Depth Cues and Mouse-Based 3D Target Selection

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ABSTRACT
We investigated mouse-based 3D selection using one-eyed cursors, evaluating stereo and head-tracking. Stereo cursors significantly reduced performance for targets at different depths, but the one-eyed cursor yielded some discomfort.

Author Keywords
Mouse, stereo display, head-tracking, one-eyed cursor.

ACM Classification Keywords
H.5.2 [Information Interfaces and Presentation]: User Interfaces – input devices, interaction styles.

INTRODUCTION
Recent work on screen-space 3D selection [2] reinforced the benefits of the "one-eyed" cursor [3] to eliminate stereo conflicts. Other research indicates that one-eyed cursors may cause eye fatigue [1] and hinder performance relative to stereo cursors. We re-evaluate the one-eyed cursor in situations where depth is irrelevant to assess its negative effects in isolation from its benefits, (e.g., remote targets).

EXPERIMENT
We used a 3D version of ISO 9241-9 [2] with 16 participants and NVidia *3DVision Pro* for stereo. Five OptiTrack S250e cameras were used for head tracking.

The software depicted the inside of a wooden crate with target spheres on wooden cylinders (Figure 1), in either stereo or mono, with or without head tracking, and with a stereo 3D or one-eyed cursor. In mono view, the same image (0 disparity) was presented to both eyes. The one-eyed cursor was only displayed to the dominant eye.

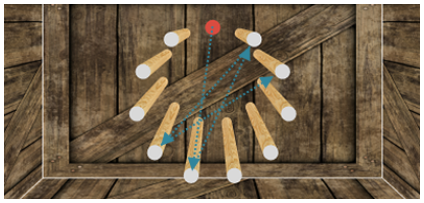

Figure 1. Experimental software depicting 11 targets. Arrows added to illustrate the ordering of the first four targets.

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Participants clicked the red target with the mouse. Each click advanced the target by the pattern shown in Figure 1.

The experiment used the following within-subjects factors:

Stereo Display: Stereo-On, Stereo-Off (i.e., mono)
Head-Tracking: HT-On, HT-Off
Cursor: STC (stereo cursor), OEC (one-eyed cursor)
Target Size: 0.5, 0.75, 1.0 cm
Target Distance: 3.5, 7.5, 9.5 cm
Target Depth: -10, 0, +10 cm

Stereo, head-tracking, and cursor were counterbalanced by a Latin square. Target size, distance, and depth were random for each target circle. There were 12 recorded selection trials per circle. Thus there were 2 × 2 × 2 × 3 × 3 × 3 × 12 = 2592 trials per participant. We only report "screen-projected" throughput [2] due to space constraints.

RESULTS
There was a significant interaction between stereo, depth, and cursor ($F_{2,30} = 12.4$, $p < .001$), see Figure 2: the STC 0 cm conditions are better than the STC +10 cm or -10 cm conditions, but not the OEC conditions. The best stereo-off conditions (both STC at +10 cm) were higher than the stereo-on at both -10 and +10 cm target depths. There was no difference in the stereo-off conditions.

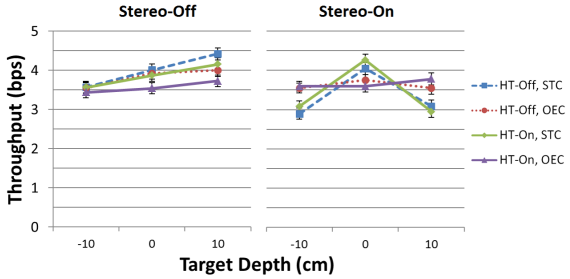

Figure 2. Throughput by condition. Error bars show ±1 *SE*.

CONCLUSION
The stereo cursor significantly hurt performance for targets at different depths. The one-eyed cursor eliminated this effect, but had a small negative effect in mono view.

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