Perceptual-motor Recalibration in Naturalistic and Virtual Environments

Investigating the Perceptual-motor loop in the context of rotational recalibration in naturalistic and virtual environments in college students.

Kei Yoshida, Dr. Benjamin Chihak, and Luzan JadKarim
Departments of Psychology and Neuroscience
Coe College, Cedar Rapids, Iowa

INTRODUCTION

As organisms maneuver around their environment, they perceive changes and adapt their actions to increase their likelihood of survival. Actions can be initiated from previous perceptual experiences, and they generate perceptual information people can use to guide further actions. This circular information processing between an organism and its environment is called a perception-action cycle, and it is shown to occur during a series of sensory-guided behavior towards a goal (Cutsuridis, Hussain, & Taylor, 2011). Over time, people learn to associate movements with a specific perceptual outcome.

Three perceptual sources have been identified from previous research that are used for the recalibration of the perceptual-action loop; visual information, proprioception, and vestibular information. Visual information allows for people to use spatial information to navigate through their surroundings. In the study conducted by Mohler et al. (2004), visual information was manipulated by changing the visual speed in a virtual environment. The results showed that people undershot their target location when viewing the visually faster condition and participants overshot their targets when they were in the visually slower condition. Proprioception is an important source of perceptual information and was found to be a major contributor to people's overall awareness of their orientation in a study conducted by Pick, Rieser, Wagner, and Garing (1999). Research has investigated how vestibular information contributes to our sense of locomotion while interacting with other sources of perceptual 3 information (e.g., Bent, Inglis, & Mcfadyen, 2004; Bent, Mcfadyen, & Inglis, 2002; Kennedy et al., 2003). Specifically, vestibular information interacts with optic flow signals from visual systems for perceptual accuracy. People then combine these sources of information to arrive at their overall sense of spatial position.

Previous research conducted in naturalistic environments examined recalibration while participants walked and conducted distance estimation tasks. These activities were used in pre- and post-tests to measure the recalibration effect. Rieser, Pick, Ashmead, and Garing (1995) investigated the recalibration of translational locomotion and demonstrated the relationship between perception and walking action.

Similar results were found when Mohler had his participants walk through the virtual environment on a treadmill where either the rate of visual motion or biomechanical speed was manipulated through the head-mounted display (HMD) or on the treadmill respectively (Mohler et al, 2004; Rieser et al., 1995). This indicates that people recalibrate to visual information and walking speed in naturalistic or virtual environments.

The purpose of this study is to see 1) if there is the same recalibration effect in naturalistic and virtual environments and 2) if the recalibration effect transferred from one environment to the other. Consistent with the finding of the study by Pick et al. (1999), we hypothesize that the overshooting recalibration effect is observed when rotational locomotion is tested in the same direction as the recalibration direction (H1) and that there is no recalibration effect when rotational locomotion is tested in the opposite direction trials (H2). In addition, based on the findings of Ziemer et al. (2013), the translational recalibration effects are hypothesized to transfer between naturalistic and virtual environments (H3).

PARTICIPANTS

- The participants for this study were Coe College students between the ages of 18-25 years.
- Out of the 35 participants, nine participants were dropped due to issues involving the tracker shutting down unexpectedly.

APPARATUS

A circular treadmill (turntable) apparatus was used. A picture of this turntable is shown below in the figure. The circular treadmill consists of a 2 m disc that functions as a platform for walking, mounted on a 0.35 m high metal superstructure for two motors. A horizontal handle (adjustable in height) is mounted on a post extending vertically through the center of the circular treadmill's platform. One motor drives the handle post at variable speeds between 0-10 RPM in either a clockwise (CW) or counterclockwise (CCW) direction. The second motor drives the platform in a similar fashion.

METHODS

Conditions: 8 different conditions (4 x 2 design)
Trials: 8 trials for each

Pre-Test	Recalibration	Post-Test
Naturalistic	Naturalistic	Naturalistic
Naturalistic	Virtual	Naturalistic
Virtual	Naturalistic	Virtual
Virtual	Virtual	Virtual

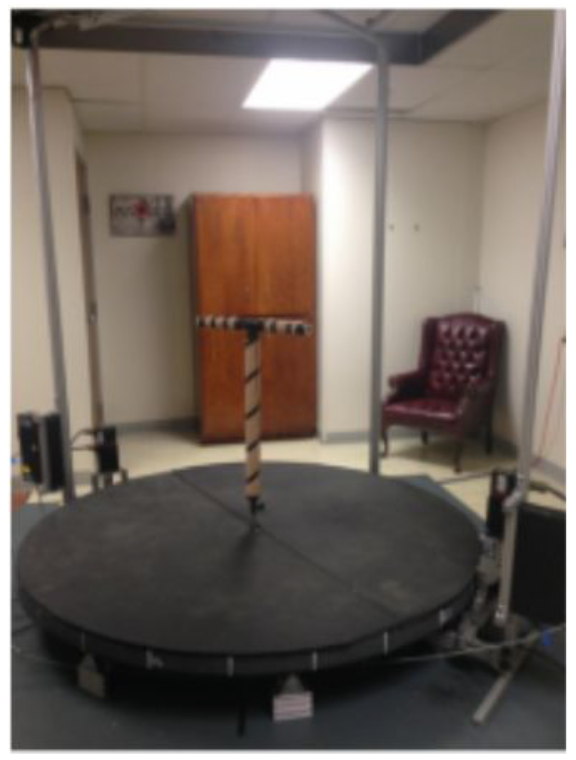

Figure 1.0 Apparatus used for the study

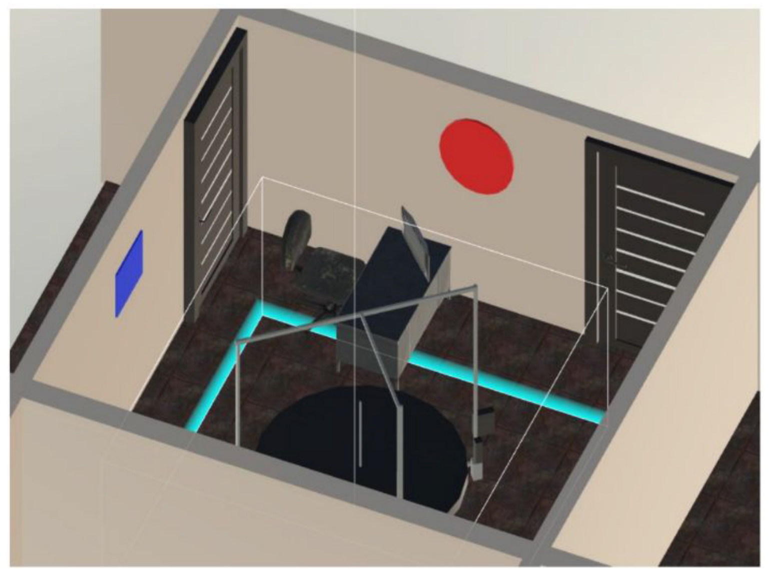

Figure 2.0 Room and Apparatus in virtual reality

Results

		Recalibration Effect: Percent Overshoot* (SD)			
		Virtual Recalibration		Naturalistic Recalibration	
Test Condition	Virtual Environment	Same	19.36 (14.62)	Same	19.60 (9.74)
		Opposite	-2.33 (7.66)	Opposite	-0.69 (10.39)
	Naturalistic Environment	Same	10.63 (15.86)	Same	20.38 (23.80)
		Opposite	-2.52 (8.18)	Opposite	-7.32 (6.08)

Mixed-model Analysis of Variance

- A statistically significant difference for Test Direction
  - F (1, 23) = 24.40, p < .001; partial η^2 = .52
- The average percent change
  - Same direction: 117.74% (SD = 16.29)
  - Opposite direction: 98.49% (SD = 8.81)
- No significant main effect of:
  - Recalibration Type: F(1, 23) = .62, p = .44
  - Test Type: F(1, 23) = .01, p = .95
- No significant interactions

⇒ This suggests that there were no barriers to complete transfer of recalibration between the virtual and naturalistic environments.

One-way T-tests

- Percent changes: significantly different from zero for:
  - Same rotation condition (t(26) = 5.66, p < .001)
  - Opposite rotation condition (t(26) = -2.065, p = .05.)

⇒ This ensures that the percent changes we observed reflected an actual change from pre- to post-test establish that the changes observed were significantly different from zero.

DISCUSSION

- The results of this study supported the hypotheses (H1-H3), which was consistent with the results of the studies by Pick et al. (1999), Kuhl (2004), and Ziemer et al. (2013).
- Similarity of results with previous studies
  - Our results: (17.74% change for the Same rotation condition and -3.24% change for the Opposite rotation condition)
  - Pick et al. (1999) (25.56% change and -3.33% change respectively)

  ⇒ This may indicate that almost the same scale of recalibration effects can be seen in naturalistic and virtual environments.
- A difference in both the scale and direction of the recalibration effect was observed depending on whether participants were asked to rotate in the same or opposite direction as that in which the recalibration had occurred.

  ⇒ Explained by the model proposed by Pick et al. (1999)
    - Same direction: the effects of perceptual motor learning and sensory fatigue (biomechanically driven) are working in conjunction to produce a large overshooting effect.
    - Opposite direction: visual-motor learning supports overshooting, but biomechanical fatigue produces undershooting.
- There was a smaller overshooting recalibration effect (although it was not statistically significant) when the subjects were tested in the naturalistic environment and recalibrated in the virtual environment than other conditions (Table 1).

  ⇒ This may suggest that a recalibration effect in virtual environments is not sufficient in naturalistic environments. This needs to be further investigated in future work.
- In order to fully understand the transfer between the virtual and naturalistic environment, future work should extend this study to more complicated conditions by implementing test phases in different environments (Table below).

Pre-Test	Recalibration	Post-Test
Naturalistic	Naturalistic	Virtual
Naturalistic	Virtual	Virtual
Virtual	Naturalistic	Naturalistic
Virtual	Virtual	Naturalistic

References

Cutsuridis, V., Hussain, A., & Taylor, J. G. (Eds.). (2011). *Perception-action cycle: Models, architectures, and hardware*. Springer Science & Business Media.

Kuhl, S. A. (2004). Recalibration of rotational locomotion in immersive virtual environments. *Proceedings of the 1st Symposium on Applied Perception in Graphics and Visualization - APGV 04.* doi:10.1145/1012551.1012555

Mohler, B. J., Thompson, W. B., Creem-Regehr, S., Pick, H. L., Warren, W., Rieser, J. J., & Willemsen, P. (2004). Visual motion influences locomotion in a treadmill virtual environment. *Proceedings of the 1st Symposium on Applied Perception in Graphics and Visualization* - APGV 04. doi:10.1145/1012551.1012554

Pick Jr, H. L., Rieser, J. J., Wagner, D., & Garing, A. E. (1999). The recalibration of rotational locomotion. *Journal of Experimental Psychology: Human Perception and Performance, 25*(5), 1179.

Rieser, J. J., Pick, H. L., Ashmead, D. H., & Garing, A. E. (1995). Calibration of human locomotion and models of perceptual-motor organization. *Journal of Experimental Psychology: Human Perception and Performance*, 21(3), 480-497. doi:10.1037/0096-1523.21.3.480

Ziemer, C. J., Branson, M. J., Chihak, B. J., Kearney, J. K., Cremer, J. F., & Plumert, J. M. (2013). Manipulating perception versus action in recalibration tasks. *Attention, Perception, & Psychophysics, 75*(6), 1260-1274. doi:10.3758/s13414-013-0473-6