



How Real Is Virtual Reality? Visual limb representation and haptic feedback impact eye and body movements, and feelings of embodiment during object interactions in real and virtual worlds



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Background

End-state Comfort

- Humans adopt initially awkward posture to increase comfort of end-state of movement [1]
- But, are people planning movements that visually appear comfortable, or those that are biomechanically comfortable (e.g. [2])?

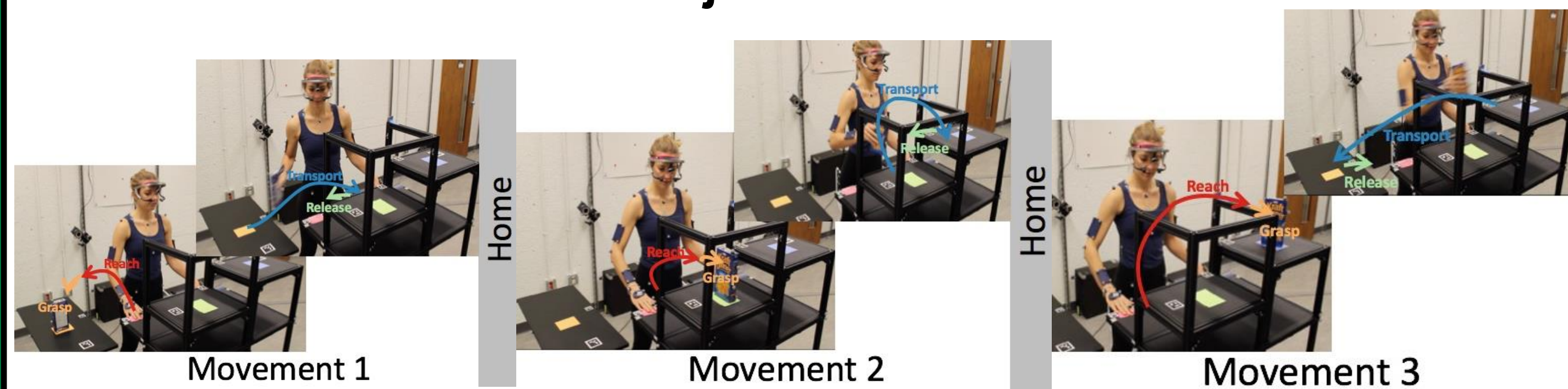
Visual Attention During Object Interaction

- Eye movements lead the hand (~0.5s prior to grasp) [3,4]
- Fixations rarely made to hand or irrelevant objects

Synchronization of Eye and Motion Tracking

- Aligning data from body, object and gaze locations more precisely maps the temporal dynamics of an object interaction [4]

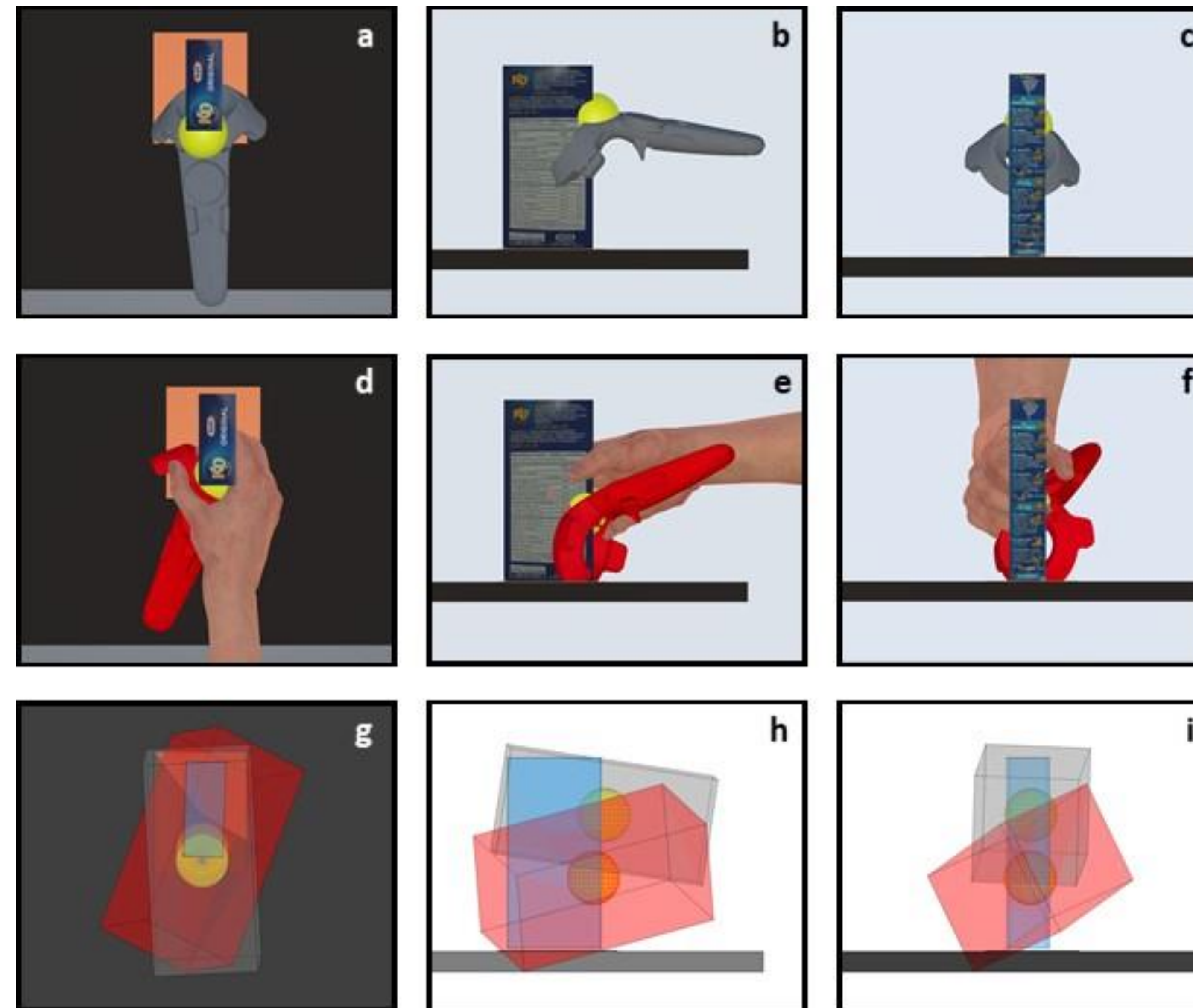
Real World Object Interaction Task



Virtual Reality

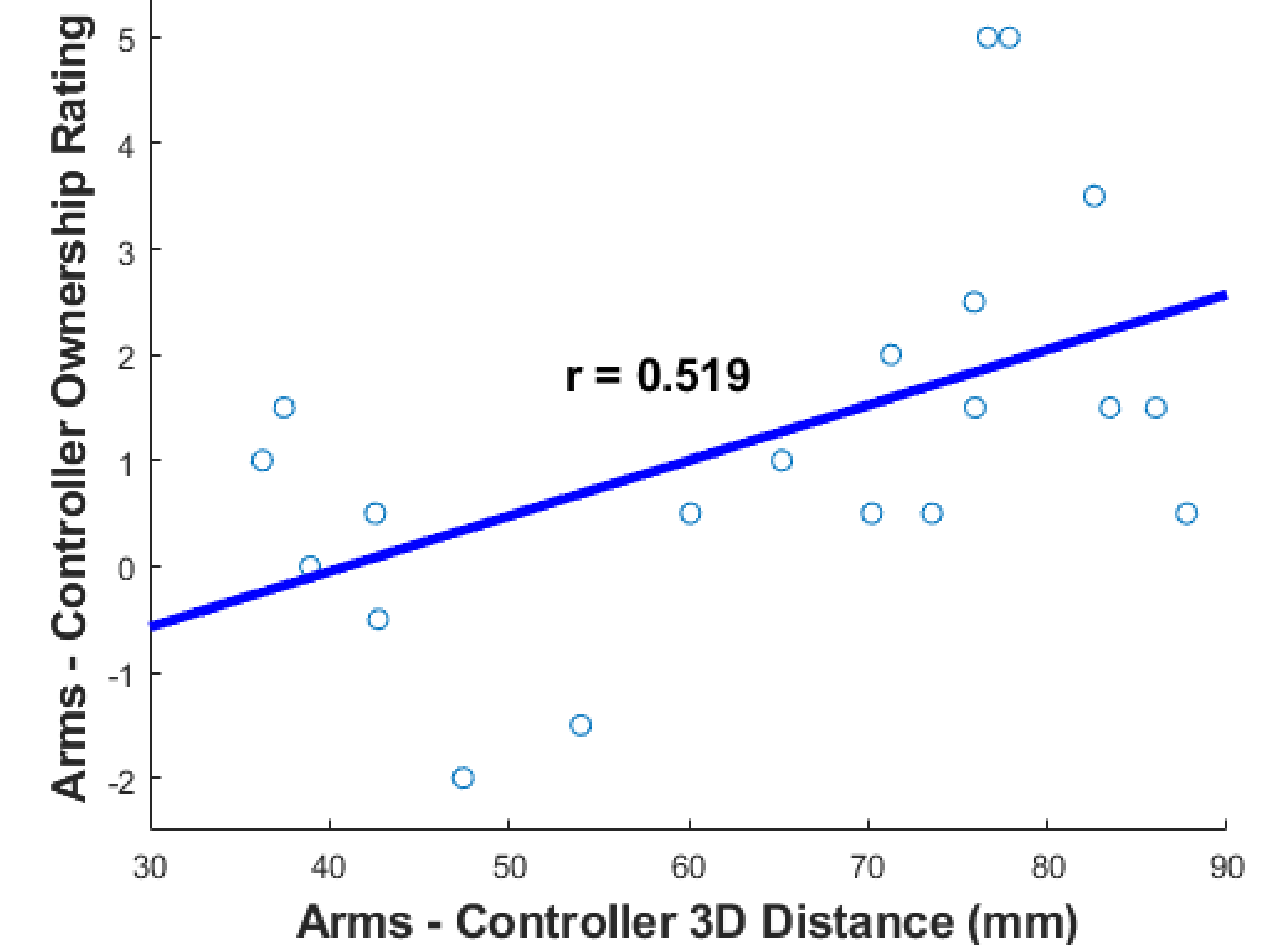
- Manipulate sensory information to see its effect on behaviour
- **How does how you see your body in VR affect your hand and eye movements? Visual or biomechanical comfort?**

Results – Controller Movements



- Orientation and position of real-world controller substantially different between the 2 viewing conditions during grasp
- Body visualization greatly affects how humans interact in the world
- **Desire to see virtual hand form to object like a real hand would**

Ownership Correlates with Movement



- **Difference in interaction location between Arms and Controllers Correlates with Difference in Ownership rating**

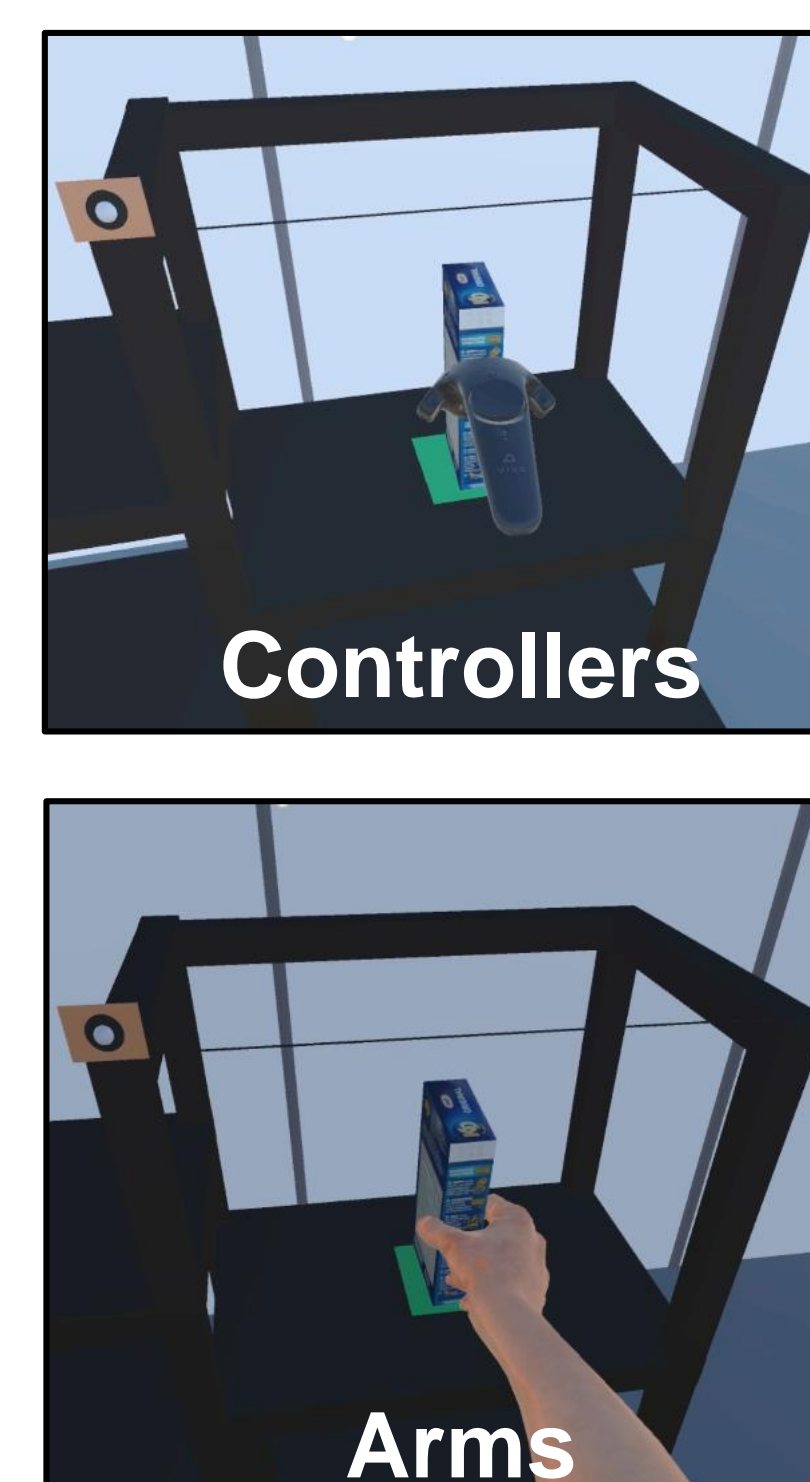
Methods

- HTC Vive running SteamVR; virtual replica of task built in Unity
- PupilLabs insertable infrared eyetrackers
- Actions are performed using HTC Vive Controllers
- 20 Participants completed 20 repetitions of 2 Conditions

Performed identical actions



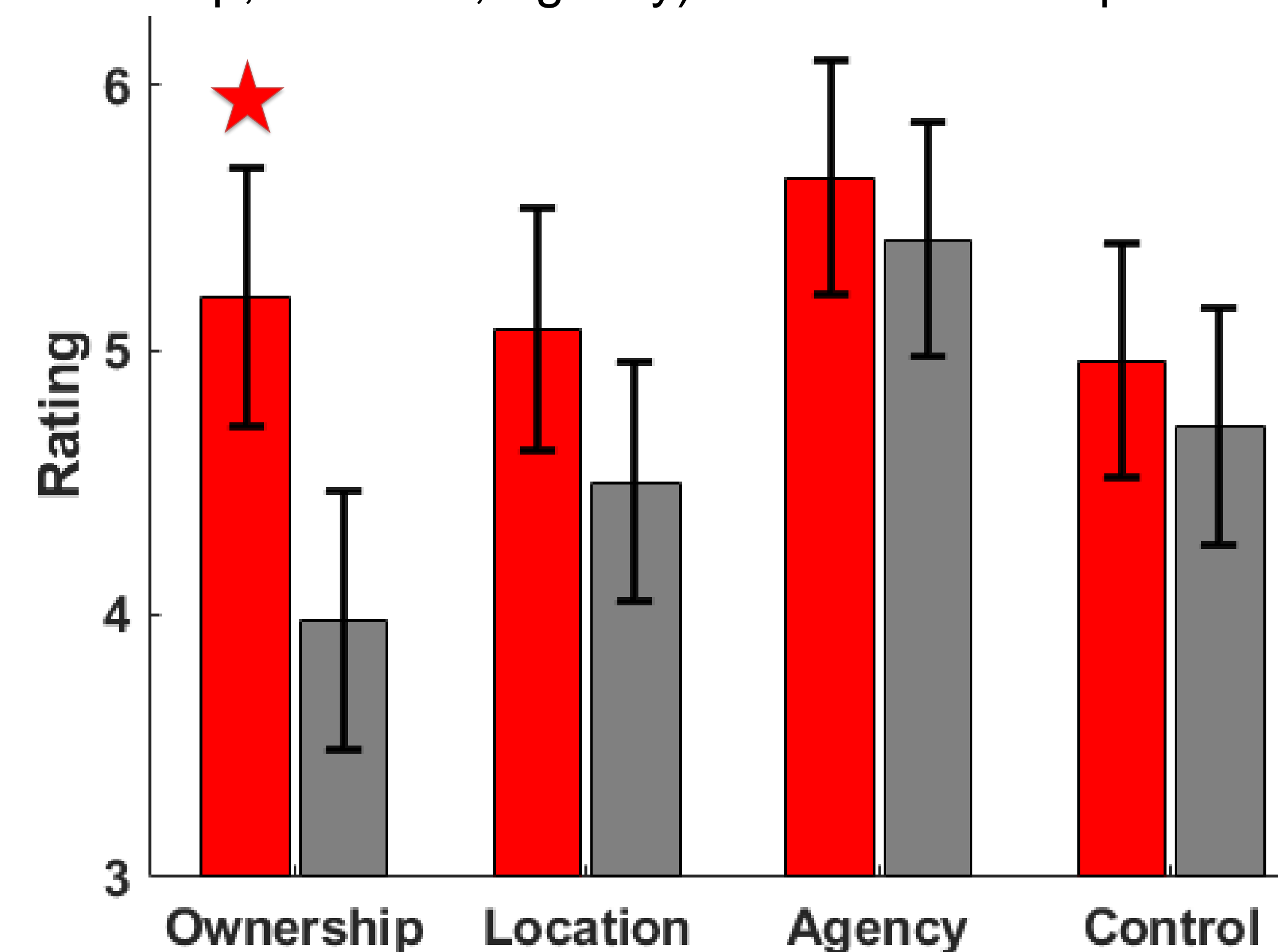
Manipulate what they saw



- Data recorded:
 - Gaze location information from built-in PupilLabs algorithm
 - Position and Rotation of the Controllers and HMD
 - Subjective Experience Questionnaire

Results - Subjective Experience

- 13 statements compiled into components of Embodiment (Ownership, Location, Agency) and Control component



- **Greater experience of Ownership over virtual limbs than virtual controllers**

Conclusions & Directions

- **What you see shapes how you move** – humans seek visually comfortable postures at the expense of biomechanical comfort
- **Seeing Arms instead of Controllers increases Ownership** as rated subjectively on questionnaire
- **Feelings of Ownership over a virtual body can be seen in participants' real-world movements**
- Future experiments will integrate haptic feedback and more natural control in VR via synchronized motion capture

