# How the fan-shaped body can integrate differential familiarity for route following in desert ants

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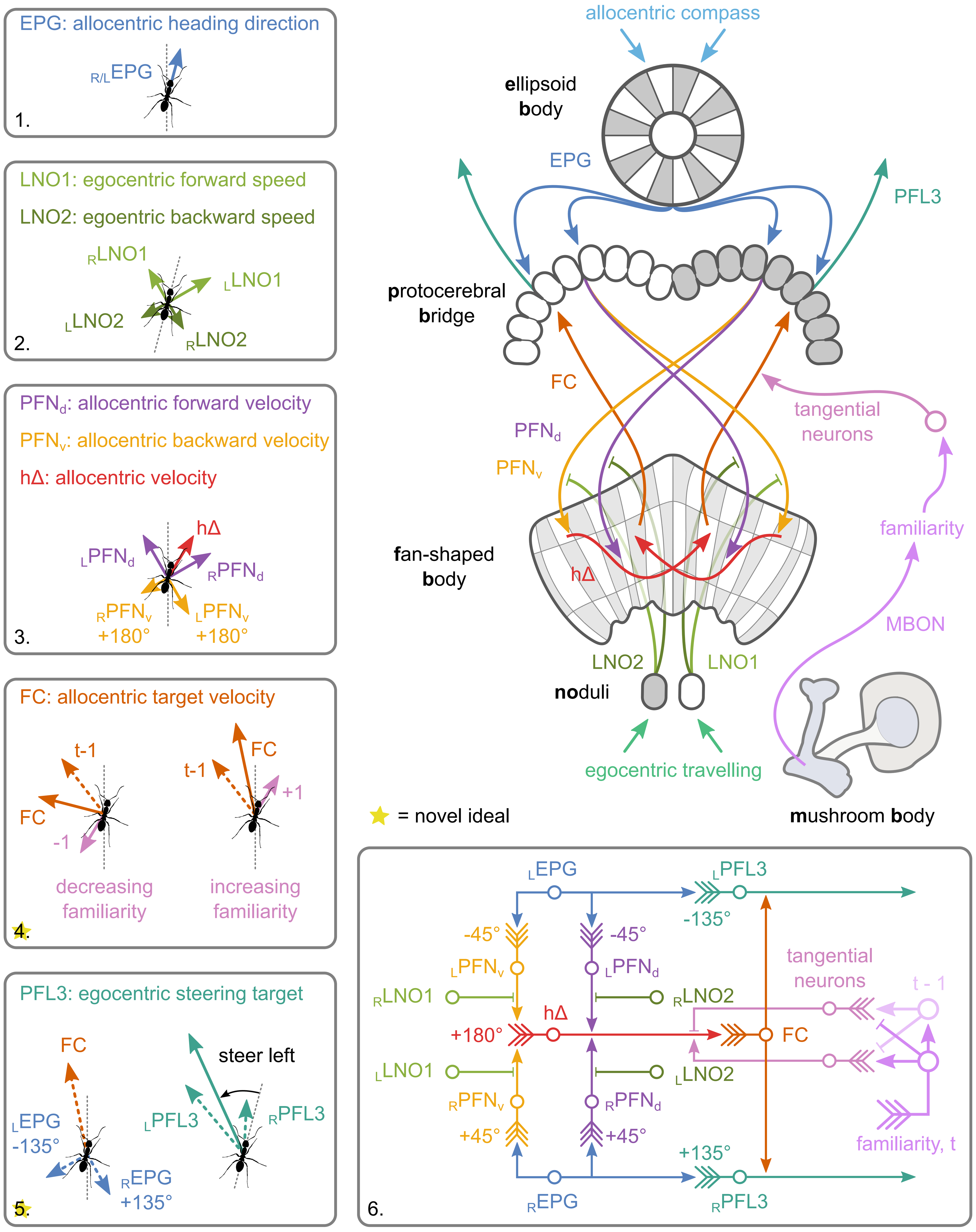
## Introduction

- Desert ants use their visual memory to follow familiar routes and find their nest, and this is usually assumed to be processed by their *mushroom bodies* (MB).
- The *MB output neurons* (MBONs) are assumed to predict the scene's familiarity, which they project to the *fan-shaped body* (FB) of the *central complex* (CX) through tangential neurons.
- We take a computational approach to explore how this familiarity input can be used by the FB to produce a target velocity for the animal, which can be used for route following.
  1. Following recent understanding of the function of PFN and hΔ neurons in the FB [1, 2, 3, 4], we build a computational model that encodes the allocentric velocity of the animal.
  2. We demonstrate computationally that columnar (FC or vΔ) neurons of the FB could encode the allocentric target velocity by integrating differential familiarity and the current velocity (hΔ).
  3. We finally showed that this target velocity can be used by the PFL3 neurons to follow a familiar route and we suggested that the performance could be enhanced by the use of PFL2 neurons.

## The effective central complex circuit for route following

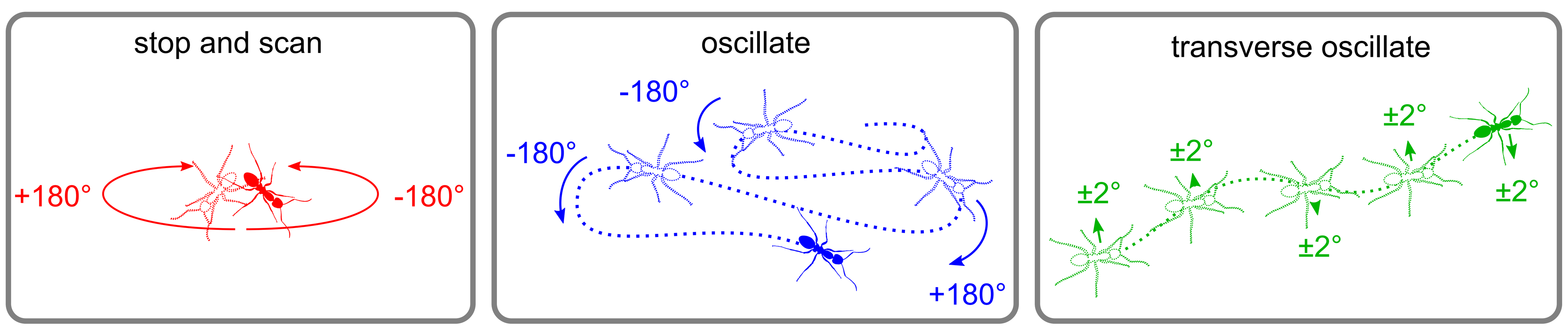



- Allocentric heading (box 1) and egocentric speed (box 2) build the allocentric velocity vector (box 3) [1].
- Current velocity contributes into the target velocity—red arrow (box 3) becomes the pink arrow (box 4).

$$\vec{\mathrm{FC}}(t) = (1-\alpha_M)\cdot\vec{\mathrm{FC}}(t-1) + [\mathrm{familiarity}(t) - \mathrm{familiarity}(t-1)]\cdot\vec{\mathrm{h\Delta}}(t) \quad (1)$$

  - $\alpha_M$: the memory decay factor of the allocentric target velocity.
- The steering direction is the subtraction of the allocentric heading from the target velocity (box 5).

## The default oscillation patterns

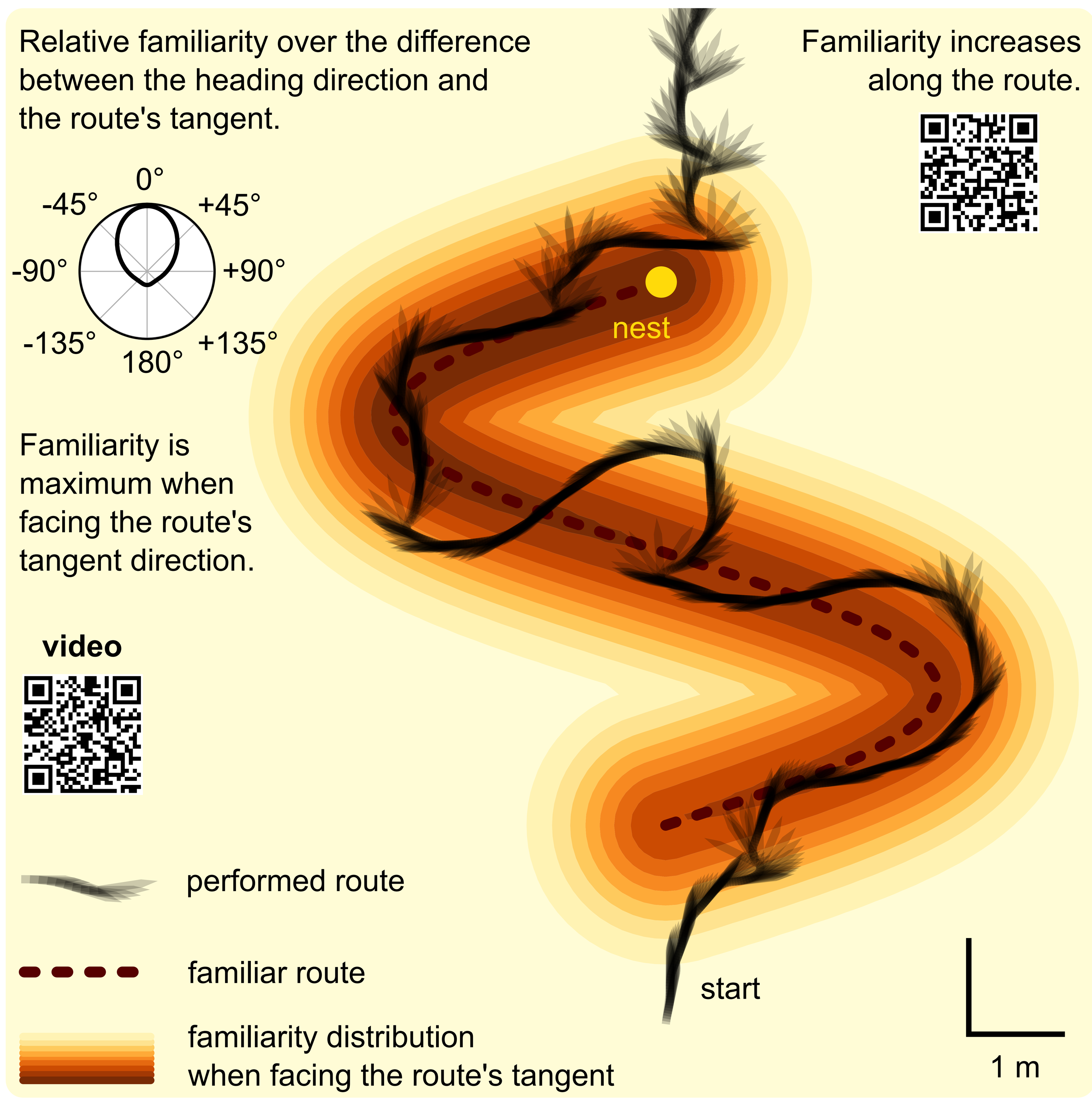



- Responses in the *lateral horns* (LHs) and *lateral accessory lobes* (LALs) can build oscillation patterns.
- The oscillations can be a trade-off between stop-and-scan and moving forwards in straight line.

## Future work

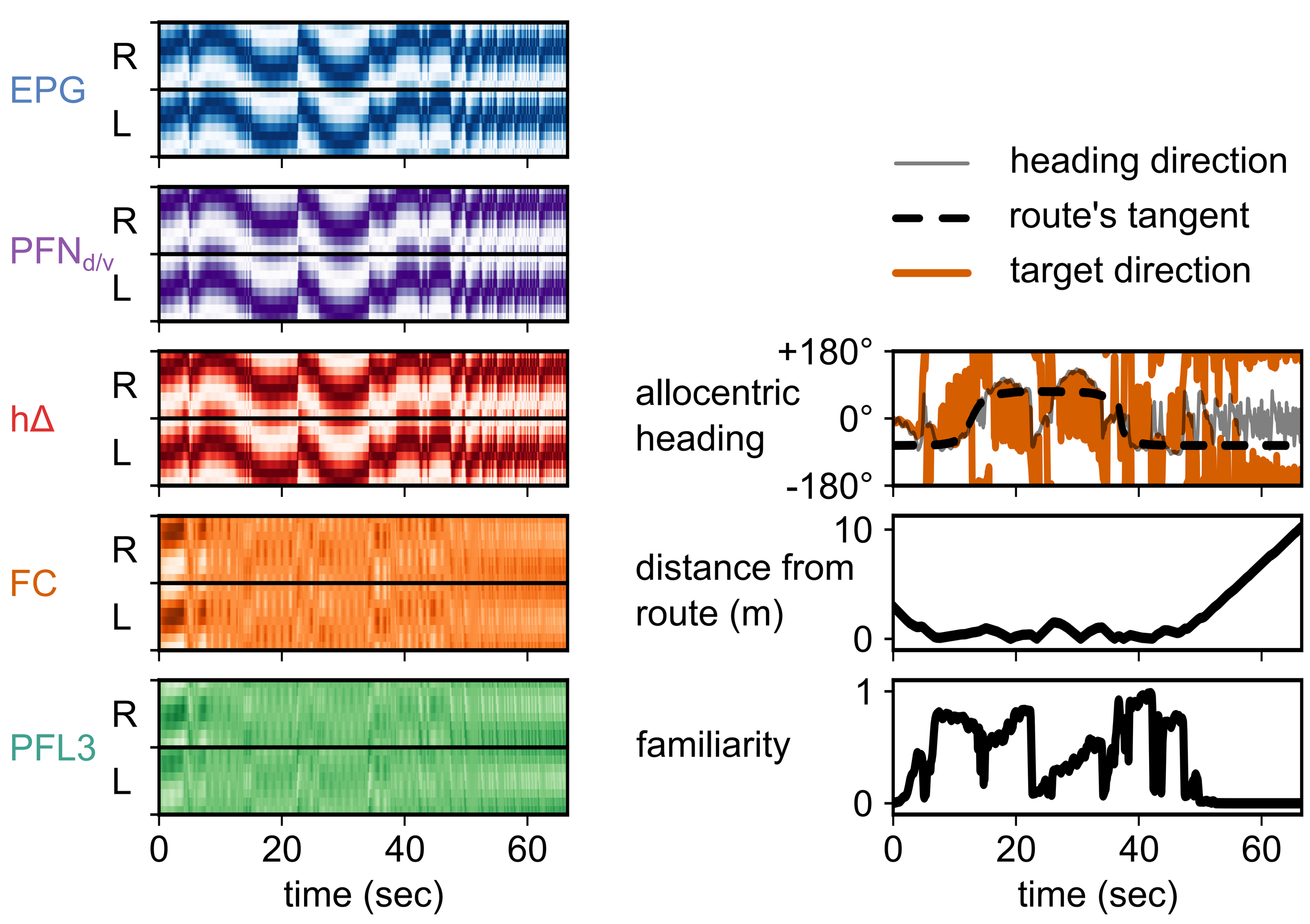
- Transverse oscillation could allow for gradient ascent while the agent's heading stays tangent to the route.
- Next, we will explore whether the PFL2 neurons could contribute in promoting this type of oscillation.

## The modelled behaviour of route following




- The model uses complex numbers to represent activity bumps.
- The default oscillations of the agent (±3°) allow for local exploration of the familiarity distribution.
- The target velocity (columnar FCs or vΔs) is updated based on the difference between consecutive familiarity estimations—see equation (1).
- Increasing familiarity shifts the target towards the current velocity.
  - Decreasing familiarity shifts the target away from the current velocity.
  - This allows for gradient ascend of the familiarity distribution.
- The result behaviour is a collection of oscillations of different sizes [5].

## The responses producing the modelled behaviour




- As the agent always moves in the heading direction, the responses of hΔ neurons are identical to the ones of PFN$_d$ neurons.
  - This is due to forward speed, which silences PFN$_v$ neurons.
- The update rate of the FC (target velocity) depends on its $\alpha_M$.
  - High $\alpha_M$ allows for stronger influence of the current velocity.
- The different (right or left) shifts in the connectivity of the EPG to PFL3 neurons ensures that at least one PFL3 vector is always non-zero.

## References

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