Evaluating Visual/Motor Coupling in Fish Tank VR  
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Introduction  
• Virtual reality (VR) often co-locates input and display  
  • Goal: Directly manipulate objects, as in reality  
  • Does this improve performance?  
  • Desktop interface uses disjoint input/display space

Fitts’ Law and Pointing  
• Fitts’ Law predicts movement time (MT) of rapid aimed movements:  
  \[ MT = a + b \cdot ID \]  
  where \[ ID = \log_2 \left( \frac{D}{W} + 1 \right) \]  
  • \( D \) is distance to target, \( W \) is size (width) of target  
  • \( ID \) is Index of Difficulty \( \rightarrow \) overall task difficulty  
  • Smaller, farther objects are harder to hit  
  • Strong predictive capabilities

Figure 1. 2D pointing task, from ISO 9241-9, compares pointing device performance.  
Figure 2. Our new 3D pointing task. Required clicking and dragging of objects with tracked stylus.

Experiment  
• User study using object movement task (Fig. 2)  
• Used stylus (Fig. 3a), tracked by OptiTrack (Fig. 3b)  
• Co-located vs. disjoint working space (Fig. 4)  
• Movements comprised of all directions along each of \( x, y \) and \( z \) axes from centre  
• Stereo to enhance depth perception

Figure 3. Equipment used in the study. (a) Tracked stylus, with pen button (under the thumb); (b) NaturalPoint OptiTrack = optical tracking system.

Figure 4. (a) Disjoint condition: required working in a space separate from the display; (b) Co-located condition: the display was under the working space. The display was moved away from the working space in the disjoint condition.

Results  
• No sig. diff. in speed between co-located and disjoint  
• Movement into the scene (down on \( y \) axis) found to take longer, in general, but significantly longer in disjoint  
• Differences found by direction of movement  
• Results likely due to lack of effective depth cues

Figure 5. Speed bar chart. (a) Co-located condition; (b) Disjoint condition.