

Deciding when to correct: threshold versus accumulator models of steering action initiation

Introduction

Intermittent sensorimotor actions can be captured using:

- **Threshold** models where responses are initiated once a fixed perceptual threshold is surpassed^[1].
- Evidence **Accumulator** models where perceptual evidence is accumulated over time until a decision boundary is surpassed^[2].

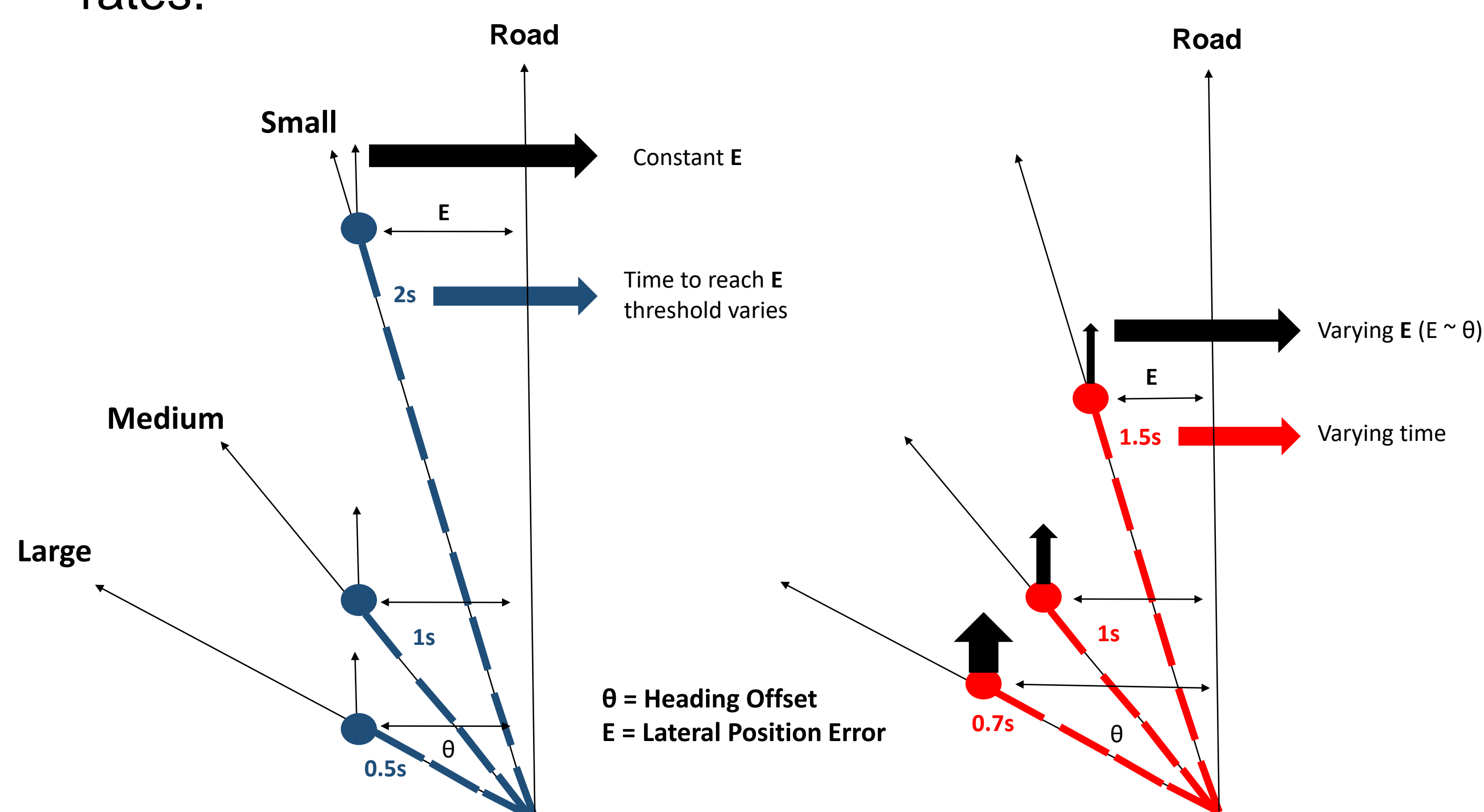
When applied to brake reaction times **Accumulator** models better captured the response distributions^[1]. Here we test how well they capture steering responses.

Aim and model predictions

Aim: Determine which model best captures steering corrections.

Threshold: drivers respond at a fixed error threshold across error rates.

Accumulator: drivers respond at an error threshold proportional to the rate of error.

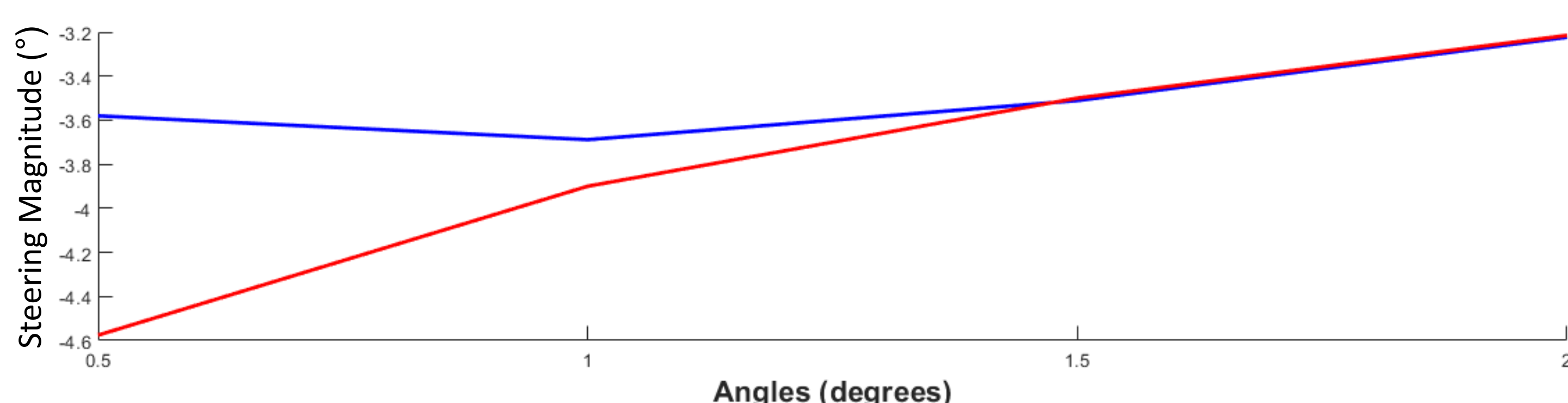
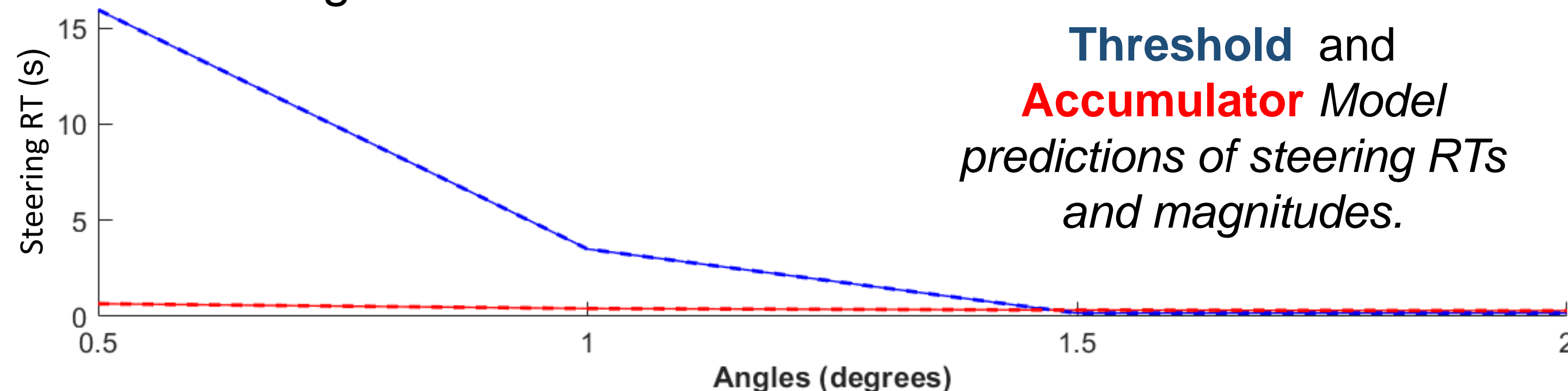


Larger heading angles produce higher rates of error growth. Maximum steering wheel angle (magnitude) will be proportional to lateral position error.

Hypotheses

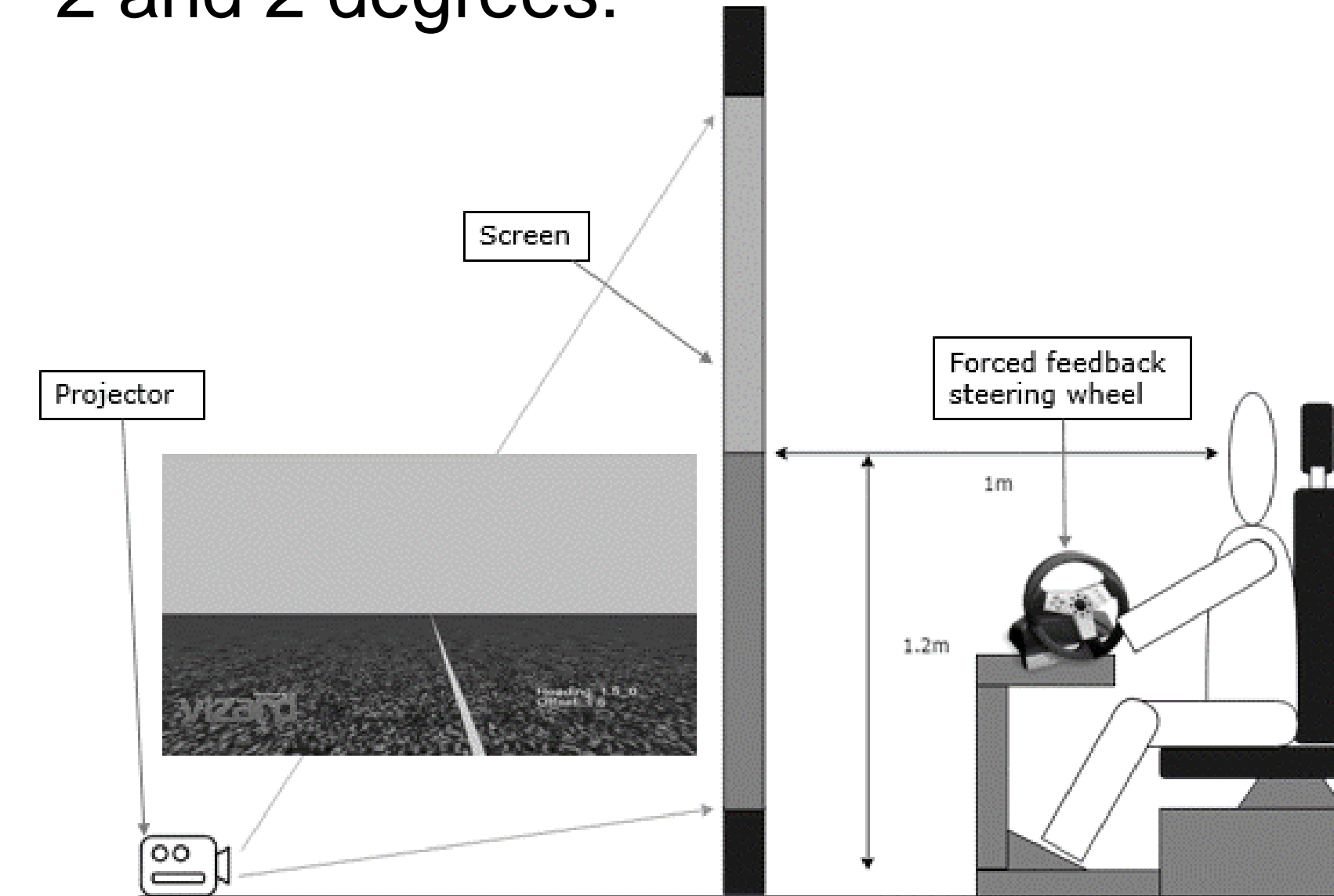
Threshold and Accumulator models provide testable hypotheses for the **magnitude** and **timing** of steering corrections.

- **Threshold:** **timing** (RTs) decreases as heading increases, steering **magnitude** remains *constant* across headings.
- **Accumulator:** **timing** (RTs) decreases as heading increases, but steering **magnitude** *increases* across heading conditions.



Method

The simulated environment displayed a textured plane with an intermittently appearing white line. Heading angle was offset relative to the road-line across 9 linearly spaced angles between -2 and 2 degrees:

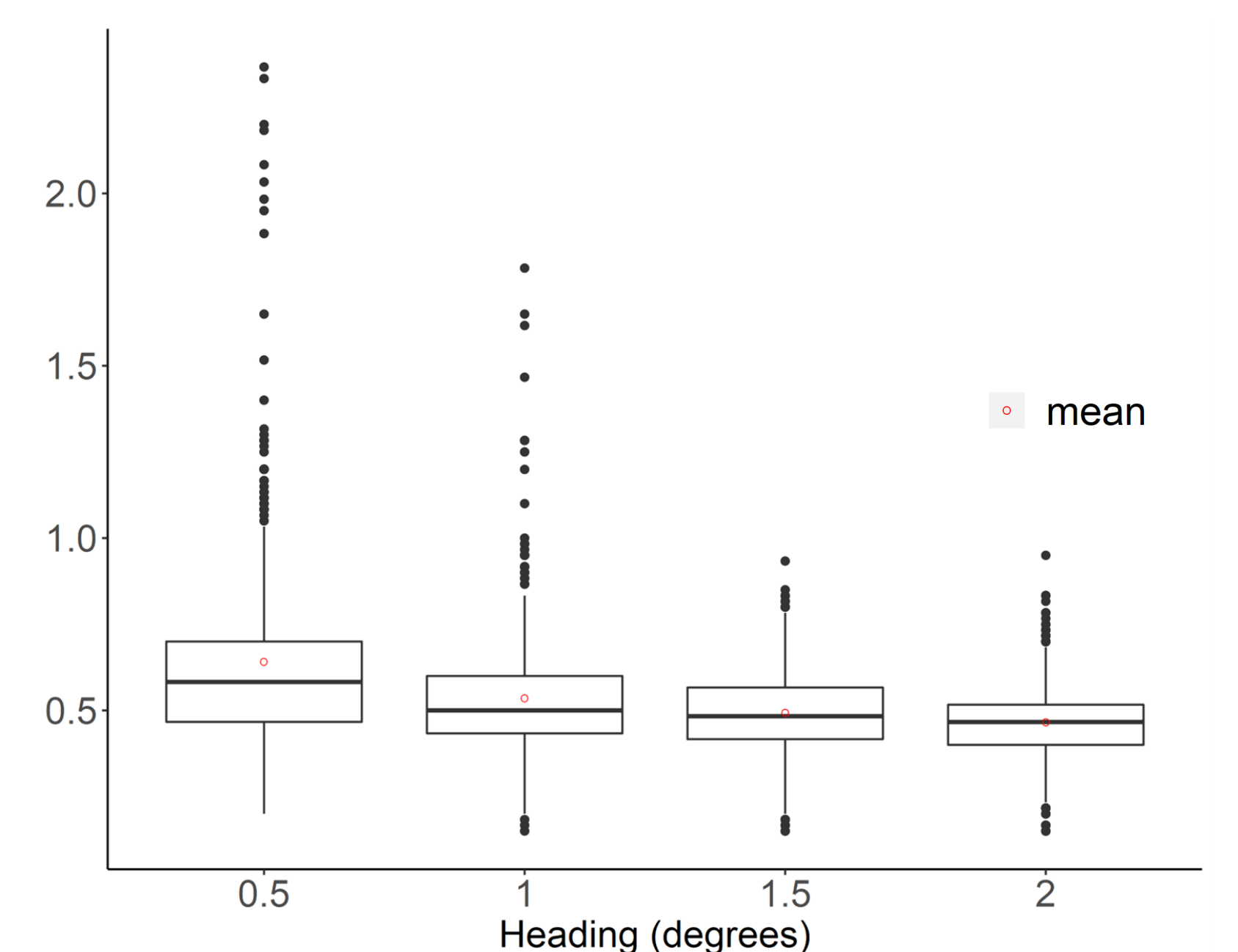


19 subjects (M = 25yrs, 12 females) driving at 10m/s steered toward the line, visible for 2.5s. 30 trials were presented at each heading.

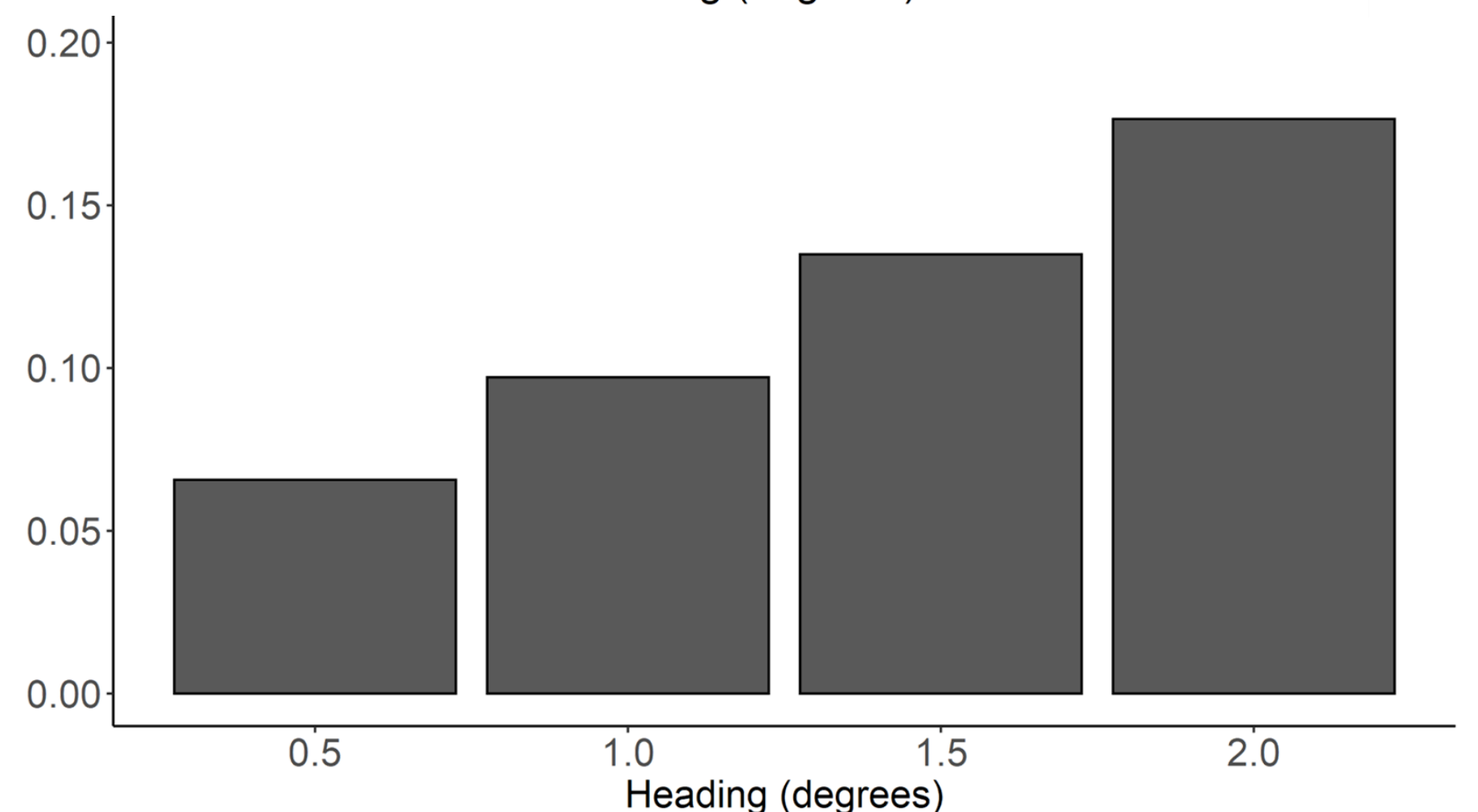
MEASURES: Steering **reaction time** (s), **lateral position** at steering onset (m), and steering **magnitude** (°).

Results

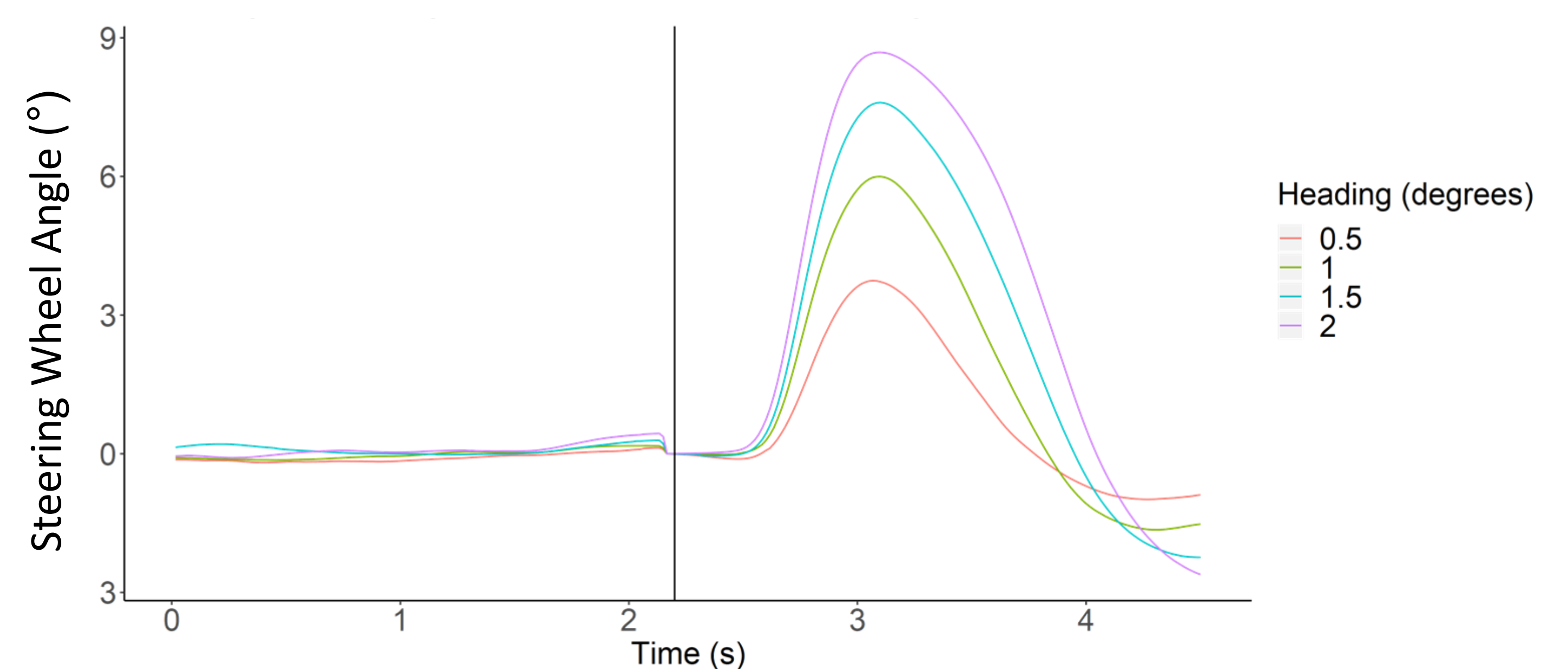
As per **Accumulator** and **Threshold** predictions, **Reaction Time (s)** decreased as heading increased.



In line with **Accumulator** predictions, **lateral position error (m)** increased as heading increased.



As per **Accumulator** predictions **steering magnitude** increased as heading increased



Future Work

Investigate what perceptual information is being used to make responses:

- How might optic flow information influence steering?

Investigate the neural underpinnings of evidence **accumulation**:

- Can EEG reveal neural signatures of evidence **accumulation**^[3] whilst driving?

1) Xue, Q., Markkula, G., Yan, X., & Merat, N. (2018). Using perceptual cues for brake response to a lead vehicle: Comparing threshold and accumulator models of visual looming. *Accident Analysis & Prevention*, 118, 114-124. 2) Markkula, G., Boer, E., Romano, R., & Merat, N. (2018). Sustained sensorimotor control as intermittent decisions about prediction errors: Computational framework and application to ground vehicle steering. *Biological cybernetics*, 112(3), 181-207. 3) van Vugt, M. K., Simen, P., Nystrom, L. E., Holmes, P., & Cohen, J. D. (2012). EEG oscillations reveal neural correlates of evidence accumulation. *Frontiers in neuroscience*, 6, 106.