

# Re-evaluating Hyper-Realism in Virtual Reality Game Design through the Embodied Simulation Gap

## Zhehao Sun

University of British Columbia  
Kelowna, BC, Canada  
V1V 1V7  
[zsun0717@student.ubc.ca](mailto:zsun0717@student.ubc.ca)

## Yuanyuan Xu

University of British Columbia  
Kelowna, BC, Canada  
V1V 1V7  
[yuanyxu@student.ubc.ca](mailto:yuanyxu@student.ubc.ca)

## Patricia Lasserre

University of British Columbia  
Kelowna, BC, Canada  
V1V 1V7  
[patricia.lasserre@ubc.ca](mailto:patricia.lasserre@ubc.ca)

## Aleksandra Dulic

University of British Columbia  
Kelowna, BC, Canada  
V1V 1V7  
[aleksandra.dulic@ubc.ca](mailto:aleksandra.dulic@ubc.ca)

## Megan Smith

University of British Columbia  
Kelowna, BC, Canada  
V1V 1V7  
[megan.smith@ubc.ca](mailto:megan.smith@ubc.ca)

## KEYWORDS

Virtual Reality; Game Design; Embodiment; Embodied Simulation Gap; Ergonomics; Phenomenology.

Proceedings of DiGRA 2026

© 2026 Authors & Digital Games Research Association DiGRA. Personal and educational classroom use of this paper is allowed, commercial use requires specific permission from the author.

## **INTRODUCTION**

Virtual reality (VR) development often treats realism as a marker of quality. The prevailing industrial logic assumes that higher physical, graphical, and audio fidelity produces deeper presence (Rogers et al., 2022). Yet design research and player experience (PX) research point to a paradox: the uncritical pursuit of hyper-realism can degrade play by introducing friction that interrupts flow. While challenging mechanics can induce flow through struggle in traditional games (Sun et al., 2026), friction caused by imperfect VR physics is unintentional and may become disruptive to immersion.

This paper examines the simulation trap, in which realistic physical simulation conflicts with the abstractions that make play possible. We call this mismatch the Embodied Simulation Gap: the gap between what the body expects to feel and what the game's physics delivers across tactile, vestibular, and metabolic registers. By analyzing interaction design, narrative delivery, and physical endurance, this study argues that VR design should prioritize embodied comfort and symbolic interaction over rigid verisimilitude.

## **THE INTERACTION PARADOX**

Traditional game design uses symbolic abstraction, such as pressing a button to reload, as a foundational design principle (Salen & Zimmerman, 2004). VR often demands 1:1 mimetic interaction instead, creating an uncanny valley of haptics. When players handle a realistic virtual object, such as a heavy steel firearm, vision anticipates inertia, while proprioception registers only the negligible weight of a plastic controller.

Recent pseudo-haptics studies try to bridge this gap by using visual dominance to simulate weight (Moosavi et al., 2023). Shimamura et al. (2024) showed that visual cues, such as material texture, create strong weight expectations that become sensory mismatches without haptic feedback. Ito et al. (2024) also found a habituation effect: the illusion of weight weakens after prolonged exposure. These findings suggest that visual manipulation alone cannot sustain embodied agencies. As AbdIkrim et al. (2024) noted, realistic interactions that rely on imperfect hand-tracking technology can turn empowering fantasies into repetitive manual labor, breaking the ludic contract (Kilteni et al., 2012). This haptic gap expands into a vestibular gap when realism moves from objects to the camera itself.

## **NARRATIVE FRICTION**

Realism also shapes narrative delivery, where cinematic techniques collide with the physiology of VR users. Camera control can trigger vestibular discomfort. Designers often mitigate this with teleportation, a mechanic that protects comfort but disrupts narrative continuity.

Caputo et al. (2023) confirmed that teleportation reduces motion sickness compared with joystick locomotion, but it also alters the user's orientation and cognitive mapping of space. This creates dissonance: the narrative premise often asks players to inhabit a grounded hero moving through a dangerous world, while the mechanics make them teleport between static nodes. The rupture breaks traversal flow and turns a continuous world into a menu of destinations (Hocking, 2009). Even when designers

resolve haptic and vestibular dissonance, a third channel remains: the body becomes the limiting factor.

## **THE LIMITS OF ENDURANCE**

Realistic VR design often overlooks the body's metabolic limits. Traditional core loops, such as RPG "grinding," are built for cognitive engagement rather than physical exertion. When VR translates these loops into gross motor input, players encounter the Gorilla Arm Syndrome (Palmeira et al., 2023).

Recent locomotion studies show that physical inputs, such as cybershoes or walking-in-place, impose higher metabolic costs and fatigue than controller-based inputs (Hirobe et al., 2024). Here, realism turns play into labor. Sustained VR engagement therefore requires a shift from hyper-realistic physics to amplified interaction, where minimal physical input produces meaningful virtual output and preserves player energy.

## **CASE STUDIES IN STRATEGIC ABSTRACTION**

This study contrasts simulation-first and abstraction-first design through three titles that use strategic abstraction to address the haptic, vestibular, and metabolic channels of the Embodied Simulation Gap:

**Beat Saber (haptic channel):** Beat Saber avoids the haptic gap by abandoning realistic combat for rhythmic abstraction. Its sabers are weightless beams of energy, so the visual expectation matches the controller's physical weight. This match matters because the game does not ask players to believe in absent mass, recoil, or resistance. It sustains flow by aligning the fiction of the action with what the hardware can provide.

**Moss (vestibular channel):** Moss addresses the vestibular gap through a fixed third-person diorama perspective. Rather than placing players inside a moving body and producing conflict between visual motion and proprioceptive stillness, Moss positions the player as a situated observer. This design shifts immersion from bodily substitution to relational agency: players are not Quill, but they guide, protect, and collaborate with her. The result preserves presence without forcing locomotion the body cannot feel.

**Red Matter (haptic channel, diegetic solution):** Red Matter avoids simulating ordinary human hands, which would require proprioceptive feedback the hardware cannot provide, and uses diegetic mechanical claw grippers instead. The gripper's trigger maps directly onto the controller's trigger, aligning the interaction fiction with the input device. This diegetic abstraction turns a hardware limitation into a coherent tool inside the world. The abstraction is therefore not a compromise; it is the design.

## **CONCLUSION**

This simulation trap shows that realism does not guarantee quality in VR. Realism is a stylistic choice with cognitive and physiological costs, and those costs appear across haptic, vestibular, and metabolic channels. The Embodied Simulation Gap explains why hyper-realistic design can break immersion when the body expects sensations current hardware cannot provide.

Future VR research should therefore move beyond fidelity as the default measure of progress. Rather than asking only how to make virtual worlds more realistic, researchers and designers should ask which forms of abstraction preserve agency, comfort, and flow. The strongest VR experiences acknowledge hardware and bodily limits, then turn abstraction into a design resource.

## FUNDING

This research was funded by GR024678 NSERC CREATE 2020 Immersive Technologies, Natural Sciences and Engineering Research Council of Canada, and GR026895 SSHRC 2022 Okanagan WaterFutures: Experiential Games for Water Responsibility, Social Sciences and Humanities Research Council of Canada. The dissemination of this work was partially supported by funds held by Megan Smith from the Canada Foundation for Innovation (CFI) and the Social Sciences and Humanities Research Council of Canada (SSHRC).

## REFERENCES

- Abdulkarim, D., Di Luca, M., Aves, P., Maaroufi, M., Yeo, S. H., Miall, R. C., ... & Galea, J. M. (2024). A methodological framework to assess the accuracy of virtual reality hand-tracking systems: A case study with the Meta Quest 2. *Behavior research methods*, 56(2), 1052-1063.
- Caputo, A., Zancanaro, M., & Giachetti, A. (2023, August). Eyes on teleporting: Comparing locomotion techniques in virtual reality with respect to presence, sickness and spatial orientation. In *IFIP conference on human-computer interaction* (pp. 547-566). Cham: Springer Nature Switzerland.
- Ito, K., Ban, Y., & Warisawa, S. I. (2024). Influence of habituation on pseudo-haptic weight perception of virtual objects. *Frontiers in Virtual Reality*, 5, 1442829.
- Hocking, C. (2009). Ludonarrative dissonance in *Bioshock*: The problem of what the game is about. *Well played*, 1, 255-260.
- Hirobe, D., Shirai, S., Orlosky, J., Alizadeh, M., Kobayashi, M., Uranishi, Y., ... & Takemura, H. (2024). User-centric locomotion techniques for virtual reality games: A survey of user needs and issues. *IEEE Transactions on Games*, 17(2), 460-473.
- Kilteni, K., Groten, R., & Slater, M. (2012). The sense of embodiment in virtual reality. *Presence: Teleoperators and Virtual Environments*, 21(4), 373–387. [https://doi.org/10.1162/PRES\\_a\\_00124](https://doi.org/10.1162/PRES_a_00124)
- Moosavi, M. S., Raimbaud, P., Guillet, C., Plouzeau, J., & Merienne, F. (2023). Weight perception analysis using pseudo-haptic feedback based on physical work evaluation. *Frontiers in Virtual Reality*, 4, 973083.
- Palmeira, E. G., Campos, A., Moraes, Í. A., De Siqueira, A. G., & Ferreira, M. G. (2023, November). Quantifying the ‘Gorilla Arm’ Effect in a Virtual Reality Text Entry Task via Ray-Casting: A Preliminary Single-Subject Study. In *Proceedings of the 25th Symposium on Virtual and Augmented Reality* (pp. 274-278).
- Salen, K., & Zimmerman, E. (2004). *Rules of play: Game design fundamentals*. MIT Press.

- Rogers, K., Karaosmanoglu, S., Altmeyer, M., Suarez, A., & Nacke, L. E. (2022, April). Much realistic, such wow! a systematic literature review of realism in digital games. In Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems (pp. 1-21).
- Shimamura, K., Shimomura, Y., Ban, Y., Ujitoko, Y., & Warisawa, S. I. (2024). Effect of virtual object material on the pseudo-haptic weight. *IEEE Access*, 12, 183143-183152.
- Sun, Z., Xu, Y., Zhen, C., Lin, Y. S., Thorogood, M., Lasserre, P., & Smith, M. (2026). Struggle as Flow: Challenge, Design, and Experience in Soulslike Games. arXiv preprint arXiv:2604.15318.
- Xu, Y., Sun, Z., Zhen, C., Lin, Y.-S., Sarker, T. H., Thorogood, M., Lasserre, P., & Dulic, A. (2026a). From engagement to resilience: A systematic review of game-based learning for environmental resilience. *Sustainability*, 18(5), 2305. <https://doi.org/10.3390/su18052305>
- Xu, Y., Sun, Z., Zhen, C., Lin, Y. S., Thorogood, M., Smith, M., & Dulic, A. (2026b). Mapping Ecological Empathy: A Semantic Network Analysis of Player Perceptions in 3D Environmental Education Games. arXiv preprint arXiv:2604.15317.