Tracking Visual Targets During Simulated Self-Motion

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Introduction

- In the real world, humans perform multiple tasks in parallel. Each may be optimized by different gaze strategies.

- Gaze patterns during simulated self-motion have predictable features: gaze is attracted to the focus of expansion[1], and smooth pursuit often undercompensates for object velocity[2].

- But, these effects are observed in experiments with single tasks or no task at all.

- How does multitasking affect optic flow gaze strategies?

Method

- Ppts (N=10) viewed optic flow stimuli that simulated running on flat ground-plane.

- In each trial, heading changed from straight-ahead (0°) to new direction (+-15°).

- Gaze position measured using Eyelink 1000 Plus at 500Hz.

- Three possible tasks: Search, Heading, Dual. Stimulus same in all tasks.

Example Stimulus Frame

10 Example Trials

Time (Secs) / Heading

Heading Task or **Search Task** or **Dual Task**

Did you see any 🔴 / 🟢 / 🟥 / 🟩 ?

Yes / No

Results

Gaze Strategies:

Heading Task

Search Task

Dual Task

Probability Density — High / Low

Elevation (°) / Azimuth (°)

- Gaze distributions depend on task. Heading task biases fixation to horizon.

- In all tasks, gaze attracted to FOE.

- Pursuit slower in heading task.

Distance of Gaze from FOE (°) — Heading / Search / Dual

Heading Change

Time (Secs)

Gaze Strategies and Task Performance:

- Performance in both tasks insensitive to pursuit gain.

- Heading errors predicted by gaze azimuth.

Heading Resonse Error (°) — Heading / Dual — Smooth Pursuit Gain

Search Proportion Correct — Search / Dual — Smooth Pursuit Gain

Heading Response Error (°) — -1 (Left) / 1 (Right)

Elevation (°) / Azimuth Relative to FOE (°)

Task Performance:

- Heading perception near-veridical.

- Minimal task differences.

- Search performance best with small heading error.

Heading Response / True Heading — Heading / Dual Task

$R^2=.950$
$R^2=.910$

Search Proportion Correct — Visual Search / Dual Task

Search Proportion Correct — Heading Response Error (°)

Smooth Pursuit Gain — Image Motion Speed (°/Sec)

Conclusions

- Gaze is attracted to the focus of expansion, even when heading is task-irrelevant. May reflect optimal strategy for image stabilization (by minimizing object velocity).

- Pursuit gain differed between tasks, but was uncorrelated with performance, indicating it may not be adaptive to task demands (contrary to [3]).

[1] Knöll, J., Pillow, J. W., & Huk, A. C. (2018). Lawful tracking of visual motion in humans, macaques, and marmosets in a naturalistic, continuous, and untrained behavioral context. Proceedings of the National Academy of Sciences

[2] Lappe, M., Pekel, M., & Hoffmann, K. P. (1998). Optokinetic eye movements elicited by radial optic flow in the macaque monkey. Journal of neurophysiology

[3] Angelaki, D. E., & Hess, B. J. (2005). Self-motion-induced eye movements: effects on visual acuity and navigation. Nature Reviews Neuroscience