



Un dispositif expérimental pour découpler des invariants optiques dans le contrôle de l'altitude des abeilles

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An experimental setup for decoupling optical invariants in honeybees' altitude control

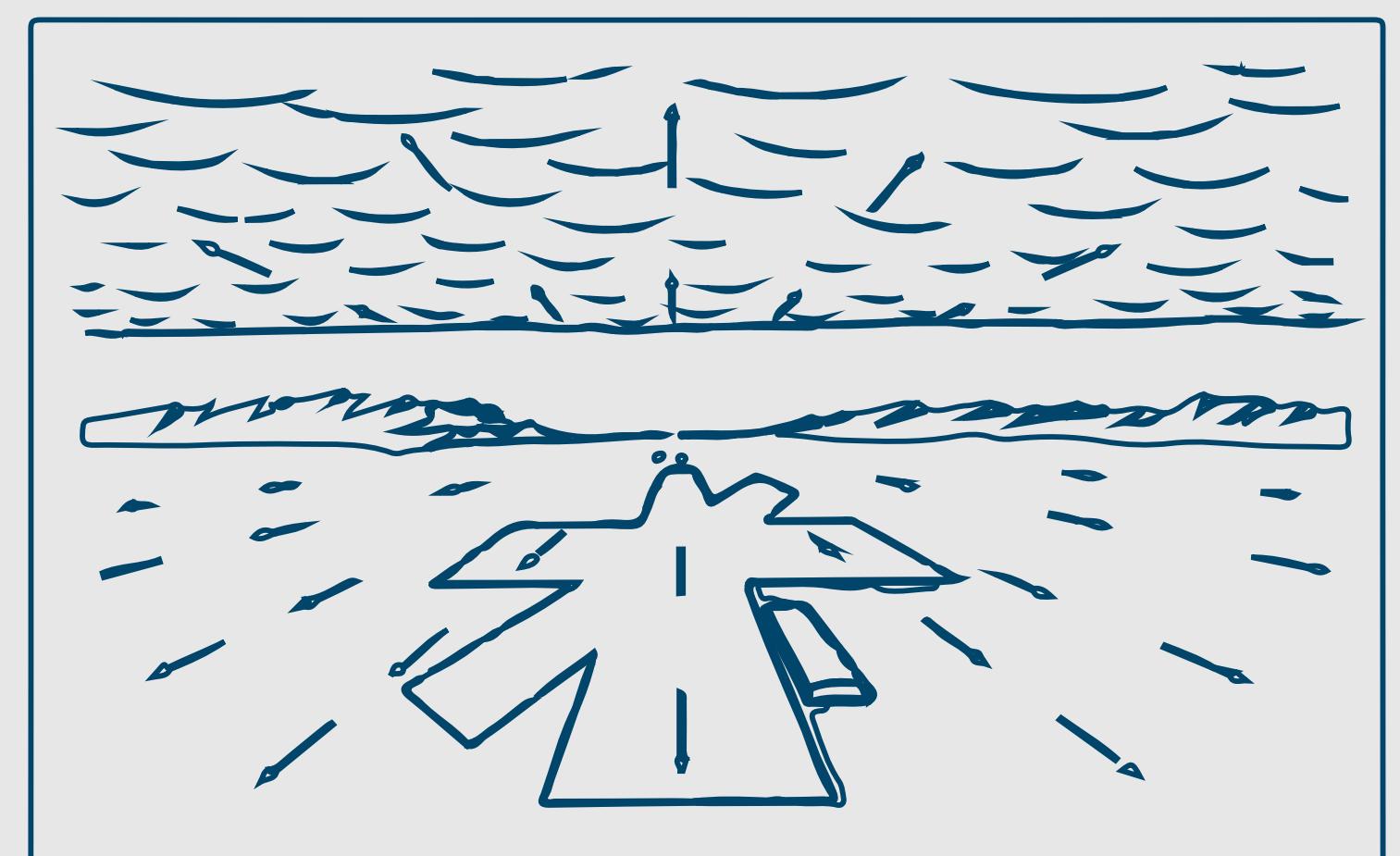
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Main question: Perceiving a complex visual environment, what optical invariant does *Apis mellifera* focus on to stabilize its altitude?



Bases and aims

Optic flow: vector field of the apparent motion of objects, surfaces, and edges in a visual scene caused by the relative motion between an agent and the scene.



Optic flow field perceived by a flying agent (Gibson 1950, 1979)

Optical invariants: particular properties of the optic flow unaltered when the agent is moving.

Two optical invariants are particularly relevant for a ground-following task:

- **optical speed rate of change $\dot{\omega}$** [used by bees and pilots]
- **splay angle rate of change \dot{s}** [used by pilots]

Aims: (1) To determine if bees also use splay angle rate of change for performing ground-following tasks
(2) To set the priority and weight system by which bees use these two optical invariants to control their altitude

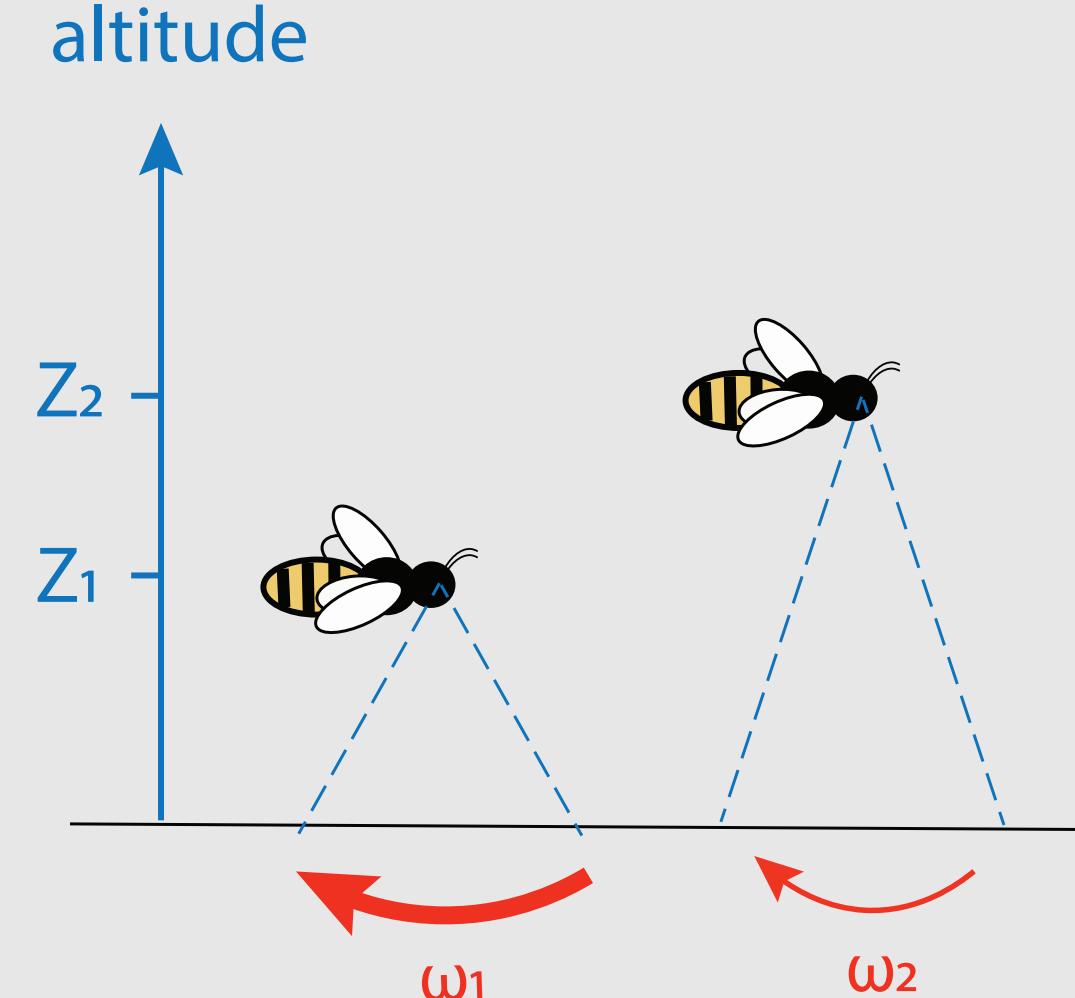


Optical speed (OS) experienced by a flying agent

OS (ω) is the speed of environment's image scrolling the retina when an agent is moving.

- OS increases for an agent going down ($\dot{\omega} > 0$)
- OS decreases for an agent going up ($\dot{\omega} < 0$)

--> **optical speed rate of change ($\dot{\omega}$) is informative about altitude change**



$$\begin{aligned}\omega &= \text{OS} \\ \dot{\omega} &= \text{OS rate of change} \\ Vx &= \text{agent's speed} \\ z &= \text{agent's altitude}\end{aligned}$$

To maintain a constant flight altitude --> keep $\dot{\omega} = 0$

observed in bees [1, 2, 3, 4, 7]

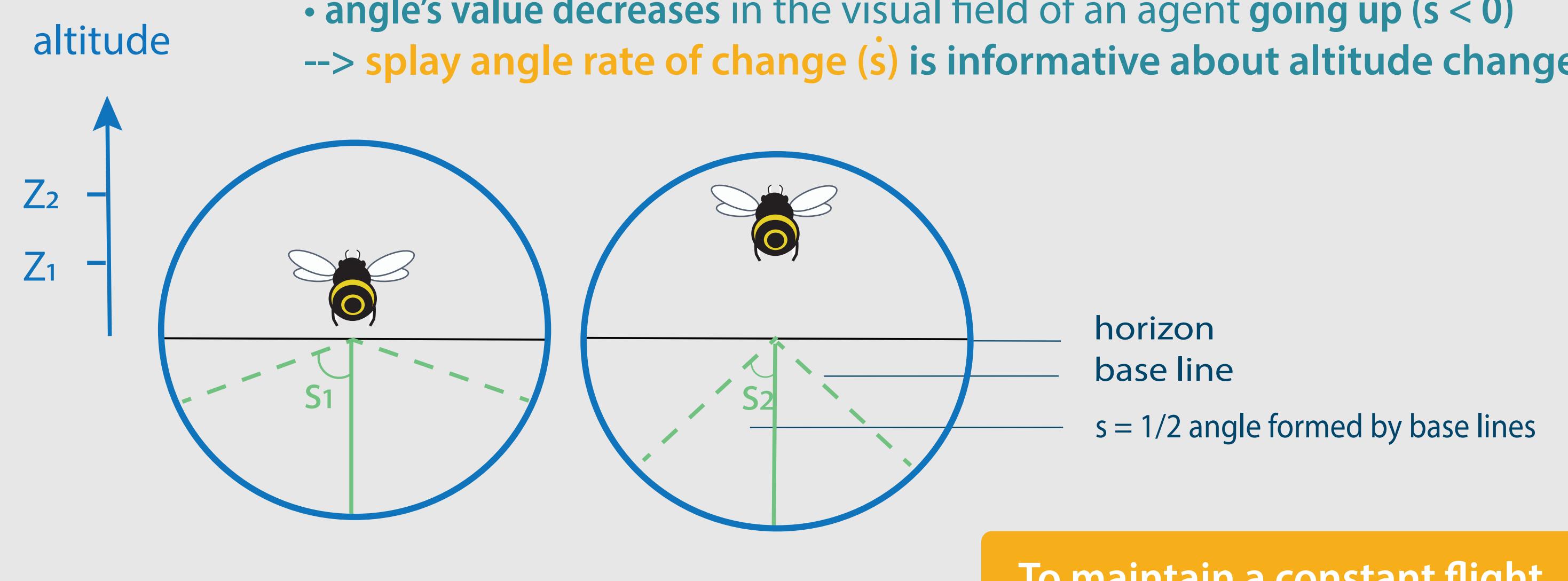


Splay angle rate of change experienced by a flying agent

Base lines join at the image's focus of expansion forming the **splay angle (s)**:

- angle's value increases in the visual field of an agent going down ($s > 0$)
- angle's value decreases in the visual field of an agent going up ($s < 0$)

--> **splay angle rate of change (\dot{s}) is informative about altitude change**

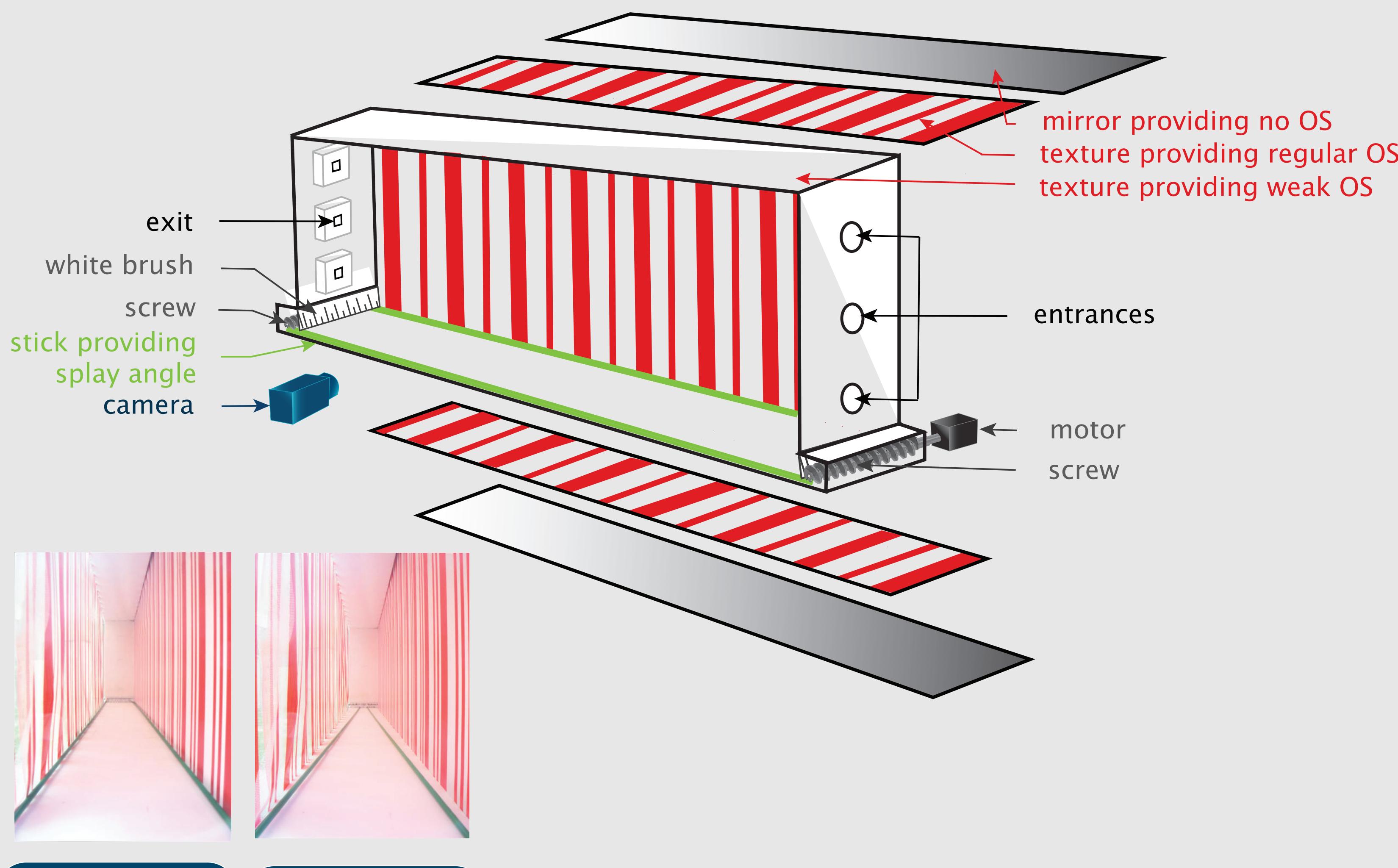


observed in humans [5, 6]

To maintain a constant flight altitude --> keep $\dot{s} = 0$

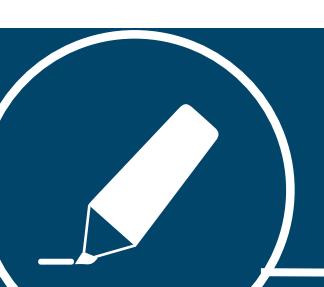


Experimental setup



Weak OS available
Regular splay angle

Weak OS available
Narrow splay angle



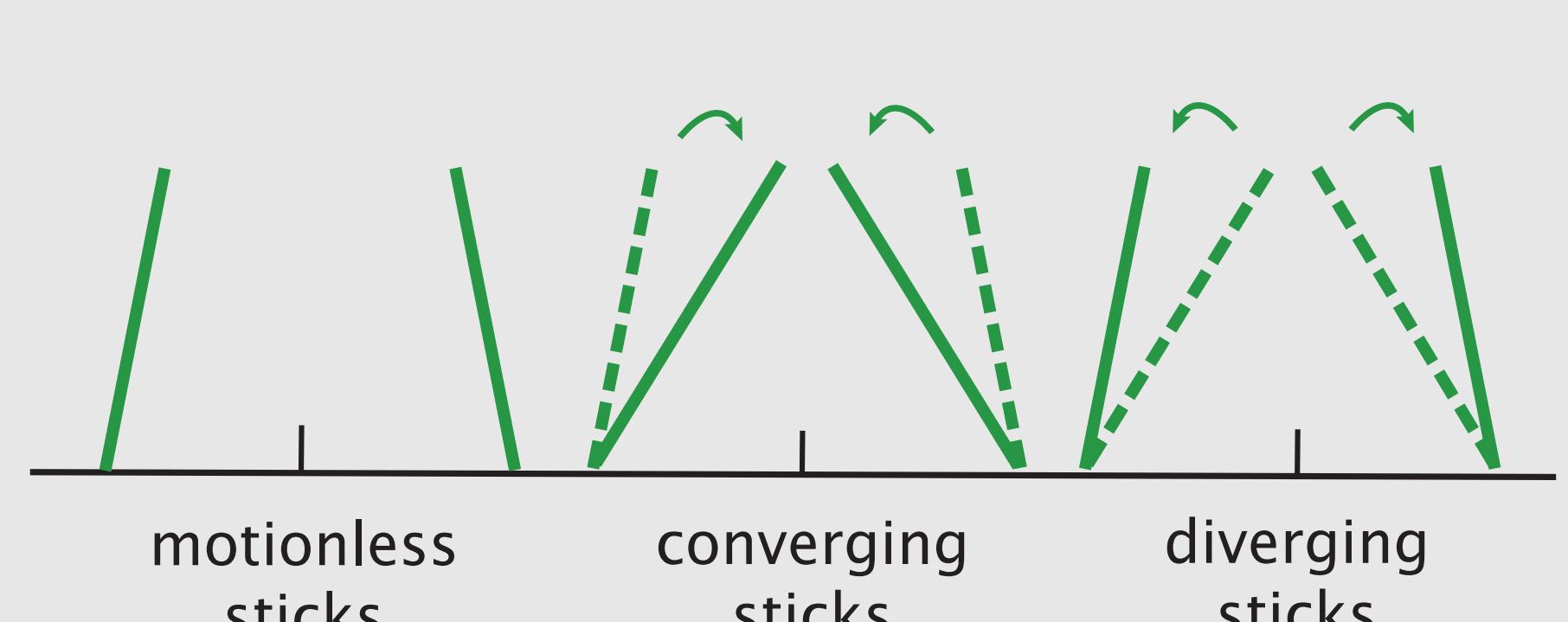
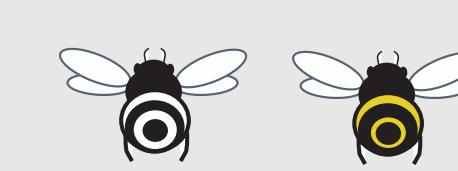
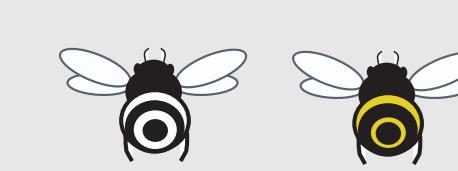
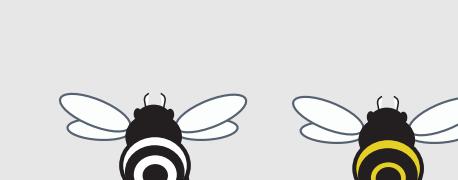
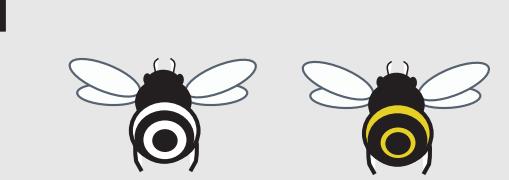
Highlights

- An experimental setup was designed to investigate whether the splay angle rate of change is implicated in bees' altitude control
- A flight tunnel was built enabling specific manipulations of two optical invariants
- Splay angle rate of change is used by bees to control their altitude in a ground-following task



Predictions and results

	predictions
	results



• A bee perceiving a **splay's enlargement** will interpret a **loss of altitude**, so it will **go up** to maintain a null splay angle rate of change ($s=0$).

• A bee perceiving a **splay's narrowing** will interpret a **gain in altitude**, so it will **go down** to maintain a null splay angle rate of change.

• A bee perceiving **weak OS** will take into account splay angle's rate of change in priority so it will show **broader altitude changes**.

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