Improving the performance of motor tasks through pseudo-haptic error amplification in VR

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Improving the performance of motor tasks through pseudo-haptic error amplification in VR
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Hintergrund

The enhancement of motor skills is a crucial area of study, spanning applications from professional training to rehabilitation. Many different strategies to enhance the learning process have been explored in research, two of which are haptic guidance and error amplification. Haptic guidance provides correct movement trajectories during a task to train the motor system to replicate them. In opposition to this, error amplification instead artificially increases performance errors. Based on the idea that learning is driven by errors, it forces the motor system to correct them more completely and quickly, potentially leading to better learning outcomes. Previous research has demonstrated that artificially increasing errors through haptic feedback can accelerate and enhance learning (Milot et al., 2010). However, this usually comes at a monetary cost for expensive, bulky, and grounded force feedback devices.

Virtual reality offers the opportunity to amplify errors only visually, through pseudo-haptic feedback, thereby intensifying the perception and correction of these errors without requiring specialized equipment. This study explores whether this pseudo-amplified error representation, in this case

through applied offsets, can still improve performance in motor tasks. Specifically, it aims to determine whether this method might be more effective for learning compared to no manipulation or traditional visual correction aids.

Zielsetzung der Arbeit

The aim of this study is to investigate whether a pseudo-haptic amplification of motor errors in virtual reality can lead to improved performance, measured by task accuracy. If this hypothesis is confirmed, the findings could be extended to more complex exercises and general learning processes in VR without the need for expensive hardware. This could have implications for applications in education and specific skill training.

Konkrete Aufgaben

Literature review on motor learning in Virtual Reality:

- Systematic review of literature on error representation and its effects on motor learning in VR.
- Analysis of studies addressing visuo-haptic illusions and their impact on performance

Design and Implementation of the Study:

- Development of the application in Unity (Creating the VR environment and implementing the tasks)
- Development of Sphere Pointer Task: Participants follow a rotating sphere using a ray pointer
- Development Hot Wire Task (Participants guide a ring along a wire without touching it)
- Implementing Control Variables: Unmodified Task (= Standard display without pseudo-amplified errors) vs. Task with pseudo-amplified errors (= Visual amplification of error when deviating from the target, e.g., pointer shows further from the target than in reality) vs. Task with Visual Correction Aids (An arrow points towards the sphere if the pointer is too far away, an arrow points towards the wire if the ring is not center)

Implementing Measures:

- Recording the number of errors and precise positions (accuracy-errors and true-accuracy).
- Recording of other potentially relevant metrics (time, error-correction-time, etc.)

Conducting the Study:

- Recruitment of Participants
- Recording of data

Data Analysis and Reporting:

- Scientific analysis of the collected data to test the hypothesis.
- Writing the final report and presenting the findings

Erwartete Vorkenntnisse

• Basic knowledge of scientific methods and data analysis. • Programming skills (Unity/C#). • Advantageous: Basic knowledge in the area of Virtual Reality

Weiterführende Quellen

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3. Feick, M., Regitz, K. P., Tang, A., & Krüger, A. (2022, April). Designing visuo-haptic illusions with proxies in virtual reality: Exploration of grasp, movement trajectory and object mass. In Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems (pp. 1-15).
4. Milot, M. H., Marchal-Crespo, L., Green, C. S., Cramer, S. C., & Reinkensmeyer, D. J. (2010). Comparison of error-amplification and haptic-guidance training techniques for learning of a timing- based motor task by healthy individuals. Experimental brain research, 201, 119-131