VReflect: Designing VR-Based Movement Training with Perspectives, Mirrors and Avatars

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ABSTRACT

Physical training in virtual environments, such as VR, has gained popularity, especially due to the coronavirus pandemic. VR training offers new opportunities compared to traditional methods, including the use of different perspectives, mirrors, and avatars to enhance the understanding of personal movements. However, the interaction of these elements has been less studied. To address this, we developed VReflect, a VR environment that uses mirrors and avatars as virtual self-visualization techniques (VSVT) to improve self-awareness during movement training. In a preliminary study on learning beginner karate movements, we tested four combinations of perspectives and VSVTs. The results indicate that neither first-person nor third-person perspectives can be universally recommended, which is in alignment with previous work. Interviews revealed a preference for the traditional combination of mirrors and first-person perspective.

CCS CONCEPTS

• **Human-centered computing** → **Virtual reality**; • **Applied computing** → Interactive learning environments.

1 INTRODUCTION

The perception of oneself in VR is heavily influenced by how we view and embody ourselves in the virtual environment [3]. Adopting different avatars or a virtual self-representation can alter behavior based on the character embodied and influence interaction
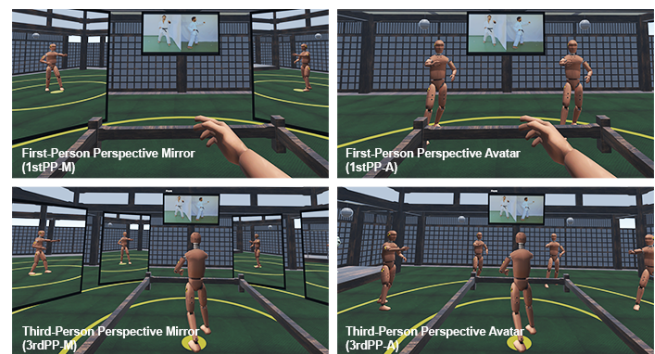
Figure 1: A screen displays karate moves from two angles, paired with one of four training setups: first- or third-person perspective, with mirrors or avatars mimicking the user.

with the virtual world [1, 7]. Virtual mirrors and avatars provide external views of one's representation, enhancing self-awareness [3]. Changing perspectives from first-person to third-person allows users to see their movements from different angles, particularly useful in sports training. Recent developments in VR training systems have focused on increasing motivation, engagement, and motor performance, improving user experiences and training outcomes [2, 6]. However, there is still untapped potential in optimizing the use of perspectives, mirrors, and avatars. Camera placement and varying degrees of embodiment can significantly affect user perception [5]. Mirrors and avatars serve as virtual self-visualization techniques (VSVT) for movement training, allowing users to observe and refine their movements. Mirrors can be reimagined in VR to offer novel perspectives and depth perception. Our research explores these possibilities through VReflect, a VR training environment featuring a virtual dojo, expert training materials, and diverse perspectives in combination with VSVTs. In a user study, we gathered data on motion, eye-tracking, ECG, and questionnaires related to workload, embodiment, presence, and enjoyment. Our analysis focused on the effects of perspectives and VSVTs on embodiment and user experience. Our findings underscore the importance of balancing innovation with familiarity to improve the training experience and effectiveness.

2 USER STUDY

Our training environment is designed within a virtual Dojo, immersing users in an authentic martial arts atmosphere. We developed training material customized for beginner students. This material includes video recordings of specific karate moves performed by a Ju-Jitsu expert. The moves are captured from two perspectives, front and side, to support different learning preferences and enhance the understanding of each movement. The videos are displayed on a 100" screen installed on two sides of the Dojo. Our training environment allows four different settings in which users can engage in karate training (Figure 1): First-Person Perspective Mirror (1stPP-M), First-Person Perspective Avatar (1stPP-A), Third-Person Perspective Mirror (3rdPP-M) and Third-Person Perspective Avatar (3rdPP-A), representing all possible combinations of the two independent variables Perspective and VSVT. In each setting, mirrors and avatars are strategically positioned in sets of eight around the participant to provide comprehensive visual feedback. We employed a within-participants experimental design with N=28 participants. The independent variables were VSVT (two levels: mirror/avatar) and Perspective (two levels: 1stPP/3rdPP), manipulated using a 2×2 experimental design. To mitigate learning effects, we counterbalanced the order of conditions using a balanced Latin Williams square design with four levels [9].

Participants were introduced to the conditions following setup and warm-up in VR. They experienced each condition as an 'Instruction & Training' session lasting 10 minutes. During this session, participants watched training videos of three karate moves looped continuously and practised these moves. In the 'Demo' session, participants demonstrated the moves they learned. After each demonstration, they completed a set of questionnaires. Finally, a concluding interview was conducted to gather feedback on their experience. We recruited 28 participants (13 male, 15 female, none diverse) aged 20 to 50 years, with a mean age of 26.88 years and a standard deviation (SD) of 6.29.

3 PRELIMINARY RESULTS
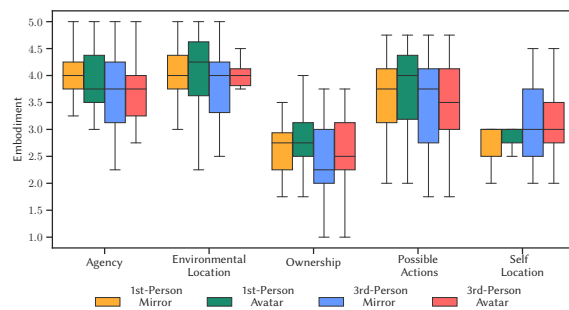
Figure 2: Participants rated embodiment on a Likert scale across categories. Overall results show significant effects of perspective on agency and embodiment.

We measured embodiment based on the work of Gorisse et al. [4]. Our participants repeated four sessions per person, for which we used a two-by-two mixed model design, with the participant

as a random effect. To validate the normality, we used the Shapiro-Wilk test [8]. We further examined our data using ART ANOVAs for the significant, not normal, distribution [10]. Furthermore, we continued with the ART contrast post hoc test for our ART ANOVA results. We received significant differences for the sub-scale of agency on the perspective ($f = 1$, $df = 298$, $F = 13.10$, $p = 0.001$ with Bonferroni adjustment). We proceeded with an ART Contrast post-hoc test for agency and found higher results for 1stPP (1stPP = 3.98, 3rdPP = 3.66). In addition, the total embodiment scale revealed significant results for 1stPP as well. An ART Contrast post-hoc test showed significance for 1stPP (1stPP = 3.49, 3rdPP = 3.66) (see Figure 2).

4 DISCUSSION AND CONCLUSION

We introduced VReflect, a VR environment for karate training using varied perspectives and VSVTs. Karate instructions were shown from two angles on a virtual screen. Our study explored the impact of perspectives and VSVTs on user experience, by collecting data on motion, eye-tracking, ECG, and questionnaires regarding workload, embodiment, presence, and enjoyment. Preliminary results on embodiment indicated that the first-person perspective significantly enhanced embodiment, particularly body ownership and agency. In addition, fourteen participants favored the first-person mirror setup for its familiarity. The study contributes to the understanding of how perspective influences embodiment in VR, providing a foundation for designing more effective and engaging VR training environments.

REFERENCES

[1] Francesco Chiossi, Changkun Ou, Carolina Gerhardt, Felix Putze, and Sven Mayer. 2023. Designing and Evaluating an Adaptive Virtual Reality System using EEG Frequencies to Balance Internal and External Attention States. arXiv:2311.10447 [cs.HC]

[2] Dennis Dietz, Carl Oechsner, Changkun Ou, Francesco Chiossi, Fabio Sarto, Sven Mayer, and Andreas Butz. 2022. Walk This Beam: Impact of Different Balance Assistance Strategies and Height Exposure on Performance and Physiological Arousal in VR. In *Proceedings of the 28th ACM Symposium on Virtual Reality Software and Technology (VRST '22)*. Association for Computing Machinery, New York, NY, USA, Article 32, 12 pages. https://doi.org/10.1145/3562939.3567818

[3] Nina Döllinger, Erik Wolf, Mario Botsch, Marc Erich Latoschik, and Carolin Wienrich. 2023. Are Embodied Avatars Harmful to our Self-Experience? The Impact of Virtual Embodiment on Body Awareness. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems* (Hamburg, Germany) *(CHI '23)*. Association for Computing Machinery, New York, NY, USA, Article 492, 14 pages. https://doi.org/10.1145/3544548.3580918

[4] Geoffrey Gorisse, Olivier Christmann, Etienne Armand Amato, and Simon Richir. 2017. First- and Third-Person Perspectives in Immersive Virtual Environments: Presence and Performance Analysis of Embodied Users. *Frontiers in Robotics and AI* 4 (2017). https://doi.org/10.3389/frobt.2017.00033

[5] Matthias Hoppe, Andrea Baumann, Patrick Chofor Tamunjoh, Tonja-Katrin Machulla, Paweł W Woźniak, Albrecht Schmidt, and Robin Welsch. 2022. There is no first-or third-person view in virtual reality: Understanding the perspective continuum. In *Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems*. 1–13.

[6] Daiki Kodama, Takato Mizuho, Yuji Hatada, Takuji Narumi, and Michitaka Hirose. 2023. Effects of Collaborative Training Using Virtual Co-embodiment on Motor

Skill Learning. *IEEE Transactions on Visualization and Computer Graphics* 29, 5 (2023), 2304–2314. https://doi.org/10.1109/TVCG.2023.3247112

[7] Xingyu Long, Sven Mayer, and Francesco Chiossi. 2024. Multimodal Detection of External and Internal Attention in Virtual Reality using EEG and Eye Tracking Features. In *Proceedings of Mensch und Computer 2024 (MuC '24)*. ACM, 15. https://doi.org/10.1145/3670653.3670657

[8] Nornadiah Mohd Razali and Bee Yap. 2011. Power Comparisons of Shapiro-Wilk, Kolmogorov-Smirnov, Lilliefors and Anderson-Darling Tests. *J. Stat. Model. Analytics* 2 (Jan. 2011).

[9] Bing-Shun Wang, Xiao-Jin Wang, and Li-Kun Gong. 2009. The construction of a Williams design and randomization in cross-over clinical trials using SAS. *Journal of statistical software* 29 (2009), 1–10. https://doi.org/10.18637/jss.v029.c01

[10] Jacob O. Wobbrock, Leah Findlater, Darren Gergle, and James J. Higgins. 2011. The Aligned Rank Transform for Nonparametric Factorial Analyses Using Only Anova Procedures. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (Vancouver, BC, Canada) *(CHI '11)*. Association for Computing Machinery, New York, NY, USA, 143–146. https://doi.org/10.1145/1978942.1978963