Interpretation of viewing context alters object motion perception

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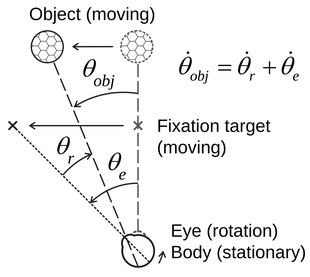
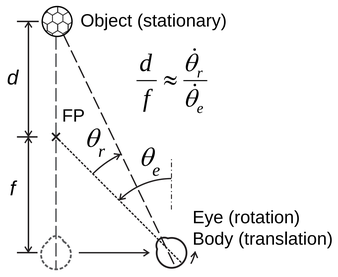
Introduction: Coordinate Transformation & Motion Parallax

- Inferring the **motion** and **depth** of an object from 2D retinal image motion is often complicated by the observer's self-motion (e.g. body translation, eye rotation). There are two well-known visual phenomena involving the interaction between retinal motion and self-motion:
- **Coordinate Transformation:** When an observer rotates their eyes, the retinal motion of a moving object reflects both its motion in the world and the rotation of the eye. With the help from extra-retinal signals or optic flow, the visual system adds the eye velocity vector to compute object motion in world coordinates [1,2].
- **Depth from Motion Parallax:** When the observer translates their body and maintain visual fixation at a stationary target, the retinal motion of a stationary object reflects its distance to the fixation. By combining the retinal motion with extra-retinal signals of eye movement, the visual system can infer the depth of the object [3,4].

Context 1: Coordinate Transformation (CT)



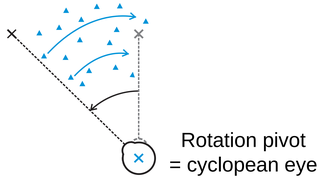
Context 2: Motion Parallax (MP)



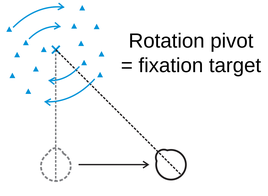
Hypothesis: Context-Dependent Perception of Motion & Depth

Distinct patterns of optic flow will be generated in different viewing contexts. Therefore, the visual system might perform distinct computations to infer motion and depth when different optic flow patterns are presented.

Coordinate Transformation (CT)

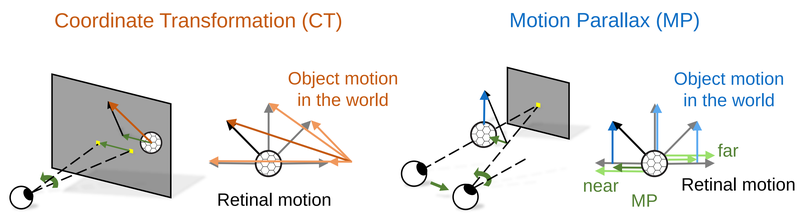


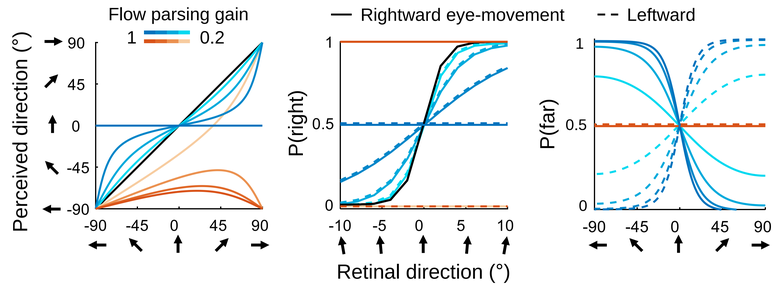
Motion Parallax (MP)



References

[1] Filehne. (1922).
[2] Warren & Rushton. (2008) *Curr Biol*.
[3] Nawrot & Stroyan. (2009) *Vision Res*.
[4] Kim, Angelaki, & DeAngelis. (2015) *Nat Neurosci*.

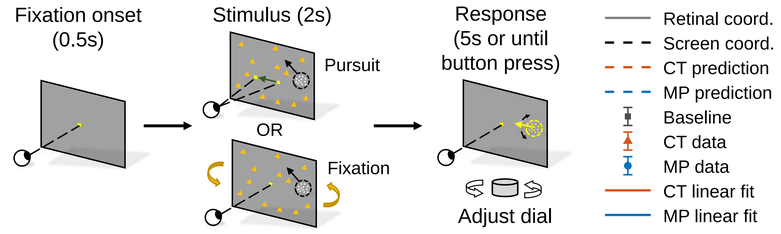


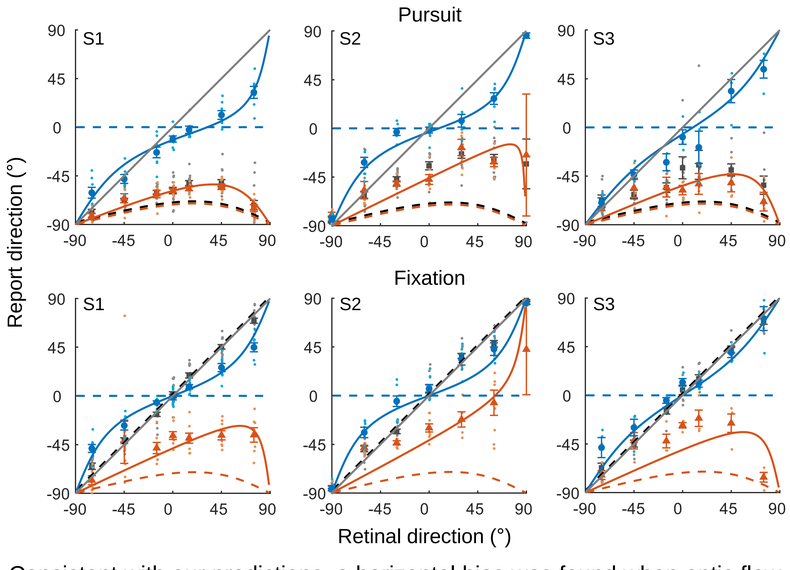


The perceived motion direction is expected to be biased towards motion in world coordinates, which means a horizontal bias in the CT context and a vertical bias in the MP context. The perceived depth is expected to be at the fixation plane in the CT context while it varies as a function of retinal direction in MP.

Experiment I. Motion Estimation

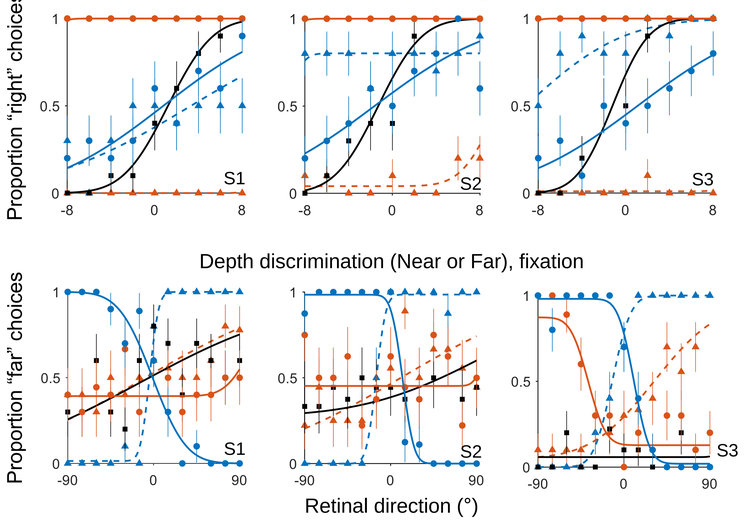
Procedure (Delayed match-to-sample)





Consistent with our predictions, a horizontal bias was found when optic flow simulated the CT context and a vertical bias was found in the MP context.

Experiment II. Motion & Depth Discrimination



In the motion task, strong biases were found for the CT context while the slope decreased in MP; In the depth task, opposite slopes were found only in the MP context when changing the direction of eye movement.

Take home messages

- Two visual phenomena, coordinate transformation and depth from motion parallax, can be unified under a framework that considers the viewing context provided by optic flow
- Humans can flexibly compute the motion and depth of an object based on the interpretation of viewing context