Sensitivity to the Gain of Optic Flow During Walking

Melissa J. Kearns\textsuperscript{1}, Frank H. Durgin\textsuperscript{2},
& William H. Warren, Jr.\textsuperscript{1}

\textsuperscript{1}Brown University, Dept. of Cognitive & Linguistic Sciences
\textsuperscript{2}Swarthmore College, Dept. of Psychology

Thanks to: Christopher Adams, Patrick Foo, Phil Fink, Michael J. Tarr & Marianne Harrison

\textit{Vision Sciences 2002}
Motivation:

• How sensitive are people to differences in the speed of self-motion specified by optic flow?

• Specifically, measured sensitivity to differences in translational gain:
  – Gain = \frac{\text{visual information}}{\text{body sense information}}
  – The ratio between the self-motion specified by optic flow and that specified by body senses
  – Body senses = info from vestibular, proprioceptive and efferent systems

• In previous homing experiments, only 25% of participants noticed gains of 150% and 67%
Main questions

• What is the difference threshold for (translational) gain?
• Does the threshold depend on the standard gain value?
• Do abnormally high or low gains influence walking speed?
• Does walking speed influence threshold?
Virtual Environment Navigation Lab (VENLab)

- Intersense tracker
- Sonic beacons (very accurate)
- Microphones (very accurate)
- Inertial system (very fast)
- Kaiser HMD
- SGI Onyx 2 IR
- 50 ft. Tracker, HMD cables
The Virtual Hallway

- 2m x 2.5m x 100m
- Random texture on all surfaces
- 400 randomly positioned poles (10cm diameter)
2 Interval Forced Choice Task

- Feedback on every trial
- Adaptive staircase method
  - 2 staircases, (“1-up/2-down” method)
  - Eight turns to termination
  - Step size was logarithmic (ratio of 1.04)
  - staircases initialized at five steps (20% difference)
Experiment 1: Method

- Tested thresholds around three different standard gains: 0.5, 1.0, and 2.0
- Blocked by standard gain value, counterbalanced blocks
- Condition 1: “Which interval is faster?”
  Condition 2: “Which interval is slower?”
- 8 participants in analyses (3 females, 5 males)
Experiment 1: Thresholds

- Overall, people sensitive to \(~15\%\) gain differences
- Significant difference between 0.5 and 2.0 (\(p \approx .05\))
  - Scaling of thresholds at different standard gains?
Experiment 1: Walking Speed

- Significant differences of walking speeds between gains
  - Paired t-tests, at least $p < .05$ for all comparisons
- People walk about 10% faster or slower than normal depending on the condition
Experiment 1: Summary

- People can detect ~15% differences in gain
- This sensitivity is reduced when gain is lower
  - Body oscillations during walking may mask differences at lower gains
- People walk different speeds depending on the standard gain
  - People may be trying to produce a normal flow rate
  - Walking speed may have influenced thresholds
Experiment 2: Motivation/Methods

• Do thresholds depend on flow rate or flow gain?
• Are thresholds affected by walking speed?
• Measure gain difference thresholds at 3 walking speeds
• Same methods except:
  – Walk speed manipulated: slow, normal and fast
  – Standard gain value always 1.0
  – 5 participants in analyses (3 females, 2 males)
Experiment 2: Thresholds

- Gain difference thresholds still ~15%
- No significant differences between walking speeds
Experiment 2: Walking Speed

- People followed the directions!
- But, not a perfect control:
  - Mean velocities differ by less than a factor of two
    (flow rates do not match flow gains from Exp 1)
Conclusions

• Overall, gain difference thresholds ~15%
  – Small scaling effect of thresholds to gains
• Standard gain influences walking speed
  – To approximate normal flow rate?
• Walking speed does not influence threshold
• Gains used in homing experiment were far above threshold
• Next step: determine thresholds for rotational gain differences
  – Same magnitude as translational gain?