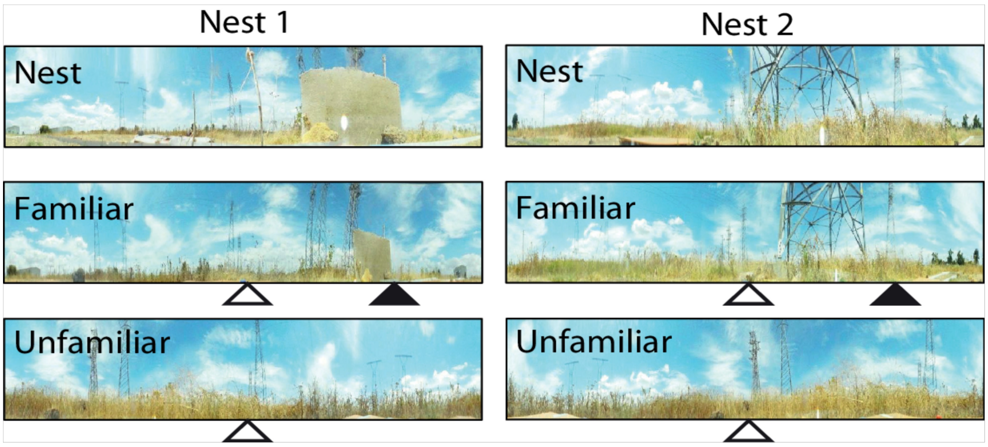
Optimal cue integration in ants using a proxy for uncertainty

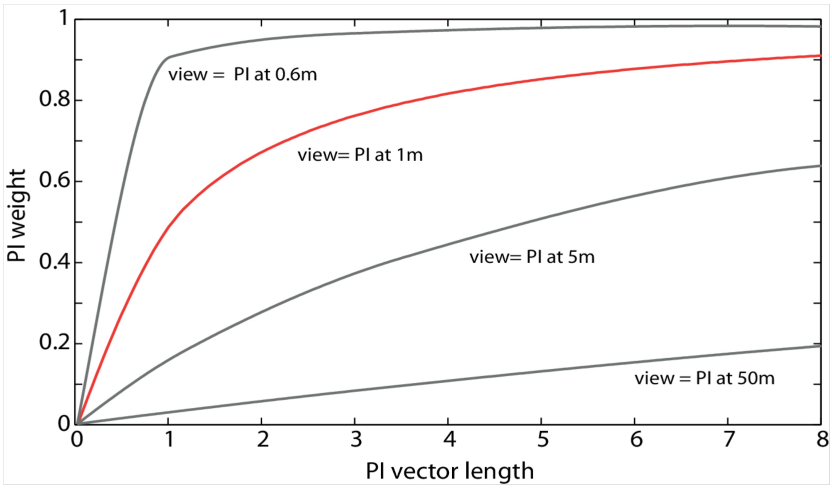
Supplemental information

Supplemental figure S1



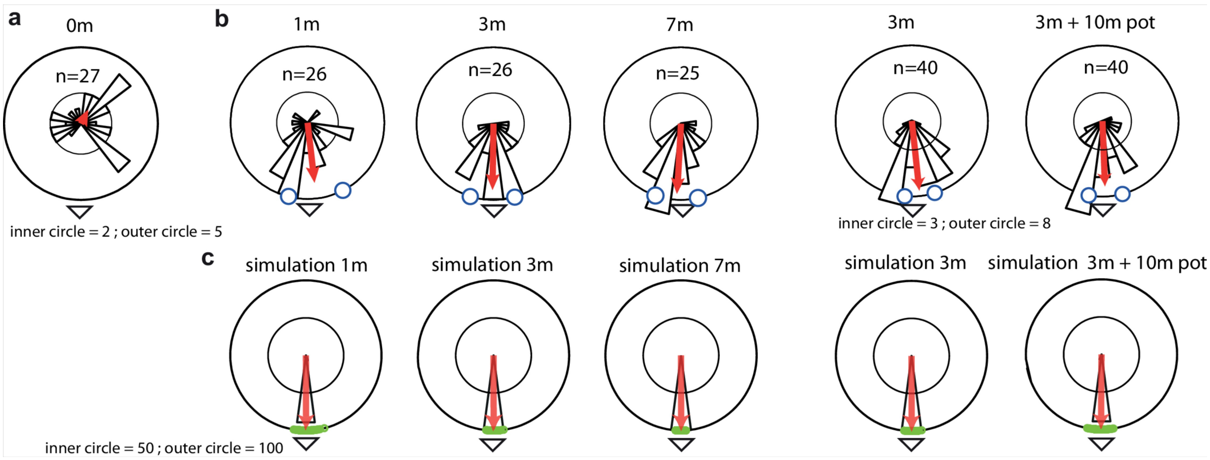
Supporting figure S1. Panoramic images sampled at both nests, and the corresponding familiar and unfamiliar release points. The familiar locations are novel to the ants (1.5m away from the nest but off the route), but the scenery contains information that the ant can match to their visual memory to head towards the nest. At totally unfamiliar locations (50m away) however, the scenery does not carry relevant information for homing, but PI can be used to set a heading based on celestial cues (see Fig. S3). Open and black arrowheads indicate PI and nest directions respectively.

Supplemental figure S2



Supplemental figure S2. Prediction for different view uncertainty. The relative weighting predicted by PI directional uncertainty varies also according to the uncertainty of the view. If the uncertainty of the view is low (lower grey curves), such as on the familiar route, PI should be weighted less (relatively) than at the familiar location used in our study (red curve); where ants were released 1.5m off the route. However, the uncertainty of the view should increase (higher curves) at locations further away from the familiar route. At a highly unfamiliar location (highest grey curve) the PI should dominate behaviour even for short PI vector length; as observed in this study when we released ants at unfamiliar locations (Fig. S3).

Supplemental figure S3



Supplemental figure S3. Headings when released on unfamiliar terrain. a) Zero vector ants (i.e. captured when exiting the nest, 0m) and released on the unfamiliar release point (50m away from the nest) were not significantly oriented in any direction (Rayleigh: p=0.2051, z=1.59), showing that the scenery at this location provided no noticeable directional information to the ants. **b)** Ants captured further along the route (i.e., 1m 3m 7m groups from Exp 1; 3m and 3m+10m pot groups from Exp 2) were significantly oriented (Rayleigh: p's<0.0001, z's=11.96) in the direction indicated by their PI vectors. The inter-individual variances shows no significant difference across groups (O'Bryan: p=0.1259; F=2,1311) and qualitative ranking is inconsistent across both nest. **c)** Predicted headings of our particle model (100 particles: green circle) calibrated given the data by Merkle & Wehner (2010, fig.1) illustrating PI directional certainty for the different walking distance experienced by the ants (S4). Decrease in PI directional uncertainty with walking distance can be observed given the scatter across particles (green circle), but are barely discernible given the resolution at which we recorded ant data (circular sector). **a,b,c)** This reveals that the absence of observable difference in directional variance across groups should be interpreted carefully, and not been taken as evidence for an absence of difference in PI uncertainty. Many possible sources of inter-individual difference might swamp the effect of PI uncertainty (e.g., real world uncontrolled stimuli, experimenter release interference, ant systematic searching). It should be noted that even if the absolute scatter of our particle model require a calibration of the PI noise, the relative weight attributed to PI across distance – which is used to test for optimality- does not (S4).

Supplemental text S4: particle filter simulation

We used a particle filter simulation to confirm and bring intelligibility to the theoretical analysis of path integration uncertainty. Each particle represents an ant moving in 10cm steps in direction 0 (towards food) with distance noise $N\left(0,\sigma_d^2\right)$ and angular noise $N\left(0,\sigma_\theta^2\right)$ added at each step. We use distance noise = 0.15*step_length and angular noise = 0.25*π; values obtained by an approximate fit to the data for path integration errors (location of start of search) in homing ants given by Merkle & Wehner (2010, figure 1). Note that we confirmed, by varying these parameters and rerunning the simulation, that the positional and directional variance for different outward distances always changes proportionally to distance and 1/distance respectively, so the parameter choice has no effect on the predicted effect of optimal weighting. We simulated 1000 ants moving 1m, 3m or 7m, and calculated both the positional (absolute distance from correct location) variance and directional (difference of home vector heading angle from the correct direction) variance.

To simulate the ant in the pot in experiment 2, each particle would first travel 3m towards the food and then describe a triangular path with sides of 10cm (comparable to the real pot diameter) for a further 10m. In this case both positional and directional variance will be increased