Arduino and PulseSensor. Comparing the Arduino and PulseSensor data showed that the PulseSensor displayed issues during sudden movements, which caused spikes in the data, making certain portions of the data unreliable. As seen in Figure 25, the heart rate is over 200 BPM at the end of the sample because the participant removed the PulseSensor after the credits started to roll. Although there were outlying spikes in the data, the overall trend of each participant's data seems to reflect how they actually felt while in the experience.

G3. Ethical Considerations

The ability to trigger a strong sense of presence, which is the perception of being inside a VR simulation, has been touted as one of the assets of the virtual medium. Over the decades, researchers have studied this affordance and employed it in various applications, including healing psychological disorders. In 1997, the experience *Virtual Vietnam* was created to heal veterans from Post-Traumatic Stress Disorder (PTSD). After treatment, patients had 34% less clinician-rated symptoms and 45% less self-rated symptoms. Since the 1990s, hundreds of studies have been developed to test VR's sense of presence and if it is conducive to generating suspension of disbelief capable of eliciting emotions such as empathy, sympathy, and compassion. Scholars and artists have promoted their VR experiences as fully capable of generating emotions even though no objective methodology exists to assess the occurrence or intensity of emotions in VR. In a 2015 TED talk, Chris Milk defined VR as the *Ultimate Empathy Machine* after gathering large donations for Syrian refugees from an audience of wealthy donors who visited a refugee camp inside a VR simulation. The TED talk generat-

ed much research and followers but also controversy, with many researchers opposing such a position and arguing the ethical validity of the practice of building VR empathy-inducing experiences. A few of these experiences are *Hunger in LA*, by American journalist Nonny de la Peña in 2012, *1000 Cut Journey* (Cogburn et al. 2018), "Carne y Arena," by Mexican filmmaker Alejandro González Iñárritu in 2017, *Becoming Homeless: A Human Experience* (Ogle, Asher, Bailenson, 2018), *I Am a Man* by designer Derek Ham in 2018. These share distinctive traits: the immersion aims to make the participant feel in the shoes of a marginalized and victimized person., the use of the first person perspective heighten the sense of reality and embodiment, and the depiction is highly photorealistic. This emphasis on creating virtually real simulations has significant consequences. The effort toward realism is misleading because it gives the sense that the events are in the real world and true, not constructed and manipulated by the director of the VR experience.

In their 2018 paper, Ramirez, Elliot, and Milam, argue the ethics of using VR as an empathy nudging tool due to the risk of instilling false beliefs of the meaning of being someone else, which end up becoming part of our moral framework, influencing judgments, decisions and behaviors (Ramirez et al., 2018).

People's decision-making processes are dictated by their needs and desires and by the stimuli provided by their environment. In the case of VR experiences aimed at putting a player in the shoes of a victimized person to allow them to understand a different perspective, the aim is educational, providing VR environments and scenarios to deepen the understanding of another person's condition, which could reveal our own biases. This grants the need for accuracy and truthfulness in depicting people and situations.

In model-based VR aimed at nudging the user toward or away from certain perceptions and behaviors, the director of the experience chooses every detail of the virtual context, influencing the users' decision-making processes, their actions inside the VR environment, and out in the world afterward based on the moral hints perceived during the experience.

In light of past research showing that users identify with their avatar, the body they

inhabit in VR (Won et al., 2015), giving them the ability to feel what it is like to be someone else, the issue of accuracy of the depiction of the avatar's identity and condition magnifies to avoid the risk of misleading the user. Empathy-nudging VR experiences hinge on perspective-shifting and making the users feel "in their shoes" or as if "they are someone else." This process implies that the user connects to their avatar by taking on their traits in appearance while remaining conscious of being different. Most VR authors have assumed that to be accurate and truthful, the visual depiction must be photorealistic despite research showing that the uncanny valley and technological limitations render it impossible to reproduce our physical world precisely. That assumption implies that a virtual environment that is almost like the real world is enough to make the user believe the virtual scenario is like it would be in the physical reality, providing perceptions as in our physical world. Moreover, every person's internalized concepts, moral values, and biases significantly differ. Hence, each individual will perceive the VR experience's content differently. The photorealistic depiction, the almost real VR characters and situations cannot produce unequivocal results given the significant cultural and social differences and modality of perception and meaning attribution between people. Considering the high costs of VR experiences, the fact that photorealistic representation is not accurate, the unlikelihood of producing the set outcomes due to individuals' differentiation of perception, and the ethical implication of possibly misleading the public to believe these VR experiences lead to unified responses, can we justify the investment?

This research proposes the use of art-based representation and narrative construction in VR because, just as in cinema, in which we identify with characters both through film and animation, it does not carry false assumptions and employs storytelling, which is one of the most ancient and established forms of social connection and sharing. Moreover, in VR, a well-executed animation with compelling art may give users a higher level of enjoyment, keeping them engaged while providing information and education on the condition of the victimized person at the center of the experience.

H. Embodied Cognition and Strategies to Reduce Prejudice

The concept of embodied cognition, by which mental activity is intended to extend to our entire being, is relevant because, in VR, the senses other than sight are diminished, limiting our cognitive capacity.

Neuroscientist Antonio Damasio proposed the concept of embodied cognition. In his recent book, *Feeling & Knowing: Making Minds Conscious*, Damasio states that feeling is the bridge between bodily sensations and the workings of the conscious mind, which unravels as a stream of images. These images are associated with an owner's perspective, a self (subjectivity) who has feelings, internal (mental) and external (physical) perceptions, and cognitive tools.

The understanding of the formation of discriminatory bias or stereotypes, how they are stored in our memory, and which mechanisms are available to lessen them are essential because this research aims to guide how to design characters, worlds, and stories that are conducive to triggering bias awareness, compassion, and prosocial behaviors.

In 1979, Allport defined stereotypes as exaggerated beliefs associated with a social group. Recent studies on learning, cognition, perceptions, and behavior explore how humans create mental representations of stimuli; a multiplicity of complex factors, including cultural influences and memory, play a role in this process. Mnemonic systems, affected by our perceptions and imagination, store for us the passing perceptions from a rapidly changing environment. Memory is a reconstruction of reality, an imaginative process, not a reproduction, an exact process.

In his 2005 book *The Ethical Brain*, Michael Gazzaniga writes that humans react to events at an instinctive and subconscious level; the brain interprets that reaction encoding it as a belief that guides our action. Moreover, he explains that when uncertainty is involved, the brain has a set of pre-determined reactions to specific situations, deriving an educated guess from past experiences. The left-brain hemisphere interpreter, a term coined by Gazzaniga, makes up stories and beliefs based on the input received from the world and assumptions

derived from prior knowledge. Humans hold on to those beliefs against the evidence of reality and deliberate, analytical, and logical thinking The connection between perceptions and predictions is another case of our brain inventing stories based on repeated past experiences. Our brain does not treat each event as a new cognitive task; instead, it estimates probabilities derived from what repeatedly happened during past experiences to reduce workload and processing time. Perception is often associated with awareness and with a conscious experience (Gazzaniga, 2005).

The definition of perception is a complex one. The Cambridge Dictionary, for example, lists four meanings for it: one concerning "belief," one "awareness," one "sight," and one "business." The American philosopher Fred Dretske, in *Perception Without Awareness*, argues that perception without awareness is the rule rather than a disputed exception to the rule. After exploring conscious versus unconscious and direct versus indirect perceptions, he concludes that humans have difficulties retaining information which are perceived at the conscious level. (Dretske, 2009)

Kahneman and his brilliant collaborator, Amos Tversky, studied the errors that arise from prediction and judgment. In their 1974 paper *Judgment under Uncertainty: Heuristics and Biases*, they prove that humans, when faced with uncertainty in complex situations, make up stories, which are illusions rooted in our memory. These replace more probable and tangible outcomes. The authors argue that predictions and assumptions generated from past experiences diminish our future possibilities and that humans' perceptions of a scenario become the only possible interpretation because people tend to favor maintaining beliefs from their perception over even contradicting evidence. (Kahneman & Tversky, 1974).

In their 2019 book *The Enigma of Reason*, scientists Hugo Mercier and Dan Sperber explore this tendency to retain information that supports people's beliefs and rejects what contradicts them. This human propensity became known as the confirmation bias.

Error minimization in our behavior is a crucial aim for the prediction mechanism. As soon as we perceive a stimulus or a situation, our brain performs a memory scan of past sim-

ilar incentives or events and decides on a course of action that most likely will "protect us" from harm. This mental scan includes cognitive biases, which are mainly culture-dependent; for example, when we think of bread, we instinctively associate butter with it, and a chair goes with a table. These associations would not have occurred in ancient Japan, where bread or tables were rare.

Our behavior considers the constant changes in the environment surrounding us, including the actions of others. Our predictions are based on the input of working memory, a short-term cognitive system responsible for temporarily holding information. Working memory involves different functions located in different parts of the prefrontal and frontal cortex. Lhermitte's syndrome is an example of dissociations between conscious intentions and decisions carried out from working memory structures; it involves "an excessive control of behavior by external stimuli at the expense of behavioral autonomy" (Bargh, 2005, p.47). In this case, priming, which is the activation of a specific representation in memory just before action, is the driving force behind behavior. In priming, just like in hypnosis, the will is controlled by external stimuli. Here again, consciousness is not a crucial factor in cognition; the unconscious driver in our brain, the neocerebellum, initiates our actions as a reflex. Social psychologist Daniel Molden explains this mechanism in "Understanding priming effects in social psychology: What is "social priming" and how does it occur?."

"The mere exposure to socially relevant stimuli can facilitate, or prime, a host of impressions, judgments, goals, and actions, often even outside of people's intention or awareness" (Molden, 2014, p.3). Various studies on priming show that we can rationally manipulate unconscious bias: "Implicit racial bias is lessened after subliminal exposure to counter-stereotypes – faces of popular celebrities of that race." (Sapolsky, 2018, p. 418)

Differences in electroencephalographic (EEG) responses showed that the stigma reaction lessened if participants unconsciously felt that they were drawing a person of a different race toward them – "if they were pulling the joystick toward themselves (versus pushing it away)." (Sapolsky, 2018, p. 419)

Another strategy to lessen discrimination is perspective-taking because participants are primed to take the role of the "Them" and feel their discomfort. Virtual reality is an ideal tool for perspective-taking because the experience participant inhabits a digital other.

Making implicit bias explicit can help increase awareness of certain behaviors and activate mechanisms that can mitigate the tendency to discriminate. The chameleon effect focuses on mimicry to trigger positive feelings. Lastly, contact theory, proposed by psychologist Gordon Allport, brings Us-es and Them-s together with a common goal. The efforts to achieve the desired goal will unite the two groups, reducing competitive instincts and negative associations.

The following are the other theories informing this research:

1 Conscious will and awareness are not the main drivers of our actions and other higher complex mental processes. We act at the unconscious level based on our perception of reality and cultural conditioning.

2 Our brain unconsciously creates mental models and stories derived from internal and external stimuli. These stories become the framework of our beliefs and culture.

3 Our brain's left hemisphere contains a region devoted to making sense" of our perceptions; this process is automatic and might result in inaccurate conclusions.

4 Predictions and judgments occur at the unconscious level and are the framework of our cognitive biases, including discriminatory biases.

5 Once a judgment and belief take shape, humans tend to hold on to it at all costs.

6 Our imagination tends to oversimplify situations, warping reality.

7 Our brain is not made to retain the details; instead, it captures the gist, categorizes and labels an event, and moves on to the next stimulus to encode in memory.

8 Errors arise because the memory of past events biases the interpretation of incoming information.

9 Biases are ingrained, unconscious human reactions, automatic activation of the amygdala and insula.

10 We cannot change our innate tendencies to dichotomize Us versus Them, nor would we want to, since group validation, which is the core of our sociality, gives meaning to our life.

11 Disgust is an active driver of the "them" perception.

12 When uncertainty is present, our brain has a set of pre-determined reactions to certain situations; it makes an educated guess based on past experiences.

13 Perspective-taking can lessen negative attitudes toward people of different groups: Repetitive perspective-taking practice of inclusive behaviors might trigger instinctive reactions (mental models) to avoid negative associations toward "them."

I. Cognitive Learning

Our brain constructs mental models of reality based on the representation of the context surrounding us. Societal and cultural structures, biological and physical stimuli, psychological conditioning, past experiences, and instincts, such as pain avoidance, drive our perceptions and make up our reality.

Our culture constantly changes, making our brains continuously adapt those mental representations based on cultural and societal pressure and progress. Culture provides the starting point in the knowledge of reality and shared intentionality; our brain and the constant adaptation of our cognitive capacity to changing physical and societal conditions determines our survival and progress.

Cognition is the mental action or process of acquiring knowledge and understanding through thought, experience, and the senses. Philip Johnson-Laird, in his 1980 book *Mental Models* strongly advocates that people act, or better yet, react to the world's stimuli, not by applying logical rules, but by tampering with their mental representation of reality.
Mental models or schemas are cognitive tools that help us organize and interpret stimuli and their implications so that the vast amount of information in the external world and within us is easily comprehendible. British psychologist Frederic Bartlett used schemas in learning

theory, but the term was first introduced by Jean Piaget, who applied it to childhood development. For Piaget, schemas are categories of knowledge and the processes of acquisition of such knowledge. While humans adapt to the environment and evolve through life, they learn new information so that their schemas change through assimilation. Further details are incorporated in existing schemas, or accommodation, with existing schema altered or new schemas replacing old ones. Piaget defined four types of schemas: person schemas, which refer to our knowledge of specific individuals; social schemas, which focus on a general understanding of how to behave in social situations; self-schemas, which apply to knowledge about our self; and events schemas are about social norms and behaviors.

Yale University social psychologist John Bargh provided evidence that conscious awareness and intentions—the abstract thinking that drives our mental processes and our motor systems, which trigger our jump into action—are "fundamentally dissociated in the brain" (Bargh, 2005, p.43). He argued that conscious awareness, located in the prefrontal cortex, is far from sending immediate feedback to the cerebellum – the "locus of automatic, non-consciously controlled motor programs" (i.e., the part of our brain that allows us to activate motion systems). Bargh proposes that we perceive the world more through fast reactions (unconscious) than deliberate, rational thinking (conscious).

"[the cerebellum] may be involved in combining these cellular elements, so that, through practice, an experiential cortex can automatically evoke an action plan" (Bargh, 2005, p.43). This statement points to the fact that the cerebellar influence extends to the prefrontal cortex, the part of the brain responsible for decision-making, personality definition, and social behavior, but in a way that hinges mainly on repetition. In other words, by reacting to a particular situation often in the same manner, our brain builds an automatic response that will be unconsciously triggered every time a specific event occurs.

Robert Sapolsky, in his 2018 book *Behave: The Biology of Humans at Our Best and Worst*, states that childhood upbringing and context, as well as our culture and society, condition us to form mental schema that we use to divide, file, and store information about the

world. At the unconscious level, our brain makes models of reality that drive our decisions and behaviors. We use these models to interpret our internal and external stimuli for decision-making and cognitive constructs. These models function as interpreters of our reality, and as a framework for creating the shared knowledge that we think of as culture, which is the underlying structure of our behavioral and affective beliefs.

In her 2003 paper *Evolution and Memes: The Human Brain as a Selective Imitation Device*, psychologist Susan Blackmore expands Thach's theory to human evolution. She states that memes, which are humans' abilities to imitate, and genes coevolved in such a way that successful imitation of a specific task favored the transmission of the genetic component needed for such imitation mechanism so that the process of memetic drive, in Blackmore's terms, shaped human evolution. (Blackmore, 2003)

The human brain is highly sophisticated and divided into two hemispheres. In the 1960s, Nobel Prize winner Roger Sperry discovered that the two hemispheres function differently: the left side is analytical, orderly, systematic, focused on linear thinking, word-making, mathematics, and logic; the right side is imaginative, intuitive, artistic, capable of feelings visualization, associative play, meaning-making, metaphor, analogy, novel ideas, self-reflection, and holistic thinking. The right brain hemisphere is responsible for emotional regulation, attention, and memory. The left brain hemisphere is for storage and categorization. The two sides work together and complement each other through the corpus callosum, which functions as an information super-highway and can inhibit one or the other hemisphere depending on the external stimuli and context. White matter is experience-dependent, allowing the transfer of information across brain regions and changes in learning and mastery of social skills (Lienhard, 2017).

In his 2011 book *Thinking, Fast and Slow*, Princeton University psychology professor and Nobel Prize winner Daniel Kahneman differentiates between fast and slow thinking, popularizing what is also called System 1 and System 2 thinking. When driving a car, one uses a near-automatic, intuitive, emotional, effortless, and unconscious process called System

1 thinking or “fast thinking”; when performing mathematical calculations, one uses a logical, rational, and conscious process that requires hard work. This is called System 2 thinking or slow thinking.

In the second half of the 19th century, Frederic William Henry Myer was the first to write about the existence of preconscious cognitive processes that he defined as subliminal self. For Myer, the unconscious was a vehicle of transcendent experience and higher potential, reaching beyond the self (Ryan, 2010).

Around 1860, Professor of Physiology Hermann von Helmholtz was the first to attribute the inference of places, objects, or people to the unconscious, while conclusions are generally to be attributed to conscious thought even though they could also be unconscious. The cognitive unconscious is the set of mental activities of which people are entirely unaware, such as the ones used in System 1/fast processes, but that make possible the ordinary thinking, remembering, and reasoning typical of System 2/slow processes. Metacognition is the knowledge of our thinking and learning; it augments students’ abilities to adapt and transfer their learning to new contexts and tasks through increasing awareness of the subject matter. It can be thought of as a higher level of cognition, also known as executive function, reflective thinking, and mindfulness, in which individuals approach different tasks and contexts by considering themselves as learners in these different contexts. Metacognition allows us to question our thoughts, assumptions, and expectations, a process called self-awareness. In cognitive processes, sensory stimuli are detected by the thalamus and then processed by the amygdala, which performs a quick threat assessment, blocking slow thinking, before moving into the cortex. In survival mode (fight or freeze response), the prefrontal cortex, the logical, rational, and conscious part of our brain, is blocked, while the limbic system (unconscious) leads our actions (Wade, 1994).

Past research proved that the illusions of the mind shape our present reality, which is a continually moving target since those illusions regularly change based on exterior stimuli and conditioning. Humans are constantly interpreting reality.

"Events are always on hand. But the coherence of these events – what one means by reality – is an imaginative construction. Reality always lies beyond – and this is as true for materialists as for idealists" (John Berger, 1985, p.279)

A critical theory developed by Kahneman and Tversky is that people's imagination tends to oversimplify situations, warping reality (Tversky & Kahneman, 1974).

According to American behavioral scientist Herbert Gintis, neuroscientific studies exhibit the genetic basis for moral behavior in the domain of morality and ethics. Human society is held together by moral values that are transmitted from generation to generation by the process of socialization. The internalization of norms presupposes a genetic predisposition to moral cognition that can be explained only by gene-culture coevolution. The human openness to socialization is perhaps the most powerful form of epigenetic transmission found in nature. (Gintis, 2011)

L. Affective Learning

This research focuses on how design strategies can foster emotional learning. Affective learning principles and techniques are foundational to the present investigation because they inform design decisions in constructing immersive story worlds.

Emotions are neurological and physiological responses to an affective stimulus initiated in the subcortical regions of the brain, such as the amygdala (limbic system), and in part in the neocortex (prefrontal cortices). They affect our physiology, the reconstruction of meaning from past affective activations, regulation (intentional efforts to mitigate or reverse emotional states), arousal (intensity of attention and engagement), and performance (quality of behavior, achievement of successful or non-successful outcomes).

While emotions are associated with responses to bodily stimuli and are activated at the unconscious level through neurotransmitters and hormones released by the brain, feelings are the conscious awareness of these emotional reactions. Feelings point to the meaning of emotions and are shaped by past experiences (memories), schema, associations, and our belief systems.

Emotionally charged stimuli and events strongly affect us and are most retained in our memory. The amygdala holds central importance in emotional arousal, regulating the release of neurotransmitters in the hippocampus, which is responsible for storing experiences in our memory (Ekman, 2007).

They shape our views, actions, and behaviors by acting on

1 Arousal levels, which carry physiological implications (blood pressure, heart rate, muscular tension changes). Low arousal points toward boredom and inactivity; high arousal renders a person energized, alert, and engaged.

2 Cognitive capacities, which are the quality of our thinking and reasoning right after receiving stimuli, drive our reactions. For example, new information can trigger unease because it is perceived as strange, nonsensical, and contradicting current knowledge and beliefs. This state of mental discomfort, defined by Piaget as disequilibrium by others' cognitive dissonance, generally motivates us to find solutions to resolve the discrepancy and unease.

3 The quality of our judgments, behaviors, and performance, which maximizes our safety and survival chances. For example, when encountering a threat, fear triggers our desire to escape, look for shelter, or a form of defense. The chosen behavior and outcome will affect subsequent emotions and actions, as well as memory encoding for future associations.

According to Hoemann, Xu, and Feldman Barrett, 2019, emotional development refers mainly to the ability to regulate innate, universal emotional reactions. To maximize their learning and abilities to survive in their surroundings, humans engage in emotion regulation, which decreases negative emotions and enhances positive ones. We can keep negative emotions under control through cognitive and affective strategies. For example, we might try to focus on our past accomplishments when we lack self-esteem or think of our loved ones when we are feeling lonely. This self-regulation ability and capacity to identify one's and others' feelings and emotions and use them to guide one's behavior is called "emotional in-

telligence," a term coined by Peter Salovey and John D. Mayer in their 1990 paper *Emotional intelligence. imagination, cognition and personality*.

The primary affect regulation system acts at the unconscious level, like a quick reaction or reflex. It is fast, automatic, and conveys our personal view and meaning-making of an object in a specific context (Fosha, Siegel, & Solomon, 2009). The secondary affect regulation system acts through mentalization by employing reflective thinking for further affect assessment, including verbalization after the primary system has processed it. Mentalization, which represents our mental states and those of others, occurs at the conscious level; it is left-brain driven, slow to occur, and connected to metacognition and self-reflection. It contributes to affect regulation by providing a sense of agency and helping us avoid or mitigate traumatizing encounters. When the neurological components responsible for receiving affective states are malfunctioning or inactive, the primary system is dysregulated, affect becomes unavailable, and dis-associated from the secondary affect regulation system. If an affective state is too intense or impactful for processing, exceeding our regulation capacity, it will be avoided through compartmentalizing. For example, disassociated emotions like daydreaming will arise to prevent awareness of the present moment and its affective implications, which are beyond our processing abilities and comprehension. Regulated affect is crucial for humans to thrive in their environment and provides a sense of self-accomplishment, safety, and wellbeing. Dysregulated affect is part of a system that is compromised at the cognitive, attentional, perceptual, representational, mnemonic, and reflective levels and leads to compartmentalization, a typical and necessary coping mechanism in an altered and suboptimal state of consciousness (Hoemann et al., 2019).

Past research focused on the right brain regulation ability and adaptive capacity as foundational for early attachment experiences. Secure attachment theory focuses on the primary task of the first year of human life, which is the creation of secure attachment between the infant and a caregiver. The mother's psychobiological attunement, expressed through facial, visual, tactile, and auditory communication, to the infant's constantly changing internal

states of arousal determines the sense of secure attachment and wellbeing for the rest of the infant's life.

The human central nervous limbic system (CNS) myelinates mainly during the first year and a half of life; the right brain (RB), which is deeply connected to the CNS, also reaches a significant level of growth during that time. RB has deep connections with the involuntary autonomic nervous system (ANS). In adulthood, internal schemas of attachment developed in early life, which reside in the RB, are foundational for the affect regulation that determines the individual's social and interpersonal wellbeing and emotional and cognitive development.

Suppose a child experiences inadequate care, abuse, or neglect in the early relational years. In that case, they may grow into adults who are often burdened by frustration, anger, lack of self-confidence or self-appreciation, fear of abandonment, and constant and excessive need for affection and affirmation. These affective deficits surface in various forms. For example, the individual might often have difficulty in interpersonal social interactions or often use self-defense mechanisms (denial, displacement, sublimation, projection) to avoid the consequences of negative feelings (i.e., anxiety) or experience severe mental challenges, like narcissistic, borderline personality disorders, and other imbalances.

Several affective regulation theories have surfaced; for example, Stephen Porges developed the polyvagal theory centered around the vagus nerve, which connects our brain to the heart and viscera. Based on this theory, higher-level brain processing activates when we are in a physiological state of safety; when we feel in danger and "fight or flight" is not an option, our nervous system takes control at the unconscious level to determine the type of behavior that will result in the least amount of harm. This affective regulation mechanism kicks in when inside a VR story world depicting situations that we perceive as safe, like in the VR experience *The Book of Distance*, analyzed in chapters three and four, or dangerous, like in the VR experiences *1000 Cut Journey* or *Becoming Homeless*, also examined in chapters three and four.

Neuroception is the mechanism that, thanks to neural networks, allows us to distinguish subconsciously between safe, dangerous, or life-threatening situations.

In his 2018 book, American neuroendocrinology researcher and Stanford biology professor Robert Sapolsky teaches us that, from the evolutionary perspective, empathy and feeling someone else's pain (affective processes) allow us to learn how to protect ourselves (cognitive processes). In humans, the anterior cingulate cortex (ACC) is the outpost of pain reception and is focused on us and our safety. When perceiving someone else's distress, the ACC activates to signal a call to help. The hormone oxytocin, which promotes bonding and affiliative behaviors, is released to reinforce this call.

The ACC allows us to perceive fear, triggering the protective instinct that keeps us out of trouble. One process of this mechanism is crucial: from the thought of the pain of an injured person to our brain transfering that thought to our own being and thinking "I need to make sure not to do what that person did to get hurt" is a mental transition that involves a shared representation, when "me" becomes "that person." This transition allows us to imagine that we are that person and feel their pain, retaining the knowledge of who we are and what not to do. All of the above occurs at the unconscious level. For example, if we take the perspective of a loved one or someone of our race who is poked by a needle, our ACC activates (the longer the pain, the higher the activation); if we watch a stranger or other-race individual be poked, the temporoparietal junction activates, not the ACC; the higher the discrepancy when watching an ingroup versus an outgroup person in pain, the less the willingness to help the latter.

Amygdaloid activation occurs when watching someone in pain, triggering the feeling of empathy for that person — the automatic mechanism underlying this feeling spans from sensorimotor to emotional contagion. Other cognitive processes involve sympathy— feeling the pain of the other but not fully understanding it (in this case, the sympathetic person has no desire to help in alleviating the pain) and perspective-taking— imagining what it would feel like to be someone in distress. The latter carries the risk that the imagined pain of the other is

so intense that the person's focus turns to discomfort, which turns off the desire to help others. All this has new dimensions in virtual reality because the leap of imagination is short due to the added possibility of the "sense of presence and embodiment," — which occurs when a participant in VR inhabits a virtual body and receives stimuli from an entirely constructed digital world.

Cognition, which resides in the prefrontal and frontal cortexes, suppresses indifference or disgust and allows us to find commonalities. The prefrontal and frontal cortexes activate to connect causality and intentionality. In exploring others' feelings, cognition kicks in to decide when a particular pain is of enough magnitude and importance to trigger empathy. Robert Sapolsky explains the need for affect and cognition to join forces to drive the sense of empathy and compassion toward an individual of the outgroup feeling pain.

"It is an enormous cognitive task for humans to reach an empathic state for someone different or unappealing. [. . .] When it comes to empathy, emotion, and cognition are false dichotomies; we need both but with the balance between the two and with the cognition doing the heavy lifting when the difference between Us and Them in pain is greatest". (Sapolsky, 2018, p.535)

This research aims at inducing the desire to do that kind of work by finding common traits with outgroup members while living their stories in virtual reality (VR) simulations, in which a participant experiences perspective-taking through embodiment, a technique in which participants are primed to take the role of "them."

Robert Sapolsky explains how humans function in relation to ingroup and outgroup psychology: our brain makes up the Them/Us dichotomy preferring the "Us." A fifty-millisecond viewing of someone of another race activates our amygdala, which is associated with emotional responses. By age three or four, kids group people by race and gender; by age six to ten, they have a negative attitude toward "Them" and perceive faces from other races as angrier than the ones from the same race. According to Sapolsky, children develop prejudices from their parents and their culture. From infancy, they tend to be surrounded by same-race

faces and by environments with stimuli inducing them to dichotomizing. This shows that racial discrimination is part of childhood development. This is proven by the fact that children adopted by a family of a different race before the age of eight tend to associate with the adoptive parents' race. (Sapolsky, 2018)

These findings support the need to develop alternative narratives, which can be experienced multiple times to train our brain to feel positive feelings toward outgroup members and lessen our instinctive mental discriminatory models. Virtual reality story worlds place participants into scenarios that can be experienced multiple times and can lead to affective learning. Hence, it is imperative to define best design practices for prejudice reduction in VR.

III. Literature Review & Methods

A. Toward a Taxonomy of Social VR for Inclusion

According to intergroup contact theory, interpersonal contact between individuals from different groups is likely to reduce prejudice when positive emotions, equal status, common goals, and collaborative endeavors are present and supported by institutions and group leaders. Most VR experiments on prejudice reduction in VR emphasize the disadvantage of individuals from minority groups through the employment of scenarios that depict painful interactions, dehumanization and violent encounters that trigger discomfort, anxiety, and fear, even though equal status of intergroup partners is one of the main conditions for intergroup contact to decrease prejudice as postulated by Allport in 1954 (Christofi & Grigoriou, 2017) and the presence of positive emotions is another necessary condition. In these scenarios with negative affect (distress, anxiety, disgust, fear, panic), can artistic representations encourage helping behavior and compassion toward stigmatized minorities? Can because lack of photorealism heighten the emotional engagement? A field research experiment inside the classrooms was conducted to answer these questions and and others related to the design and visual appearance of virtual environments for inclusion.

This research hypothesizes that art-based representation and narrative construction with positive affect in VR may foster prosocial attitudes more effectively than photorealistic representation and fear arousal scenarios. Artistic representations build an alternative reality that requires imagination, the belief that we are part of a world removed from our physical reality. This leap of faith may allow the de-escalation of negative emotions and foster a richer cognitive, social, and affective experience. Indeed, based on intergroup contact theory, to reduce bias, we should create virtual environments where trust, physical and affective closeness, a sense of community, and collaboration thrive, far from fear and anxiety and limbic system arousal to the point of engaging self-preservation instincts.

Considering the sparse literature on how aesthetic and artistic choices affect perceptions in VR for bias mitigation and our training in visual art and design, capitalizing on two decades of experimentation in making VR worlds, we draw from our analysis of the state-

of-the-art VR experiences aiming at reducing bias to validate our theory.

B. Literature Review

The last two decades of research in the field of VR for behavioral and affective health and learning are captured through hundreds of papers and a few art experiences, including serious games. While many scholars tout the medium as an "empathy machine" and praise its effectiveness for mental health, others question the ethical validity of what they consider 'forced' empathy. In all these studies and experiences, the lack of experimentation with visual representation styles and universally accepted assessment tools to determine the magnitude of change that VR can bring is a significant research limitation.

Moreover, the shortsightedness derived from a strict separation of the disciplines involved (social psychology, computer science, interaction design, communication, cognitive science) has prevented the ideal development and implementation of contemporary VR for prejudice mitigation. One of the issues is that media arts college-level programs are often housed in computer science or engineering departments, while artists undergo an education still mainly focused on traditional methods (fine art, photography, video, and graphic design). Hence, VR is currently out of reach to artists because they lack the necessary technical skills and it is designed by social psychologists and computer scientists, who lack foundational art and design skills.

Considering these shortcomings, this research proposes a taxonomy as a guide for VR practitioners that shows artistic choices can support compassion, prosocial attitudes, and bias reduction inside VR narratives. A literature review of the state-of-the-art VR for inclusion was performed to find insights from past research into the use of visual elements in the settings of intergroup contact, including experimental studies from film and cinema.

Based on the author's two decades of experience building VR narratives, the taxonomy of Social VR for inclusion culminating in this research includes twelve categories tied to sensory, psychological, and motivational perceptions, explored from the point of view of art

and design across six immersive experiences aimed at inducing compassion and understanding for the condition of discriminated individuals at the center of their stories in VR.

To determine how visual representation and narrative influence affect, perception, and behavior, some of the themes investigated in the literature review are:

- The use of light or colors to guide participants' attention and/or trigger emotions.
- The artistic strategies that foster an emotional connection or distance to the protagonists, their life experiences, and their perspective (i.e., use of real photos in Book of Distance).
- Narrative flow and plot transitions as emotional and cohesive recurrences.
- The quality and intensity of emotions in art-based versus photorealistic VR.
- Level of curiosity and engagement triggered by visual clues and the narrative.
- Use of time (different eras occurring in the same virtual environment versus the use of the present only, for example) and space (proximity or distance) to trigger cognitive and affective states.
- Difference in narrative enjoyment, engagement, and emotions as determined by the participant's level of agency and their perspective-taking position (1st versus 3rd and if embodying the victim or acting as a witness).
- Scale manipulation to trigger affective states.
- The manipulation of the participant's point of view to enhance the narrative flow and affective engagement. For example, the VR experience *Reeducated* employs a birds-eye view, dwarfing the figures, and a worm-eye view during surgery to convey the victim's sense of fragility and powerlessness.
- Progression of revealing the virtual environment to direct the viewer's eye and determine a hierarchy of importance of the VR elements. For example, in Reeducated rooms are first empty, then slowly get 'populated' with furniture and human bodies to build a sense of crowded oppression.
- Characters' appearance and customization to construct social identity and presence.

This literature review starts by querying scholarly databases through keywords and related searches of relevant articles listed in the references. This review considers the insights on the literature search process highlighted in “Reconstructing the Giant: On the Importance of Rigour in Documenting the Literature Search Process,” written in 2009 by Brocke, Simons, Niehaves, Riemer, Plattfaut, and Cleven.

Full-length articles in English in scientific journals and proceedings of international conferences published between 2015 and 2023 are included in the literature review. This period is justified by the fact that, in 2015, videographer Chris Milk, in a TED talk, labeled VR as an “empathy machine” because of the pouring of donations after showing a 360-degree VR video of a little girl in a refugee camp to wealthy donors. This talk escalated the number of studies and publications in the field of VR to trigger human emotions such as empathy and compassion, the VR’s aim at the center of this research.

To ensure the credibility, reliability and validity of the papers, this literature review includes primarily scientific articles published in the information system top-ranking journals as identified in 2003 by Peffers and Ya (326 journals) and the Index of Information Systems Journals, which lists 248 active IS journals as of November 2023 (https://www.igi-global.com/search/?dt=complete-listing&ctid=2, accessed 02-28-2024), conference proceedings, theses and dissertations.Within these journals, sources were selected if they contained a classification of VR-based strategies in the context of developing inclusive attitudes or affective and cognitive learning toward reducing bias or inspired the identification of VR solutions.

In order to identify scholarly articles, keyword searches were performed, which led to contributions that were evaluated and assessed as relevant based on their abstracts.

For each search, the documentation of the literature review is shown through tables listing the keywords employed, the number of hits received, the journal databases, the title of the specific papers chosen, and the reasons for the selection.

The systematic literature review process was performed in three steps:

Step 1: Definition of the research questions: The scope and contexts of the review.
Step 2: Search for relevant studies & selection of studies: Keywords selection, search strings, and forward searches to determine the most significant scholarly work
Step 3: Data synthesis and analysis: Summary of the findings from the scientific articles selected in the literature review.

Step 1: Definition of the research questions

Category: Visual Representation and Sound (space, scale, time, and point of view):
This category includes all the decisions on the assets and appearance of the virtual environment. It explores how the design of the visuals might affect the VR participant's perceptions, emotions, sense of presence, and social identity.

Questions pertaining to this dimension are:

a. Can past literature allow us to identify a set of guiding principles in the design and visual representation of VR to employ in immersive narratives aimed at triggering prosocial behaviors?

b. Is photorealistic representation effective or should it be avoided due to the uncanny valley? Is non-photorealistic VR conducive to inducing presence and immersion in VR storytelling aimed at triggering prosocial behaviors?

c. Which design features of the virtual environment and characters are most conducive to promoting prosocial attitudes, compassion, and understanding of the condition of marginalized or victimized individuals?

d. Which design strategies for the avatars inside an immersive narrative are most conducive to triggering the sense of social identity?

Searches pertaining to this set of questions (a,b,c,d):

1. Virtual Reality+Visual Representation
2. Virtual Reality+Uncanny Valley
3. Virtual Avatar+Social Identity

Category: *Social Psychology*

This dimension includes VR strategies to ensure entitativity, triggering positive perceptions toward a person of a different group, and awareness of one's bias.

e. Can the embodiment in a virtual avatar with a visual appearance belonging to a different group trigger prosocial attitudes, compassion, understanding for people belonging to the group the avatar belongs to, or awareness of one's prejudicial bias?

f. Which elements can trigger a sense of belonging to a particular group?

g. Which narrative is most conducive to sparking compassion and prosocial behaviors?

h. Which kind of intergroup contact in VR will likely trigger action to protect or improve the condition of the protagonist, who is part of a marginalized group?

Searches pertaining to this set of questions (e,f,g,h) are:

1. Virtual Reality+Inclusion
2. Virtual Reality+Prejudice
3. Immersive+Social Change
4. Virtual Reality+ProSocial

Category: *Cognition and Cognitive Learning*

This dimension includes ethical questions of VR as an awareness tool.

i. Can VR elicit an understanding of one's condition, prosocial attitudes, and behaviors?

k. Is it ethical to employ VR to induce empathy and compassion?

l. Can VR narratives instill bias when depicting the lives of marginalized individuals?

m. Which kind of knowledge may be achieved when immersed in VR narratives depicting situations in which under-represented individuals are mistreated?

Searches pertaining to this first set of questions are (i,k,l,m):

1. Virtual Reality+Ethics
2. Virtual Reality+Ethical
3. Virtual Reality+Social Cognition
4. Virtual Reality+Cognitive Empathy.

Category: *Emotions and affective learning*

This dimension includes VR strategies to trigger emotive responses and aims to identify if they aid in promoting prosocial attitudes toward victims of discrimination.

n. Do affective visualization methods promote or prevent social intergroup contact?

o. Are VR experiences representing groups of people (through showing multiple individuals) or cultural belonging (through showing iconic cultural artifacts) promoting intergroup content more than environments depicting mainly one person or neutral environments?

p. What are the effects of virtual human appearance fidelity on emotion contagion in affective interpersonal simulations?

q. When and why does emotional design foster learning?

r. Can VR elicit empathy?

Searches pertaining to this set of questions (n,o,p,q,r):

1. Virtual Reality+Affective
2. Virtual Reality+Disgust
3. Virtual Reality+Compassion
4. Virtual Character+ Empathy

Category: *VR narrative*

This dimension is about employing VR for storytelling focused on prejudice.

s.Is experiencing stigmatization while embodying a person from a marginalized group enough to trigger prejudice reduction?

u. Can designing and making VR stories trigger prejudice reduction?

Searches pertaining to this set of questions (s,t,u,v):

1. Interactive Narrative+Prejudice
2. Virtual Reality+Storytelling

Step 2: Search and Selection of relevant studies from 2015 to 2023 (as of November 2023)

To find answers, queries were performed using keywords with at least two categories

pertaining to the main fields of this research (VR, art and design, storytelling, social psychology, cognition, and emotions) related to inclusion.

Table 1 below shows the search strings and results obtained through the database of the California Polytechnic State University, San Luis Obispo (https://lib.calpoly.edu/). For each keyword query, the following selection requirements were applied:

Years of publication: 2015 to 2023.

Language: English.

Articles included: Contained the fields described in the keywords or closely related fields.

Resource types included Articles, conference proceedings, theses, and dissertations.

Resource types excluded: Books, book chapters, newsletters, magazine & encyclopedia articles, text resources, preprint and patents, Datasets.

General fields included in all queries because relevant: Virtual Reality, Science & Technology, Technology, Computer Science (all types), Engineering (all types), Visualization, Representations, Virtual Environments, Augmented Reality, Avatars, Social Sciences, Psychology, Imaging Science & Photographic Technology, Algorithms, COMPUTERS Design - Graphics & Media Video & Animation, Digital Cinematography, Space Perception and Motion Pictures, Motion Pictures Aesthetic, 3-D films, COMPUTERS Digital Media Video & Animation, Attention/Perception and Psychophysics.

Fields excluded, not relevant: Life Sciences & Biomedicine (all types), Computational and Systems Biology, Biology and Medical Research (all types), Applied mathematics and nonlinear sciences, Medicine and mental health-related fields 360 degrees Video-based VR.

Journal collections included: Taylor & Francis Ltd, Arxiv.Org, Directory of Open Access Journals (DOAJ), Ebook Central Perpetual and DDA, eBooks on EBSCOhost, Elsevier ScienceDirect Journals Complete, Free E-Journals, IEEE Electronic Library (IEL) Conference Proceedings, IEEE Xplore, IngentaConnect Journals, Material Science and Engineering Collection, METADEX, Science Citation Index Expanded (Web of Science), Springer Books, Springer Nature OA Free Journals, SpringerLink Journals, WLeBooks, Web of Sci-

ence, ProQuest Dissertations & Theses Global, SAGE Publications, IJLECR (International journal of language education and cultural review), Virtual Worlds Research Consortium.

Papers were excluded if:

- No categories relevant to VR or VR solutions and features were explored or proposed.
- The VR solutions pertained to health care (including mental health), medical or commercial realms (medical training and retail or product-related applications), cybersex, or were focused on a specific discipline or field of expertise (for example, VR learning strategies applied only to a particular discipline were excluded, all general learning was included).
- The classification was not specific to the categories or domains described by the keywords
- The scientific article could not be retrieved due to restricted access or lack of sharing by the authors.
- The scientific article was in a language other than English.

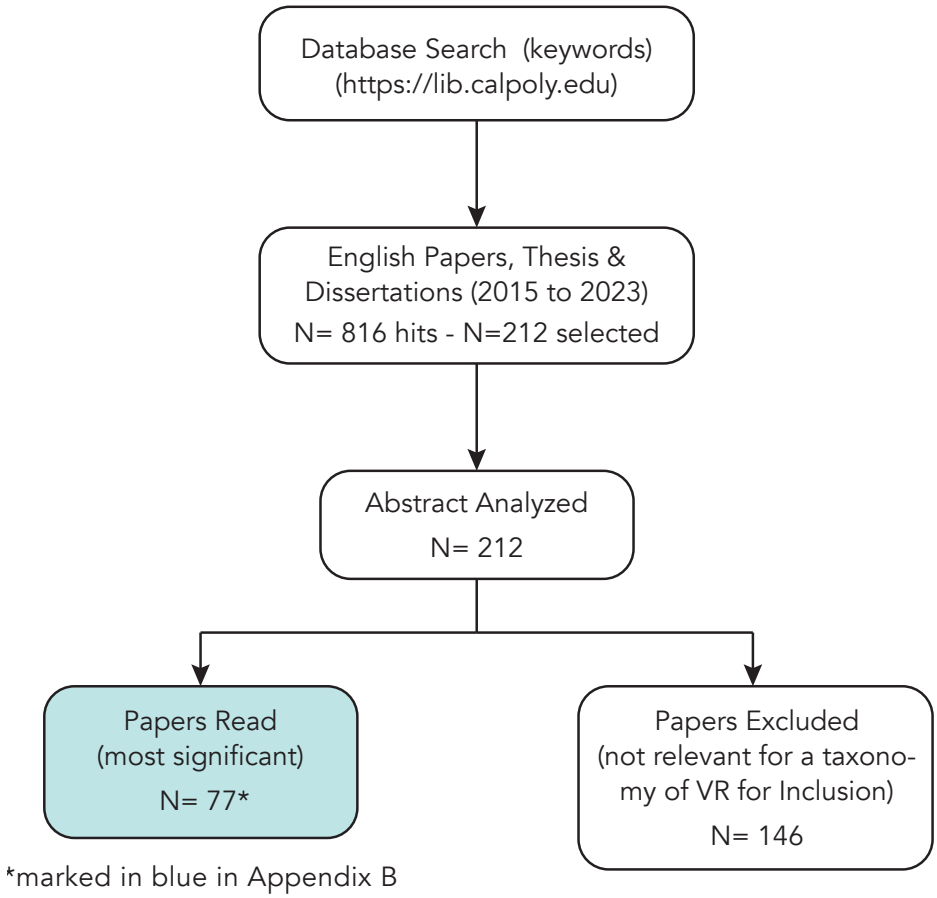


Fig. 29. Literature review process

Table 1. Search strings, number of hits and results.

Fields and Number of Searches	Search Strings (keywords)	Hits	Selected Articles
Art & Design 3	1. Virtual Reality+Visual Representation	75	10
	2. Virtual Reality+Uncanny Valley	24	10
	3. Virtual Avatar+Social Identity	21	10
Social Psychology 4	1. Virtual Reality+Inclusion	150	2
	2. Virtual Reality+Prejudice	13	9 (1 repeat#)
	3. Immersive+Social Change	37	10
	4. Virtual Reality+ProSocial	22	13
Cognition 4	1. Virtual Reality+Ethics	80	14 (4 repeat*)
	2. 1. Virtual Reality+Ethical	102	27 (4 repeat*)
	3. Virtual Reality+Social Cognition	31	4
	4. Virtual Reality+Cognitive Empathy.	10	8
Emotions 4	1. Virtual Reality+Affective	178	72 (1 repeat#)
	2. Virtual Reality+Disgust	6	2
	3. Virtual Reality+Compassion	23	7
	4. Virtual Character+ Empathy	13	9
Narrative 3	1. Interactive Narrative+ Prejudice	20	2
	2. Virtual Reality+Storytelling+ Empathy	10	7
	3. Virtual Reality+Storytelling+ Enjoyment	1	1
Total		816	212 (excluding repeats)

Step 3: Summary of the findings from the scientific articles selected

Given the large amount of results, Table 2 displays the most significant papers for each category. Appendix B lists the selected publications.

Table 2. Examples of the Most significant papers.

Categories	Paper	Methods	Contexts	Technology	Findings
Visual Representation, Embodiment and Emotions	Hepperle, Purps, Deuchler, Wölfel (2021)	Online surveys for two studies about visual (self-) representation using avatars.	Humans' visual representation for self-identification and emotional response	HMD, 2D monitors	No standard for-self-identification through visuals exists. The uncanny valley effect is more pronounces in VR.
Visual Representation, Sense of Presence	Autengruber, Chacon, Pirker, Safikhani (2022)	Questionnaires (IPQ, SUS, NASA TLX) and bio signal recordingsduring 4 VR scenarios	How visual style and lighting influence presence, usability and mental workload in VR	ECG, heart rate (HR) and heart rate variability (HRV)measured during VR	Visual representation factors influence on presence, not on usability and mental workload
Visual Representation, Scale Perception	Wijayanto, Babu, Pagano, Chuang (2023)	Empirical evaluation (verbal and physical responses) of size perception of objects in a between-subject design over 4 conditions of VR visual realism (Realistic, Cartoon, and Sketch)	Relationship between size perception and four conditions of visual realism in VR (Realistic, Lighting, Cartoon, and Sketch)	HMD	Size perception was accurate in the realistic condition and in the non-photorealistic conditions. Size estimates in verbal and physical responses were different in real world and VR and moderated by trial presentation over time and target object widths.
Visual Representation, uncanny valley, Space Manipulation	Singh, Chen, Cheng, King, Ko, Gramann, Lin (2018)	Event-related potential (electroencephalogram-based approach). 3-D object selection task with space manipulation	How the rendering style of the users' hands affects behavioral and cognitive responses	HMD, ECG	The more realistic the visual representation, the more sensitive the user becomes toward errors like tracking inaccuracies.

Categories	Paper	Methods	Contexts	Technology	Findings
Visual Representation, Sound, Space Manipulation	Fichna, Biberger, Seeber, Ewert (2021)	Scene visual representation: loudspeaker array rendering the sound with or without HMD	Effect of scene complexity and visual representation of the scene on psychoacoustic measures	HMD, 86-channel loudspeaker array	No significant effect of wearing the HMD on the data
Social Identity in space, time, entitativity, presence, enjoyment, and realism in VR	Eugy, Miller, DeVeaux, Jun, Nowak, Hancock, Ram, Bailenson (2023)	In Study 1 (n = 81), entitativity, presence, enjoyment, and realism increased over 8 weeks. Study 2 (n = 137), participants cycled through 192 unique virtual environments. Assessment through questionnaires and behavioral tasks.	Understanding how people use virtual reality to learn and connect. Transformed Social Interaction paradigm was used to examine different avatar identities and environments over time	HMD	•Avatars resembling participants increased similarities between them. •Self-avatars increased self-presence/realism, decreased enjoyment. •As space increased, so did nonverbal synchrony, restorativeness, entitativity, pleasure, arousal, self- and spatial presence, enjoyment, and realism. •Outdoor environments increased perceived restorativeness and enjoyment more than indoor environments.

Categories	Paper	Methods	Contexts	Technology	Findings
Embodiment, Intergroup contact, Virtual Social Inclusion	Tassinari, Aulbach, Jasinskaja-Lahti (2022)	Lit. review	Systematic lit. review of the use of VR in studying intergroup attitudes, bias and prejudice. Advantages and limitations compared to other tools.	review of quantitative and peer-reviewed studies that use VR to create an interaction with one or more avatars belonging to an outgroup	All studies showed VR contact to improve intergroup relations. Nevertheless, the results suggest that under certain circumstances VR contact can increase prejudice as well
Affective and Cognitive Integroup attitudes	Chen, Ibasco (2023)	between-subjects experiment (84 participants). Assessment through questionnaires.	Compare affective (empathy) and cognitive (stereotypes) mediators of prejudice reduction in VR	HMD	Findings from this research provide support for affect as a key component of virtual experiences and how they shape intergroup perceptions
Impact: Behavioral Change, Emotions	Shoshani (2023)	2 experiments in which positive affect and sense of competence were examined as mediators between the VR prosocial play and real-life prosocial behavior (166 and 173 participants). Assessment: behavioral tasks after VR games.	Gamified learning's impact on preschool children's prosocial behavior	HMD	•Children in the prosocial virtual reality condition exhibited greater sharing and helping behaviors. •Positive affect mediated the effect of the prosocial virtual reality game on prosocial behavior.

Categories	Paper	Methods	Contexts	Technology	Findings
Impact: Behavioral Change, Emotions	Martinez-Cano, Lachman, Canet (2023)	systematic literature review of empirical research on VR media's potential to elicit prosocial behaviors	Impact of (VR) audiovisual content	systematic literature review in accordance with the guidelines of the PRISMA statement	Identification of trends, predictors, moderators, mediators, effects, in research on the prosocial potential of VR content. perspective taking is the most common strategy.
Embodied Social Cognition, Presence, Time	Rooney, Burke, Balint, O'Leary, Parsons, Lee, Mantei (2017)	Field Research Experiement: manipulated the way in which viewers engaged with a VR character, including eye-gaze behaviour. Questionnaires.	Exploration of the effects of manipulation on self-reported presence	HMD	No significant effects of character's eye-gaze behaviour on participant's feelings of presence or their perception of time. Eye-gaze behaviours are associated with higher levels of social cognition towards the character
Cognitive, Affective Learning in VR	Parong, Mayer (2021)	media comparison study in which students viewed a biology lesson either as an interactive animated journey in IVR or as a slideshow on a desktop monitor	Understand how immersive VR systems (IVR) affect learning outcomes and the underlying affective and cognitive processes	HMD, desktop screens, EEG recording device	Students who viewed the IVR lesson performed significantly worse on transfer tests, reported higher emotional arousal, more extraneous cognitive load and showed less engagement based on EEG measures than those who viewed the slideshow lesson

Categories	Paper	Methods	Contexts	Technology	Findings
Narrative Flow: Perspective-taking in 1st versus 3rd person	Turbyne, de Koning, Smit, Denys (2021)	subject study for 17 participants: electrical stimulation at pseudorandom intervals and anatomical locations. ECG & ICG measured	Whether affective and physiological responses to painful stimuli differed between a first and a third person perspective	HMD, ECG & ICG monitoring devices	A 1st person perspective did not generate distinct physiological benefits or improved physiological stress responses to acute pain in VR.
Engagement in VR Storytelling through immersion, presence, agency, usability, and user experience	Avila-Garzon, Bacca-Acosta, Chaves-Rodríguez (2023)	Structural model-based hypothesis was validated using partial least squares structural equation modeling (PLS-SEM) with data from 212 university students	Definition of the predictors of engagement in VR storytelling environments	HMD	The results show that our model explains 55.2% of the variance in engagement because of the positive influence of immersion, presence, agency, usability, and user experience
Enjoyment, Presence and Flow in VR Storytelling	Yang, Zhang (2022)	A cognitive experience model with presence, flow, credibility, empathy, understanding, and enjoymentwas employed. 131 participants were exposed to 360-degree VR videos, or 2D videos, then rated their experiences.	Exploration of what Influences Enjoyment in Virtual Environments	HMD, desktop screens,	Results showed that the VR and 360-degree videos were more highly evaluated in each path when compared with 2D videos. presence played a vital role in news promotion, while flow was positively affected by presence; flow also affected other variables when combined with presence.

B1. The Taxonomy Categories

Based on the literature review and the selected papers' outcomes and conclusions, the following categories were identified as crucial in designing VR narratives aimed at inducing prosocial attitudes and included in a taxonomy of VR for Social Inclusion (VRSI):

SENSORY PERCEPTIONS:

Visuals & Sound - This category aims to identify the most effective design elements and strategies to guide the participant's attention and trigger emotions. Several papers in the literature review showed sound and visuals, including scale, space, point of view, and time manipulations, as essential elements of VR design and able to trigger emotive states.

PSYCHOLOGICAL PERCEPTIONS

Affective Learning & Emotions: This category aims to identify the most effective strategies to connect emotionally with the protagonists of the story (positive, negative, uncanny).

Interactivity: This category pertains to the level of agency, which involves the ability to choose different scenarios and move in the virtual environment given to the VR participant and determine if this dimension is a crucial driver of the participant's perception of the story's meaning.

Embodiment & Sense of Presence: This dimension pertains to the feeling of being there and, if the participant has the feeling of identifying with the social identity of the avatar. Literature shows that higher immersion leads to higher sense of presence (Tang et al., 2022).

Cognitive Learning & Cognition: This dimension pertains to the level of learning about the VR protagonist's context achieved by the students through the VR experience. Literature shows that higher immersion leads to lowered extraneous cognitive load (Tang et al., 2022).

Narrative Flow: This dimension pertains to the design of the succession of events and scenes. VR experiences can have a linear and continuous flow or can be episodic, like a series of scenes with transitions in between. Even though literature shows that "interactive

narratives may be effective tools in helping reduce prejudice toward marginalized social groups" (Parrott, Dillman Carpentier, Northup, 2017), there are no studies exploring which kind of narrative flow is most effective. This research aims to fill this gap.

MOTIVATIONAL PERCEPTIONS

Enjoyment: This dimension pertains to interest and engagement. Literature shows that students score significantly higher when learning through VR experiences compared to watching videos on presence, enjoyment, and interest (Makransky & Mayer, 2022; Tang, Wang, Liu, Liu, Jiang, 2022).

Impact: This dimension pertains to the level of prosocial attitudes triggered, including making connections to personal experience and the desire to explore the victim's social condition and context or/and act for their betterment.

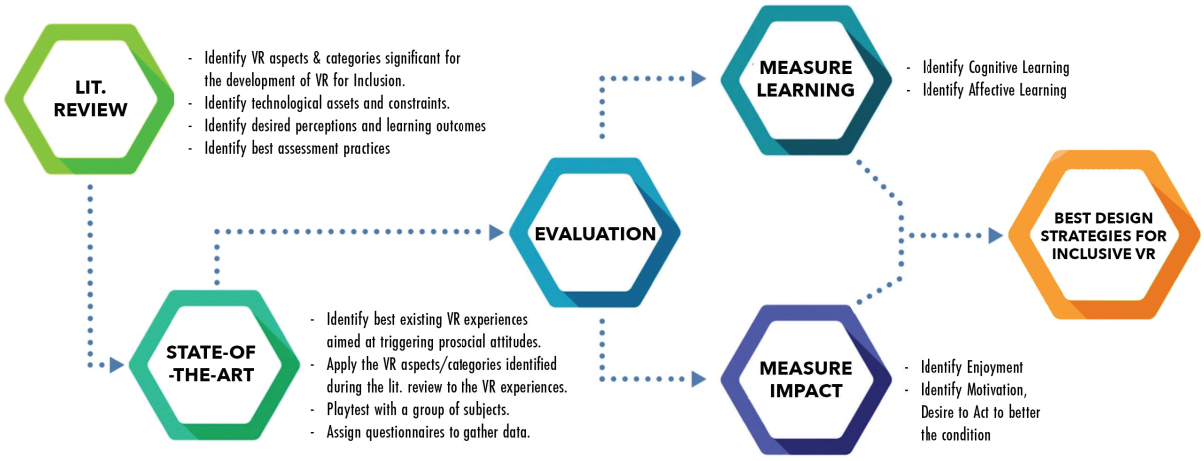


Fig. 30 Research procedure.

C. Method: Action Research

To assess the magnitude of relevance for these dimensions, a search of the available VR state-of-the-art storytelling was performed, which led to the selection of six VR experiences that were then playtested inside a classroom focused on immersive VR storytelling.

It is impossible to find VR experiences focused on intergroup contact or VR storytelling depicting minority groups by performing a Google search because it produces

a broad spectrum of results instead of downloadable files to play inside a head-mounted display. For example, on November 26, 2023, a Google search like "VR+experiences+inter-group contact" led to 1,360,000 results, and a Google search for "VR+storytelling+minority groups" led to 2,230,000. The best strategy to search for VR experiences focused on exposure to the lives of marginalized others is to explore channels that sell VR, such as

- Meta "VR for Good - Virtual Reality Storytelling" (https://about.meta.com/community/vr-for-good/), which mainly includes film-based VR but also a few CGI-based experiences.
- Games for Change (https://www.gamesforchange.org/),
- Film festivals (FF) with VR categories, such as the Venice Film Festival, Tribeca Film Festival, SXSW Festival, the Sundance Film Festival, and many more.
- Conferences, such as Siggraph VR Theater, Ars Electronica VRlab, and many more.
- News outlets that support VR, such as The New Yorker and the Guardian, and more.
- Academic institutions that create VR experiences for research purposes, such as the Virtual Human Interaction Lab at Stanford University, MIT's Imagination, Computation, and Expression Laboratory (ICE Lab) in the US, the Event Lab at the University of Barcelona in Spain, and many others around the world.
- Film boards/groups, such as the National Film Board of Canada (https://www.nfb.ca/).
- Distribution platforms like Steam and Viveport, ACM, and many more.

The main selection requirements for the VR experiences are:

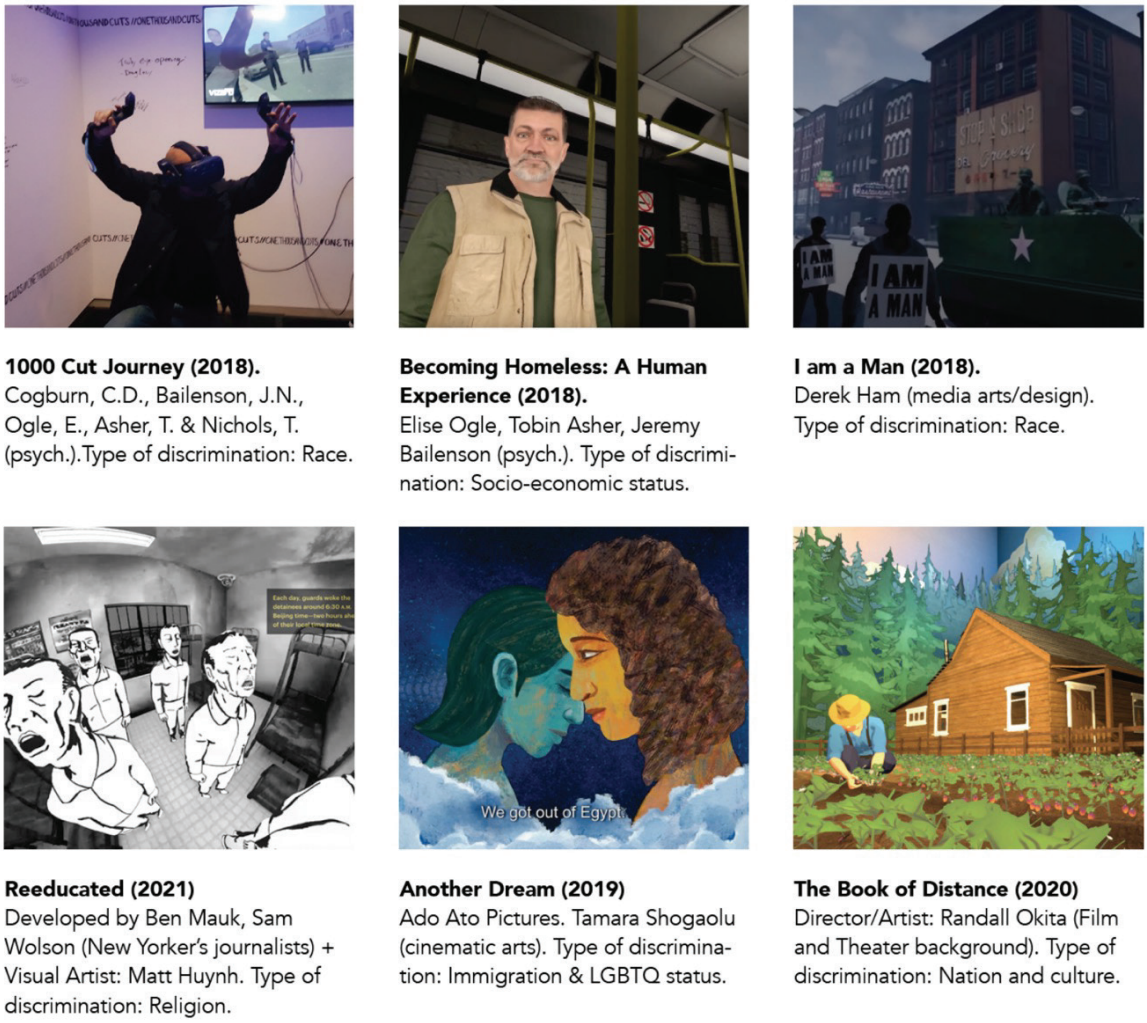
- VR experience must reflect the most recent technological advances and include only VR created with three-dimensional assets (CGI), not with 360-degree cameras (film-based). The search aimed to find VR experiences created after 2015 and select a group that was created in a period not longer than four years. This allowed an equitable comparison because the tools available to the authors were at similar levels of technological advancement.
- VR experiences exe or similar executable files must be available for playtesting.
- VR experiences must expose the participant to marginalized individuals or groups.

Table 3. VR Experiences search results [accessed on 11-27-2023]

Title and Authors	Year	Source and Selection	Reasons
Passage Home, by Fox and Olson	2020	I found it through a paper . Not selected	Files not available (emails were sent to the authors but received no response)
Another Dream, by Adoato Pictures	2020	Viveport. Selected	Fits all selection requirements.
She, by Lee, Yu-Hao, Neng-Hao, Wei-Zhe	2021	SIGGRAPH '21 VR Theater. I found it through a paper. Not selected.	Files not available (emails were sent to the authors but received no response)
1000 Cut Journey by Cogburn, Bailenson, Ogle, Asher & Nichols	2018	Stanford VHIL, Tribeca F.F., SIGGRAPH '18 and Games for Change. Selected	Fits all selection requirements.
Homestay by Smith	2018	National Film Board of Canada, Games for Change. Not selected	Files not available (emails were sent to the authors but received no response)
The Book of Distance by Okita	2020	Venice VR Expanded Biennale 2020, Steam and Meta. Selected	Fits all selection requirements.
Queerskin: A Love Story by Cloudred	2018	Steam, Meta, Tibeca F.F. Not selected	Film-based VR + CGI. Religious stand can bias playtesting.
I am a Man, by Ham	2018	Meta, Siggraph '18 Immersive Pavillion. Selected	Fits all selection requirements
Upstander, by Phan, Aha and Wow	2020	Meta, Tribeca F.F., XR Must F.F., Virtual Reality Experience 2023	Files not available (emails were sent to the authors but received no response)

Title and Authors	Year	Source and Selection	Reasons
Reeducated, by Wolson, Huynh at The New Yorker VR	2021	Venice Biennale 2021. Selected	Fits all selection requirements.
Dreamin' Zone, by Giezendanner	2020	Venice Biennale 2021. Not Selected	Files not available. (emails were sent to the distribution channel, diversion cinema, but received no response).
Becoming Homeless: A Human Experience, by Ogle, Asher, Bailenson	2018	Steam. Selected	Fits all selection requirements.
Notes on Blindness, by La Burthe, Colinart, Spinney,Middleton	2016	Meta, MIT Docubase	Files not available
Injustice, by Cho, Kothari, Ding, Won, Fawaz, Cheng	2015	Siggraph '16,	Files not available

C1. State-of-the-Art of VR for Inclusion



1000 Cut Journey (2018). Cogburn, C.D., Bailenson, J.N., Ogle, E., Asher, T. & Nichols, T. (psych.).Type of discrimination: Race.

Becoming Homeless: A Human Experience (2018). Elise Ogle, Tobin Asher, Jeremy Bailenson (psych.). Type of discrimination: Socio-economic status.

I am a Man (2018). Derek Ham (media arts/design). Type of discrimination: Race.

Reeducated (2021) Developed by Ben Mauk, Sam Wolson (New Yorker's journalists) + Visual Artist: Matt Huynh. Type of discrimination: Religion.

Another Dream (2019) Ado Ato Pictures. Tamara Shogaolu (cinematic arts). Type of discrimination: Immigration & LGBTQ status.

The Book of Distance (2020) Director/Artist: Randall Okita (Film and Theater background). Type of discrimination: Nation and culture.

Fig. 31. The selected State-of-the-Art VR for Inclusion.

The Book of Distance (2020)

Director and Artist: Randall Okita

Producer: David Oppenheim at The National Film Board of Canada (NFB)

Executive Producer: Anita Lee at The National Film Board of Canada (NFB)

On Steam for Valve, HTC Vive, Oculus Rift, Windows Mixed Reality at

https://store.steampowered.com/app/1245640/The_Book_of_Distance/

Summary: Randall Okita created this VR experience to celebrate his great-grandfather, Yonezo Okita, who left Hiroshima, Japan, in 1935, his native country and culture, to emi-

grate to Canada. In 1941, when Canada entered a war against Japan, he became an enemy of the state and was separated from his family while placed in internment camps. This VR experience is an interactive, immersive biography generated through three-dimensional digital assets mixed with original photos, letters, and narration.

Techniques from theater choreography, lighting, and woodblock printmaking are mingled with contemporary and minimalistic character designs to take the participants across time and space. The narrative alternates memories of Yonezo Okita's life as a victim of racism and abuse and Randall Okita's father's voice and memories of Yonezo, his grandfather. Throughout the entire experience, Randall Okita is present on the stage with the VR participant as a guide on the poetic and engaging journey through his family history.

This experience is unique because the author, who is the narrator, appears in it dressed in modern and casual contemporary clothing while speaking colloquially, being relatable, and engaging in the actions. He talks openly about his feelings toward the events and his ancestors, which emotionally connects us with him and his family's story. Even though he is narrating a story that happened long before his birth, the fact that the experience includes him among the protagonists conveys the sense that his present life is affected by Yonezo's past prejudicial abuse. This "time-machine" effect uniting past and present permeates the experience with a sense of transcendence, magnified by the voice recordings of the narrator's father, who also exists in the present, and the photos and digital representation of the great-grandfather and his family members, which belong to the past and are always silent. The player connects with these characters through interactive elements, highlighted by animated glowing particles, that can be manipulated to help the silent figures in critical moments of the journey. For example, the participant packs the grandfather's suitcases to travel to Canada, takes photographs of the family, passes the family food, and helps the family build a farm, including planting strawberries.

About the Author: Randall Okita graduated from the Canadian Film Centre, The Berlinale Talents, the talent development program of the Berlin International Film Festival, the Na-

tional Screen Institute Diverse Director Program, and the TIFF Director's Lab, the Toronto International Film Festival's talent development program. Thanks to Okita's education firmly rooted in film, theater, and narrative, "The Book of Distance" differs from most VR experiences focused on prejudice and discrimination that use photorealistic renditions and little narrative transitions and flow.

Reeducated (2021)

Ben Mauk, developper, and Sam Wolson, director.

Visual Artist: Matt Huynh

Lead Animator: Nicholas Rubin

On Oculus and Cardboard viewer at https://www.newyorker.com/news/video-dept/reeducated-film-xinjiang-prisoners-china-virtual-reality

Summary: This experience is a New Yorker's immersive VR documentary that explores a "reëducation" camp in Xinjiang, China, through the memories (12 hours of recorded interviews) of three detainees, Erbaqyt Otarbai, Orynbek Koksebek, and Amanzhan Seituly. The VR experience's visual rendition is given by the animation of artist Matt Huynh's detailed two-dimensional ink illustrations, reminiscent of calligraphy, combined with three-dimensional assets (outdoor grassy field) and short video clips of the three protagonists with textual information about their current situation.

Dirt Empire, an animation company led by Nicholas Rubin, supervised all of the animation production of the project with a core team of visual effects artists to bring the project into stereoscopic virtual reality over one year.

About the Authors: Ben Mauk is a graduate of the Iowa Writers' Workshop and writes for The New York Times Magazine, The New Yorker, Harper's, and the London Review of Books, among other publications.

Sam Wolson is an Emmy nominated, immersive film director, photographer, and journalist with partners including National Geographic, The New York Times, and The New Yorker.

Matt Huynh is a Vietnamese-Australian, New York-based visual artist and storyteller. Cal-

ligraphic Eastern sumi-e ink traditions and popular Western comic books inform his bold brush and ink paintings. His work has been exhibited by the Museum of Modern Art in New York, The Smithsonian, and The Sydney Opera House.

Nicholas Rubin earned a bachelor's degree in animation, interactive technology, video graphics, and special effects from Rhode Island School of Design and from New York University with a Master's degree in interactive telecommunication programs. He is the founding partner, chief executive immersive producer, and director at Dirt Empire, a production and animation enterprise. He won the Peabody Emmy Award in 2022 in the Immersive and Interactive category.

Becoming Homeless: A Human Experience (2018)

Developer: Elise Ogle, Tobin Asher, Jeremy Bailenson

Publisher: Virtual Human Interaction Lab

On Steam for HTC Vive and Valve: https://store.steampowered.com/app/738100/Becoming_Homeless_A_Human_Experience/ [Accessed February 12, 2024]

Summary: In this immersive virtual reality experience from Stanford University's Virtual Human Interaction Lab, spend days in the life of someone who can no longer afford a home. Interact with your environment to save your home and protect yourself and your belongings as you walk in another's shoes and face the adversity of living with diminishing resources. Researchers from Stanford have run thousands of participants through this experience to study the effect of VR experiences on empathy. Across our studies, we demonstrate that a VR experience changes helping behavior more than other types of perspective-taking exercises, and the effect lasts months afterward. While this 7-minute journey does not come close to the immense burden of living without a home, researchers continue to find that VR experiences can be a powerful tool to help put oneself in the shoes of another.

About the Authors: Elise Ogle received her BA and MA from Stanford University, where she studied the psychological and behavioral effects of virtual reality on empathy.

Tobin Asher is the Associate Director of Global Partnerships at the Virtual Human Interac-

tion Lab at Stanford University. He has worked at Stanford's Virtual Human Interaction Lab since 2015, where he facilitates research projects and lab outreach and travels around the world to share findings and insights from the lab's work. He also creates VR interactives, programs virtual worlds, shoots and edits 360 videos, and composes music scores.
Jeremy Bailenson is the founding director of Stanford University's Virtual Human Interaction Lab, Thomas More Storke Professor in the Department of Communication, Professor (by courtesy) of Education, Professor (by courtesy) Program in Symbolic Systems, a Senior Fellow at the Woods Institute for the Environment, and a Faculty Leader at Stanford's Center for Longevity. He earned a B.A. cum laude from the University of Michigan in 1994 and a Ph.D. in cognitive psychology from Northwestern University in 1999. He spent four years at the University of California, Santa Barbara, as a Post-Doctoral Fellow and then an Assistant Professor. Bailenson studies the psychology of Virtual and Augmented Reality, particularly how virtual experiences lead to changes in perceptions of self and others.

1000 Cut Journey (2018)

Directors: Courtney Cogburn, Elise Ogle

Producers: Jeremy Bailenson, Courtney Cogburn

Key collaborators: Virtual Human Interaction Lab, and Cogburn Research Group

Funded by The Brown Institute for Media Innovation

VR Headsets: HTC Vive, Meta Quest.

Summary: This VR experience places the participant in the avatar and life of a black individual, Mike Sterling, throughout his life, from childhood to adulthood while victimized with microaggressions.

About the Authors: See Courtney Cogburn, Elise Ogle, Jeremy Bailenson's bio from "Becoming Homeless: A Human Experience"

Another Dream

Author: Ado Ato Pictures, led by Tamara Shogaolu, a new media artist who earned an MFA from Southern California's School of Cinematic Arts. She was nominated for Outstanding Interactive Media and won an Emmy in the News and Documentary category in 2020.
VR Platform: HTC Vive.
Summary: Another Dream is a hybrid animated documentary and VR game that depicts the love story of an Egyptian lesbian couple. Due to hatred against the LGBTQ community, they escape Cairo to seek asylum and acceptance in the Netherlands. An accompanying installation allows audiences to reflect on what they have seen, heard and felt in VR. Another Dream is the second installment of Queer In A Time Of Forced Migration, an animated transmedia series that follows the stories of LGBTQ refugees from Egypt, Sudan, and Saudi Arabia and from the 2011 revolutions in the Middle East and North Africa region.

I Am a Man (2018)

Author: Developer and publisher Derek Ham earned a master's in architecture from Harvard University's Graduate School of Design in 2003 and a Ph.D. in design computation from MIT in 2005. He is an academic at NC State [University]'s College of Design.
Platform: Oculus Rift.
Summary: This experience aims to render history in a way that provides a personal and deep understanding of the struggles of the civil rights leaders who fought for freedom and equality. It allows participants to walk in their shoes. Through historical film photographs and voice narrations of actual Civil Rights participants, this interactive documentary takes participants to the days of Martin Luther King's murder, ending with the tragic event marked by the fatal gunshot. Later on, the participant watches on TV the announcement of King's assassination while riots rage in the city streets.

C2. Playtesting and Assessment

After downloading the selected VR experiences on four workstations, each installed with the required hardware system, between mid-January and mid-March 2023, fifteen students enrolled in Art350 Computing for the Interactive Arts Capstone I at the California Polytechnic State University playtested each experience. Eighteen students were in the class, three of whom did not complete playtesting, one due to a skin condition, psoriasis, which made wearing the headset painful; the other two did not complete the questionnaires.
Races: 5 Caucasian, 8 Asian, 1 Latino/Asian, 1 Caucasian/Asian
Gender: 3 Non-binary, 5 Males, 7 Females - Ages: 20 to 22 years old
Majors: 6 engineers (Computer Science/Engineering, Software Engineering), 6 Art and Design, 1 Liberal Art and Engineering Studies, 2 Business and Administration.

The students stated they had exposure to VR before playtesting through video games, they cared about social justice, and they were comfortable with exposure to the six experiences and filling out the assessment questionnaire, which included twelve categories about sensory (Visuals/Sound, Point of View, Space, Scale, and Time), psychological (Emotions, Interactivity, Embodiment, Narrative Flow and Cognition) and motivational perceptions (Impact and Enjoyment). After playtesting and completing assessment questionnaires, students expressed their points of view, feelings, and concerns during in-class discussions, which focused on.

- Strategies to convey the VR protagonist's social identity or group belonging (SIG)
- Visual style in general and specific to human representation (VSH)
- Use of sound, light and color (SLC)
- Emotional connections with the protagonist (EC)
- Use of space, time, and scale (STS)
- Interactivity and enjoyment's (IE)
- Immersion, presence and embodiment (IPE)

Table 4. Significant themes discussed after playtesting that guided the development of taxonomy.

	1000 Cut Journey	Becoming Homeless	I Am a Man	Reeducated	Another Dream	The Book of Distance
SIG	Technological constraints given by depicting non playable characters through video prevents the player from feeling sense of closeness with the characters. No clear cultural clues give a sense of belonging to a specific ethnic group or culture.	The VR participants have no exposure to cultural clues. The only element that conveys a sense of belonging to a specific group is the choice of the skin color of the participant's hands. The majority of the experience occurs without people, except for a scene on a bus, which is fear-arousing putting the player on defense mode.	The visual style, original film footage, loyal depiction of the settings and presence of people of color in every scene allows the player to perceive a strong sense of belonging to the depicted era, and events.	The loyal depiction of the spatial surroundings and ethnic features of the people involved, guards and detainees, conveys a strong sense of cultural belonging, making the players feel as if they are prisonners in the detention camp.	The Arabic writing during the scene transitions, and depiction of the protagonists' journey through different countries and cultures makes the players feel a strong sense of belonging to the protagonists' emotional and physical story and culture.	Old family photos, recorded phonecalls and use of Japanese colors and culture give a sense of belonging to the protagonist's family. The players are included in the story as events facilitators making them part of the Japanese family's story.
VSH	The assets and scenes are photorealistic. The protagonist is computer generated and uncanny; the non playable characters are video-based, physically and emotionally distant.	The assets and scenes are photorealistic. The player embodies a set of computer generated hands, which is prompted to choose the skin color; the non playable characters are photo-realistic and uncanny.	The visuals are a hybrid of black and white videos/ photos and characters and worlds' 3D models. The human figures are generic, whithout facial expression. As in a documentary, the 3D worlds are reproduction of the 1960es.	Watercolor effects allow the player's space exploration. Human figures' inked outlines are in constant wobbly motion, which shows the detainees as very much alive in their state of submission, suffering, and powerlessness.	This experience is depicted for the most part through drawings, with a few 3D modeled environments. Non-photorealistic 2D and 3D visuals allows to avoid the uncanny valley, and heighten the engagement due to the variety of styles and places depicted.	As on a theater stage, props and sets complement the events unfolding. Simple 3D models (without eyes) prevents the characters from looking photo realistic and uncanny. The toon shading makes them appear vulnerable, emotionally distant and real in their stoic suffering.

	1000 Cut Journey	Becoming Homeless	I Am a Man	Reeducated	Another Dream	The Book of Distance
SLC	Lights and colors aim at emulating photorealism and tend to be neutral. The sound is the voices of non playable characters during the scenes and of a narrator during the transitions in which the player is in front of a mirror and prompted to waive while watching the same motion in the mirror.	Lights and colors aim at emulating photorealism. they tend to be neutral. The voice of a narrator, radio and ambient sounds accompany the events.	Lights and colors aim to emulate the 1960es, hence hightly saturated, and dark during the 3D modeled scenes. Black and white historical videos and photos appear several time to remind us that this is a documentary experience.	The majority is in black and white with occasional muted colors in the outdoors of the detention center, through the cell's window, to signify that joyful life is out of reach. The light is used to drive the attention and encourage the exploration of the bleak setting of the prison. The sound is the narration of 3 detainees.	Light and colors change to convey the protagonists'mood, alternating from bright and cheerful in peaceful scenes to highly saturated during the escapes or scenes at the immigration offices, city environments or when the protagonists cross a dark and scary forest. The sound is the narration of the events through the two protagonists' voices.	Sound is the soothing voice of a narrator. Beams of spotlights surround the characters while animated glowing particles highlight objects that the participant can interact with. The use of warm and cool colors communicates affective shifts and happy or sad moments.
EC	The transitions in which the player is in front of the mirror aim at creating emotional connection, sense of embodiment and self-identification with the avatar of the protagonist, Michael Sterling.	The players are prompted to choose the skin color of a set of hands that they identify with. This strategy aims at creating a connection with the protagonist and instill compassion when all the belonging disappear and they become unhoused.	The historical footage and photos emotionally connect the player to the events and people at the cented of the experience.	The detainees' narration and beautiful visual depiction of their condition inside the camp create emotional engagement, and compassion. The end of the experience shows the real protagonists through videos, heightening the awareness that real events and victims are depicted.	The recurring depictions of the two protagonists intimate conversations and settings, accompanied from their emotions as perceived through their voices narrating the events, give the experience a sense of realism and connection to the suffering of the two lovers.	The recurring appearance of family photos, and the player's acts to help the protagonists create closeness. The author, also narrator, exists in the present, speaking colloquially about feelings toward the events and his ancestors, which emotionally connects the player with him and his family's story.

	1000 Cut Journey	Becoming Homeless	I Am a Man	Reeducated	Another Dream	The Book of Distance
STS	*Space* includes photo-realistic interiors and exteriors. Non-playable characters are video-based. The player cannot ever get close to them. At the end of the experience, a scene outside with policemen pinning down the player is enacted on a sidewalk but the space is vast. *Time* progresses through episodes of the protagonist's life, from chilhood to adulthood. The transitions in between the ages occurs in fron of a mirror. *Scale* is photo-realistic and aimed at mimicking the scale of real objects.	*Space* is a crucial element because at the center of the experience is the loss of a home. First, the space become emptied when all persona belonging are sold, the thefamiliar and secure environment of the apartment is lost. *Time* is linear, with no events in the past or the future, only the present. *Scale* is photo-realistic and aimed at mimicking the scale of real objects.	*Space* includes photo-realistic interior and exteriors. *Time* is a crucial element because it's a documentary focused on depicting the day in 1968 when Martin Luther King was killed. The use of historical film with the real voices of the civil rights movement's leaders and photos, add depth to the story. *Scale* is photo-realistic and aimed at mimicking the scale of real objects.	*Spaces* are revealed through animations. Calligraphic lines gradually materialize to define rooms and props. A scene in the middle of the experience is different because computer generated and 3D. *Time* spans from the past, narrated by three detainees and illustrated with art-based animations, to the present, depicted at the end through videos of the three detainees, to imagined, shown in the middle of the experience when a computer generated outdoor scene shows one of the detainees singing in a grass land. *Scale* is art based, far from realistic, still conveys the story well.	*Space* is crucial because the main theme is travel and escape. Diverse environments, from 2D intimate conversations on a couch to 3D cities, forests and interiors, accompany the player on the journey with the two story's protagonists. *Time* spans from the past, narrated by two lovers and illustrated with multiple styles of animations (2D and 3D), to the present, at the end of the experience, when the player is asked to respond. *Scale* is art based, alternating between 2D and 3D assets. It is far from realistic, still conveys the story well.	*Space* is intimate like on a theater stage. The set and characters are three-dimesional. Two-dimensional planes with old family photos slide in front of the player to humanize the characters, and remind us this is a true story. *Time:* the author of the experience, also narrator, appears as one of the characters in the present, narrating his grandfather's story that happened long before his birth. *Scale:* Interiors are small, populated with objects to interact with in order to progress. Outdoor scenes depict broad environments, at times, dark to convey despair, at times, bright to convey joy.

	1000 Cut Journey	Becoming Homeless	I Am a Man	Reeducated	Another Dream	The Book of Distance
IE	*Interactivity* allows the player to progress through the entire experience. *Enjoyment:* The fearful ending with a police attack is unpleasant. The interactivity does not work smoothly, which adds frustration.	*Interactivity* allows the player to progress through the entire experience. *Enjoyment:* The depressing theme and fearful encounter on the bus render the experience less enjoyable.	*Interactivity* allows the player to progress through the entire experience. *Enjoyment:* The alternating of historical videos and artistically rendered computer generated scenes renders the experience informative and enjoyable.	*Interactivity:* The experience does not require the player to act. Just like the detainees, the player has no agency or ability to change their condition. *Enjoyment:* The artistic rendition and engaging narration spark interest, curiosity and enjoyment.	*Interactivity* occurs in between each chapter of the journey. The player has to trace arabic words to progress through the experience *Enjoyment:* The artistic rendition and engaging narration triggers interest, curiosity rendering the experience enjoyable.	*Interactivity:* Props (magazines, letters, photos, etc.) require physical action to progress in the narrative, triggering curiosity and engagement. *Enjoyment:* Like in a play, the participant is an actor, with the protagonist's grandson, who is the author and part of the story through the lens of his own memories.
IPE	*Immersion & Presence*:* The technical aspects of a VR system did not work properly, which prevented sense of immersion and experiential quality in the virtual environments (presence). *Embodiment:* The actions in front of a mirror, prompted by voice commands, aim at inducing embodiment.	*Immersion & Presence*:* Students felt that immersion and presence was strong and even traumatizing in the scene on the bus. Some screamed while inside VR and brough up that scene during the in class discussion. *Embodiment:* The choice of skin color for the hands aims at inducing sense of embodiment..	*Immersion & Presence*:* Students felt that immersion and presence was strong. *Embodiment:* No strategies are employed to make the player feel that they are occupying an avatar or social identity. The player is a spectator.	*Immersion & Presence*:* Students felt that immersion and presence was strong but the the lack of interactivity/agency reduced the illustion of being there. *Embodiment:* No strategies are employed to make the player feel that they are occupying an avatar or social identity. The player is a spectator.	*Immersion & Presence*:* Students felt that immersion and presence was strong but would have liked more interactivity/ agency to truly feel as part of the story. *Embodiment:* No strategies are employed to make the player feel that they are occupying an avatar or social identity. The player is a spectator.	*Immersion & Presence*:* Props are placed in front of the participant, promoting immersion in the experience, and solidifying the "illusion" that the participant is part of the story. *Embodiment:* Even though the player is not given a avatar, proximity to the characters and intimate space conveys a strong sense of belonging.
	*Students struggled with these two categories because perceived as the same and hard to pinpoint.					

C3. The Play-testing Questionnaire

Category 1 [Visuals & Sound]

Please take a moment to consider the overall combined use of the visual and sound to guide your attention and focus. Here is what to pay attention to color, scale, visual paths (real or implied/suggested), narration, music, or ambient sound.

Please state your level of agreement or disagreement to the following statement:

Q1. Visual elements and sound help direct my attention and focus.

Strongly Disagree					Neutral					Strongly Agree
0	1	2	3	4	5	6	7	8	9	10
○	○	○	○	○	○	○	○	○	○	○

Additional Essay Questions:

Q1a. Was there any point during the experience where you didn't know where to look (you were lost)?

Q1b. If you did know where to look, what encouraged you to look in that direction (please state if use of visual clues or sound helped)?

Q1c. What scenes, visual elements or sounds were most memorable, if any? Why did they stand out to you?

Q1d. If there was music in the experience, did it affect the mood of the VR experience? If yes, What kind of mood or tone did the music create?

Category 2 [Interactivity]

Please take a moment to consider the overall interactivity and sense of agency (make choices) inside the VR experience. Please state your level of agreement or disagreement to the following statement:

Q2. The experience has interactive elements, allowing me to make choices and act.

Strongly Disagree					Neutral					Strongly Agree
0	1	2	3	4	5	6	7	8	9	10
○	○	○	○	○	○	○	○	○	○	○

Additional Essay Questions:

Q2a. Would you have liked the experience (more) interactive?

Q2b. Was there any gameplay that you enjoyed or did not enjoy? What was it? Why did you enjoy it or not?

Category 3 [Time]

Please state your level of agreement or disagreement with the following statement:

Q3. The use of time* in the piece helps to convey the mood/message/meaning of the story.

*Time refers to the narrative timeline, including the past, present or imaginary time. The experience can display different times (i.e., past, present, imaginary), or only one (present). To assess the use of time in this experience, you could ask yourself questions like: When does this experience take place? In the present, past or is there a scene that seems imagined? If only the present is shown, would you have liked to know more through having information from the past?

Strongly Disagree					Neutral					Strongly Agree
0	1	2	3	4	5	6	7	8	9	10
○	○	○	○	○	○	○	○	○	○	○

Category 4 [Space]

Please think about the spatial design and the feel of the 3D environment inside this VR experience. Sense of space can guide the eye and trigger emotions. For example, lots of empty (sparsely populated) space around an object/person tends to lead the focus to it/them. Closed and cluttered space triggers anxiety, and open space triggers serenity and calmness. Please state your level of agreement or disagreement with the following statement:

Q4. The use of space helps to convey the mood/message/meaning of the story.

Strongly Disagree					Neutral					Strongly Agree
0	1	2	3	4	5	6	7	8	9	10
○	○	○	○	○	○	○	○	○	○	○

Q4a. Were there scenes with a lot of empty space? Did you like it or not (maybe made you feel lost or calm/serene)? Why?

Q4b. Were there scenes with a lot of objects surrounding you? Did you like it or not (maybe made you feel cluttered/overwhelmed)? Why?

Q4c. At any point, did any objects seem out of reach (too much spatial distance)? Did you try to or wanted to pick them up?

Please state your level of agreement or disagreement to the following statement:

Q4d. Environments within the experience made me feel serene or calm.

Strongly Disagree					Neutral					Strongly Agree
0	1	2	3	4	5	6	7	8	9	10
○	○	○	○	○	○	○	○	○	○	○

Please state your level of agreement or disagreement with the following statement:

Q4e. Environments within the experience made me feel anxious or afraid.

Strongly Disagree					Neutral					Strongly Agree
0	1	2	3	4	5	6	7	8	9	10
○	○	○	○	○	○	○	○	○	○	○

Category 5 [Scale]

This part refers to the size of the assets/elements in the VR scenes/environments and the size of the avatar (body the user inhabits). Scale can help guide the eye and trigger emotions. For example, depicting a character as small next to a larger and imposing one can convey to the participant that the small one is a victim and the large one a perpetrator of unfair practices. Moreover, if the landscape scale is large and the participant avatar is small, it can make the participant feel lost and vulnerable.

Please state your level of agreement or disagreement to the following statement:

Q5. The use of scale* helps to convey the mood/message/meaning of the story.

* i.e., if the experience aimed at instilling positive feelings and associations, a realistic scale would be employed; if the experience aimed at instilling negative feelings and associations,

a too big/imposing or too small/diminishing scale would be employed.

Strongly Disagree					Neutral					Strongly Agree
0	1	2	3	4	5	6	7	8	9	10
○	○	○	○	○	○	○	○	○	○	○

Additional Essay Questions:

Q5a. At any point during the experience, were there any objects, buildings, or people that were unrealistically sized? Were they large or small? If yes, how did size make you feel?

Q5b. At any point during the experience, were did you feel large or small compared to your environment? If yes, how did size make you feel?

Category 6 [Point of View (POV)]

Q6. Please state your level of agreement or disagreement to the following statement:

The point of view* helped convey the mood/message/meaning of the story.

Strongly Disagree					Neutral					Strongly Agree
0	1	2	3	4	5	6	7	8	9	10
○	○	○	○	○	○	○	○	○	○	○

*Point of View (POV) can be used to frame the environment in ways that trigger emotions. For example, if the participants are placed in the position to look up (worm-eye view) at characters staring down at them, they'll likely feel vulnerable and small. If the participants are looking down at the scene (bird-eye view), they will likely feel powerful and in control. Moreover, if the characters inside the experience are far, they'll be perceived as emotionally detached, if close, they'll be perceived as relatable and engaging.

Category 7 [Impact]

Impact is aimed at measuring, by the end of the experience, if you felt like you wanted to do something in the physical world to become more aware or change the status quo about the topic/story depicted.

Please state your level of agreement or disagreement to the following statement:

Q7. I became motivated to advocate for the condition of the protagonists because of the story in this VR experience.

Strongly Disagree					Neutral					Strongly Agree
0	1	2	3	4	5	6	7	8	9	10
○	○	○	○	○	○	○	○	○	○	○

Q7a. By the end of the experience, did you feel like you wanted to do something (even simply know more about the topic of the experience)?

Q7b. Do you think this VR experience will stay with you longer than others?

Category 8 [Emotion]

Please state your level of agreement or disagreement to the following statement:

Q8. I felt emotions while inside the experience.

Strongly Disagree					Neutral					Strongly Agree
0	1	2	3	4	5	6	7	8	9	10
○	○	○	○	○	○	○	○	○	○	○

Additional essay questions:

Q8a. Which emotions did you feel throughout the experience?

1. Positive. Why was it a positive experience?

2. Negative. Why was it a negative experience?

3. Other. [please elaborate]

The perception of the human character can affect the experience. For example, you might prefer a more or less photo-realistic or cartoony style. To assess if the characters' depiction made you feel engaged or not in their journey, please state your level of agreement or disagreement to the following statement:

Q8b. The human characters are aesthetically pleasing.

Strongly Disagree					Neutral					Strongly Agree
0	1	2	3	4	5	6	7	8	9	10
○	○	○	○	○	○	○	○	○	○	○

Additional essay questions:

Q8c. Were there characters within the experience relatable? Why?

Q8d. Did you perceive characters within the experience unsettling or uncanny*? What about them made you feel that way? *Eerie, strange or mysterious, especially in an unsettling way.

Category 9 [Embodiment]

Embodiment refers to the perception or illusion that our virtual bodies momentarily substitute our real bodies.

Please state your level of agreement or disagreement to the following statement:

Q9. I felt as if I was inhabiting the body of the virtual character and was present inside the VR story/scenarios and situations.

Strongly Disagree					Neutral					Strongly Agree
0	1	2	3	4	5	6	7	8	9	10
○	○	○	○	○	○	○	○	○	○	○

Additional essay questions:

Q9a. In this experience, did you embody a character? Yes / No, If yes, what character did you feel that you embodied? Did you perceive an social identity blend with the character?

Q9b. At any point during the experience, did you feel as though your virtual body within the VR experience was your real body?

Category 10 [(Narrative) Flow]

The flow of the experience can be continuous/linear (the story goes through events which are sequential in time) or episodic/non-linear (fragmented, jumping across different times). Please think of which of the two is used in this experience and if it helps conveying the meaning of the story or allows the participant to connect to the story's protagonist(s).

Please state your level of agreement or disagreement to the following statement:

Q10. The flow of this experience helps convey the story's message/mood.

Strongly Disagree					Neutral					Strongly Agree
0	1	2	3	4	5	6	7	8	9	10
○	○	○	○	○	○	○	○	○	○	○

Category 11 [Cognition]

Cognition is learning something new or becoming aware of and familiar with something you did not know prior to this VR experience.

Please state your level of agreement or disagreement to the following statement:

Q11. The experience added to my knowledge about the depicted topics.

Strongly Disagree					Neutral					Strongly Agree
0	1	2	3	4	5	6	7	8	9	10
○	○	○	○	○	○	○	○	○	○	○

Q11a. Is there something you learned from this experience that you did not know before?

Q11b. Did it teach you only about one person's condition (mono-level of knowledge) or about an entire culture/setting (multi-level of knowledge) surrounding that person's condition?

Category 12 [Enjoyment]

Please state your level of agreement or disagreement to the following statement:

Q12. I enjoyed the experience.

Strongly Disagree					Neutral					Strongly Agree
0	1	2	3	4	5	6	7	8	9	10
○	○	○	○	○	○	○	○	○	○	○

Q12a. After finishing the experience, please specify if the experience left you with negative feelings, like sad or angry, or positive ones, like happy or pleased.

Sad/Angry [or similar]

Happy/Pleased [or similar]

Other: [specify]

Q12b. If given the option, would you repeat this VR experience? Why or why not?

Q12c. If there was something you could change about this experience, what would you change and why?

C4. Procedure and Discussions

The choice of the six experiences arose from their significantly different nature from the design perspective. The authors come from diverse fields of expertise, with the ones from the world of psychology employing a photo-realistic rendition and the ones with an artistic background employing a fully art-based approach or a middle ground.

During playtesting, students were instructed to remove the headset if at any moment they felt nauseated, sick, emotionally traumatized, or in distress. During the questionnaires, the students were encouraged to answer questions only if they felt comfortable and told there was no problem skipping questions. The goal was to allow the students freedom and promote a sense of empowerment so that their responses could reflect their level of engagement and impact toward the themes faced inside the VR experiences.

Students experienced the six immersive stories in an identical sequence. After the students completed playtesting and assessment for each experience, a class discussion addressed their questions and empowered them to advocate for the cause depicted in VR or voice their preferences, appreciation, and express their critical thinking toward the authors' design choices.

The most controversial experiences were the ones rendered photo-realistically, *1000 Cut Journey* and *Becoming Homeless: A Human Experience*. In each of these experiences, one episode was perceived as traumatizing: the encounter with the police in the first one and an encounter on the bus in the second one. Some students felt these moments were necessary to convey the overall message. In contrast, others disagreed because they thought it took away from empathizing with the protagonist, putting the focus on their distress. Moreover, they felt that the photo-realism contributed to rendering the characters less relatable

due to uncanniness, and the lack of positive elements contributed to the student's frustration, even though some students felt it was helpful to understand the protagonists' conditions.

One of the experiences, *The Book of Distance*, was loved by everyone. Many confessed that it brought tears and heightened positive and moving emotions.

Two of the experiences, *Reeducated* and *Another Dream*, which were also art-based, were perceived positively but at times overwhelming visually and emotionally.

The appreciation for the last experience, *I Am a Man*, which employed a realistic rendition mixed with artistic stylizations, was reduced by the fact that it was difficult to understand which components were interactive, allowing them to progress through the experience; the pauses to figure it out led to a broken narrative flow. Overall, students enjoyed playtesting the experiences, completed the questionnaire promptly, and participated actively in the discussions. Additionally, of the 18 students in the class, twelve chose to create virtual reality projects for the class's final project and reported that playtesting and discussions about the six state-of-the-art VR experiences were crucial to guide them conceptually and in terms of narrative flow and visual and sound design choices.

IV. Results and Conclusions

A. Data Visualization and Qualitative Analysis

Before performing the qualitative analysis of the data collected through the playtesting questionnaires and plotting graphic visualizations, a statistics professor, past research collaborator, and friend from the California Polytechnic State University in San Luis Obispo, Dr. Soma Roy, recommended specific style of graphs, best suited for the data, and encouraged to show each student's scoring style, by assigning to each student as identification a unique color, revealing how each individual's score changes across the six experiences.

Lastly, she recommended also showing person-adjusted means, which are the mean scores given to each experience after removing the effect of the person's scoring style, revealing how the experience rates, regardless of who is scoring the experience. The person-adjusted means ended up matching the average scores.

The students who playtested the six experiences and filled out the questionnaires were enrolled in a capstone upper-level class of the Computing for the Interactive Arts (CIA) minor, which requires them to attend four to eleven weeks of courses with the author across two or three years. I am the only active advisor for the CIA minor, and I follow each student closely to ensure they successfully fulfill all the requirements. The students display much appreciation for the individual attention they are given and the opportunity to be part of a transdisciplinary community like the CIA, which gave me hope they might do their best in this action-based research.

At the beginning of the class, the author presented the focus of the research with passion but without revealing my hypothesis to avoid influencing the students' assessment of the six VR experiences. She explained that if they completed the playtesting and filled the questionnaires with truly pondered and meaningful answers, they could contribute to making a significant difference in advancing an unexplored field of research. Still, the worry was that students might go through the questionnaires as quickly as possible due to the lengthiness of it or the lack of a reward in terms of improving their overall class grade. As Dr. Roy suggested, color-coding each student to identify their scoring styles addressed it.

The following graphics show the quantitative and qualitative values provided by the students, each represented as a colored dot for the most critical categories. The art-based experiences are *Reeducated*, which displays two-dimensional drawings; *The Book of Distance*, which employs three-dimensional artistic assets; and *Another Dream*, which employs a combination of two-dimensional drawings and three-dimensional assets. The photo-realistic experiences are *1000 Cut Journey*, *Becoming Homeless*, and *I Am a Man*, which employ a few artistic strategies within the photorealism.

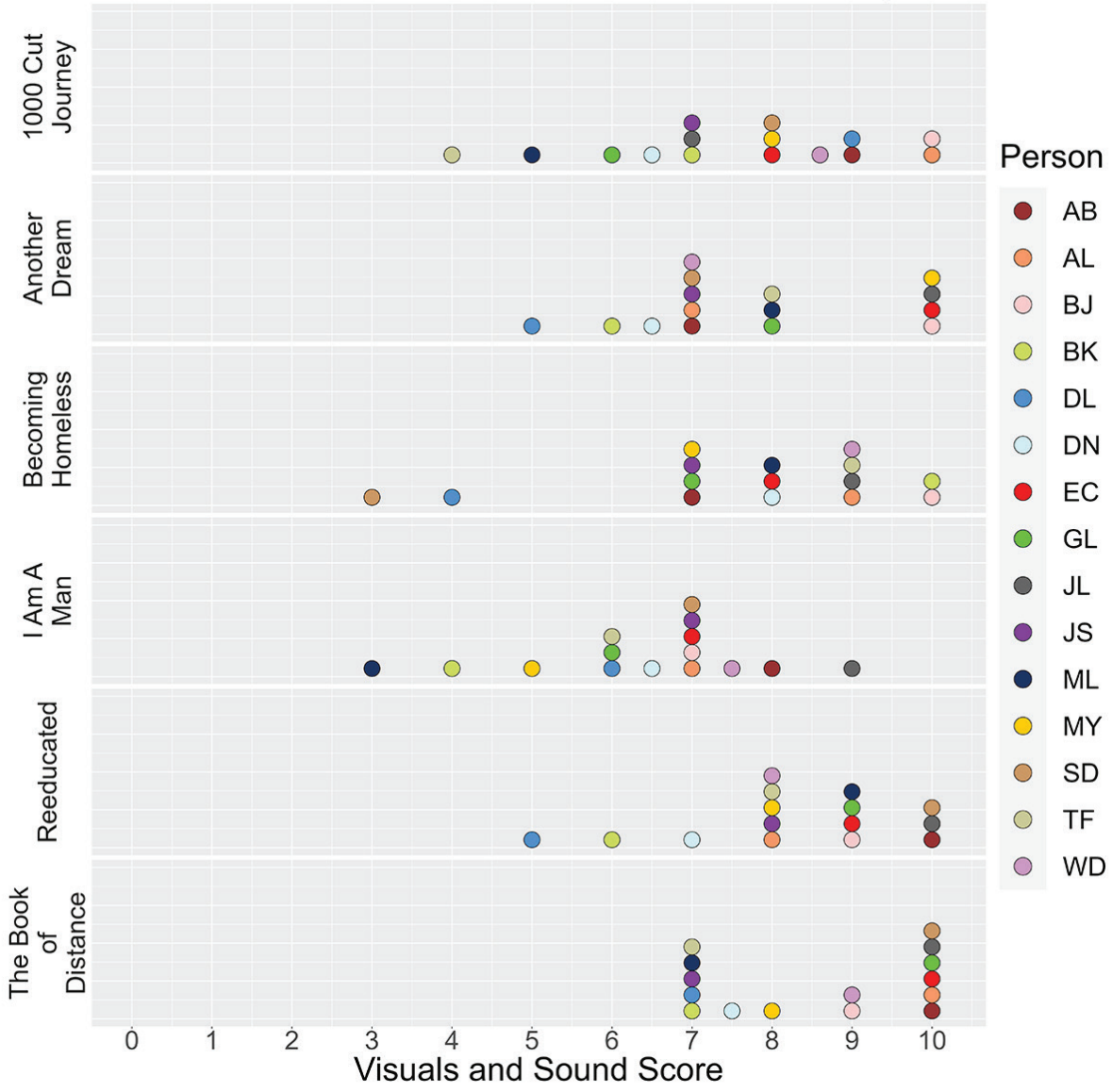


Fig. 32. Students' scores from zero (Strongly Disagree) to 10 (Strongly Agree) the statement: "Visual elements and sound helped direct my attention and focus."

Fig. 31 shows that the the artistic experiences' visuals and sounds directed the students' focus and heightened their attention more than the photorealistic experiences. Comparing the "Visuals and Sound" (Fig. 31) with the "Cognition" category scores (Fig. 32), we can see parallels with students scoring lower the experiences *I Am a Man*, which receive 7 as highest score, *Becoming Homeless*, which also received the most ratings at seven for both categories, and *1000 Cut Journey*, which three students rated at 7 in the visuals/sound category, and four students rated at 6 in the cognition category.

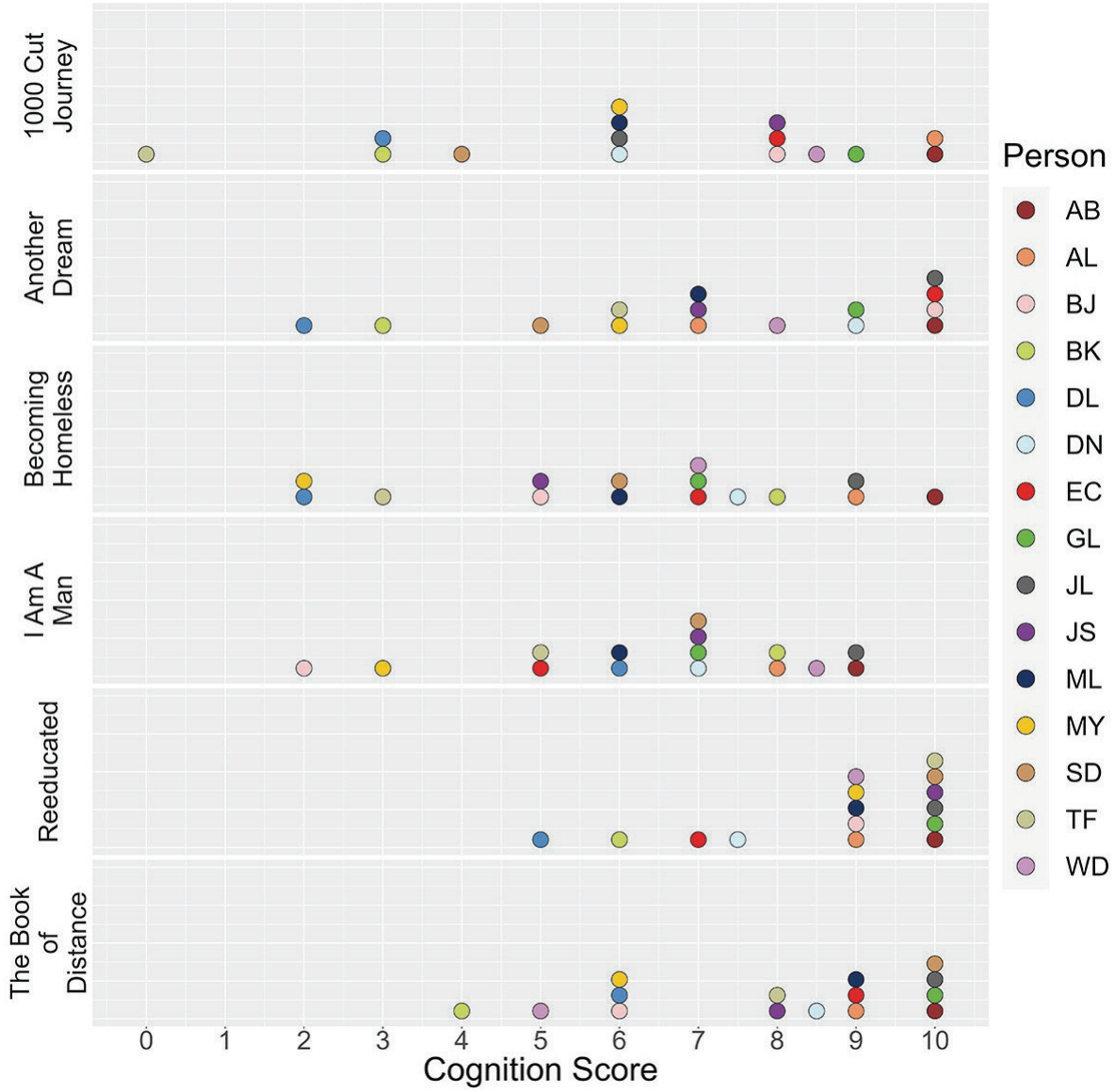


Fig. 33. Students' scores from zero (Strongly Disagree) to 10 (Strongly Agree) the statement: "The experience added to my knowledge about the depicted topics."

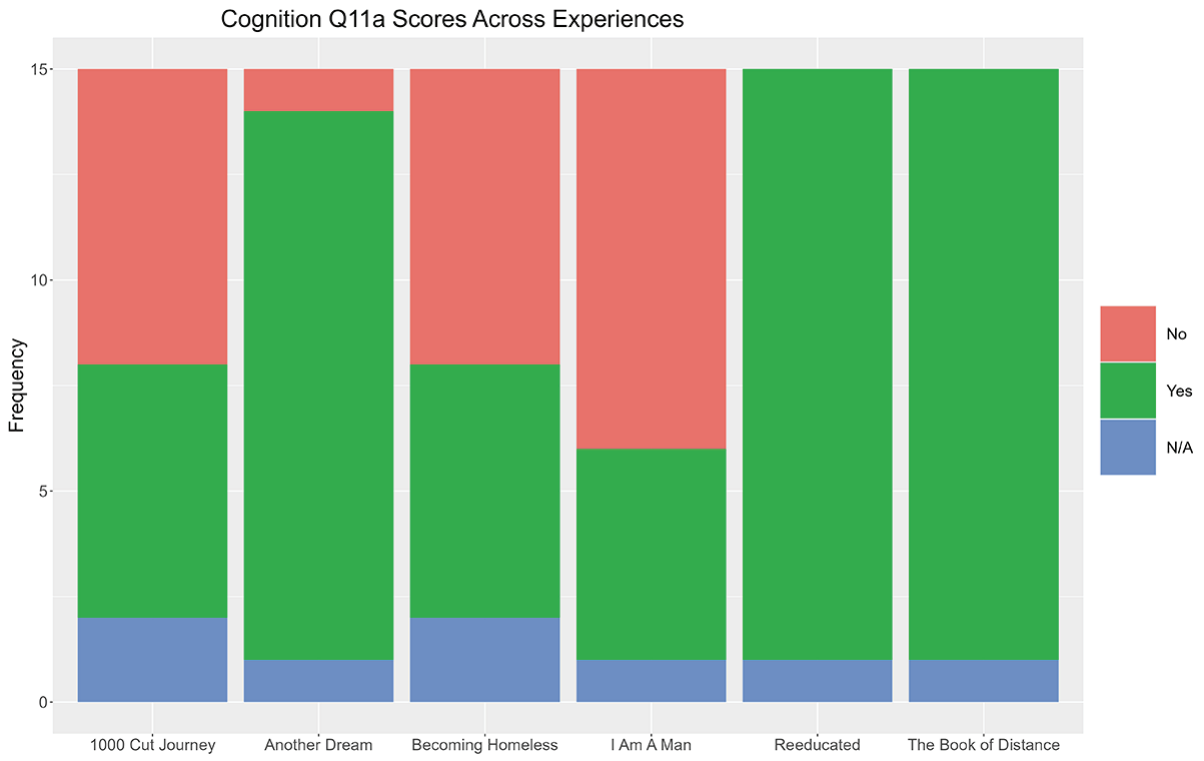


Fig. 34. Students' responses to the essay question Q11a:
"Is there something you learned from this experience that you did not know before?"

Figures 33 shows the responses of the essay questions 11a, providing a deeper understanding about the students' knowledge acquisition and cognitive learning. Students gained most novel insights from the art-based experiences, *The Book of Distance*, *Reeducated* and *Another Dream*.

Students' answers to question 11b show that imagined intergroup contact and perspective-taking are in each experience. Students felt that the narrative, even if centered around one or two people, extended to their social belongings and culture (Figure 32).

The experience titled *The Book of Distance* borrows from the world of theater, placing the VR participant in the center of a stage, acting as the protagonists' companion and helper. This theatrical approach might be the reason for the students' narrower perspective, since the *The Book of Distance* is the only experience in which students did not extend the narrative to the larger social group or people in the same condition.

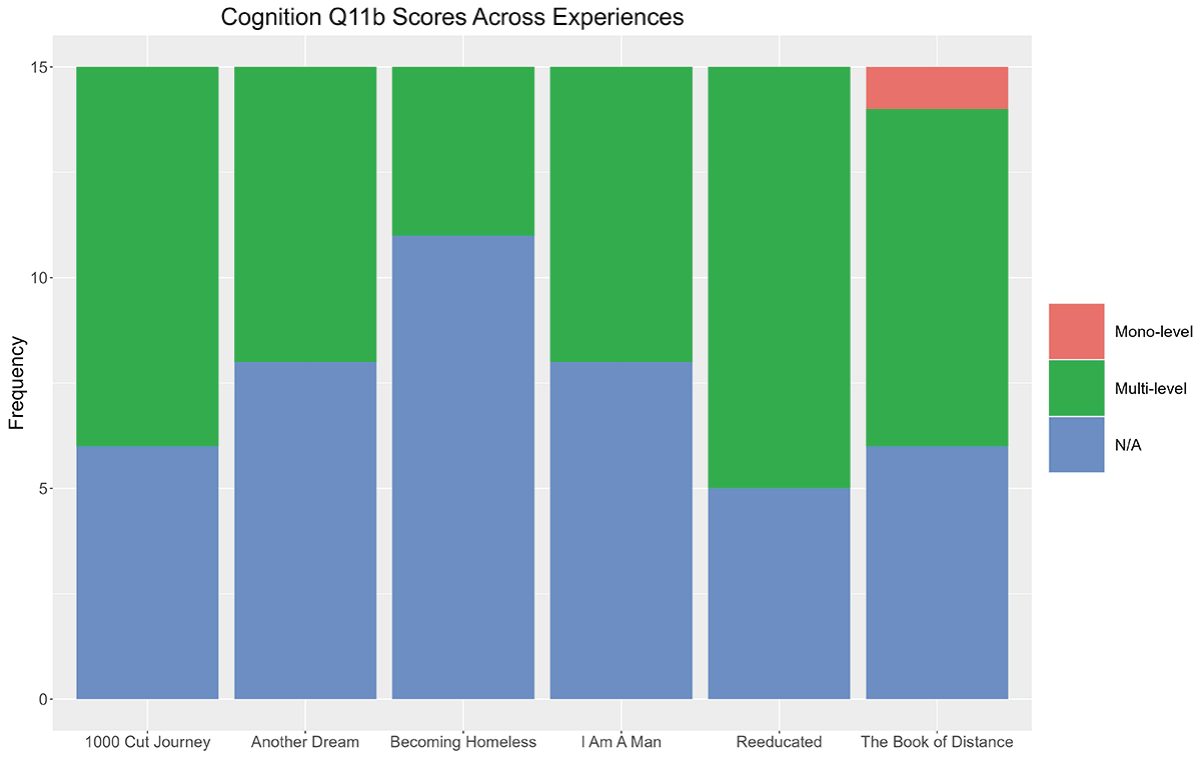


Fig. 35. Students' responses to the essay question Q11b: "Did it teach you only about one person's condition (mono-level of knowledge) or about an entire culture/setting (multi-level of knowledge) surrounding that person's condition?"

In their 2022 paper, psychologists and leaders in multimedia learning research, Guido Makransky, and Richard Mayer, placed two cohorts of students learning the same content through two viewing methods: watching a 2D video projected on a large screen in the classroom and through head-mounted displays with rotational tracking. The latter group scored significantly higher in the sense of presence and enjoyment, as well as immediate and delayed retention, which, in line with the immersion principle, by which immersion impacts the learner's affective processing, proved greater learning outcomes.

The following figures focus on the students' scores of their level of enjoyment, cognition, and impact for each experience. My hypothesis implies that art-based experiences score highest in the appreciation of visuals and sounds and enjoyment, cognition, and impact, which refers to the student's desire to act to better the protagonists' condition.

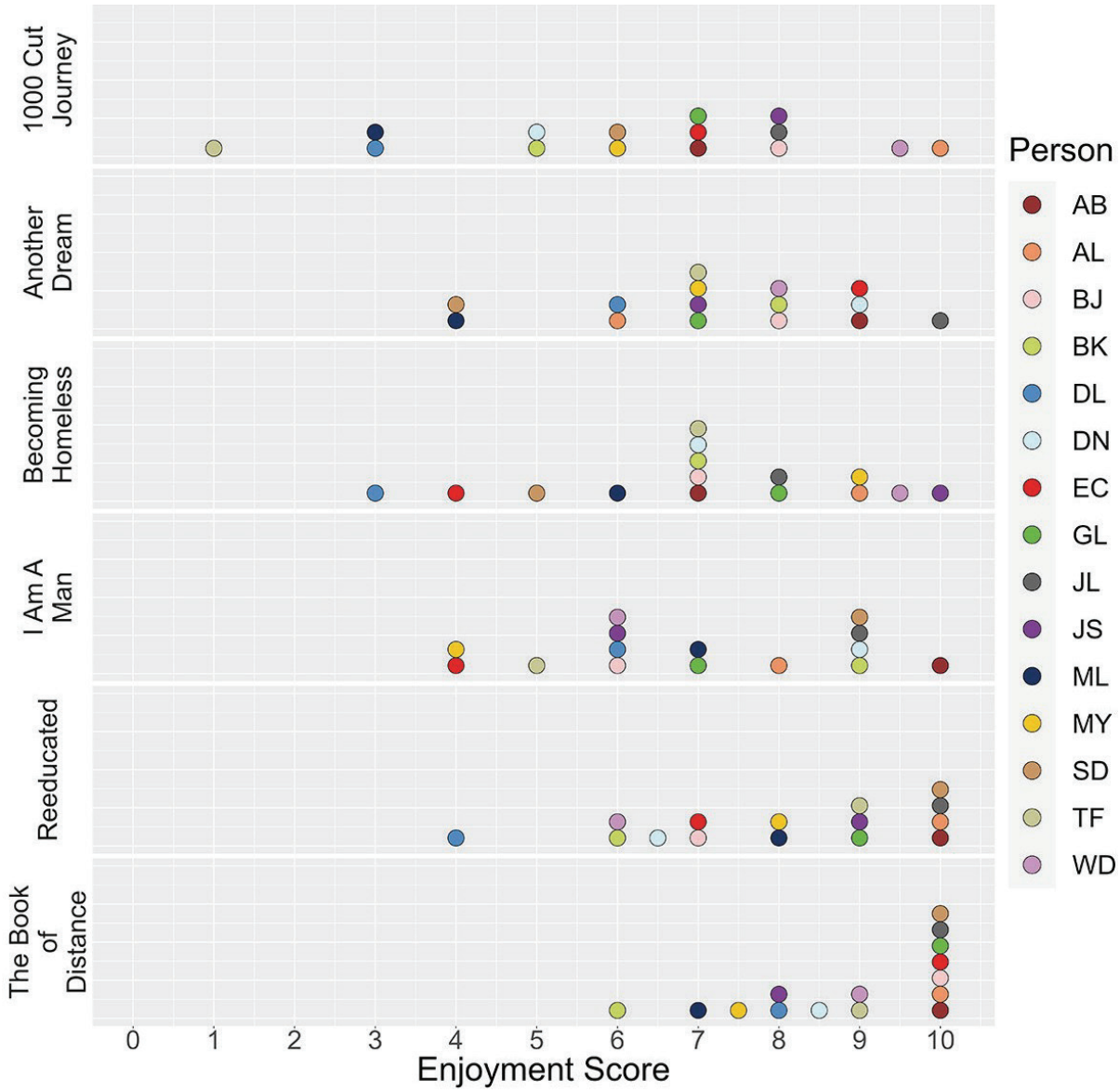


Fig. 36. Students' scores from zero (Strongly Disagree) to 10 (Strongly Agree) the statement: "I enjoyed the experience"

Two of the three art-based experiences scored highest in the Enjoyment category, with seven students rating *The Book of Distance* at a maximum of 10, four students rating Reeducated at 10, and three at 9. In comparison, only one student scored enjoyment at 10 for the other experiences (Fig.33). Amongst the six experiences, *The Book of Distance* received the highest scores for "visuals/sound," "Enjoyment," "emotions," "cognition," and "impact."

Social psychology intergroup contact theory proposes that, under certain conditions, ingroup members with interactions with outgroup members tend to develop positive perceptions toward that outgroup, leading to prejudice reduction and the development of mutual understanding. One of the conditions is mitigating inter-group conflicts, anxiety, and negative emotions during contact. Considering that some experiences have fearful encounters, two of the playtesting questionnaire questions (Figures 34 and 35) assessed the nature of students' feelings after each experience. One of the art-based experiences, the Book of Distance, triggered only positive emotions; the other two art-based experiences, Reeducated and Another Dream, scored significantly higher in positive affect than the photorealistic ones, *1000 Cut Journey*, *Becoming Homeless*, and *I Am a Man*, which triggered anger, sadness and negative emotions.

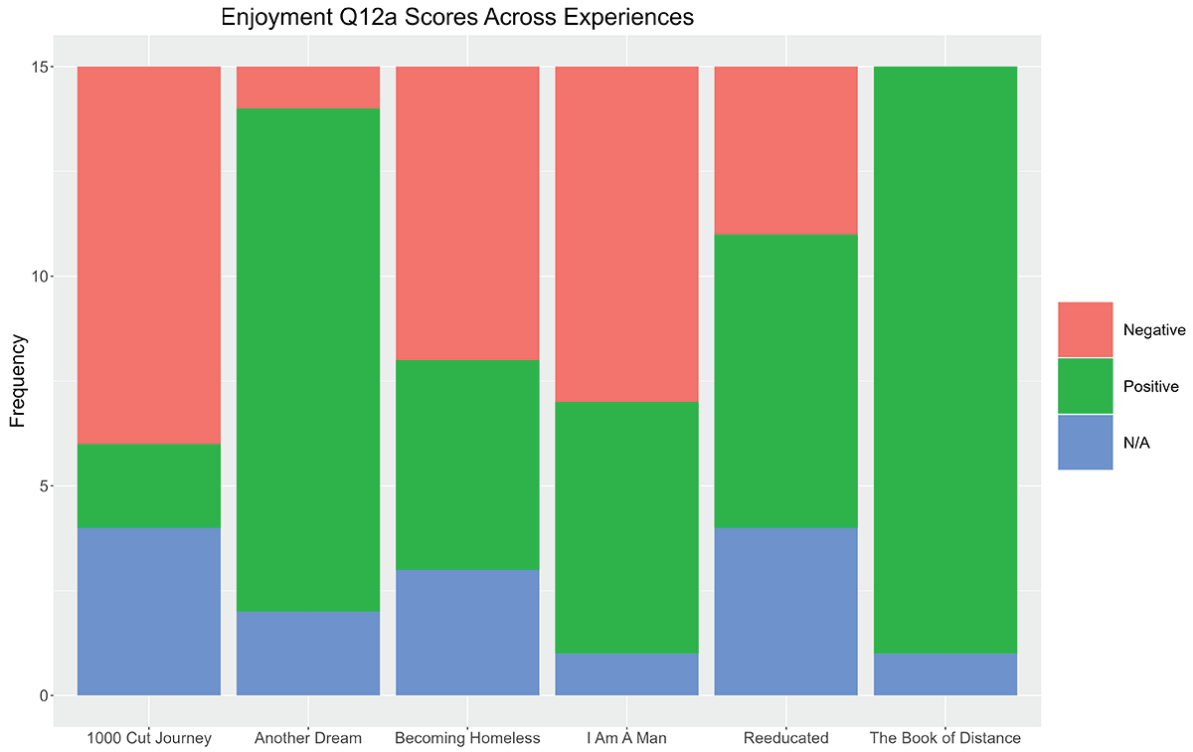


Fig. 37. Students answers to the essay question Q12a: "After finishing the experience, please specify if it left you with negative feelings, like sad or angry, or positive ones, like happy or pleased"

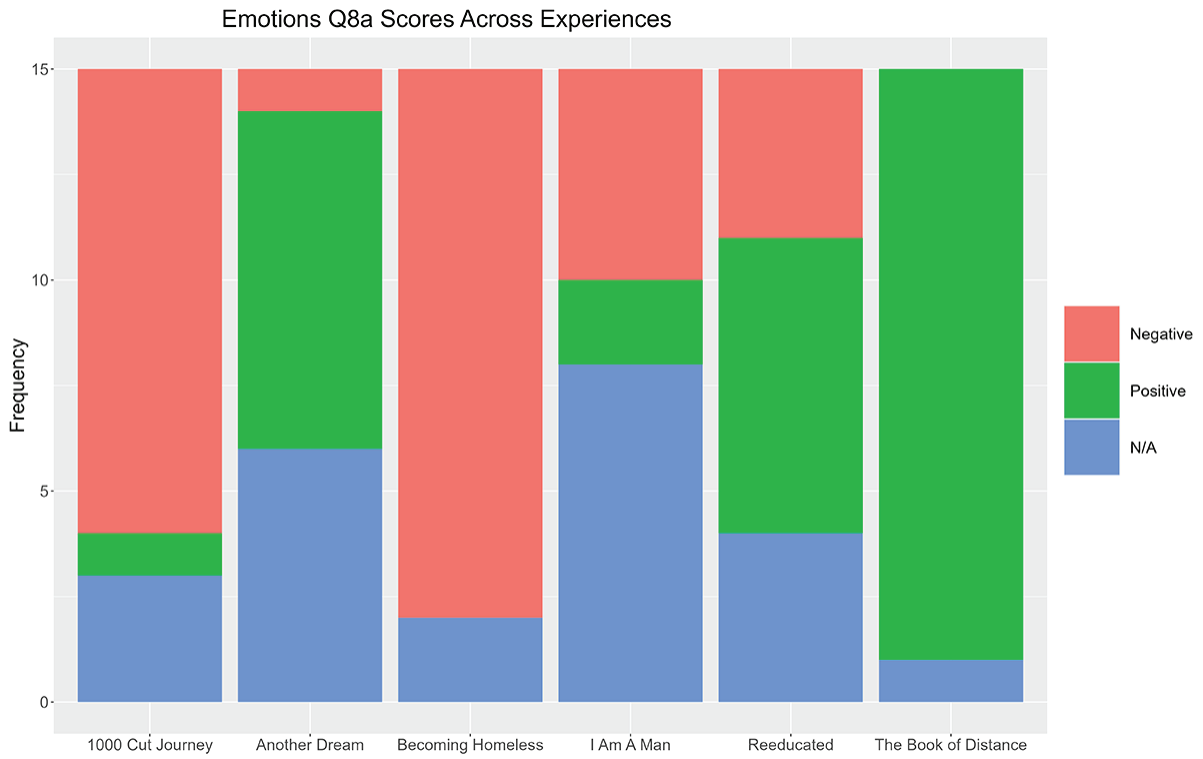


Fig. 38. Students answers to the essay question Q8a:
"Which emotions did you feel throughout the experience? "

Questions 8c and 8d assess students' feelings toward the characters in each experience and if the uncanny valley effect is present. The figures for these questions are challenging to interpret. For example, tudents scored the characters of *Becoming Homeless* as relatable (Figure 36) and as uncanny, which points to eerie and unsettling, which is a sense of repulsion (Figure 37). The experience *Another Dream*, with drawings and colorful characters, scored highest for most relatable characters, not uncanny.

Fig. 39. Characters visual style for each experience.

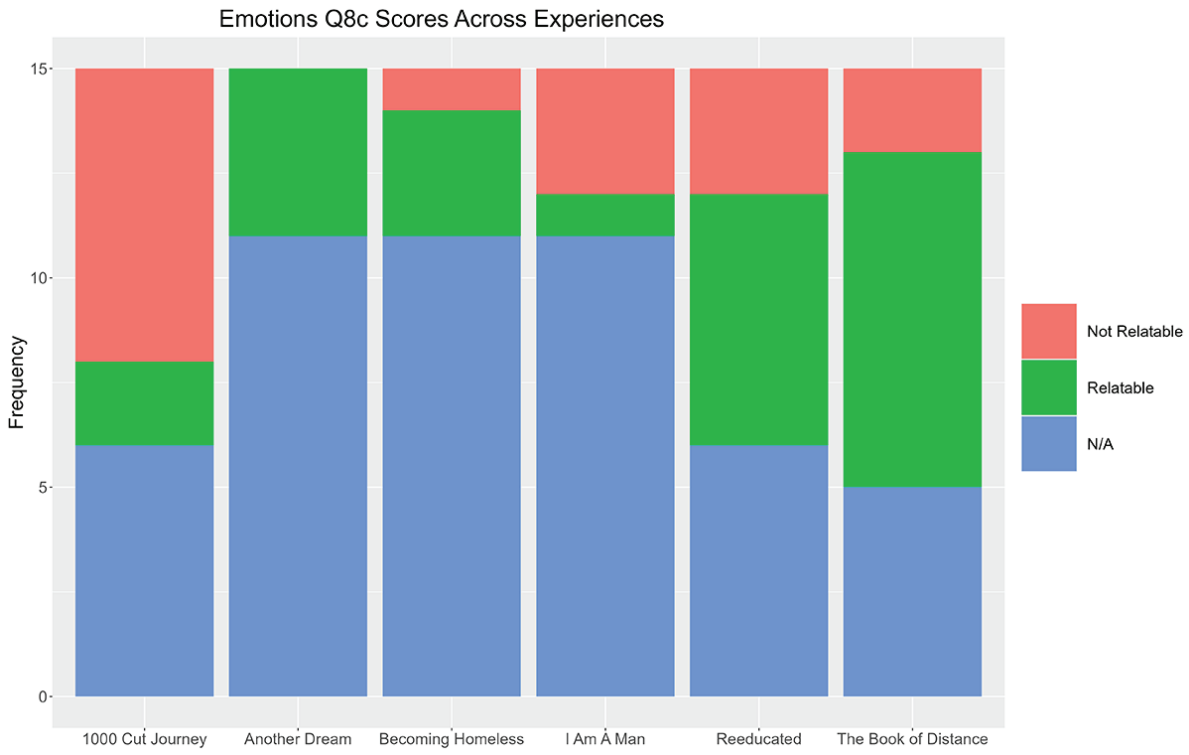


Fig. 40. Students' answers to the essay question Q8c: "Were there characters relatable?"

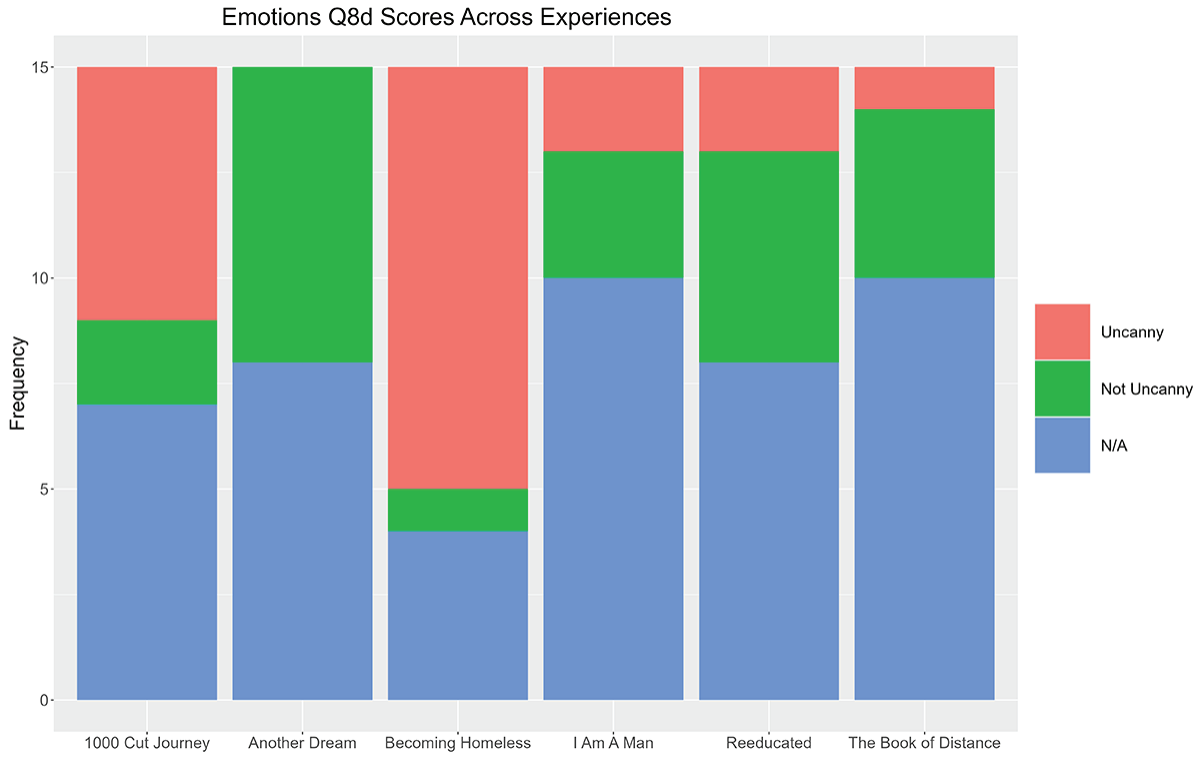


Fig. 41. Students' answer to the essay question Q8d:
"Did you preceive the characters unsettling or uncanny?"

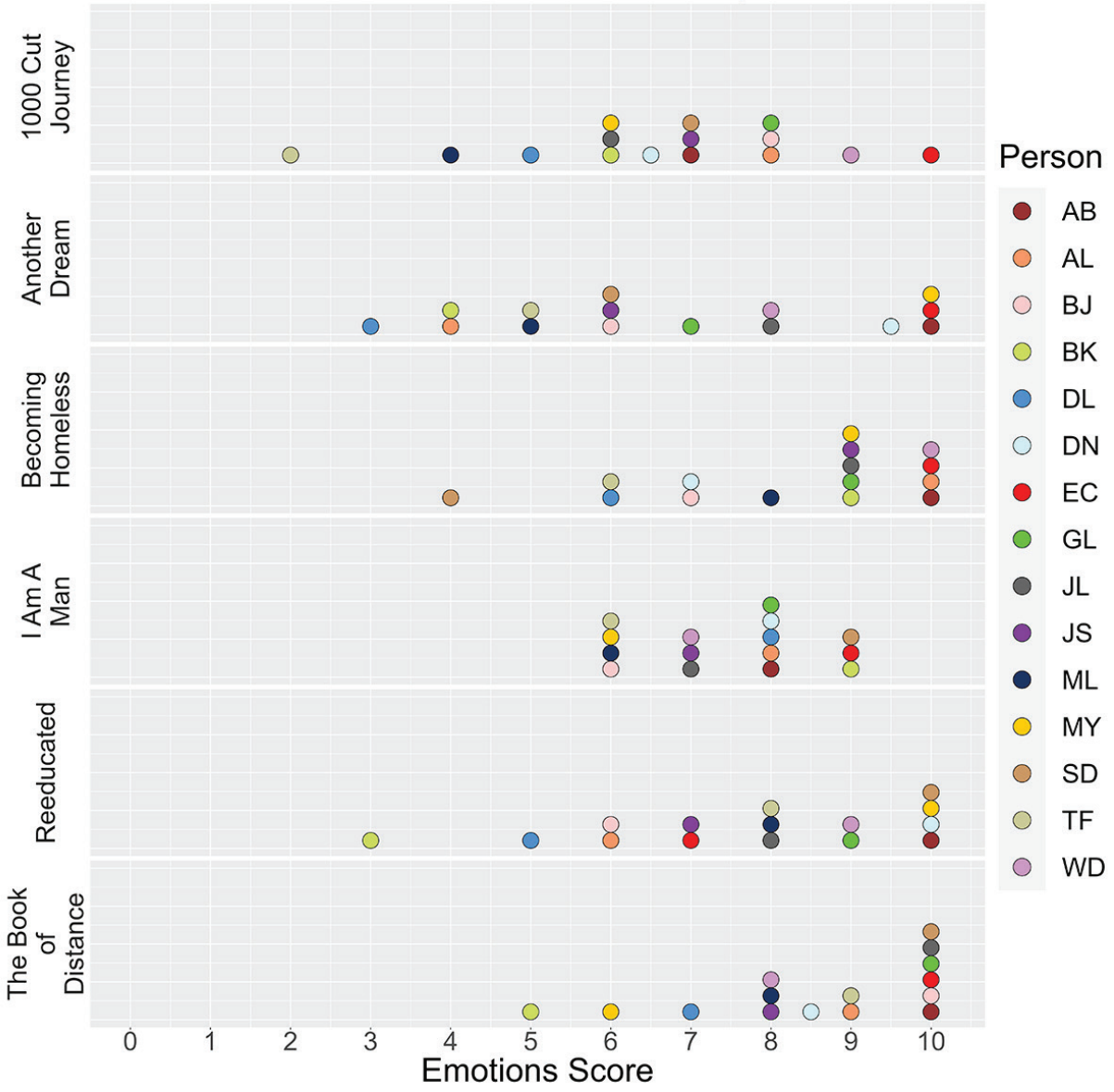


Fig. 42. Students' scoring from zero (Strongly Disagree) to 10 (Strongly Agree) the statement: "I felt emotions while inside the experience"

In the emotion category, students scored highest in the experience *The Book of Distance*, which does not include drama or fearful situations, with eight students scoring nine and ten. *Becoming Homeless* consists of an extraordinarily startling and frightening moment on a bus in which the participant feels followed and harassed. This experience also scored high in the emotion category but likely for different reasons than the *The Book of Distance* or *Reeducated*, which also scored high, with six students rating it at nine and ten, and no

fear-arousing moments.

The category "Impact" aimed to measure if the student felt like doing something in the physical world to change the condition of the VR experience's protagonist social group or status quo about the topic/story depicted. In this category, Reeducated received the highest scores, with nine students assigning between 9 and 10 points. Becoming Homeless, The Book of Distance, and Another Dream also receive high scores. It is important to note that, in Figures 38-39, student AB gave a score of ten nine times out of twelve.

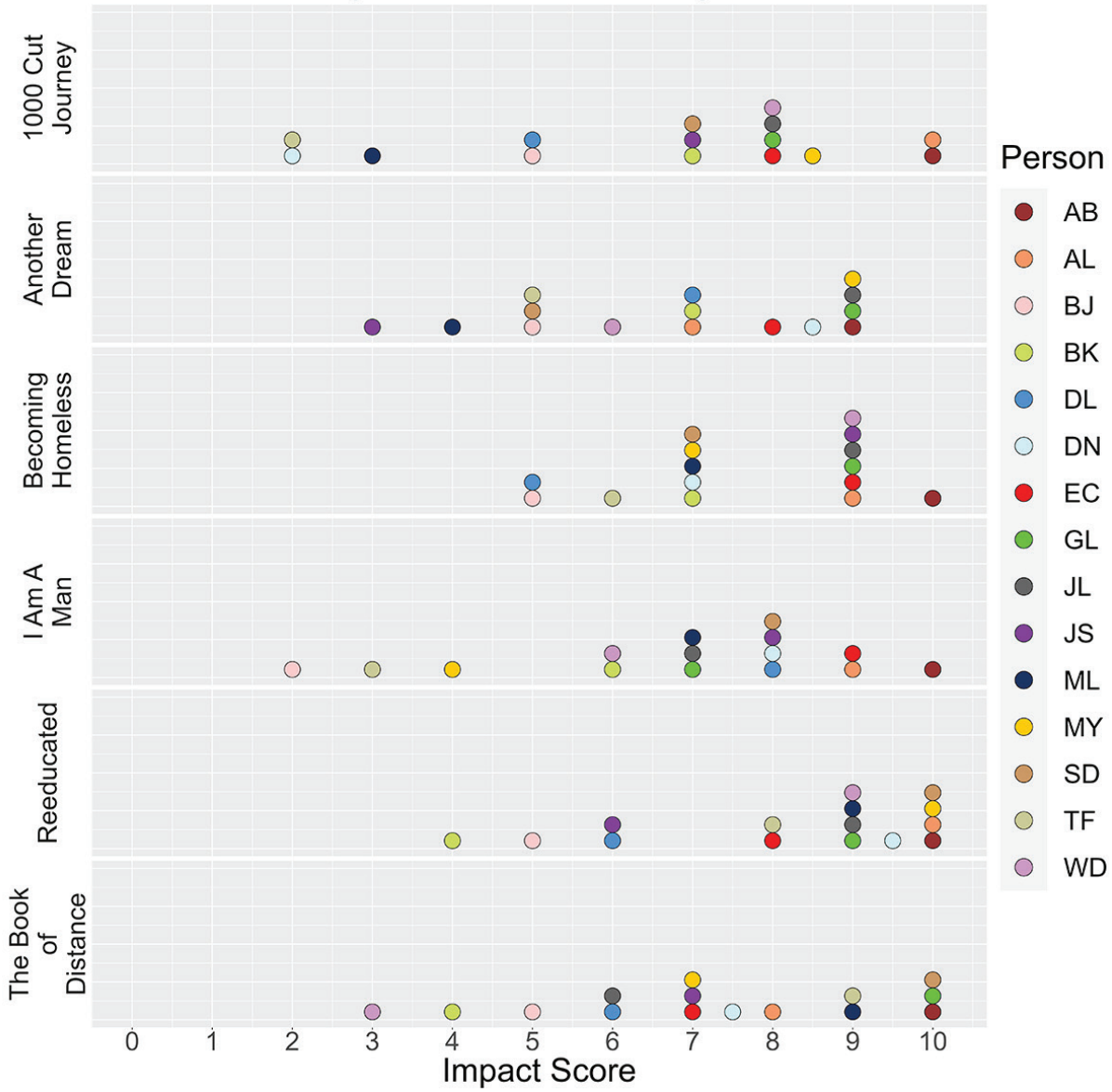


Fig. 43. Students scoring from zero (Strongly Disagree) to 10 (Strongly Agree) the statement: "I became motivated to advocate for the protagonists' condition because of this VR experience."

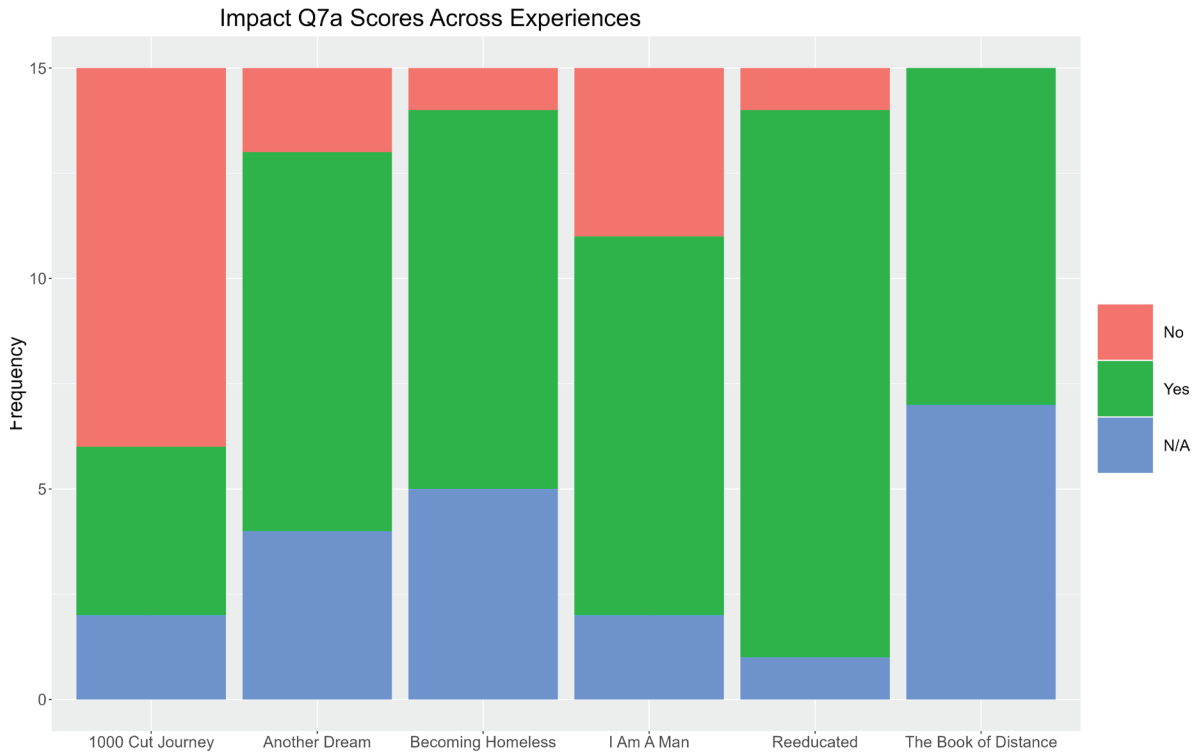


Fig. 44. Students answers to the essay question Q7a: "By the end of the experience, did you feel like you wanted to do something (even simply know more about the topic of the experience)?"

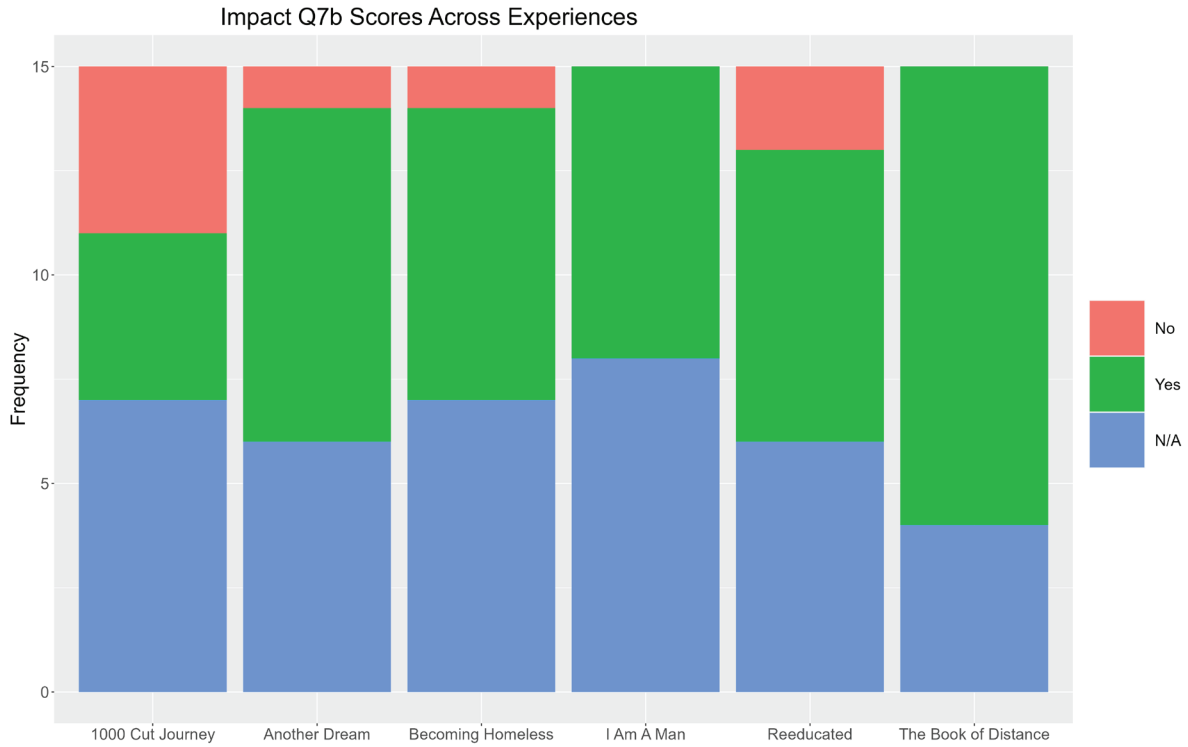


Fig 45. Students' responses to the essay question Q7b:
"Do you think this VR experience will stay with you longer than others?"

Figures 40 and 41 show that students felt most compelled to do something or learn more about the protagonist's condition after experiencing *The Book of Distance*, with half of the responses pointing to wanting to do something and three-quarters of the responses stating that the impact of this experience rendered it more memorable than the others.
The experience that scored lowest is *1000 Cut Journey*, with more than half of the responses pointing to not wanting to act to better the condition of the protagonist, who is a black person victimized from childhood to adulthood by an arousing encounter with the police.

The embodiment allows the VR participant to feel as if inside another person's body with all the affordances given, but such identity switches. Questions eight and nine aimed at assessing the students' perceptions of the design of VR human figures, the sense of embodiment perceived depending on the existence or lack of an avatar to embody, and the correlation between the avatar visual representation and the sense of embodiment.

Past research focused on studying avatar customization and visual appearance tends to employ photo-realistic avatars and techniques. For example, Waltermate et al., in their 2018 paper *The Impact of Avatar Personalization and Immersion on Virtual Body Ownership, Presence, and Emotional Response*, only employs photorealistic three-dimensional humans created with body scanners and point clouds from camera-based images, promoting the use of depth cameras or photogrammetry methods to create avatars.
One of the few extensive studies investigating the use of realistic versus stylized rendering styles for avatars is documented in the 2012 paper *Render Me Real? Investigating the Effects of Render Style on the Perception of Animated Virtual Humans*. The authors conducted several psychophysiological experiments to assess explicit and implicit measures on the perception of eleven rendering styles for a virtual character depicted while still and in motion. "Cartoon characters were considered highly appealing and were rated as more pleasant than characters with human appearance when large motion artifacts were present. They were rated as more friendly than realistic styles."

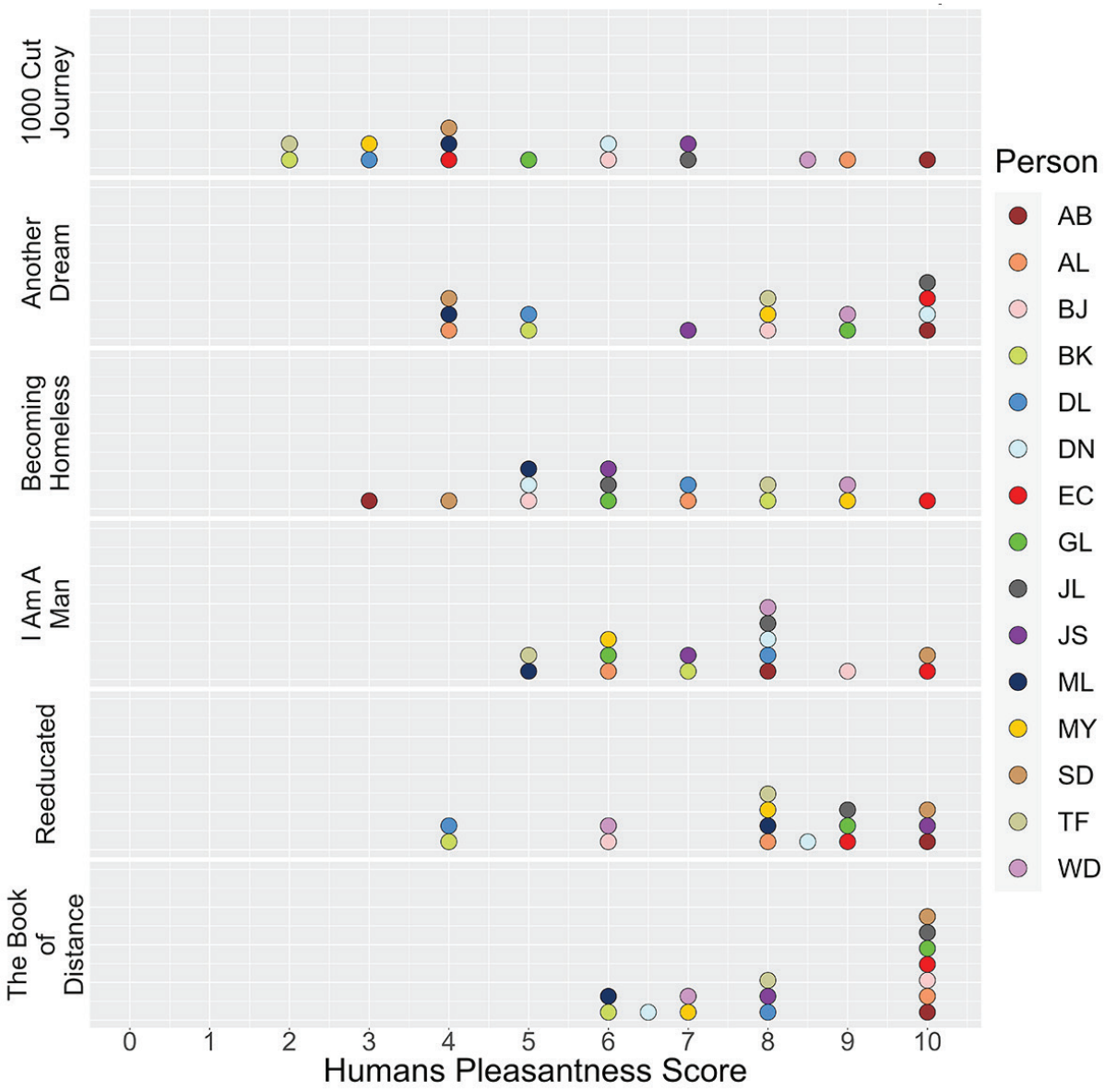


Fig. 46. Students scoring from zero (Strongly Disagree) to 10 (Strongly Agree) the statement: "The human characters are aesthetically pleasing."

Fig. 47. *The Book of Distance*'s character design.

Even though the characters in *The Book of Distance* are silhouettes with no facial features, the students rated their visual style as most appealing, with seven students rating it at ten. The realistic experiences, *1000 Cut Journey* and *Becoming Homeless*, received the lowest scores, which might be explained by the students' answers to question 8d (Fig. 37) and their perception of uncanniness.

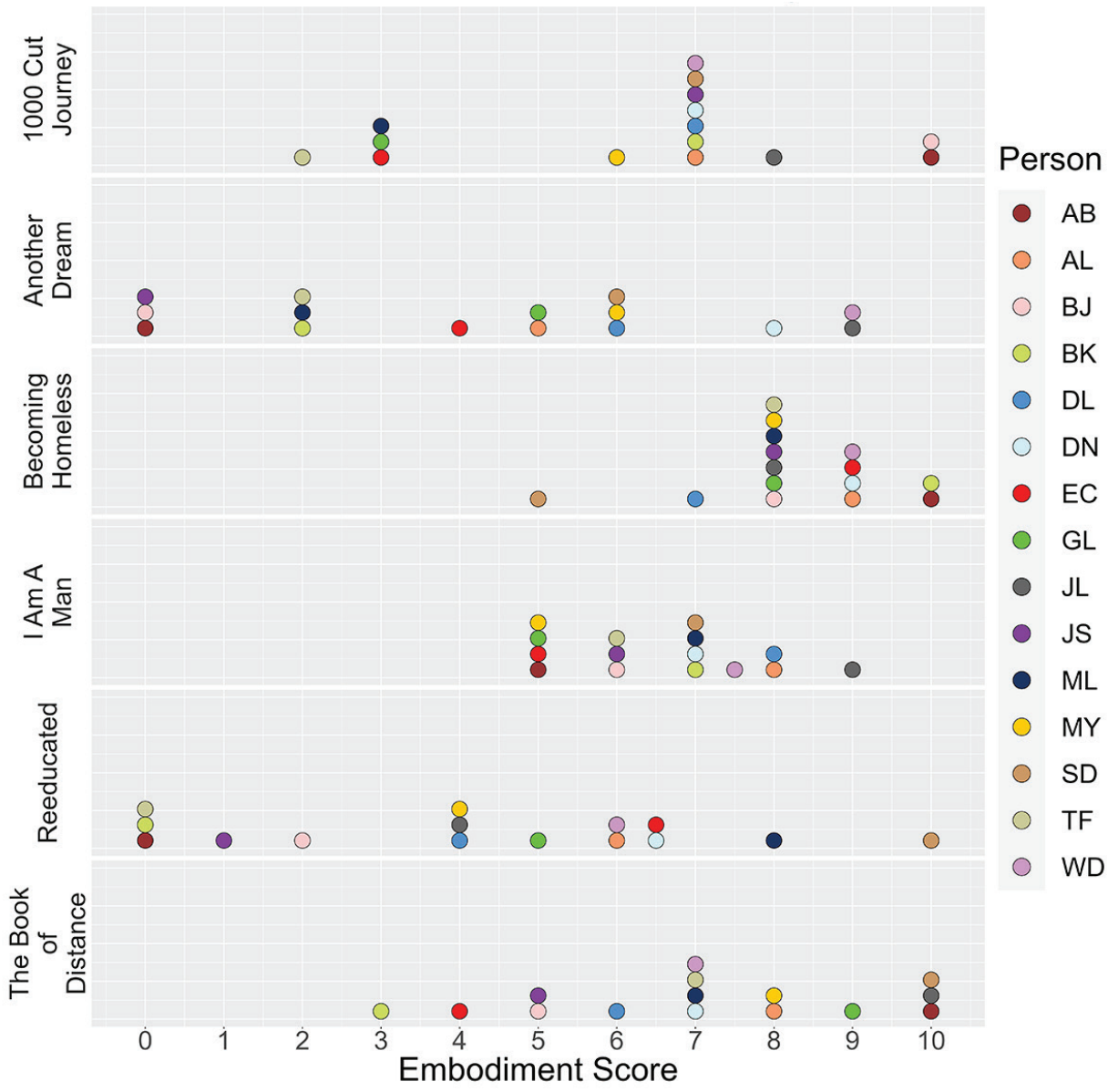


Fig. 48. Students scoring from zero (Strongly Disagree) to 10 (Strongly Agree) the statement: "I felt as if I was inhabiting the body of the virtual character and was present inside VR."

In the experience *1000 Cut Journey*, the participant embodies Mike Sterling growing up, with the transitions between childhood, teenage years, and adulthood occurring in front of a mirror, which reflects the participant's motions while inside Mike Sterling's appearance of a Black man. This is the only experience amongst the six in which a full-body avatar surrounds the participant. *Becoming Homeless* allows the choice of skin color for the hands the participant will see as their hands, and "I Am a Man" provides the participant with black

hands for the interactions. In the other three experiences, the participants don't have a body to inhabit nor see their hands. In Reeducated, they feel like a detainee in the prison camps surrounded by other detainees and guards; in *The Book of Distance*, as an actor in the play depicting Yonezo's life, the Japanese man who ends up separated from his family and in the internment camps; and in *Another Dream*, as a spectator watching the LGTBQ women's journey. Figure 44 shows that the students felt embodiment more in *The Book of Distance*, even though they did not have an avatar, than in *1000 Cut Journey* or *Becoming Homeless*, in which they did. This result points to the fact that embodiment can be perceived strongly without a digital avatar or that the uncanny valley prevented the feeling of embodiment with the provided digital avatar.

Figure 44 shows that the students felt embodiment more in *The Book of Distance*, even though they did not have an avatar, than in *1000 Cut Journey* or *Becoming Homeless*, in which they did. This result can be attributed to the fact that embodiment can be perceived without a digital avatar or that the uncanny valley in the photorealistic experiences prevented embodiment.

According to the Cognitive Affective Model of Immersive Learning (CAMIL), interactivity and immersion in VR are determining factors that facilitate or impede learning. In their paper, Bøg Petersen, Petkakis, and Makransky demonstrated that "the effects of interactivity on agency and embodied learning is higher when immersion is low" (Bøg Petersen et al. 2022, p.11).

Figure 45 shows the students' assessment of the level of interactivity for each experience. The case of Reeducated confirms Bøg Petersen, Petkakis, and Makransky's conclusions. The experience is devoid of interactivity to give the participant the sense of powerlessness the detainees feel in the camps. During in class discussions, students felt that immersion was low because they could only watch, not act. *Reeducated* has low agency, immersion, and interactivity. Still, cognition is perceived at the highest level among all experiences.

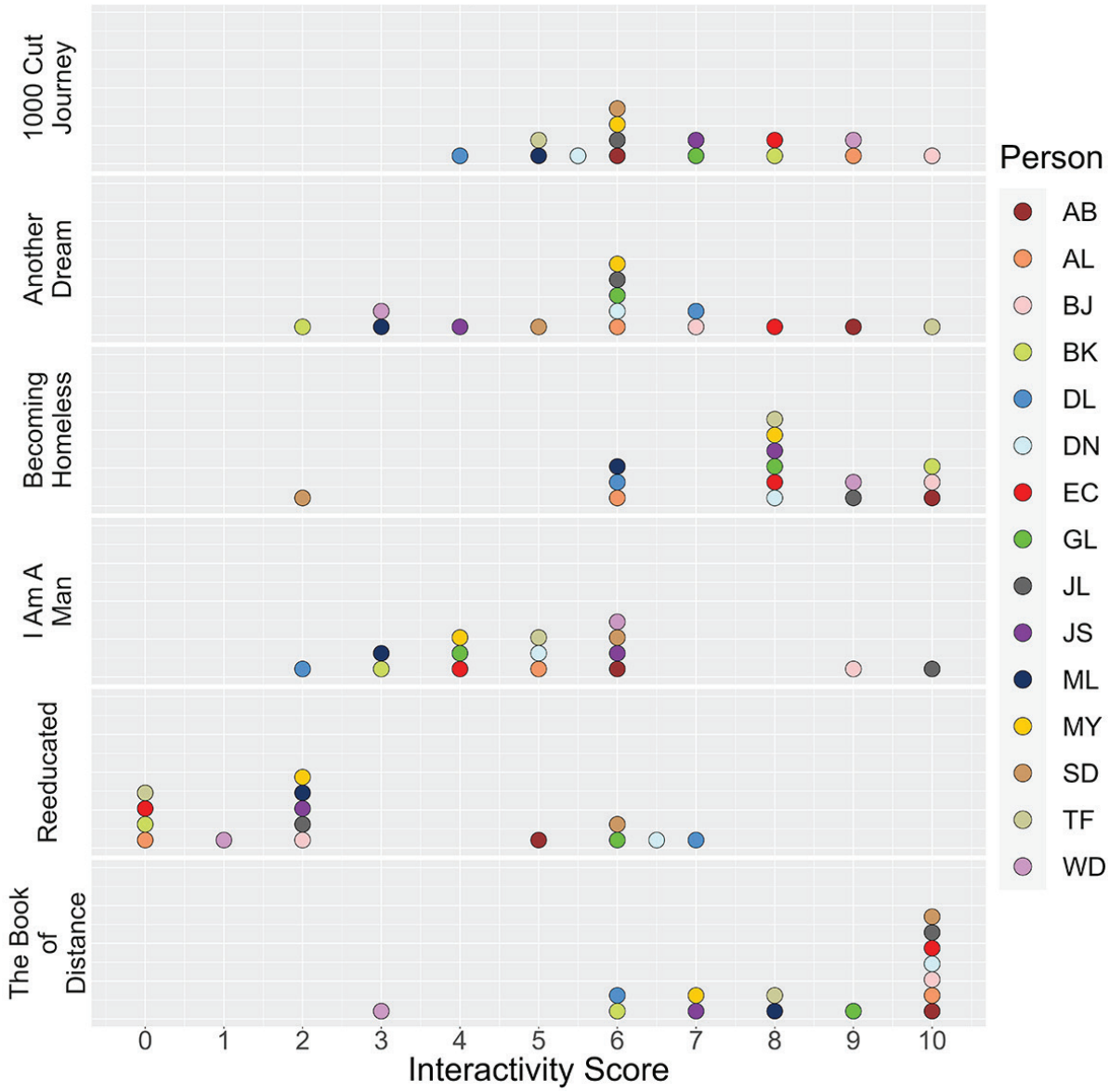


Fig. 49. Students scores from zero (Strongly Disagree) to 10 (Strongly Agree) the statement: "The experience has interactive elements, allowing me to make choices and act."

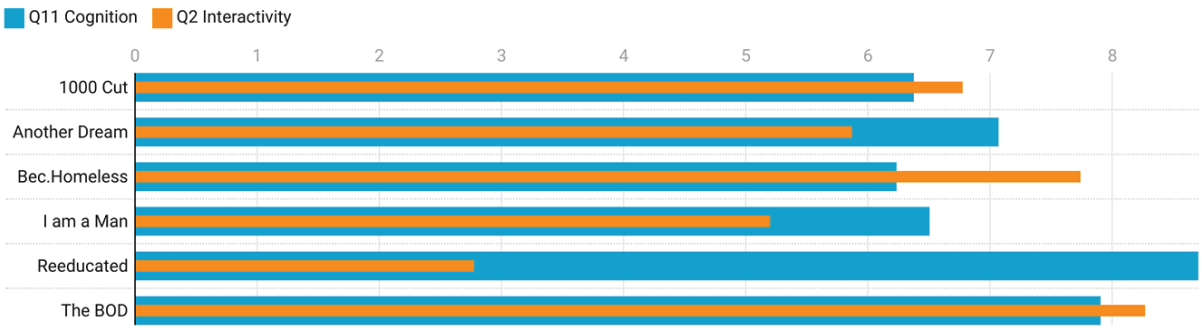


Fig. 50. Interaction between Interactivity and Cognition in all experiences.

B. The Interactive Taxonomy

This research has an interactive online companion, a taxonomy of VR Design aimed at instilling inclusive attitudes, which illustrates each category for each of the six VR experiences, and displays the students' assessment scores:

https://talassa3.github.io/VR-4-Inclusion/

The taxonomy includes a large amont of information. By design, each category must be accessed with one or two clicks. A wheel with wedges for each category and color coding for eachVR experiences was developped though a rough sketch and later Adobe Creative Suite software and implemented though web coding, HTML, CSS and JavaScript.
When clicking of the names of the experiences on top of the screen, the students' assessment scores are displayed giving the viewer an understanding of the students sensory and psychological perceptions. The following images show the development:

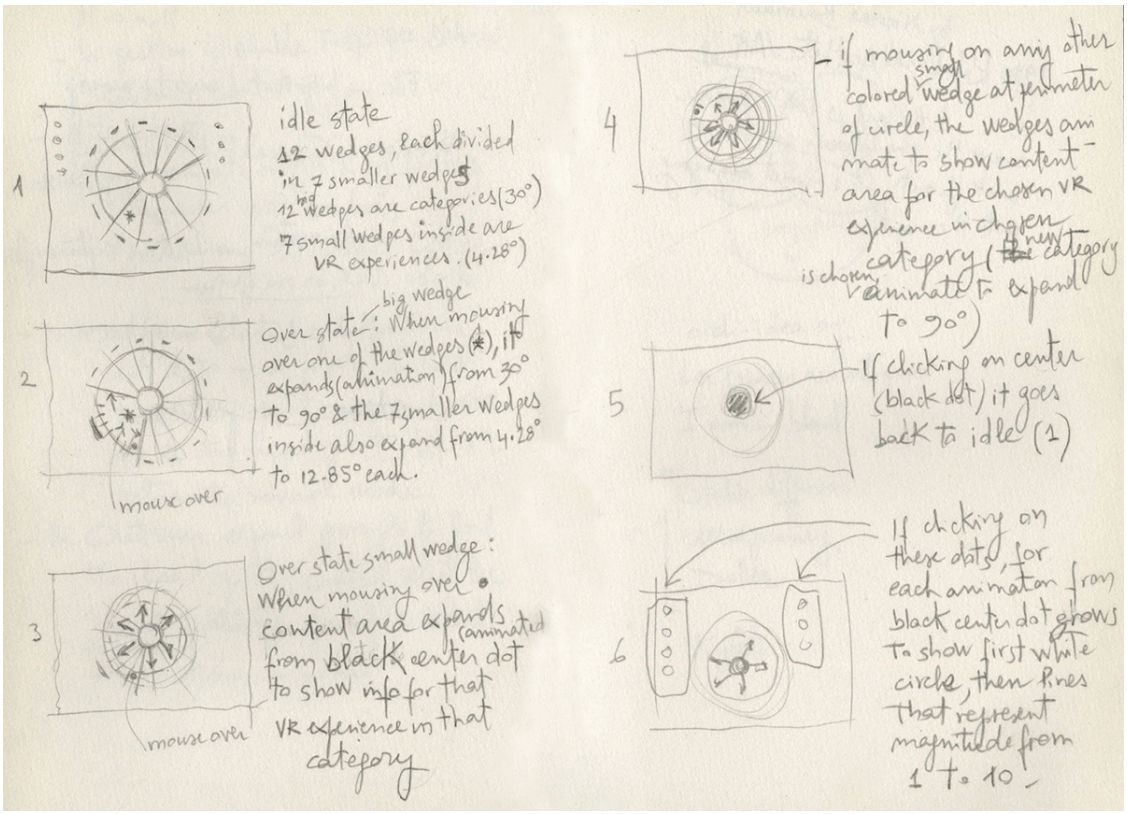


Fig. 51. Initial sketch for the design of the interactive taxonomy.

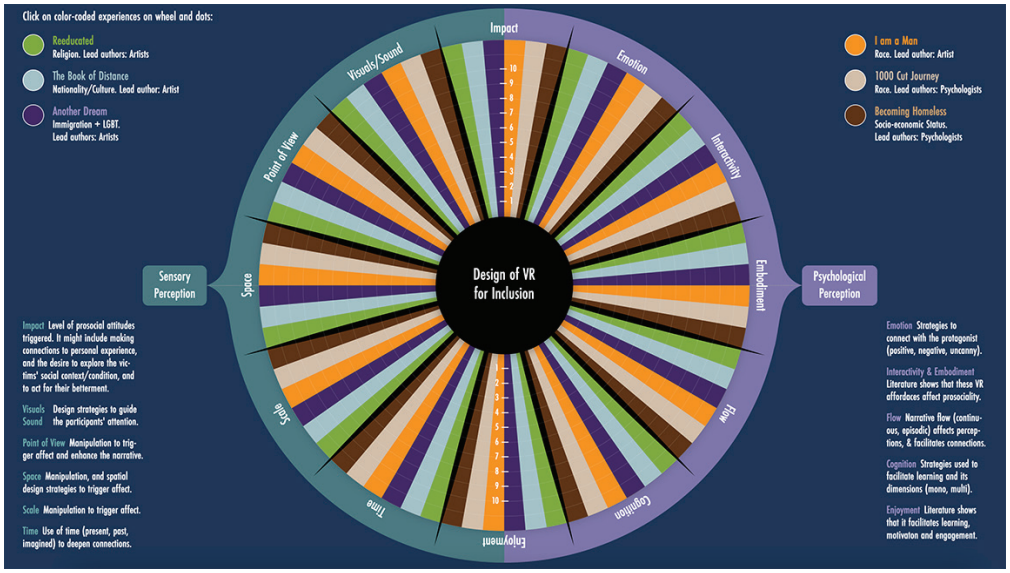


Fig. 52. Interactive taxonomy during the idle state.

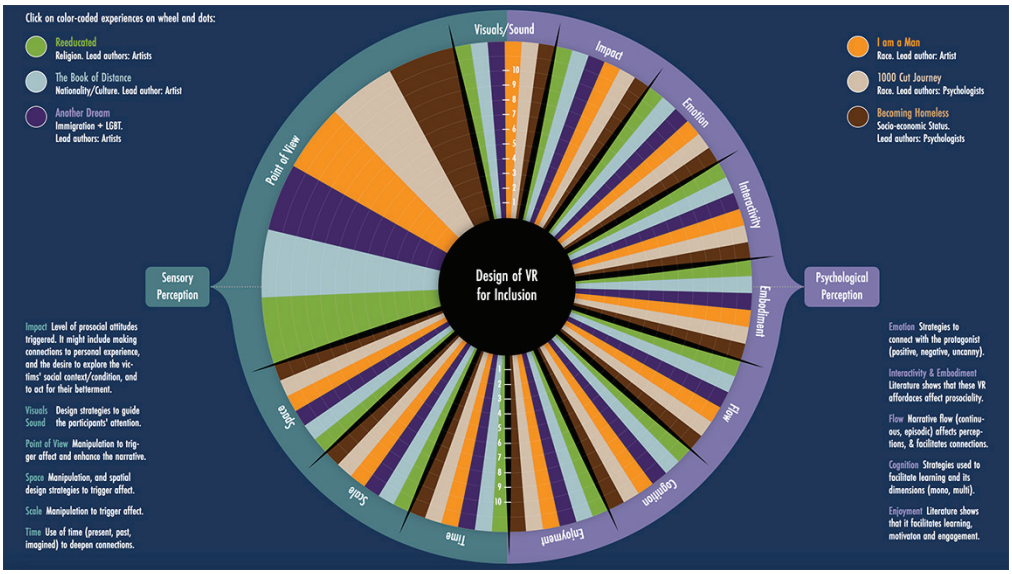


Fig. 53. Interactive taxonomy after clicking on the "point of view" wedge.

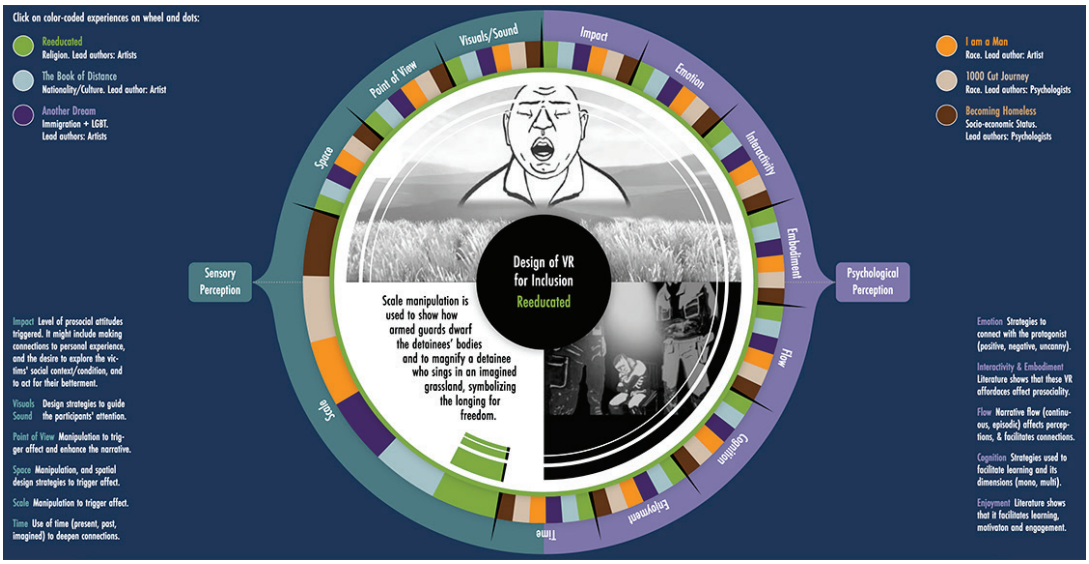


Fig. 54. Interactive taxonomy after clicking on green wedge of the "scale" category.

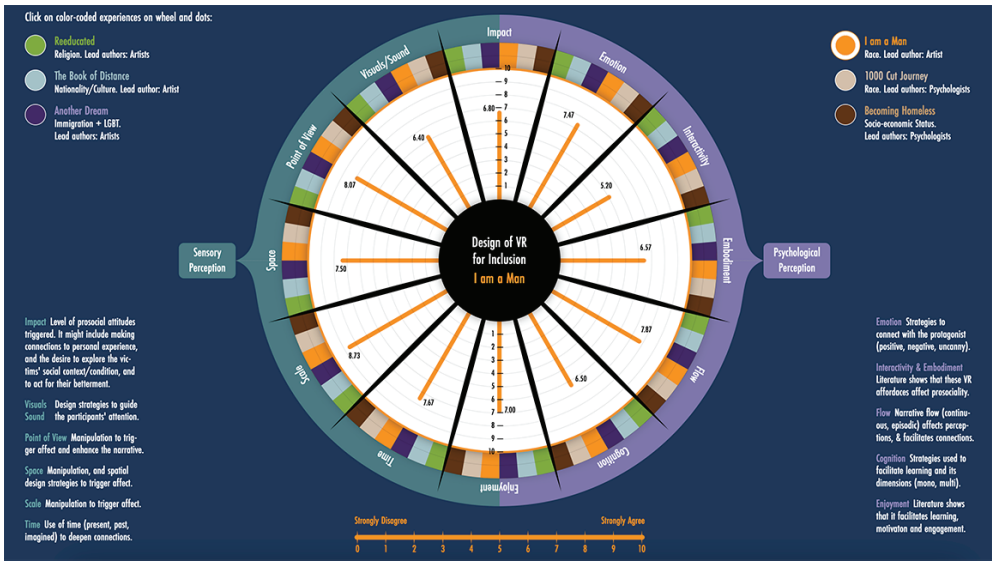


Fig. 55. Interactive taxonomy after clicking on yellow circle at top of the screen, showing intensities of each catergory from playtesting assessment scores.

C. Best Practices, Limitations, Future Developments

Through the creation of a taxonomy of design for inclusive VR, developed from playtesting six state-of-the-art VR experiences, the present investigation identifies which affordances and methodologies are significant in inducing prosocial attitudes in immersive social encounters. The taxonomy aims to guide future practitioners in the field. It can be used by clicking on the names of each VR experience at the top of its interactive interface to access each category's numerical scores or by clicking on the experience's color on the twelve wedges in the center wheel, one per category, to read a description and images of that particular category. For example, to identify the experience that elicits more significant impact, such as the desire to better the condition of the protagonist, VR for inclusion designers can click on the names of each experience on top of the interface to find the experience with the impact category's highest score, then click on that experience's color in the center wheel's wedges to find out through text and images aspects of that experience for each category. They can compare that experience to the others by clicking on the colored slivers representing each experience. This exploration of the experience with the highest impact score and comparison with the others may give a broader picture of how to design an impactful VR experience.

In general, four crucial elements surfaced as best design principles for VR story worlds aimed at triggering prosocial attitudes and prejudice reductions. These, borrowed from social psychology, in particular intergroup contact theory and multimedia learning, are the following:

1. The author of the VR experience must avoid the depiction of fear-arousing situations and include elements that trigger anxiety and unease. In danger and "fight or flight" scenarios, automatic and unconscious reactions kick in, activating self-preservation behaviors to avoid harm (Sapolsky, 2017). When the narrative conveys a physiological state of safety, higher-level brain processing activates conscious choices, which lead to a better understanding of the situation and opportunities to feel compassion toward the victimized protagonist (Miller, et al., 2004).

2. Based on intergroup contact theory, exposure between "Them" and "Us" groups, including the act of sharing spaces, tasks, and goals, can lead to prejudice reduction (Pettigrew & Tropp, 2006). An important takeaway from the interview with Prof. Mancini (Appendix A) is that in designing story worlds aimed at prejudice reduction, it is crucial to convey the sense of group belonging by depicting an entire community of the same group, including cultural and social identities. This insight is confirmed by the data collected through playtesting. Amongst the six VR story worlds examined, *The Book of Distance* and *Reeducated* are the only ones in which the VR participant experiences close contact with the Japanese culture and family in the first, and a large group of Chinese detainees sharing songs, meals, dreams, and suffering in confined environments in the second. Those VR experiences received the highest scores in the "visual and sound," including "human pleasantness," "cognition," "enjoyment," and "learning about an entire culture or group" categories compared to experiences focused on only one person with few secondary characters.
3. Based on Richard Mayer's twelve principles of multimedia learning, "People learn better when cues that highlight the organization of the essential material are added." (Mayer, 2009, p. 108). This principle is called "signaling" or "cueing." *The Book of Distance* is the only experience employing it methodically through embedding visual elements, light particles swarming around interactive assets, to draw attention when action choices become available and repeating those visuals to guide the learners' focus and ensure they understand the organizational elements. Additionally, signaling is employed through an original use of colors, with large solid areas, rendering the characters and worlds unfinished and avoiding the dead eyes and uncanny valley effect. Worlds become more detailed and colors brighter to call for attention or reveal information. The photorealistic experiences, *1000 Cut Journey*, *Becoming Homeless*, and *I Am a Man*, did not employ signaling or use it in an organized manner; for example, employing the same visual to signify the interactive assets. The lack of or

improper use of signaling causes confusion. It increases the cognitive load by leaving the learners to guess which elements are interactive, causing long pauses because the narrative cannot continue without the interactions. Moreover, the fear-arousing scenarios at the end of each of these experiences rendered them less enjoyable, startling students and forcing them to focus on their safety instead of the virtual narrative. *Another Dream* did not use signaling, lacked spatial and temporal contiguity, and employed a wide variety of styles and colors that resulted in overwhelming imagery, increasing cognitive load. The recurring transitions of writing in Arabic lacked interest, novelty, and enjoyment. In *Reeducated*, the drawn visuals, use of space, scale, point of view, and of different time modalities (present, past, and imaginary) rendered the experience exciting and unique.

4. The freedom of employing interesting effects, like the almost magical gliding above a city in *Another Dream*, as well as signaling techniques, such as adding graphic elements to call for attention, can happen freely in art-based renditions because there is no pressure of replicating the physical world in which elements like light particles would stand out as odd and out of place. Hence, the taxonomy shows that art-based representation is as effective as the photorealistic one, and, for certain aspects can be even more suitable for immersive stories that foster understanding of marginalized individuals.

This research's limitations are

- The small cohort size of college students was non-diverse in terms of socio-economic status, age, educational level, and cultural perspectives.
- The VR experiences selected for playtesting are not equal; some were created within academic settings for research purposes by faculty members with limited time and resources, others by professional companies in entertainment, producers of high-quality journalism to document social issues, and artists.
- The playtesting and questionnaires occurred as part of a class, not inside a study

conducted by a team of experts, including psychologists and statisticians. Students did not fill out a pre-playtesting questionnaire to disclose personal and biographical information, which might have given more meaning and context to their assessment.

Future directions include employing evidence-based research conducted by a transdisciplinary team of experts. Ideally, several systematic studies across years with diverse populations experiencing identical VR narratives created in a photorealistic style, like *1000 Cut Journey* and *Becoming Homeless*, an artistic style, like *Reeducated*, *The Book of Distance*, and *Another Dream*, and a hybrid style, realistic with stylized elements, like *I Am a Man*.

The systematic studies should account for playtesters' individual differences and their influence on the learning process with immersive technologies, as well as cultural affordances and personal traits.

This research contributes a pragmatic approach to the design of VR for bias reduction while considering the craft, ethical, and humanistic dimensions of the medium. It is timely in demanding a commitment to develop methods that leverage technological affordances to mitigate prejudice and foster inclusive attitudes and behaviors, considering the current urgency to create professional and academic environments where individuals' differences are celebrated, and ending an era of social inequality.

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Appendix A.

Interview with Tiziana Mancini

Associate Professor Tiziana Mancini
Source: LinkedIn Profile.

Tiziana Mancini is an associate professor in the department of Humanities, Social Sciences, and Cultural Industries at the University of Parma and the president of the Master's in Social and Clinical Applied Psychology.
Her primary research topics are:
- Psychology of migratory processes, including identifying individual and social factors that affect the formation and diffusion of prejudice and social discrimination.
- Analysis of identity processes in virtual contexts with particular reference to the relationships between virtual and offline realities.

Interview

Enrica: Considering that VR still hinges heavily on visuals, we still don't have an accepted visual language conducive to triggering specific perceptions and emotions. Many companies are already selling VR experiences that aim to reduce bias without supporting studies showing what works. Social psychologists have defined the theory of intergroup contact, proving that anxiety and fear are not conducive to instilling prosocial behavior, which is an essential guiding principle for designers of VR experiences; we have nothing on the visual side.
I would love to know your opinion regarding VR's ability to instill compassion and understanding for someone else's condition and even reduce prejudice if we immerse individuals in stories of people from minority groups. Do you think VR is a medium that can do it?

The second question pertains to the sense of embodiment: how can we induce a shift of identity effectively and successfully? For example, in "1000 Cut Journey," which is a VR experience aimed at putting people through the life of a Black man who's a victim of micro-aggressions and injustice, the participant is placed in front of a mirror and instructed to

move while seeing themselves in the body of a Black child, first, and adult, later. Is this the best strategy? How can we design visual clues to facilitate the identity shift during embodiment?

Prof. Mancini: Regarding VR's ability to reduce prejudice . . .I want to make a general disclosure that I know VR on the theoretical side but not as much on the experiential side. My opinion is that VR has less potential to reduce prejudice than non-virtual reality.

Enrica: Do you mean the physical reality or the augmented one?

Prof. Mancini: Compared to Facebook and other social media channels, it has less potential because it allows such a strong sense of immersion that it is too intense to generate a significant change. I mean that VR is so intense that it prevents activating the person's defensive measures. This is my opinion, based primarily on my theoretical studies, not as much on my practical experience inside VR.

Enrica: So, you think that, in VR, our senses are heightened to such intensity that, when stimulated, we go into defense mode instead of prosocial mode?

Prof. Mancini: Social psychology studies have proven that the advantage of having social relations with another through digital channels that do not employ VR, like a chat or other interaction, is that people feel protected. Why do I say this? From the point of view of social psychology, prejudice is associated with contact between people, not as single individuals, but as part of specific groups, and that's the lever that sparks bias. Prejudice is a defensive response related to the group we belong to and our social identity. This belonging is the foundation of our self-esteem and the principal driver of our identity. Based on this mechanism, to feel like another is difficult in VR because the medium might not allow enough distance from the other to enable you to see that person as part of a group different than yours, as belonging to a different group. For example, there is a universally accepted theory in the psychosocial literature that inspires research studies and empirical studies on stereotype reduction; Gordon Allport developed it in the 1950s and focused on contact between people from different groups. Without concentrating on Allport's original theory that identifies certain conditions,

the literature showed that some are good. Still, that contact can have positive outcomes also without some of those . . .but, beyond the conceptual original nucleus of contact theory, we have extensive literature demonstrating that between-group contact and prejudice reduction there are various processes; one of those processes, the one that makes me think VR works less than other mediums, is intergroup anxiety. People tend not to interact with people from different groups because they are afraid that they cannot control the situation because they don't know what to expect from others who are different. This feeling induces anxiety. Paradoxically, the contact online, not in VR, works because it is mediated; there is no direct contact and no anxiety. This is just my opinion.

Enrica: In a way, VR can isolate people because wearing a headset makes them disconnected from their physical and social environments.

Prof. Mancini: The main problem is the transfer. How do you transfer what you experienced in VR to offline reality? This is why so much promise is placed on augmented reality, which creates a connection between mediated and non-mediated worlds.

Enrica: Currently, AR is not widespread because of the large variety of devices we use and the lack of a uniform technology that is inclusive and fully accessible by all people. We have no standard or prevalent hardware and software, with little progress over the years on a prevalent technology. Even in AR, the gadgets employed, whether tablets or cell phones, can become a barrier. If VR uses a headset, which isolates it from physical reality, AR uses a screen, which can also become a divider that separates us from the other side of the screen. What does the future hold in terms of digital societies and social groups? Are young people becoming more and more interested in living in digital worlds?

Prof. Mancini: I am not very worried about this. Just this morning, I was showing my students data from data banks. I always use the same one, "We are Social," which creates a report once a year, sometimes two, documenting the use of social media. This year's report is four hundred slides showing a lot of data. The April 2023 report shows a reduced time on social media compared to the January 2023 one. This descending trend might be a good

indicator of future predictions. For a while, everyone became very excited about how much we could do with all the new technological gadgets, but we also discovered that they do not provide the same satisfaction we feel in the real world. I think that people are getting tired of relying so much on technology. This doesn't mean that we'll stop having people who become dependent and addicted to social media, but overall, we will have less use. I believe that the experience of COVID-19 helped us give more value to face-to-face contact.

Enrica: What about multimedia learning? Can technology improve pedagogical methods?

Prof. Mancini: I have several research experiences in gamification of learning with a colleague, Federica Sibilla, who did a doctorate with me; we researched a lot of online role-playing games, and in particular, online identity, which is my expertise. I wrote several books on it. I find the construction of the relationship between people and their avatars fascinating.

Enrica: Do you know of any identified rule of what works and what doesn't in triggering embodiment from the visual point of view?

Prof. Mancini: When writing my latest book, I explored this topic; I ran into a study in which people embodied the opposite gender in VR. In that study, they did find that stereotype reduction occurred. I am not saying that VR cannot work; I'm saying that we must know the theories behind it to make it work. Hence, we must introduce elements in the VR environment that respect intergroup contact conditions to ensure that we achieve the desired outcome; one of these is to reduce the encounter's anxiety, not increase it, and avoid increasing negative emotions. All the literature on risk perception has demonstrated that by creating an ad campaign based on risk terrorizing people, you will not achieve the result of protecting people.

Enrica: Regarding the principles of a visual language for online identification with an avatar, do you have information on this process? How and why do we choose one avatar instead of another?

Prof. Mancini: There is no difference from the psychological point of view. A while ago, we did research that we had never published on which shape to give to an avatar, if humanoid or not, and it made no difference in that study. What makes a difference is how much a person

cares for the avatar, if the person feels inside the body of it, identifies with it, and develops a form of affection for it.

Enrica: I'm interested in the initial choice of the shape that likely will trigger that affective relationship. For example, games allow players to choose a "skin" to wear; sometimes, skins have different powers on top of diverse visual appearances.

Prof. Mancini: Sure, and if you identify with it, you'll also identify with the avatar's personality.

Enrica: I always wonder what instigates that initial choice of avatar or skin for it.

Prof. Mancini: That choice is determined by multiple factors; one is why people use the avatar. This happens in the video-ludic world. If you play to reach the objectives the game allows, it doesn't matter if you look like a spider or a sheep. In multiplayer games, you might play to socialize and feel part of something, so the look is more important. Maybe being represented with a humanoid shape is more important because it facilitates establishing a relationship with another player.

Enrica: Given the age of VR and the explosion of gaming, it seems strange that we have so little research and have achieved so few results in designing visual representations to trigger certain emotions and effects. One reason might be that VR experts and pioneers come from computer science and psychology. Mel Slater, in Barcellona, is a computer scientist; Giuseppe Riva is a psychologist.

Prof. Mancini: He is very much into cognition at the individual level.

Enrica: Another pioneer, Jim Blascovich, who did a lot of research on VR and prejudice starting in the 1990s, is also a psychologist. He developed a psychophysiological method to assess human reactions called "Challenge and Threat." Strangely, designers are missing; I think they should be part of the research, joining teams of psychologists and computer scientists.

Prof. Mancini: Absolutely. There is a lack of collaboration, which may be of respect to specific disciplines, and it might be challenging to have a dialog between people from very

different fields of expertise. It is the same in Italy. A few years ago, we worked on a big project with a computer scientist that aimed at building a video game for children with learning disabilities to improve their executive functions. The research has yet to be published, but the data was gathered despite the difficulty of working during COVID-19. We had a long discussion on how to design the avatar for the game, and it took a lot of work to convince the engineers that the kids should choose their avatar's color, eyes, and facial expression. It looks like these matters are left to luck, without pondered design decisions taken by visual experts.

Enrica: This really baffles me, especially because there is a large amount of money spent on building applications that are crucial for a healthy society, like bias training.

Prof. Mancini: I think that the problem, independent of the technology used, is that when the topic of prejudice reduction or other social themes is presented, the digital tools available are in a unilateral, one-way-only direction. I mean that, for example, in the bias training, they come up with scenarios that a person can like or not or feels more or less engaged with. Still, their decisions for whatever story or situation presented are based on abstract and generalized theory without considering objective, real, and concrete contexts.

Enrica: Do you mean that, in the bias training, people are passive receivers without empowerment?

Prof. Mancini: Yes, they offer you a product, and you must make the required motions. In other cases, they present too many options, which means the results are not controllable. We need a middle ground, in which we give agency to the audience, who can be active in the choice of their path, without the risk of getting lost by overstimulation, when there are so many choices that the user cannot choose, even if that's the strengths of videogames that work, like War of Worldcraft.

Enrica: Do you think that's OK in entertainment and games but not for social change?

Prof. Mancini: Well, social change can also happen through games. A few years ago, we did a very simple study on War of Worldcraft that used a questionnaire. The results showed that the people who used an avatar belonging to a particular group made the player develop prej-

udicial attitudes toward members of the opposing group. The exceptional finding was that a prejudice reduction occurs if a person has more than one avatar and one or more of these avatars belong to the other group.

Enrica: Do having multiple identities force you to see things from different perspectives?

Prof. Mancini: Absolutely.

Enrica: Well, thank you for this wonderful chat. I learned a lot. I would be honored to collaborate with you if you ever see a possibility.

Prof. Mancini: Yes, and vice versa. Let's stay in touch.

APPENDIX B: Literature Review

Keywords Searches

LEGEND

Blue text: entire publication was read in full

Black text : only abstract was read in full

Searched Keywords: **VR+Visual Representation**

Argelaguet, F., Hoyet, L., Trico, M., & Lécuyer, A. (2016). *The role of interaction in virtual embodiment: Effects of the virtual hand representation*. 2016 IEEE Virtual Reality. https://doi.org/10.1109/vr.2016.7504682

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Virtual Reality +Storytelling + Enjoyment

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