Consistent Left-Right Errors for Visual Path Integration in Virtual Reality: More Than a Failure to Update One's Heading?

Bernhard E. Riecke*
Max Planck Institute for Biological Cybernetics, Tübingen, Germany

Introduction & Methods Optic flow has been the subject of extensive research, and the literature suggests that optic flow can be used to solve a number of task including, e.g., heading estimation, estimation of distances and turns, and navigation. Hence, one might be tempted to conclude that just about any task that involves self-motion can, *in principle*, be performed on the basis of optic flow. Recently, however, [Riecke and Wiener 2007] showed that naive participants produced rather drastic errors even for seemingly simple spatial orientation tasks: After visually displayed passive excursions along 1- or 2-segment paths that included one simulated rotation (0°, 30°, 60°, 90°, 120°, 150°, or 170°), participants were asked to point toward the starting point "as accurately and quickly as possible" using a joystick-like pointer (see Fig. 1). In addition to a high variable error, six of the 16 participants in [Riecke and Wiener 2007] also produced consistent qualitative (left-right) errors. That is, even though those six left-right inverters clearly understood the experimental instructions and did not misperceive the simulated turning directions, they consistently pointed into the *opposite*, left-right mirrored direction. Only when the upcoming turning angle (but not direction) was announced before each trial and experienced psychophysical observers (lab members) were used did those left-right inversions and high variable errors disappear. The current study was designed to test if non-experienced, naive participants (N=24) would similarly benefit from advance knowledge of the upcoming turning angles or produce left-right inversions. The experimental procedures closely replicated those of [Riecke and Wiener 2007] to allow for direct comparisons (see Fig. 1).

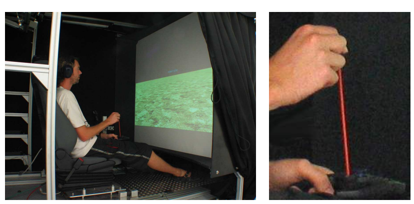

Figure 1: *Participant with pointing device (modified game-pad) seated behind the projection screen (FOV: $84° \times 63°$) displaying a textured ground plane devoid of any landmarks.*

Results Despite advance knowledge of turning angles, both constant and variable pointing errors increased significantly with turning angle ($F(5, 110) > 2.5$, $p < .05$), suggesting higher task difficulty and/or uncertainty for larger rotations. Moreover, 11 of the 24 participants showed consistent left-right inversion for both the 1- and 2-segment experiments, as illustrated in Figure 2. Left-right errors were associated with lower overall mental spatial abilities, corroborating [Riecke and Wiener 2007].

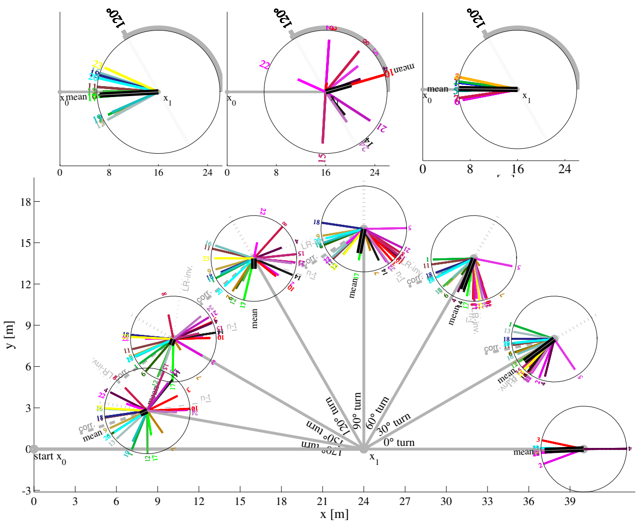

Figure 2: ***Top:*** *120° condition of the 1-segment experiment for the 13 non-inverters (left) and the 11 inverters (middle), for comparison with the experienced psychophysical observers of [Riecke and Wiener 2007] (right). Plotted is a top-down schematic view of the excursion path (in solid gray) from x_0 to x_1 and the subsequent 120° turn. Direction and length of the colored bars indicates participants' circular mean pointing direction and pointing variability, respectively.* ***Bottom:*** *2-segment experiment illustrating left-right inversion for the same 11 participants (plotted in reddish colors).*

Discussion & Conclusions We were able to replicate the occurrence of consistent left-right inversion errors in more than 40% of naive, psychophysically inexperienced observers. A detailed analysis suggests that failure to update one's heading during rotations seems to be the origin of the observed left-right inversion for some – but not all – of the left-right inverters. One of the most striking results was the relatively poor overall performance for all but a few participants, especially given that they had advance information about the exact turning angle and were able to perform virtually flawless in a real-world pre-test. Overall rated task difficulty was surprisingly high, and not a single participant reported having any kind of natural or intuitive spatial orientation in VR – not even the VR-experienced lab members in [Riecke and Wiener 2007]. Thus, at least for the current VR setup, optic flow seems insufficient for enabling natural and intuitive spatial orientation for even the most basic and seemingly trivial trajectories, even when additional information about the turning angles is provided.

References

RIECKE, B. E., AND WIENER, J. M. 2007. Can People Not Tell Left from Right in VR? Point-to-origin Studies Revealed Qualitative Errors in Visual Path Integration. In *Proceedings of IEEE Virtual Reality 2007*, IEEE, 3–10.

*e-mail: bernhard.riecke@tuebingen.mpg.de

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