A robot model of compass cue calibration in the insect brain

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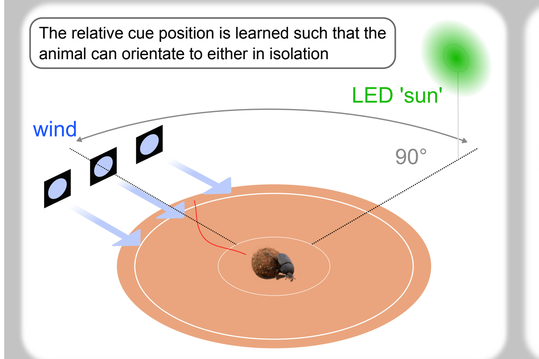
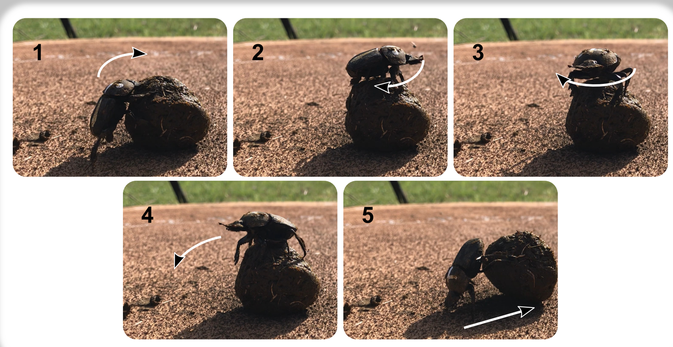
Motivation

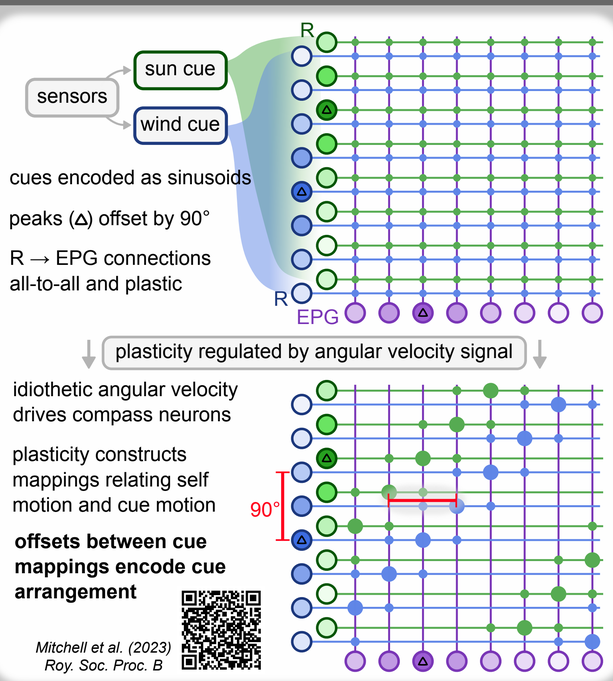
Dung beetles learn the spatial arrangement of available orientation cues



Behavioural evidence indicates this learning takes place during the dung beetle 'dance'

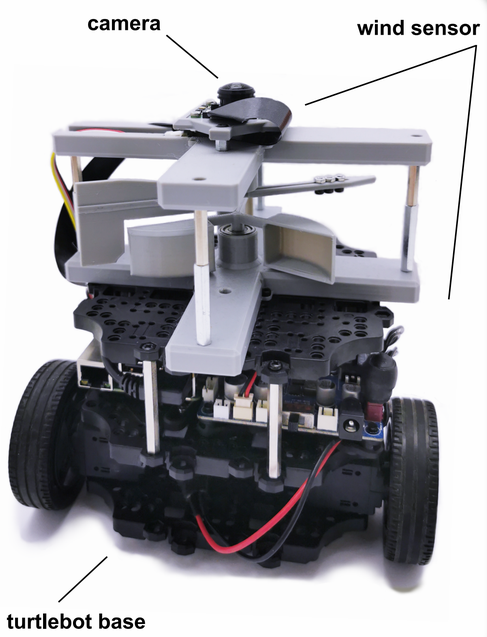


Our neural cue integration model can learn cue arrangements in simulation

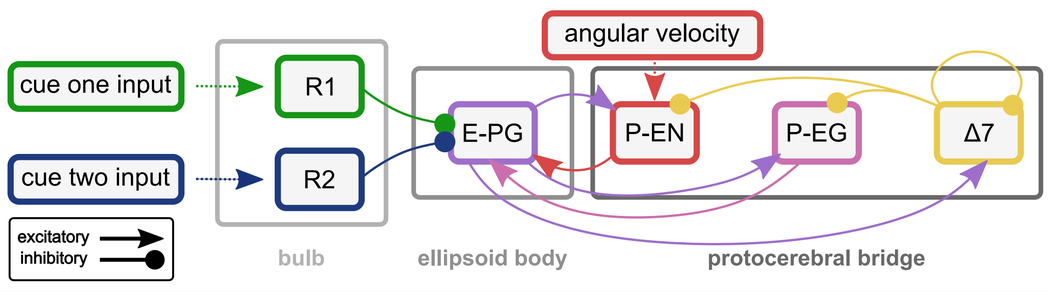


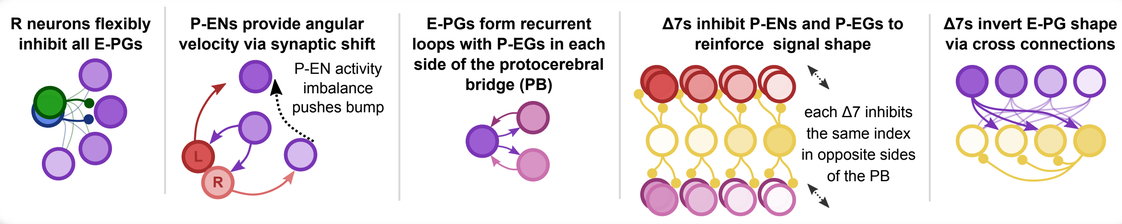
Mitchell et al. (2023) Roy. Soc. Proc. B

We placed the model on a robot to see if it can work in the real world

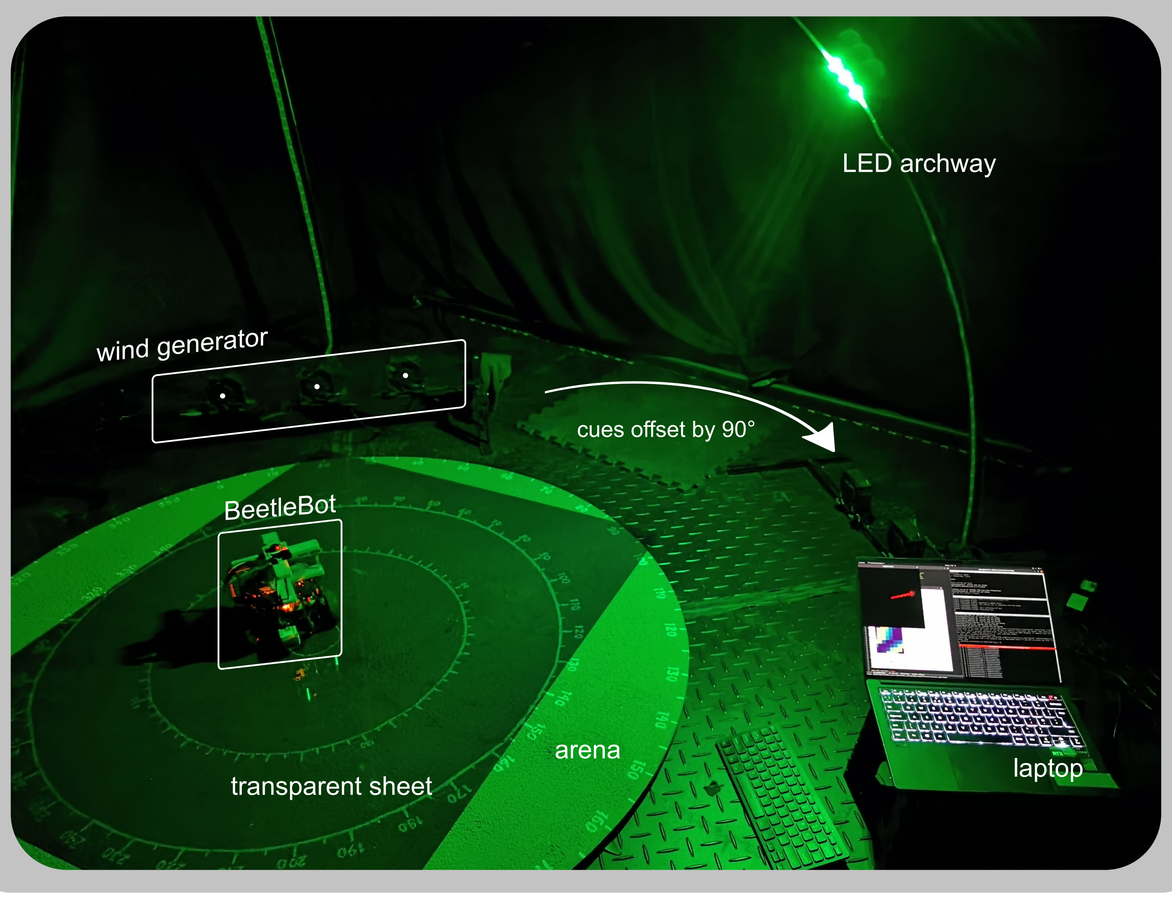


Model





Replicating the dung beetle experiment

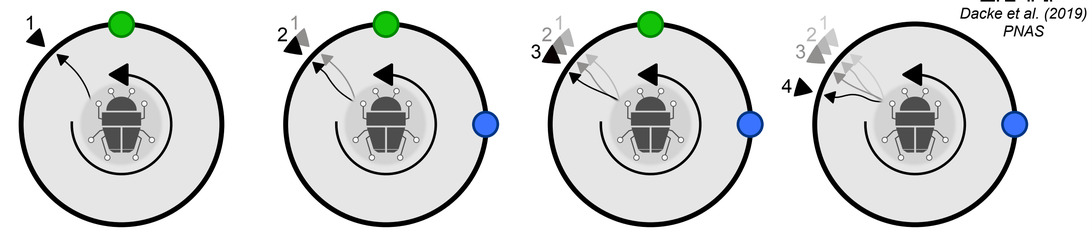


Assay

Same assay used in dung beetles by Dacke et al. (2019), *PNAS.*

Allow BeetleBot to 'dance' and exit arena four times.

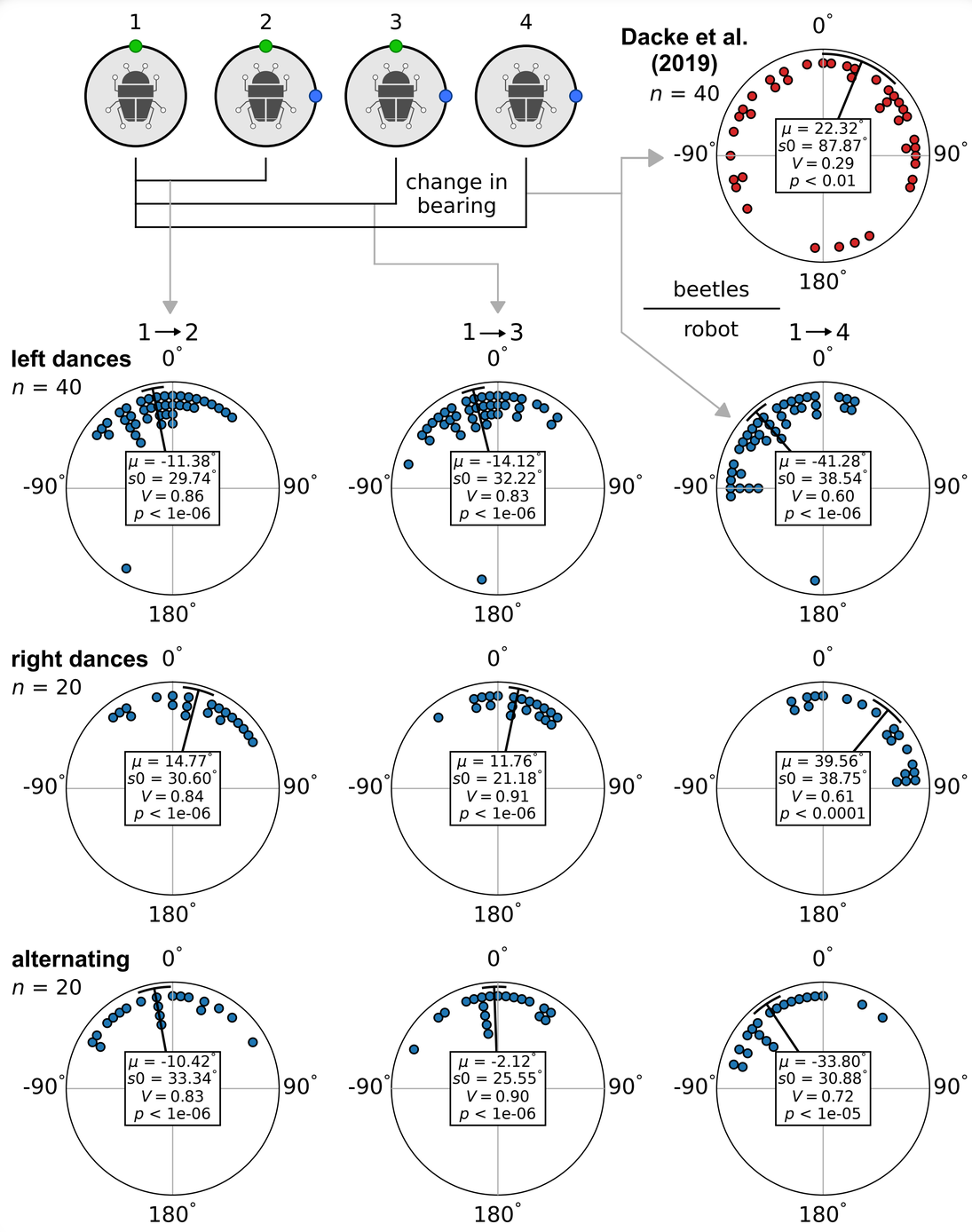
Dacke et al. (2019) PNAS



Exits are compared to see how consistently the robot keeps its bearing

If the bearing is consistent, the robot has learned the spatial relationship of the cues.

Robot results

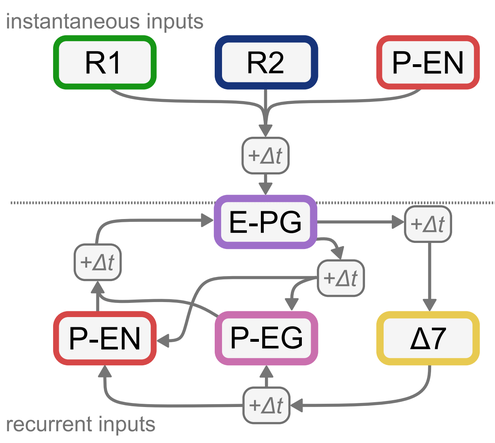


Conclusions

The model works (statistically) ***but*** the robot drifts. Why?

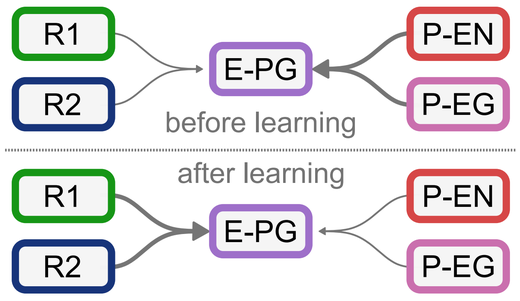
drift depends on

temporal conflict between neural inputs



inputs to the compass come from different points in time

plasticity causing shift in neuron influence



mappings rely on relationship between self-motion and world-motion

learning changes *relative* influence of self-motion/cue inputs

this breaks the relationship between motion from different input channels

It is not clear if or how the real brain would regulate these interactions!

Relevant review articles

Central complex anatomy
Yvette Fisher. Flexible navigational computations in the Drosophila central complex. *Curr. Op. Neurobiol.* (2022).

Dung beetle behaviour
Marie Dacke et al. How Dung Beetles Steer Straight. *Annu. Rev. Entomol.* (2021)

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