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LVDS: A Virtual Reality Serious Game Framework for Social Bias Reflection Through Label-Driven Human Visibility Distortion

Jiamin Wu
Institutional Affiliations: China–Korea New Media Institute, Zhongnan University of Economics and Law, Wuhan, China

Pengcheng Du
Institutional Affiliations: Faculty of Creative Industries, City University Malaysia, Petaling Jaya 46100, Selangor, Malaysia

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ABSTRACT: Social labeling plays a significant role in shaping interpersonal perception and reinforcing social bias, yet existing bias intervention approaches often struggle to provide immersive and behavior-driven reflective experiences. This study proposes When Labels Distort Human Visibility, a virtual reality serious game framework designed to visualize social labeling processes and promote bias reflection and intervention through interactive immersion. The system allows players to select, attach, and remove social labels within a VR environment, where non-player characters (NPCs) dynamically change their visibility in response to labeling behaviors.

Using a mixed-methods research design, the study integrates virtual reality interaction design, serious game mechanics, and social psychology perspectives to construct the proposed framework. Experimental evaluation combines behavioral observation, participant feedback, and interaction analysis to investigate how immersive label manipulation influences users' awareness of social bias.

Results indicate that the visualization of labeling consequences can strengthen participants' reflective understanding of prejudice, while interactive de-labeling behaviors encourage reconsideration of human perception and social judgment. The proposed framework demonstrates the potential of virtual reality serious games as tools for social bias intervention and contributes a novel design approach for immersive human-centered interaction research.

KEYWORDS: Virtual Reality, Serious Game, Social Bias, Bias Intervention

1. INTRODUCTION

In contemporary society, social labeling has become an important mechanism influencing interpersonal perception, social judgment, and behavioral decision-making. Individuals are frequently categorized through simplified descriptions associated with identity, occupation, appearance, personality, or social status. Although labels can function as cognitive shortcuts that facilitate rapid information processing, excessive reliance on labeling mechanisms often reinforces stereotypes, prejudice, and dehumanization, limiting the ability to perceive others as complex and complete human beings. In recent years, increasing attention has been devoted to methods for reducing social bias and improving social cognition, with existing approaches primarily focusing on educational communication, empathy cultivation, and perspective-taking strategies. However, many traditional interventions still depend on passive knowledge transmission, narrative persuasion, or cognitive instruction, making it difficult for participants to directly experience the social consequences of labeling behavior.

With the rapid development of virtual reality (VR) technology, immersive digital media have demonstrated growing potential in human–computer interaction, serious game design, and social cognition research. Compared with conventional digital media environments, VR systems provide embodied interaction, real-time feedback, and experiential learning mechanisms, transforming abstract social concepts into perceivable and operable interactive experiences. Existing studies have explored the use of VR in empathy building, identity perspective shifting, and social

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awareness enhancement, highlighting the value of immersive experience in behavioral reflection and cognitive change. Nevertheless, several limitations remain. Current VR-based bias intervention systems tend to emphasize role-switching experiences or narrative immersion while paying relatively limited attention to visualizing the mechanism of social labeling itself. Furthermore, direct dynamic relationships between user behavior, social judgment, and perceptual consequences are often insufficiently represented in existing methods.

To address these challenges, this study proposes When Labels Distort Human Visibility: A Virtual Reality Serious Game Framework for Social Bias Reflection and Intervention. The proposed framework constructs an interactive VR-based labeling environment in which players can select, attach, and remove social labels, while non-player characters (NPCs) dynamically change their visibility according to player behavior. By integrating perspectives from social psychology, immersive interaction design, and serious game methodologies, this research aims to transform abstract mechanisms of bias formation into directly observable and experience-driven interactive processes.

The main contributions of this study include:

(1) A virtual reality serious game framework for visualizing social labeling mechanisms is proposed, enabling users to interactively understand how labeling behavior influences interpersonal perception and social visibility.

(2) An immersive interaction model combining label attachment, behavioral feedback, and dynamic visibility transformation is designed to strengthen reflective understanding of prejudice formation and dehumanization.

(3) A human-centered bias intervention pathway based on serious game design is constructed, providing a novel design perspective for the interdisciplinary integration of virtual reality technologies and social psychology research.

In recent years, researchers have increasingly explored the application of virtual reality, serious games, and immersive interaction systems in bias intervention, empathy cultivation, and behavioral improvement studies. Although previous research has achieved meaningful progress, existing approaches still suffer from limited visualization of social labeling processes, insufficient behavioral interactivity, and weak direct feedback mechanisms connecting user actions with the consequences of bias formation. In response to these limitations, this study develops and analyzes a VR-based serious game framework aimed at exploring the visualization of labeling behavior and its potential applications in social bias reflection and intervention.

2.LITERATURE REVIEW

2.1 Labeling, Stigma, and Social Categorization

Social labeling plays a fundamental role in shaping human perception, interpersonal evaluation, and social identity formation. Early stigma research conceptualized labeling as a social process through which individuals are assigned “spoiled identities,” influencing both external social judgment and internal self-understanding (Goffman, 1963). Rather than functioning as neutral descriptors, labels often carry normative meanings that affect how individuals are categorized, evaluated, and treated within social systems.

Building on this perspective, Link and Phelan (2001) proposed that stigma is not an isolated act of naming but a continuous social mechanism involving labeling, stereotyping, separation, status loss, and discrimination. Their model highlights how seemingly simple categorization behaviors can trigger broader social consequences. In digital and interactive environments, these mechanisms remain relevant, as identity cues and symbolic classifications continue to influence user perception and behavior.

Social categorization research further explains why individuals tend to divide others into simplified group structures. According to Social Identity Theory and Self-Categorization Theory, people construct social understanding through “ingroup” and “outgroup” distinctions, which strengthen perceived group similarity and intergroup difference (Hornsey, 2008). Similarly, Hugenberg and Sacco (2008) demonstrated that categorization biases directly influence perception, memory, and judgment, often encouraging individuals to perceive outgroup members as homogeneous rather than unique persons.

These studies collectively suggest that labeling is not merely linguistic behavior but a cognitive and social mechanism capable of shaping interpersonal attitudes, social visibility, and behavioral responses.

2.2 Dehumanization and Human Perception

Research on dehumanization examines how individuals or groups become perceived as lacking essential human qualities. Haslam (2006) described dehumanization as a process through which people deny emotionality, individuality, morality, or agency to others, thereby positioning them below the status of “fully human.” The study proposed a dual framework distinguishing animalistic dehumanization from mechanistic dehumanization, the latter referring to perceiving others as object-like, emotionally cold, or machine-like entities.

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Further research by Haslam and Loughnan (2014) emphasized that dehumanization is not restricted to extreme violence or wartime propaganda. It also appears in everyday social contexts, including subtle forms of interpersonal judgment and social exclusion. Related work on infrahumanization suggests that individuals often attribute fewer uniquely human emotions or characteristics to outgroup members (Leyens et al., 2001; 2007).

From a moral psychology perspective, Bandura (1999) argued that dehumanization contributes to moral disengagement, allowing harmful actions to be cognitively justified by weakening moral self-regulation. Complementing this, Gray et al. (2007) proposed the Mind Perception Theory, which identifies agency and **experience** as two key dimensions through which humans attribute mind and personhood to others.

Together, these studies demonstrate that labeling and categorization can influence not only social judgment but also the perceived degree of humanity assigned to others. Such findings provide an important conceptual foundation for understanding how symbolic labels may alter perceived human visibility in interactive systems.

2.3 Virtual Reality, Empathy, and Bias Intervention

Recent developments in immersive technology have positioned virtual reality (VR) as a promising medium for studying empathy, social cognition, and prejudice reduction. Compared with conventional digital media, VR offers stronger immersion, embodied interaction, and first-person perspective experiences, allowing users to engage with simulated social situations in more direct and experiential ways.

Dhiman (2023) argued that VR environments can enhance emotional understanding and empathy through presence, embodiment, and perspective-taking mechanisms. However, empirical findings remain nuanced. A meta-analysis conducted by Ventura et al. (2020) reported that VR demonstrates strong effects on perspective-taking, while its overall influence on generalized empathy appears more limited and context-dependent.

Research specifically examining prejudice reduction has produced similarly complex conclusions. Tassinari et al. (2022) found that VR can facilitate prejudice research and intervention through avatar embodiment, cross-group interaction, and immersive identity simulation. Nevertheless, outcomes vary depending on design context, narrative framing, and interaction structure.

Despite increasing interest in VR-based empathy and bias research, many existing studies focus primarily on emotional immersion or avatar substitution. Comparatively fewer studies investigate how symbolic labeling behaviors, visualized social categorization, and dynamic changes in perceived human visibility can be translated into interactive VR experiences.

2.4 Research Gap

Existing studies have established valuable theoretical foundations regarding labeling, stigma, dehumanization, and VR-mediated empathy intervention. However, several limitations remain.

First, traditional stigma and dehumanization studies primarily rely on textual analysis, questionnaires, or observational methods, offering limited opportunities for embodied experiential exploration. Second, current VR empathy research often emphasizes emotional immersion or avatar embodiment while paying comparatively less attention to how symbolic social labeling dynamically transforms interpersonal perception.

Moreover, few existing studies integrate labeling theory, dehumanization mechanisms, and immersive VR interaction design into a unified serious game framework capable of visualizing changes in human visibility and promoting critical reflection on everyday bias.

To address these gaps, the present study proposes a VR serious game framework based on the Label Visibility Distortion System (LVDS)**,** exploring how labeling behaviors can be translated into visual, interactive, and embodied experiences that encourage reflection on social bias and human perception.

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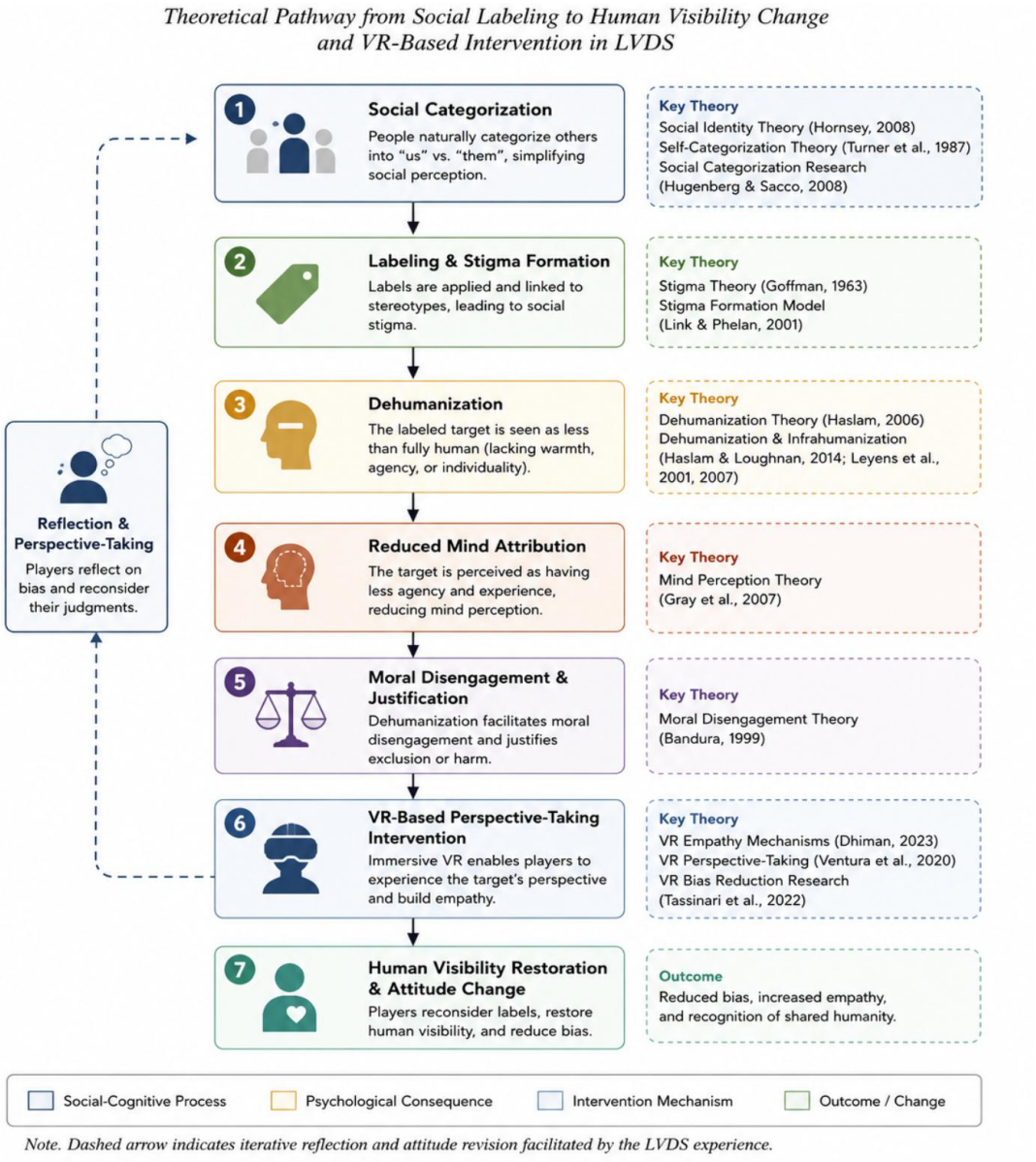


Figure 1 LVDS Overall Conceptual Framework

3. MATERIALS AND METHODS

3.1 Preliminary Study Design

Prior to the development of the Label Visibility Distortion System (LVDS), a preliminary exploratory study was conducted to understand real-world experiences of labeling, psychological responses to social categorization, and user attitudes toward immersive bias-related experiences. The preliminary study consisted of two stages: semi-structured interviews **and a** preliminary questionnaire survey**.**

3.1.1 Semi-Structured Interviews

Semi-structured interviews were conducted with participants from different social backgrounds, including undergraduate students, postgraduate students, and working adults. The interviews aimed to investigate participants' personal experiences of being labeled, perceived psychological consequences, sources of labeling, and attitudes toward possible "de-labeling" experiences.

The interview protocol focused on four thematic dimensions:

1. personal labeling experiences;
2. psychological and behavioral impacts;
3. linguistic and social dissemination of labels;
4. possibilities of identity reconstruction beyond labels.

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The qualitative findings informed the conceptual direction of LVDS, particularly the design of negative label categories**,** NPC visibility distortion**,** and the label removal mechanism**.**

3.1.2 Preliminary Questionnaire Survey

Following the interview stage, a preliminary questionnaire survey was conducted to collect broader user perceptions regarding social labeling and virtual reality intervention.

The survey consisted of six modules:

- demographic information;
- experiences of being labeled;
- social dissemination of labels;
- psychological effects of labeling;
- attitudes toward VR-based visualization;
- open-ended reflections on labeling experiences.

The survey data served three design purposes:

1. validating the prevalence of labeling experiences;
2. identifying commonly encountered negative labels;
3. establishing the rationale for immersive visualization of bias in VR environments.

The open-ended responses were additionally used as reference material for constructing the fixed negative label library used in the LVDS system.

3.2 Participants

A total of 20 participants (N = 20) were recruited for the LVDS experimental study.

Participants consisted primarily of university-aged users familiar with digital interaction environments. Participation was voluntary, and informed consent was obtained before the VR session.

Because the study focused on embodied interaction and social perception within immersive environments, no prior expertise in virtual reality was required.

The participant sample was used for:

- system evaluation;
- bias-related measurement;
- behavioral logging analysis.

Table 1 Participant Demographics

Variable	Value
N	20
Hardware	Quest 3S
Engine	Unreal Engine 5.7
Environment	VR Serious Game

3.3 LVDS System Design

The Label Visibility Distortion System (LVDS) was developed as a virtual reality serious game framework designed to visualize the relationship between labeling behavior, social perception, and human visibility.

The system was implemented in Unreal Engine 5.7 and deployed using Meta Quest 3S hardware.

The design objective of LVDS was not merely to present labeling as textual information, but to translate social bias into an embodied, interactive, and visually observable process.

3.3.1 Hardware and Development Environment

The experimental system was developed using Unreal Engine 5.7, enabling real-time rendering, interaction logic construction, and visual feedback implementation.

The VR environment was deployed on Meta Quest 3S, supporting head-tracked immersive interaction and controller-based object manipulation.

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The system architecture integrated:

- VR locomotion;
- hand-based interaction;
- label attachment mechanics;
- NPC dissolve visualization;
- behavioral data recording.

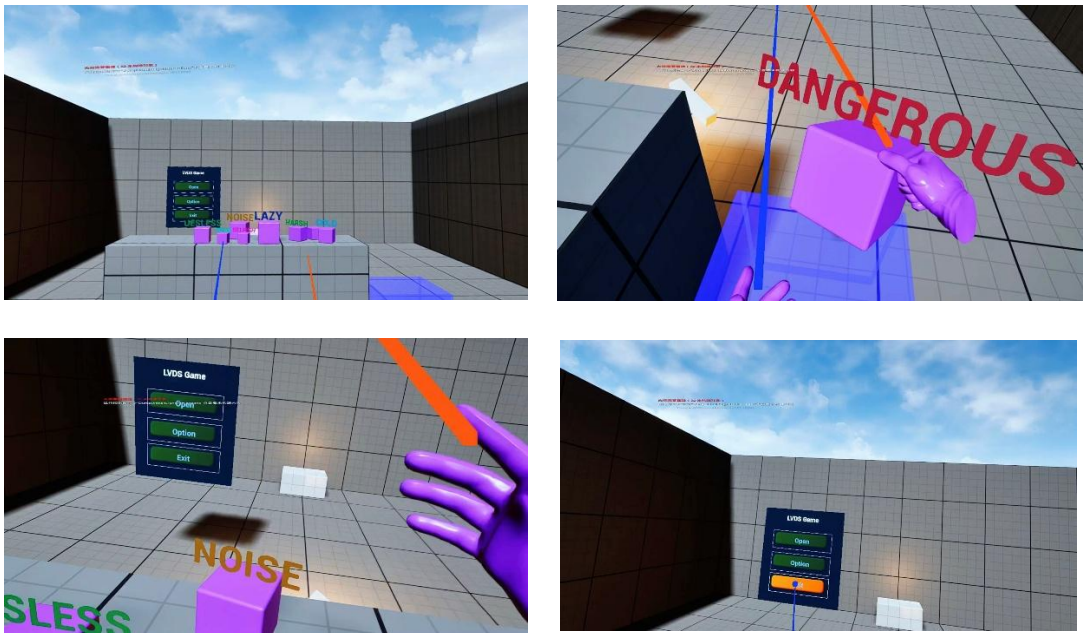
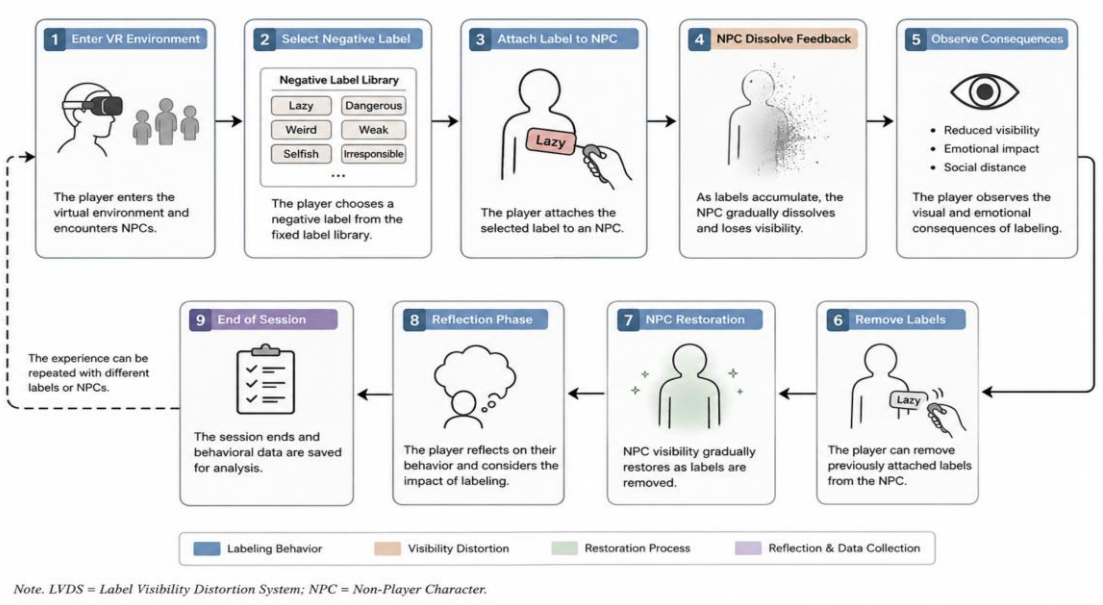


Figure 2 VR Scene Experience

3.3.2 Gameplay Workflow

LVDS adopts an interaction flow centered on label application**,** visibility transformation, and behavioral reflection.

Players first enter the VR environment and encounter non-player characters (NPCs). They are then presented with a fixed negative label library, from which labels can be selected, grabbed, and attached to NPCs.



Note. LVDS = Label Visibility Distortion System; NPC = Non-Player Character.

Figure 3 LVDS Gameplay Workflow

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As labels accumulate, NPCs gradually undergo visual transformation through a dissolve-based visibility distortion mechanism.

Players subsequently observe the consequences of their actions and may choose to remove previously attached labels.

When labels are removed, NPC visibility progressively returns toward its original state.

This gameplay structure was designed to encourage users to recognize, question, and reflect upon labeling behavior through embodied interaction rather than passive narrative instruction.

3.3.3 Interaction Interface and Negative Label System

LVDS employs a fixed negative label library as its primary interaction mechanism.

Unlike free-text input systems, the label set was predefined to ensure experimental consistency and controlled behavioral comparison.

Players interact with labels through controller-based grabbing mechanics within the VR environment.

Each label exists as an interactable virtual object that can be physically manipulated and attached to NPC targets.

The label interaction system emphasizes embodied action, transforming abstract categorization behavior into tangible spatial interaction.

3.3.4 NPC Visibility Distortion Mechanism

A dissolve-based visual feedback mechanism was implemented to represent changes in perceived human visibility.

When negative labels are attached to NPCs, their visual appearance gradually changes according to label accumulation.

The visibility distortion process includes:

- decreasing visual coherence;
- increasing dissolve intensity;
- progressive loss of human readability.

Conversely, label removal initiates a restoration sequence, allowing NPCs to gradually recover visual integrity.

This mechanism operationalizes concepts derived from dehumanization theory, translating symbolic labeling behavior into dynamic visual feedback.

4. RESULTS

4.1 Preliminary Investigation Results

The preliminary investigation indicated that labeling experiences were prevalent among participants.

A total of 20 respondents (N = 20) completed the preliminary questionnaire survey. Participants ranged from 19 to 27 years old and represented different genders and social backgrounds.

Within the labeling experience dimension (Q5–Q9), most respondents reported having experienced different forms of social labeling.

Frequently reported labeling sources included:

- peer relationships;
- social environments;
- broader evaluative social systems.

Results from the social dissemination dimension (Q11–Q12) showed that participants generally perceived labels as socially transmissible and capable of persisting across different contexts.

In the psychological impact dimension (Q13–Q15), participants reported associations between labeling experiences and emotional reactions, identity perception, and interpersonal interaction.

In addition, most respondents expressed positive attitudes toward VR-based bias visualization and regarded immersive media as providing perceptual experiences distinct from conventional text-based representation.

Open-ended responses indicated that commonly reported negative labels were mainly related to:

- competence evaluation;
- social identity;
- moral judgment;
- interpersonal assessment.

These findings were subsequently used to construct the fixed negative label library adopted in the LVDS system.

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4.2 Bias Reduction Results

Bias outcomes were calculated based on post-experiment questionnaire data collected from 20 participants (N = 20).

The questionnaire employed a five-point Likert scale.

Results showed an overall mean bias score of:

Table 2 Bias Reduction Outcomes

Indicator	Value
Mean	2.01
SD	0.67
Min	1.00
Max	3.35

Distribution analysis further indicated that:

- **67%** of participants fell within the low-bias range (≤2);
- **26%** fell within the moderate-bias range (2–3);
- **7%** fell within the higher-bias range (≥3).

Overall results indicated relatively low levels of explicit labeling endorsement.

4.3 Empathy Results

Empathy outcomes were measured using the Interpersonal Reactivity Index – Perspective Taking Scale (IRI-PT).

The measurement was based on post-experiment responses from 20 participants.

Results showed an overall average score of:

Table 3 Empathy Measurement Results

Indicator	Value
Mean	4.33
SD	0.69
High Empathy	73%
Low Empathy	20%

Overall, participants demonstrated relatively high scores in the perspective-taking dimension.

4.4 Dehumanization Results

Dehumanization outcomes were assessed using the Haslam Dehumanization Scale.

Questionnaire responses from 15 participants (N = 15) were included in the analysis.

Results indicated that the mean score for mechanistic dehumanization was:

Table 4 Dehumanization Results

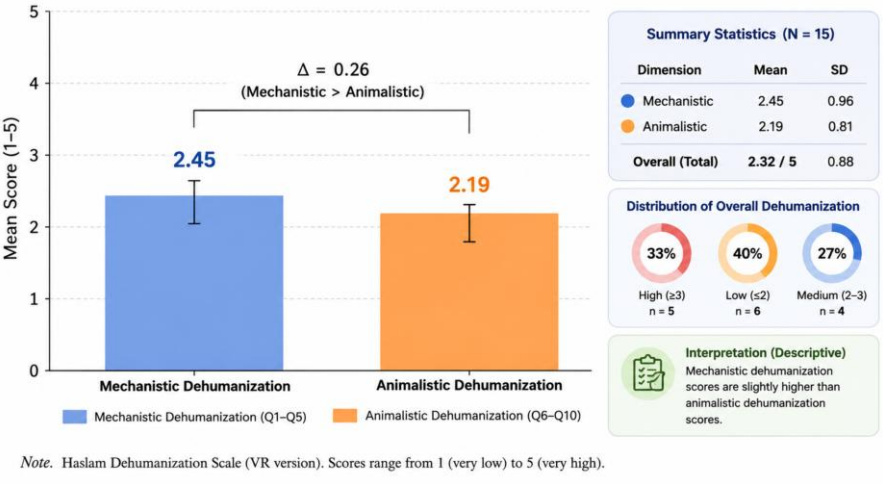
Dimension	Mean
Mechanistic	2.45
Animalistic	2.19
Overall	2.32

Further distribution analysis showed that:

- **33%** of participants fell within the higher dehumanization range (≥3);
- **40%** fell within the lower dehumanization range (≤2).

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Mechanistic dehumanization scores were slightly higher than animalistic dehumanization scores.



Note. Haslam Dehumanization Scale (VR version). Scores range from 1 (very low) to 5 (very high).

Figure 4 Dehumanization Dimension Comparison

4.5 Presence Results

Presence outcomes were measured using the **Igroup Presence Questionnaire (IPQ)**.

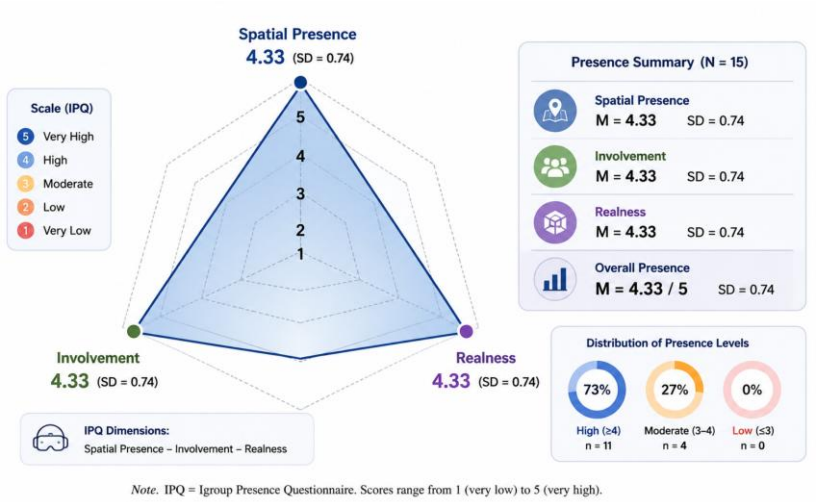
The analysis included data from **15 participants**.

Results showed an overall mean presence score of:

Indicator	Value
Mean	4.33
SD	0.74
High Presence	73%
Low Presence	27%

No participants fell within the low-presence category (≤3).

Overall, participants reported relatively high levels of immersive presence during the VR experience.



Note. IPQ = Igroup Presence Questionnaire. Scores range from 1 (very low) to 5 (very high).

Figure 5 Presence Measurement Results

4.6 User Experience Results

User experience was evaluated using the **User Experience Questionnaire (UEQ)**.

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The mean values across six UEQ dimensions were as follows:

Dimension	Mean
Attractiveness	5.63
Perspicuity	5.90
Efficiency	5.63
Dependability	5.47
Stimulation	6.13
Novelty	6.30

Among the six dimensions, Novelty obtained the highest score, followed by Stimulation.Overall, all dimensions demonstrated relatively high evaluation scores.

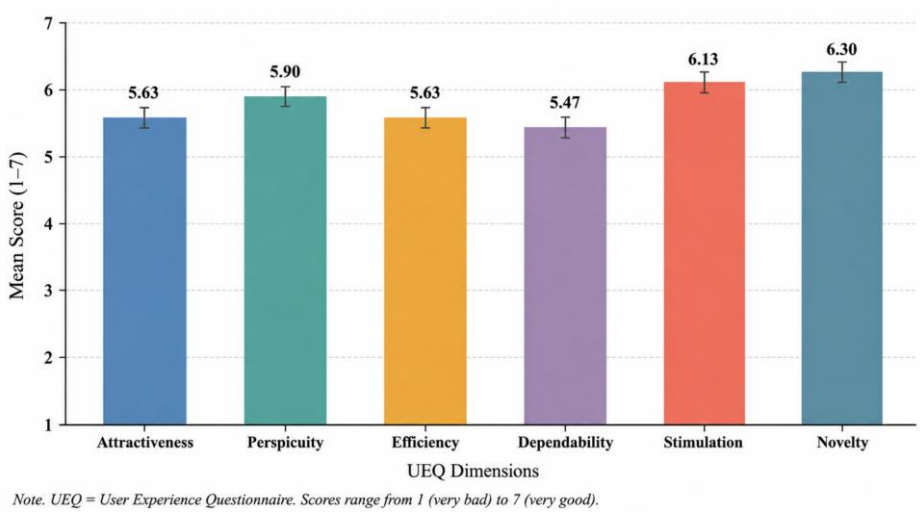


Figure 6 UEQ Dimension Comparison

5.DISCUSSION

5.1 Bias Reflection, Empathy, and Immersive Mechanisms

The experimental results suggest that LVDS may function as an effective immersive framework for bias reflection.

The relatively low bias score **(**M = 2.01/5**)** indicates limited explicit endorsement of labeling attitudes after the experience. Rather than communicating prejudice through textual explanation, LVDS externalizes labeling into a visual and interactive process in which participants actively select, apply, and observe labels within the VR environment.

This mechanism is consistent with Labeling Theory (Goffman, 1963; Link & Phelan, 2001), which conceptualizes labeling as a broader social process involving categorization, stereotyping, and identity degradation.

The empathy findings further support this interpretation. Participants demonstrated relatively high perspective-taking scores **(**IRI-PT: M = 4.33/5). Previous studies suggest that VR environments can strengthen empathy through presence, embodiment, and first-person experience (Ventura et al., 2020; Tassinari et al., 2022). The high IPQ score **(**M = 4.33/5**)** observed in the present study also indicates strong immersive involvement during gameplay.

Together, these results suggest that immersion may contribute to how players perceive, experience, and reflect upon labeling behavior.

5.2 Dehumanization and Visual Translation of Social Theory

The dehumanization findings provide further insight into the visual logic underlying the LVDS framework.

Participants reported an overall dehumanization score of 2.32/5, with mechanistic dehumanization (2.45) slightly exceeding animalistic dehumanization (2.19)**.**

This pattern corresponds closely with Haslam's Dual Model of Dehumanization (2006), particularly mechanistic dehumanization, which describes the perception of others as lacking emotional depth, individuality, and human agency.

Within LVDS, NPCs gradually lose visibility, emotional readability, and embodied coherence as labels accumulate. The Dissolve effect therefore

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operates not merely as an aesthetic device, but as a visual translation of theoretical concepts related to dehumanization, social categorization, and identity reduction.

These findings demonstrate how abstract social-psychological theories may be transformed into observable interaction mechanics within immersive systems.

5.3 Design Implications, Limitations, and Future Work

The UEQ findings showed consistently positive evaluations across usability and experiential dimensions, particularly Novelty (6.30) and Stimulation (6.13)**,** suggesting that participants perceived the system as engaging and experientially distinctive.

From a design perspective, LVDS illustrates how concepts such as labeling, stigma, and dehumanization can be translated into serious VR gameplay through embodied interaction and visual feedback rather than explicit instruction.

Several limitations should nevertheless be acknowledged. The study employed a relatively small participant sample and relied primarily on self-report questionnaires. In addition, the current prototype uses a fixed negative label library, limiting contextual variability.

Future research could incorporate larger samples, adaptive or AI-generated labeling systems, behavioral logging, and longitudinal evaluation to further examine the intervention potential of immersive bias-related serious games.

6. CONCLUSION

This study proposed and developed LVDS (Label Visibility Distortion System), a virtual reality serious game framework designed to explore social labeling, bias perception, and immersive interaction design through visualized labeling mechanisms.

At the theoretical level, the study integrated Labeling Theory, Dehumanization Theory, Social Categorization Theory, and contemporary research on VR empathy and immersion to establish a conceptual connection between social-psychological mechanisms and interactive system design. By translating abstract concepts into concrete mechanics such as NPC transparency, visual distortion, dissolve effects, and immersive tagging interaction, LVDS investigated an alternative VR-based approach for representing social bias processes.

Experimental findings showed relatively low bias scores **(**M = 2.01/5**),** high perspective-taking ability **(**IRI-PT: M = 4.33/5**)**, and positive outcomes in both presence **(**IPQ: M = 4.33/5**)** and user experience dimensions. The dehumanization findings further revealed slightly higher mechanistic dehumanization scores than animalistic scores, supporting the relationship between the NPC dissolution mechanism and dehumanization theory.

Overall, the findings suggest that VR serious games may function not only as expressive media for social-psychological concepts but also as potential tools for encouraging bias reflection, perspective-taking, and immersive experiential engagement.

Future work may expand participant diversity, incorporate behavioral logging, adaptive AI-generated labeling systems, and longitudinal evaluation methods to further examine the long-term intervention potential of immersive bias-related serious games.

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Corresponding Author: Pengcheng Du