

Temporal dynamics of judging heading and scene-relative object motion from optic flow

Yonglun Ji^{1,3}, Bao Hong^{1,3}, Jing Chen^{2,3}, Li Li^{2,3,1}

¹ School of Psychology and Cognitive Science, East China Normal University, Shanghai, PRC

² Faculty of Arts and Science, New York University Shanghai, Shanghai, China.

³ NYU-ECNU Institute of Brain and Cognitive Science at New York University Shanghai, Shanghai, China.

Introduction

During self-movement, the visual system can perceive the direction of self-movement (heading) and identify scene-relative object motion (flow parsing) from optic flow (Rushton, Chen, & Li, 2018). However, little is known about the temporal dynamics of these two processes. Here we examined how the precision of heading judgments and flow parsing changes with duration of optic flow to find the temporal dynamics of these two processes and how they are related to each other.

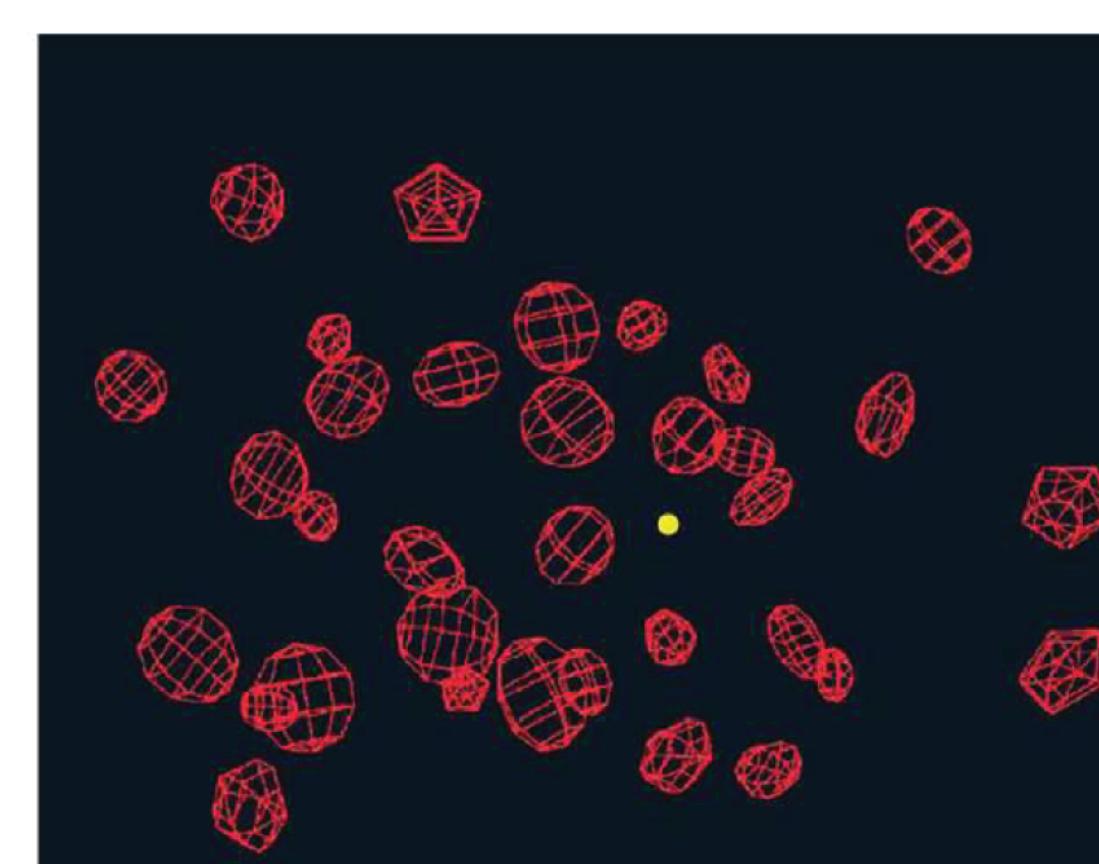
General Methods

Participants:

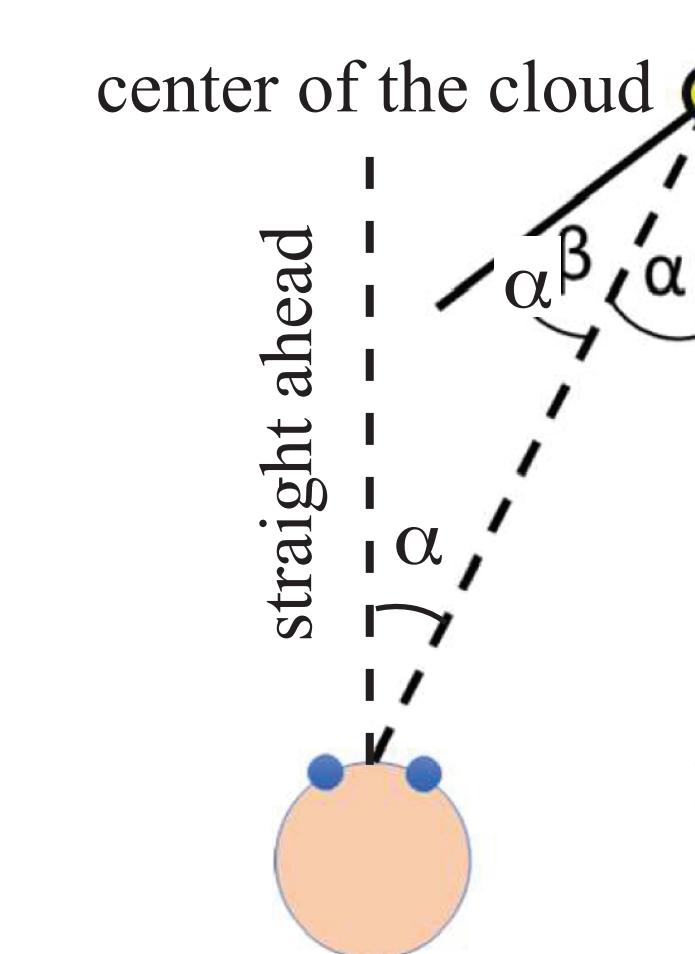
N = 20 (10 females), age: 19 - 26 years.

Visual stimuli:

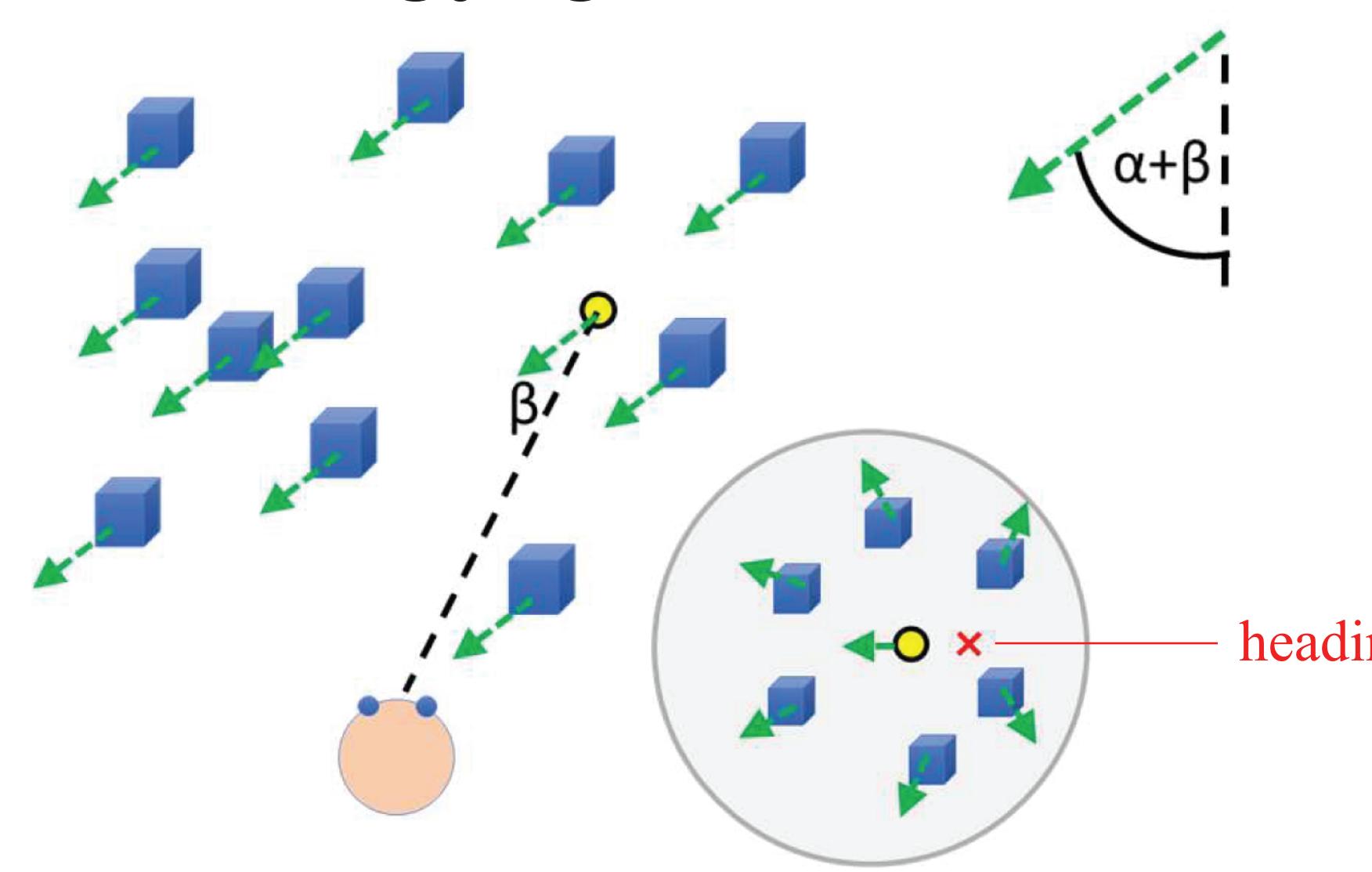
A stereo display ($56^{\circ}\text{H} \times 33^{\circ}\text{V}$, 120 Hz) simulated forward translational self-movement (speed: 0.125m/s) through a cloud composed of 44 red wireframe objects (depth range: 0.55m - 1.05m). A yellow target sphere (radius: 0.1 cm) was initially placed at 2.5° (α) to the left or right of the center of the cloud (i.e., straight ahead) and had a movement direction β relative to α . The observer viewed the scene through shutter glasses.



(adapted from Rushton, Chen, & Li, 2018)

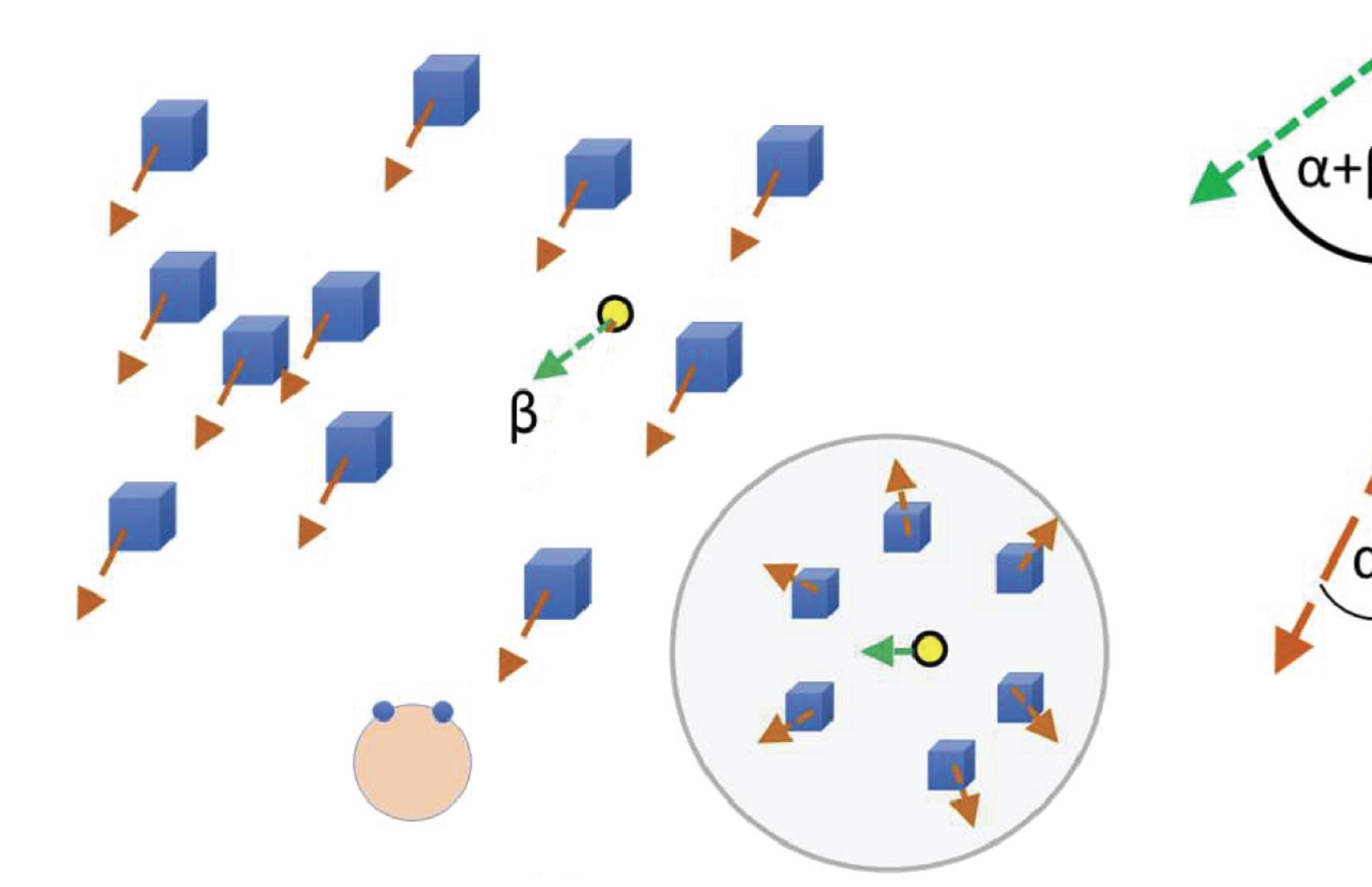


Heading judgement task



The target sphere and scene objects all moved in the same direction ($\alpha + \beta$), β is the target-heading offset angle. Participants judged if they would pass to the left or right of the target.

Object movement judgement task



Scene objects moved in direction α , the target sphere was presented and moved in direction ($\alpha + \beta$) for the last 200ms in each trial, β is the target-scene offset angle. Participants were asked to judge whether the target moved left or right relative to the scene.

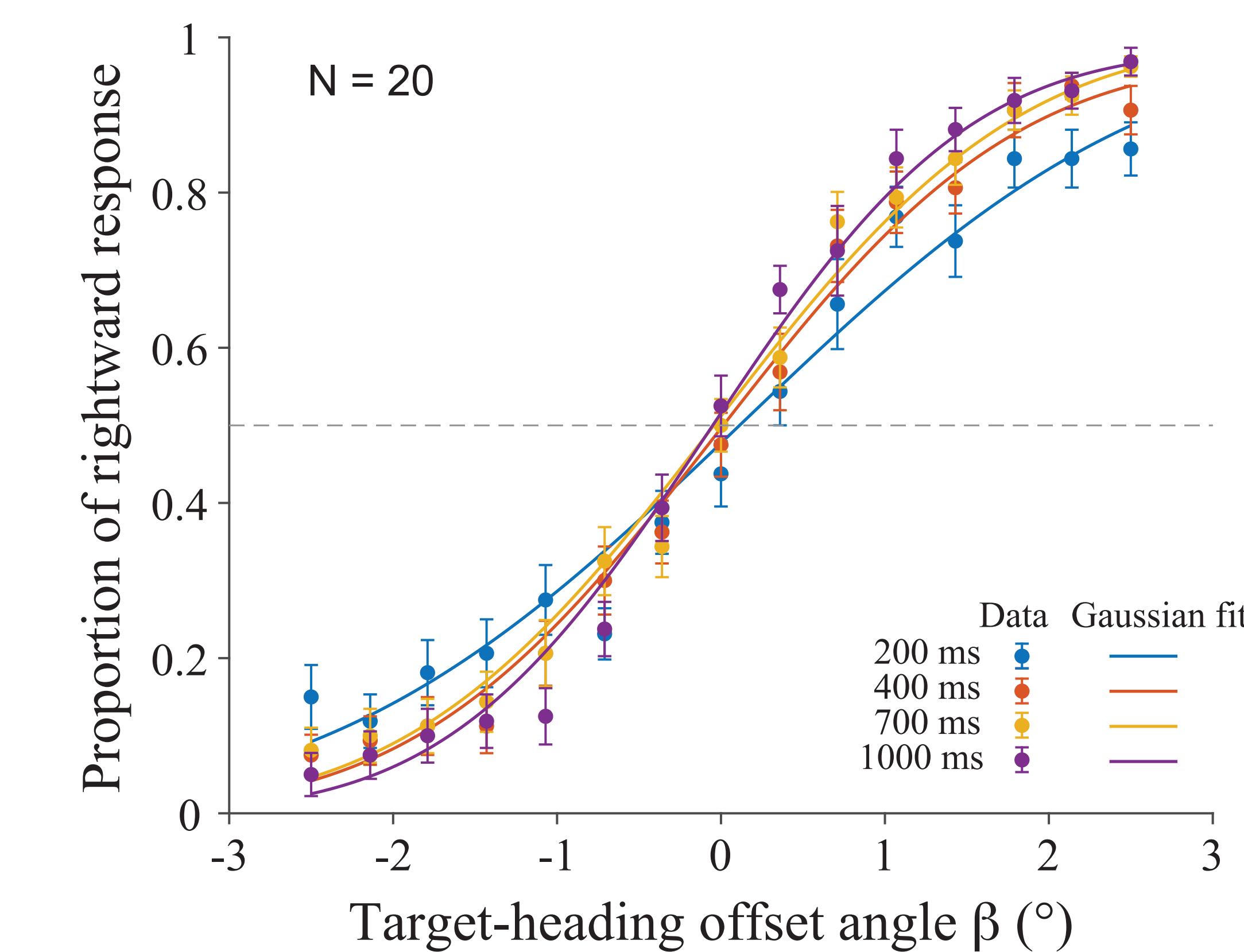
Condition:

Method of constant stimuli was used in both tasks. In both tasks, 15 equally spaced β angles ranging from -2.5° (left) to 2.5° (right) were selected. Both tasks were tested under four display durations (200 ms, 400 ms, 700 ms, and 1000 ms).

This design ensured that all parameters, except for the target movement, were identical in the two tasks, allowing for a direct comparison of the precision of heading judgments and flow parsing.

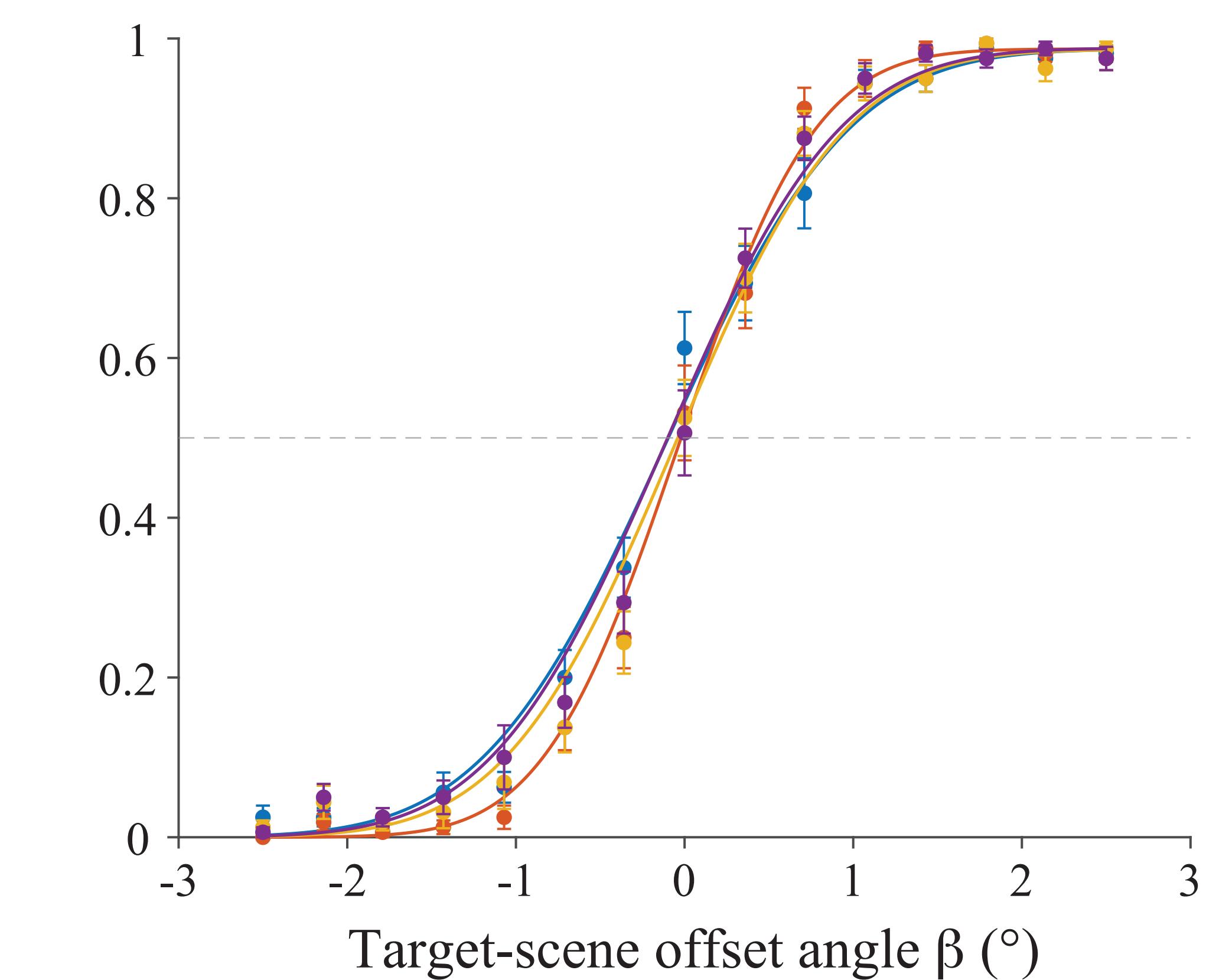
Results

Heading judgement task

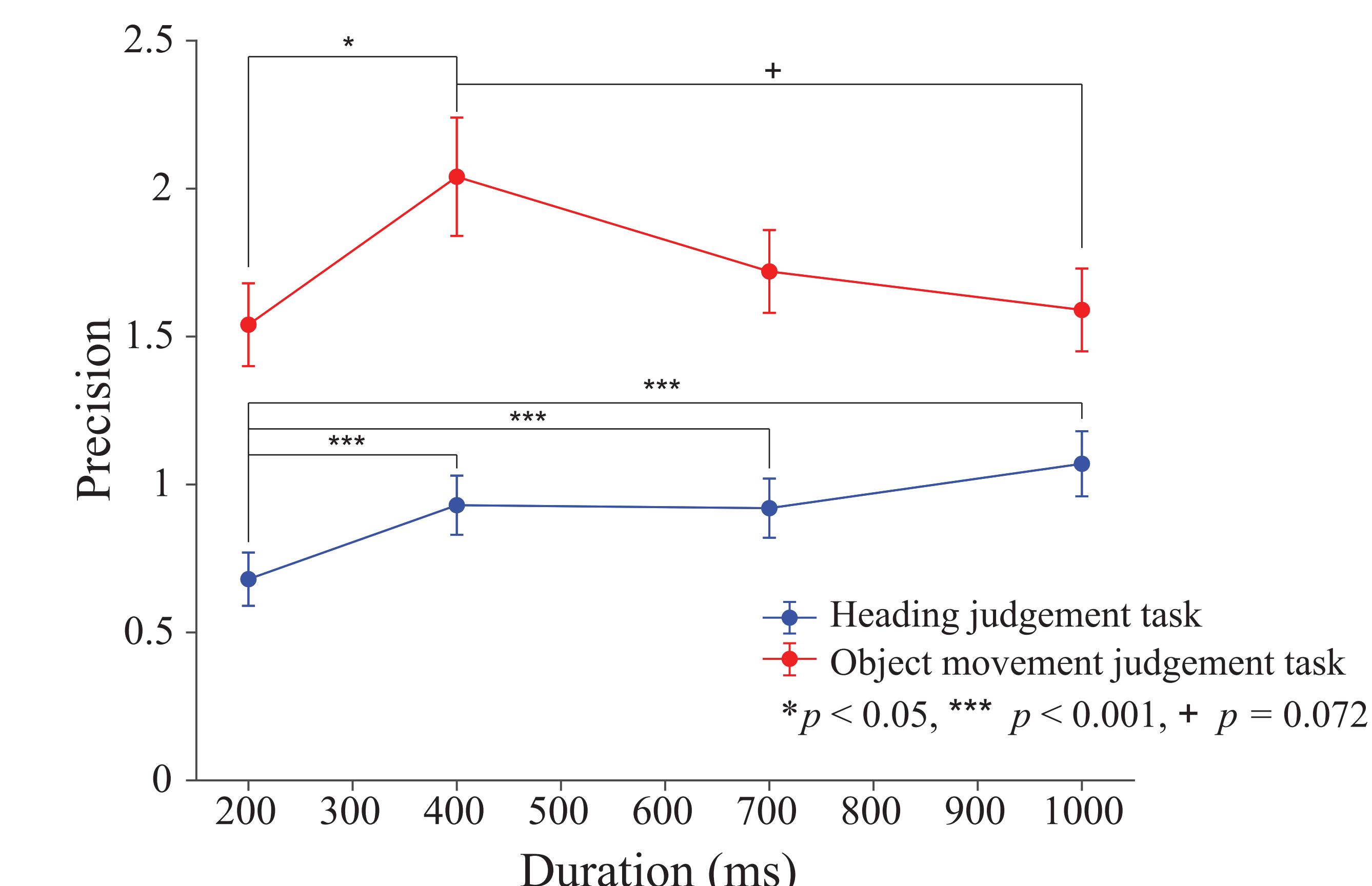


- A cumulative Gaussian function was used to fit participants' response data to obtain a psychometric curve.
- The standard deviation of the best-fitting Gaussian, inversely related to the slope of the psychometric curve, served as an indicator of the precision of heading judgement (left panel) and scene-relative object movement judgement (right panel).

Object movement judgement task



Temporal dynamics of heading judgement and flow parsing



- The precision of heading judgement shows an overall increasing trend with longer display durations.
- The precision of scene-relative object movement judgement peaked at 400 ms and then decreased with longer display durations.
- Overall, the precision of object movement judgment is significantly higher than that of heading judgment, consistent with previous findings.

Conclusion

The different trend of temporal dynamics of heading and scene-relative object movement judgments suggests that although these two processes both rely on optic flow, they operate as separate processes. The perception of heading is likely processed through a slower visual pathway compared with flow parsing.

Acknowledgements

This study was supported by research grants from the National Natural Science Foundation of China (32161133009, 31800904), Shanghai Science and Technology Committee (20ZR1439500, the basic research project 19JC1410101), China Ministry of Education (ECNU 111 Project, Base B1601), NYU shanghai (the major grant seed fund and the boost fund) and East China Normal University (the "Flower of Happiness" fund pilot project 2019JK2203).

References

- Warren, P. A., & Rushton, S. K. (2009). Optic flow processing for the assessment of object movement during ego movement. *Current Biology*, 19(18), 1555-1560.
- Rushton, S. K., Chen, R., & Li, L. (2018). Ability to identify scene-relative object movement is not limited by, or yoked to, ability to perceive heading. *Journal of Vision*, 18(6), 11-11.