User Sensitivity to Speed- and Height-Mismatch in VR

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Concepts: • **Computing methodologies~Perception** • **Computing methodologies~Virtual reality** • ***Applied computing~Psychology***

Introduction

Facebook's purchase of Oculus VR in 2014 ushered in a new era of consumer virtual reality head-mounted displays (HMDs). One of the biggest issues for *HMDs that lack external tracking* is **drift** in the user position and rotation sensors. **Drift can cause motion sickness and make stationary items in the virtual environment appear to shift in position**. For developers who seek to *design VR experiences that are rooted in real environments*, **drift can create large errors in positional tracking if left uncorrected over time**. Although much of the current VR hardware makes use of external tracking devices to mitigate positional and rotational drift, **the creation of head-mounted displays that can operate without the use of extremal tracking devices would make VR hardware more portable and flexible, and may therefore be a goal for future development.**

Until technology advances sufficiently to completely overcome the hardware problems that cause drift, **software solutions** are a viable option to correct for it. It may be possible to speed up and slow down users' virtual movements in order to bring a tracked virtual position back into alignment with the position in the real world.

If speed changes can be implemented without users noticing the alteration, it may offer a seamless solution that does not interfere with the VR experience.

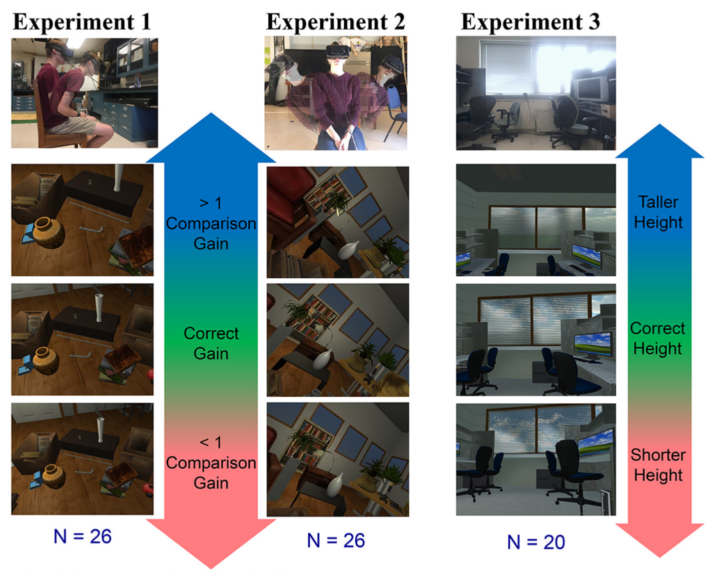
Experiments

In Experiments 1 and 2, we artificially introduced **speed changes** that made users move through the VR environment either faster than or slower than their actual real-world speed. Users were tasked with correctly identifying when they were moving at the correct true-to-life speed when compared to an altered virtual movement speed.

In Experiment 3, we presented alternating views of the virtual scene from **different user heights**. In this study, users had to correctly distinguish the view of the virtual scene presented at the correct height from incorrect shorter and taller heights.

All three experiments utilized a **staircase design** to assess the **threshold of detection** for speed and height changes.

Methods



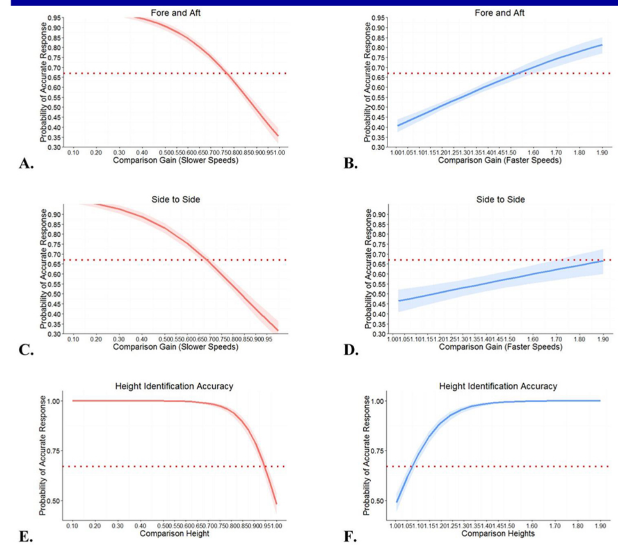
- Each trail consists of a pair of scenes
  - A scene with Gain = 1 or Correct Height
  - A scene with Reduced or Increased Gain or Height
- Participants leaned forward/aft or side to side or looked around in each scene
- Participant selected the scene they believed had Correct Gain or Height
- Gain deviation from 1 decreased on each successive trial until the participant could no longer accurately select the scene with Correct Gain or Height

Results

	Experiment 1: Fore / Aft		Experiment 2: Side to Side		Experiment 3: Height	
	Slow	Fast	Slow	Fast	Short	Tall
M	74%	163%	65%	190%	- 6 cm	+7 cm
SEM	±4%	±10%	±4%	±15%	± 1 cm	± 2 cm

Exp1 and 2 Speed Decreases and Increases and Exp3 height decreases and increases necessary for detection at the 67% threshold level

Results Continued



The probability of accurately selecting the correct (gain = 1) scene given: **A.** a slower comparison speed when leaning fore/aft. **B.** a faster comparison speed when leaning fore/aft. **C.** a slower comparison speed when leaning side to side. **C.** a faster comparison speed when leaning side to side. **D.** a shorter comparison height. **E.** a taller comparison height. Dashed lines depict the 67% threshold for accurate detection.

Conclusion

These experiments determine the **thresholds of detection for speed changes** when moving fore and aft and side to side, as well as the **detection threshold for changes in user height**. Experiments 1 and 2 demonstrate that regardless of leaning direction, **users are more sensitive to speed decreases than speed increases**. In Experiment 3, the VE was rich in cues of familiar size making information about eye height readily available. The high accuracy of the participants in Experiment 3 suggests that the lack of sensitivity to speed changes found in Experiments 1 and 2 is likely not due to limitations of the hardware. **Users are clearly able to distinguish the correct height from only slightly deviant heights**, indicating features absent from both virtual environments, such as avatars, and hardware peculiarities do not interfere with the ability to identify the correct scene when presented in conjunction with an incorrect alternative.

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