# CALIBRATION AND ORIENTATION IN VIRTUAL ENVIRONMENTS

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We continue to investigate the utility of immersive interfaces. In the laboratory at Ames, we compare how well people acquire mental models of spatial layout from immersive and non-immersive displays. Our previous studies used simple, single-room environments. Our current studies examine acquisition of mental models of a multi-chambered environment. Our future study will utilize an even more complex environment: the International Space Station. Here, the chambers are distributed in three dimensions, without a consistent orientation (i.e., the individual chambers have different local verticals).

The laboratory at the University of Virginia is investigating how optical flow and physical effort impacts people's calibration of distance and speed in virtual and real environments. The majority of our oral presentation and poster this year will focus on these studies.

Virtual environment (VE) studies of locomotor activity assume that correct geometric principles define the relationship between walking speed and environmental flow. However we have observed that, during locomotion on a treadmill, geometrically correct VE flow appears, subjectively, to be too slow. We sought to measure the magnitude of this effect in conjunction with a study of locomotor recalibration (Durgin, et al., ARVO 2000). Thirty participants walked on a treadmill set to 3 mph while wearing a immersive display. In the virtual environment, participants moved down a straight road that had billboards and objects along the sides. The speed of environmental flow in the VE scene was initially set to 3 mph (i.e., the geometrically correct VE flow). Participants reported whether the speed of optic flow should be faster or slower to simulate correct locomotion, given the motor effort they were exerting on the treadmill. A modified method of limits was used to determine the speed of optic flow that perceptually matched participants' motor effort. The 3 mph treadmill speed was matched to an average optic flow of 4.7 mph. This is significantly faster than the geometrically correct optic flow of 3 mph ($t(29) = 6.272$, $p < .001$). During treadmill walking in a virtual environment, a mismatch between motor speed and optic flow best simulates the perception of normal walking. The source of this mismatch is unknown, although its direction indicates that it stems from visual underestimation, motor overestimation, or both. By allowing participants to calibrate the virtual environment to their actions, as in this study, performance may be facilitated. This prediction is borne out in a study of locomotor recalibration (cf. Durgin et al., ARVO 2000). We then investigate how modifying people's gaze point while walking impacts speed estimates. Generally, increasing the amount of laminar flow (e.g., gazing to the side or downward) results in more canonical speed estimates.
We then examined the impact hyper/hypo gravity might have on distance perception. Centuries ago, Berkeley (1709) proposed that space is perceived in terms of effort.

Consistent with his proposal, we found that egocentric distances appear greater when people are encumbered due to their wearing a heavy backpack or following a visual-motor adaptation that reduces the anticipated optic flow coinciding with walking effort. In accord with Berkeley's proposal and Gibson's theory of affordances, these studies show that the perception of spatial layout is influenced by locomotor effort.

In summary, research in our laboratories demonstrates the utility of immersive displays for conveying egocentric, body-scaled spatial layouts and the potential of VE systems for acclimating people to the altered spatial/locomotor calibrations encountered in hyper- and hypo-gravitational environments.