Rethinking Defaults: Examining the Effects of Default Camera Height and Angle on Embodied Presence in Cinematic Virtual Reality

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Abstract. This study investigates the avatar-less embodiment experienced by viewers in cinematic virtual reality (CVR), with a focus on comparing grounded and aerial camera perspectives. We conducted an experiment using a between-subjects design with 63 participants across nine viewing scenarios in a virtual Hogwarts environment. The scenarios systematically manipulated camera height (Grounded or Aerial) and angle (High, Eye level, Low). Participants completed adapted questionnaires measuring embodiment and discomfort. Our analysis reveals pronounced effects of camera positioning on embodiment, with aerial heights eliciting higher embodiment than grounded positions across angles. Low aerial angles further enhanced embodied sensation. Interestingly, adding virtual grounding elements at aerial heights balanced increased stability with slightly reduced embodiment. These empirical findings provide insights to help CVR practitioners optimize default camera settings for crafting appropriately immersive, comfortable VR narrative experiences aligned to specific narrative goals.

Keywords: Default camera · Cinematic virtual reality · Embodiment

1 Introduction

Cinematic virtual reality (CVR) offers audiences the unique experience of being 'inside' films, representing a new form of immersive storytelling [10]. This transformation is shaped by embodiment in VR, which enhances users' sense of presence and identification [8]. As storytelling in CVR format requires much more user-centered engagement, it is thus essential for researchers to define into the effect of embodiment during the content creation process to optimize the immersive experience [2]. To render a virtual scene, a default virtual camera is always needed so that 3D-modeled scene elements can be projected onto a displayable 2D visual field. In VR, there are two horizontally displaced virtual cameras to enable stereoscopic projection. The head-mounted display fuses these projections to facilitate stereoscopic viewing. VR also allows for non-stereoscopic, 360-degree

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panoramic images. The need for a single default virtual camera still applies in scene rendering for both stereoscopic and non-stereoscopic cases. We can generalize both cases as using a default virtual camera, which functions as the vantage point in VR experiences. The positioning of this default camera, particularly its height and angle, is instrumental in shaping viewers' engagement, emotional responses, and the sense of presence experienced within a virtual environment [7]. However, research on default camera settings in CVR remains limited. We aim to address this gap by examining how camera height and angle impact avatar-less embodiment and discomfort, with a focus on comparing grounded and aerial perspectives. The finding may inform CVR practitioners to appropriately adjust default camera setups and construct scenes that effectively align with the intended narratives.

In this paper, we present an experiment taking place in a virtual environment modeled after the iconic Hogwarts Castle from the Harry Potter series. This realism-oriented setting supports a feeling of authentic narrative immersion, while also providing sufficient space to explore different camera perspectives. Specifically, we systematically vary camera height between Grounded and Aerial positions, as well as camera angle among High, Low, and Eye level views. As illustrated in Fig. 1, this experimental design enables us to examine how different visual framings of the highly familiar Hogwarts landscape influence users' sense of experience.

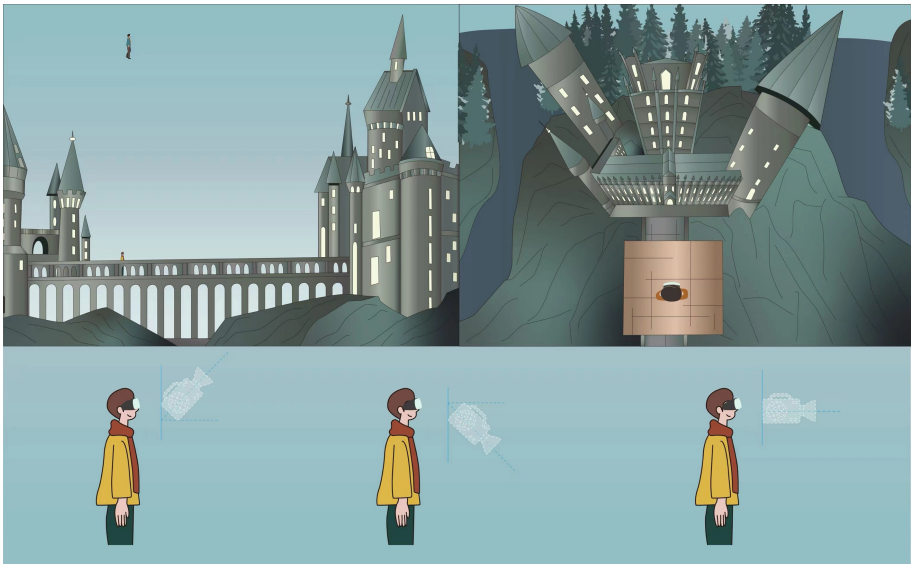

Fig. 1. Experimental viewing scenarios: default camera settings overview

Unlike traditional cinema, CVR introduces the dimension of embodiment, which raises important questions around the use of aerial camera perspectives.

While we manipulate camera heights as an experimental factor, the elevated, aerial shots may impact viewer immersion, embodiment, and potential discomfort in CVR. Though aerial and establishing shots are commonplace and crucial storytelling devices in conventional films [1], their effects may differ in embodied CVR experiences. Therefore, we also integrate a novel grounding element in our aerial scenarios. This visual flooring applied at aerial heights is designed to test its influence on viewers' sense of embodiment and discomfort mitigation. By incorporating this grounding cue, we can systematically assess its effectiveness in enhancing embodied presence and reducing unease during aerial CVR footage.

2 Related Works

In the evolving field of CVR, the role of camera height, viewer position, camera distance, shot size, and field of view has been a subject of extensive research. These elements are critical in determining the viewers' experience, influencing factors such as presence, embodiment, and emotional response. Keskinen et al. [7] investigated the impact of camera height and viewer position on the viewer experience, identifying a more natural and comfortable camera height around 1.5 m for both seated and standing viewers. Rothe et al. examined how camera positioning and field of view affects presence, sickness, and overall experience in CVR, seeking to provide guidance on optimal camera placement for enhanced immersion, also highlighted the acceptance of camera heights lower than the viewer's own height [13,14,16]. Pope et al. [11] contrasted staging techniques between 360° cameras and traditional positioning, noting the importance of proxemics in narrative performances. Rothe et al. [15] further explored the application of traditional shot sizes in CVR, categorizing them based on proxemic distances. Dooley [3] suggested that Edward T. Hall's proxemics theories could inform spatial screen grammar in 360° CVR and also aid 2D filmmakers in considering character spatial relationships. This was supported by Dooley's later findings that factors such as proximity and gaze direction influence viewer empathy [4]. Probst et al. [12] discussed how various camera distances in CVR elicit emotional responses akin to shot sizes in traditional films. Zhiyuan et al. [18] suggest CVR's embodied, interactive qualities altered the impact of cinematic techniques, which enhances engagement through heightened arousal and lowered dominance.

These insights are important for understanding the spatial cognition in CVR. However, research specifically addressing default camera settings in CVR production remains limited. Our research aims to fill this gap, offering a comprehensive understanding of how various default camera settings can enhance or alter the embodiment level in CVR. This assists CVR practitioners in their production process and provides a guideline on how various cinematic techniques can be effectively adapted and optimized for immersive VR experiences across different storytelling contexts.

3 Methodology

This study investigates the effects of default camera angles and heights on the avatar-less embodiment level in CVR, with an additional focus on examining the influence of grounding in aerial height scenarios. To evaluate the impact on embodiment, our study employed a between-subjects design with 63 participants. They experienced nine viewing scenarios, each utilizing VR headsets to deliver diverse perspectives within the virtual environment. Viewer experiences were evaluated through questions adapted to align with our experimental context from the selected questionnaires. These adapted questions were specifically chosen to reflect the unique conditions of our study, enabling an accurate measurement of avatar-less embodiment levels and any associated discomfort.

3.1 Materials and Apparatus

The experimental viewing scenarios were generated using Unreal Engine 5 due to its advanced graphical rendering capabilities, which are crucial for creating realistic and detailed virtual environments. The Pico 4 Pro VR headset was selected for the experiment to ensure a high-quality visual experience, allowing for an accurate representation of different camera heights and angles as experienced by the user.

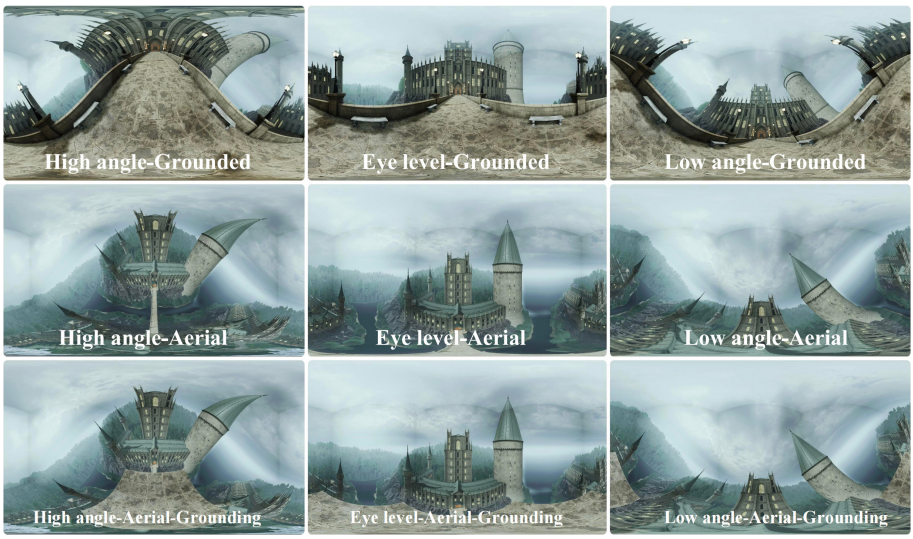

Fig. 2. 9 viewing scenarios in different default camera settings

Figure 2 illustrates the nine different viewing scenarios, each representing a unique combination of default camera settings. These scenarios were designed

to systematically vary in camera height (Grounded or Aerial) and camera angle (High angle, Eye level, Low angle), with the additional variable of a virtual floor providing grounding in aerial height.

3.2 Measurements

To assess the embodiment levels and discomfort experienced by participants, our methodology incorporated a combination of three widely-used questionnaires, including Igroup Presence Questionnaires (IPQ) [17] and Embodiment Questionnaires (EQ) [5], in conjunction with the Simulator Sickness Questionnaire (SSQ) [6]. The IPQ was utilized to measure the sense of spatial presence, involvement, and experienced realism within the VR environment. Specific questions selected from the IPQ focused on aspects like the sense of 'being there' in the computer-generated world and feeling surrounded by the virtual environment. In addition to the IPQ, we adapted questions from the EQ to specifically gauge the embodiment level, which included perceptions of body changes in response to camera height and angle. These questions were carefully chosen to align with the context of our CVR study, ensuring the relevance and accuracy of our findings.

- IPQ Questions for Sense of Presence:
  - In the computer-generated world, I had a sense of "being there". (−3: fully dis-agree, 3: fully agree) - Somehow, I felt that the virtual world surrounded me. (−3: fully disagree, 3: fully agree) - I felt present in the virtual space. (−3: fully disagree, 3: fully agree) - I was completely captivated by the virtual world. (−3: fully disagree, 3: fully agree)
- EQ Questions for Embodiment:
  - I felt out of my body. (−3: fully disagree - 3: fully agree) - I felt that my own body could be affected by camera height. (−3: fully disagree - 3: fully agree) - I felt that my own body could be affected by camera angle. (−3: fully disagree - 3: fully agree)

The SSQ was used to measure symptoms of simulator sickness, including general discomfort, eyestrain, difficulty focusing, nausea, difficulty concentrating, and dizziness. This comprehensive questionnaire approach aimed to provide an understanding of the technical aspects of CVR and their embodiment impact on the viewer's immersive experience.

3.3 Participants and Grouping

A total of 63 individuals were recruited to participate in the study, with a wide age distribution ranging from 20 to 50 years and a balanced gender ratio of 33 males and 30 females. Most were in their twenties and had little to no previous experience with VR. Participants were evenly distributed into the nine VR viewing scenarios, seven per scenario, to ensure diverse responses across different default camera setting.

3.4 Procedures

Before the commencement of the experiment, a thorough briefing was conducted with participants to ensure they were well-informed about the process and any potential health concerns, such as motion sickness or physical discomfort. Participants had the option to halt the experiment at any time should they feel uneasy.

The experiment was conducted in a controlled, quiet environment where the objectives and procedures were clearly articulated. Participants were acquainted with the IPQ, EQ, and SSQ questionnaires and their relevance to the study. Upon viewing, each participant was in standing position and wearing the Pico 4 Pro headset, which was adjusted to their individual interpupillary distance to achieve the clearest virtual imagery possible. Upon successful calibration, participants were immersed in the predefined default camera settings.

To ensure the accuracy of responses and to capture the immediacy of the participants' reactions, researchers verbally administered each questionnaire item during the viewing scenario. Participants responded to a series of thirteen questions, with the entire session lasting approximately 3–4 min. Throughout this process, re-searchers recorded each response and observed the participants' physical and emotional reactions, providing a rich dataset for subsequent analysis. This detailed procedure was designed to obtain a genuine first-hand account of the participants' experiences, reflecting the true impact of the default camera settings on their sense of presence, embodiment, and comfort within the virtual environment.

Participants' responses to the questionnaires were quantified based on a scoring system where higher scores correlated with greater immersion, embodiment, and discomfort. Specifically, the IPQ-EQ included items such as 'sense of being there', 'feeling surrounded', 'being captivated', and 'perception of camera height and angle affecting the body'. These items were designed to cumulatively represent the degree of embodiment experienced by the participants.

4 Result

We computed the mean scores for each of the nine groups, with seven participants in each group, to establish average indices for embodiment and discomfort. This approach allowed us to evaluate the overall impact of camera settings on the participants' virtual experience. The sum of scores from each item within the questionnaires provided a composite measure of embodiment level and the degree of discomfort, with the intention of reflecting the participants' immersive experience in the CVR environment.

The evaluation concentrates on discerning the influence of diverse default camera heights and angles, and the implementation of grounding with aerial heights, on participants' perceived level of embodiment and discomfort. The results reveals associations between various default camera settings and their impact on the sense of avatar-less embodiment, as well as the extent of discomfort experienced by viewers.

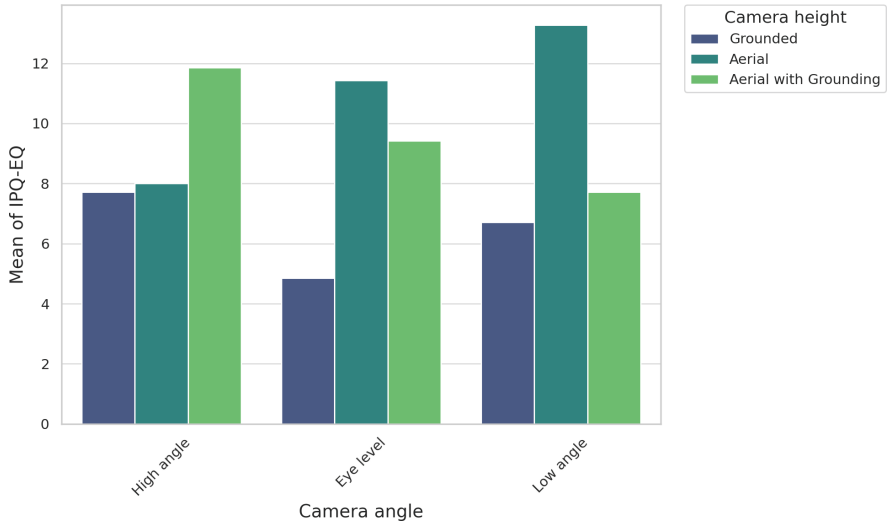

Fig. 3. IPQ-EQ Mean Scores Bar Chart

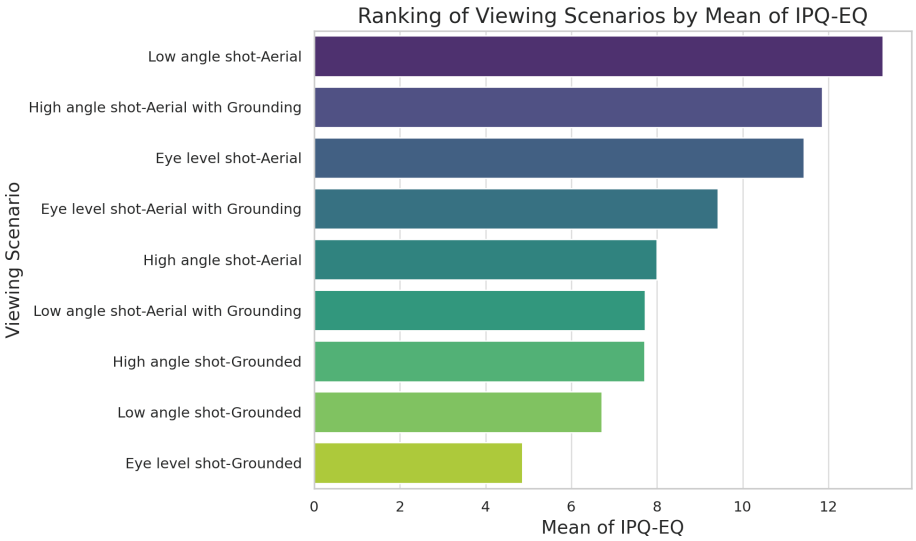

Fig. 4. Ranking of Viewing Scenarios by IPQ-EQ Scores

Figure 3 displays a bar chart illustrating the mean IPQ-EQ scores across various default camera settings in our viewing scenarios. It is apparent that camera height invokes different levels of embodiment within the same camera angles, as reflected by the IPQ-EQ scores. This suggests that camera height plays a role in influencing the viewer's sense of embodiment.

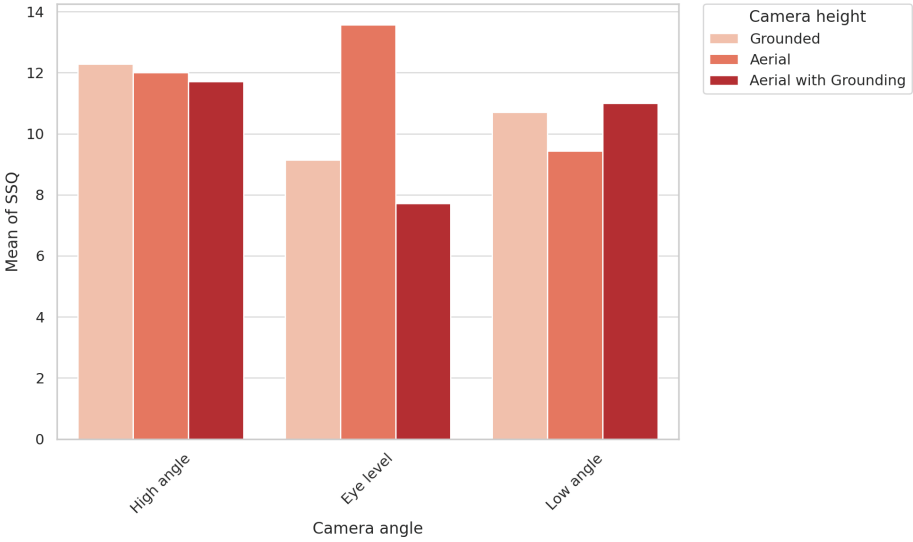

Fig. 5. SSQ Mean Scores Bar Chart

The mean IPQ-EQ scores were ranked, providing a comparative measure of immersion across different experimental conditions (see Fig. 4). This ranking offers valuable insights into which specific default camera settings contribute the most to the sense of embodiment in CVR environments. The aerial low-angle garnered the highest mean IPQ-EQ score, suggesting an amplified sense of embodiment in comparison to the other conditions, while the grounded eye-level angle recorded the lowest score.

The SSQ score bar chart (Fig. 5) illustrates the mean SSQ scores across different camera perspectives, focusing primarily on comparing aerial heights with and without grounding. The SSQ scores for the high-angle shot in both aerial height scenarios were nearly identical, while the low-angle shot showed slight changes with grounding. However, the eye-level view demonstrated an apparent reduction in discomfort when a virtual floor was added at the aerial height.

We then ranked the mean level of the SSQ (Fig. 6), which indicates that the eye-level shot in the aerial height scenario led to the highest level of discomfort among viewers, as denoted by the red bar reaching the furthest on the scale. Conversely, the eye-level shot in the aerial height with the grounding scenario showed the least discomfort. The variation in bar lengths across different scenarios suggests a correlation between camera angles, heights, and grounding and the intensity of discomfort experienced by viewers.

These findings are pivotal for crafting CVR experiences that aim to understand avatar-less embodiment and offer a potential solution to minimize discomfort at aerial heights. The insights gathered from the analysis of these visualizations are beneficial in refining default camera settings for a suitable content

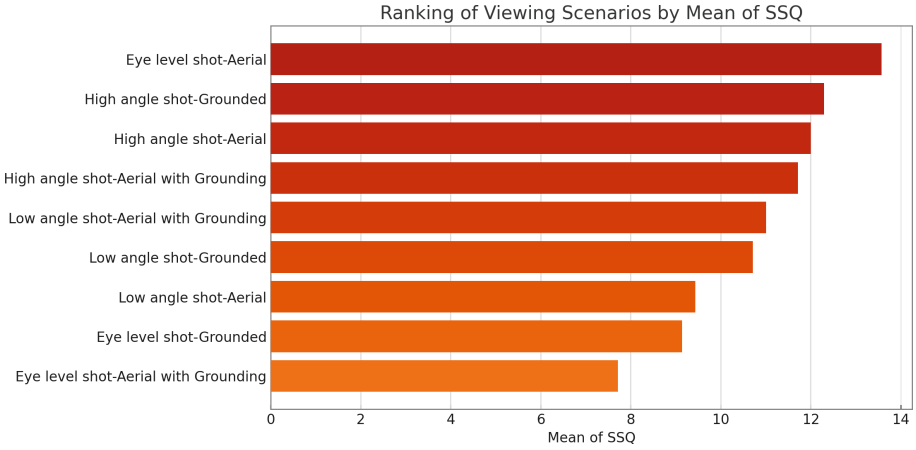

Fig. 6. Ranking of Viewing Scenarios by SSQ Scores

user experience in CVR, providing a foundation for further research on the interplay between default camera settings and viewer embodiment level in immersive narratives.

5 Discussion

Our study results demonstrate that across nine viewing scenarios, in comparison to grounded height perspectives, all aerial height perspectives elicited a heightened level of avatar-less embodiment. The embodiment experience in CVR is indeed influenced by the camera's position relative to the virtual environment. The aerial low angle shot exhibited the highest level of embodiment, whereas the grounded-eye-level shot scored the lowest. Thus, the high embodiment level observed in the aerial low-angle shot established its uniqueness within the CVR, eliciting stronger user engagement and substantial physiological stimulation owing to its height difference from the ground and a fixed upward viewing angle. The lowest embodiment performance might be because the grounded eye-level camera position aligns more closely with the everyday physiological state of individuals. These findings highlight the impact of camera placement within the virtual environment and default camera tilt on the viewer's sense of embodiment and immersion.

Furthermore, the SSQ indicates that the grounding elements in aerial scenarios can influence and potentially alleviate viewer discomfort. The aerial eye level with grounding effectively reduced viewer discomfort compared with the aerial height eye level. This aspect of our research is especially relevant to CVR practitioners, who emphasize the importance of grounding elements in mitigating discomfort while maintaining a strong sense of embodiment.

In traditional filmmaking, established shots are often composed of extremely long shots combined with various camera angles, serving to orient the audience

within the geographical context of the narrative and establish character relationships. These shots are typically utilized at both ground and aerial heights, without the need to account for the viewer's physical experience, as the audience is not a physical part of the environment in conventional cinema. In contrast, the embodiment approach in CVR dramatically alters the audience's spatial perception. Because of the 360-degree immersion in CVR, as opposed to traditional film and television, there is enhanced spatial cognition [9], especially in distinguishing the differences in embodiment between aerial and ground perspectives. The sense of presence brought about by CVR implies that the default camera settings for establishing shots become a critical element of storytelling.

6 Conclusion

Our findings reveal a pronounced effect of camera perspective on embodiment, with the default camera height clearly impacting the sense of embodiment. All aerial heights led to higher embodiment than grounded camera positions across different angles, with low-angle aerial shots particularly enhancing embodied sensation. Interestingly, adding a virtual floor at aerial heights appeared to balance increased stability with a slightly reduced feeling of embodiment, especially for eye-level shots.

However, there are some limitations to this initial study. While diverse, our relatively small sample size may limit generalizability of the results to a broader population. Moreover, as just one technique in the cinematic toolkit, established shots require further exploration within full narratives.

To look ahead, a clear need exists to investigate emotional impacts of default camera positions and subconscious viewer behaviors in CVR. More extensive studies could recruit larger, more varied samples to enable robust statistical analysis. Additionally, examining a broader range of camera manipulations and their specific effects on emotions and instincts could reveal the underlying explanations for these reflexive reactions, leading to a more comprehensive understanding of the embodied CVR experience.

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