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)  **

Object (moving)

\[ \theta_{\text{obj}} = \theta + \theta_{\text{eye}} \]

Fixation target (moving)

Eye (rotation) Body (stationary)

\[ d \]

\[ f \]

\[ t \]

\[ \theta \]

\[ \theta_{\text{eye}} \]

\[ \theta_{\text{obj}} \]

\[ \theta_{\text{stationary}} \]

**Context 2: Motion Parallax (MP)  **

Object (stationary)

\[ \theta_{\text{obj}} = \theta_{\text{eye}} \]

Eye (rotation) Body (translation)

\[ d \]

\[ f \]

\[ t \]

\[ \theta \]

\[ \theta_{\text{eye}} \]

**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.

**Experiment I. Motion Estimation**

**Procedure (Delayed match-to-sample)**

Fixation onset (0.5s)

Stimulus (2s)

Pursuit

Fixation

Response (5s or until button press)

Adjust dial

**Experiment II. Motion & Depth Discrimination**

Motion discrimination (Left or Right), fixation

Proportion "right" choices

Depth discrimination (Near or Far), fixation

Proportion "far" choices

**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.**

**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.