How are stimuli parsed to enable behavior? To transition from sending signals around to coordinating a behavior, *Physarum* needs to somehow store and process information about stimuli. Stimuli are commonly encountered at the edge of an individual's network, where flows become vanishingly small. Any molecular signal triggered by a stimulus at the edge will therefore not be homogenized throughout the network. Instead, the organism may use the resulting local concentration gradient to 'remember' the location of a stimulus. However, the idea of memory in a slime mold is speculative and how information is processed within the organism remains to be discovered.

Are the behaviors of Physarum unique? No. Although *Physarum* is not a fungus, fungi also grow as networks and many species forage for scarce and heterogeneously distributed resources, for example fallen wood. Both slime molds and fungi are major components of the biodiversity of ecosystems. Although both groups are of obvious ecological relevance, the behaviors of slime molds and fungi are also intrinsically fascinating. Integrated behaviors require communication and decisions. The mechanisms used by *Physarum* to coordinate growth and make choices will almost certainly inform our understanding of other species' behaviors.

Where can I find out more?

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[1]School of Engineering and Applied Sciences and Kavli Institute for Bionano Science and Technology, Harvard University, Cambridge, MA 02138, USA. [2]Department of Organismic and Evolutionary Biology, Harvard University, Cambridge, MA 02138, USA.
*E-mail: kalim@seas.harvard.edu

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Correspondences

Ants use a predictive mechanism to compensate for passive displacements by wind

A. Wystrach[1,3,*] and S. Schwarz[2,3]

Insect navigation is a fruitful system for analysing the ingenious and economical mechanisms that can underlie complex behaviour [1]. Past work has highlighted unsuspected navigational abilities in ants and bees, such as accurate path integration, long distance route following or homing from novel locations [2]. Here we report that ants can deal with one of the greatest challenges for any navigator: uncontrolled passive displacements. Foraging ants were blown by a jet of air over 3 meters into a dark pit. When subsequently released at windless unfamiliar locations, ants headed in the compass direction opposite to the one they had been blown away, thus functionally increasing their chance of returning to familiar areas. Ants do not appear to collect directional information during the actual passive displacement, but beforehand, while clutching the ground to resist the wind. During that time window, ants compute and store the compass direction of the wind. This is achieved by integrating the egocentric perception of the wind direction relative to their current body-axis with celestial compass information from their eyes.

Melophorus bagoti ants forage individually during the hot central Australian summer days, seeking seeds and roasted insects while ground temperatures rise above 50°C. Each forager develops its own idiosyncratic visually-guided route that meanders between buffelgrass tussocks [3]. Thermal turbulences due to solar heating of the ground create frequent wind gusts and it is not rare to see ants getting blown away from their familiar route. The displacement may only be a few meters, but for an ant this corresponds to hundreds of body lengths of violent tumbling through dust and vegetation, making it virtually impossible to determine and integrate self-motion during the displacement.

We investigated how *M. bagoti* copes with such passive displacements by simulating wind gusts using a leaf blower. Two small piles of cookie crumbs were placed 10 cm north and south of the nest entrance (Figure 1A, grey dots). As soon as an individual ant emerged from the nest and picked up a cookie crumb, a horizontal wind was generated along the ground, blowing the ant 3 m either east or west towards a vertical barrier designed to stop the passive displacement. Displaced ants would then fall into a pit, then be transported in darkness and released in windless conditions at a distant unfamiliar location (see Supplemental Information available on-line with this issue).

A control group of ants that did not get blown away showed the characteristic undirected headings of a systematic search (Figure 1H), confirming that the scenery at the release point did not provide any directional information. In contrast, ants that had been blown away showed directed headings. They walked in the compass direction opposite to the blast of air they had experienced: ants blown eastwards headed westwards and vice versa (Figure 1B). Two replications of this condition — with ants from another nest and at another release location — gave similar results (Figure 1C,D). This indicates that *M. bagoti* ants can somehow collect information about the compass direction in which they have been blown away.

Given how quick and turbulent the passive displacement is (see Supplemental Movie S2), how can ants derive such directional information? We first suspected a role for the ocelli, the three small single-lensed eyes on top of the ant's head, which mediate fast sensing of body rotation in some flying insects [4] and extract celestial compass information in ants [5]. We repeated the experiment
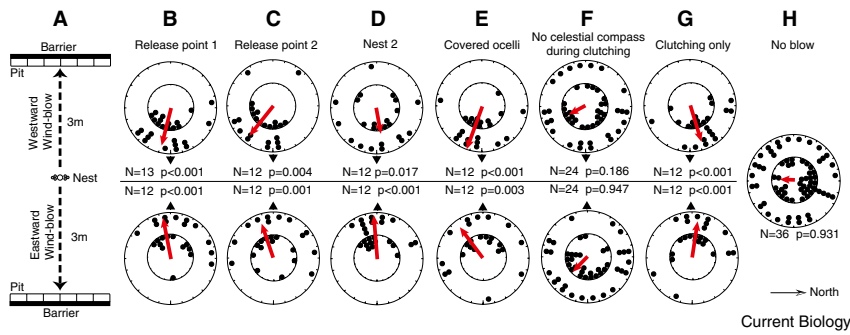
Figure 1. Heading directions of ants released on windless unfamiliar locations after being subjected to a westward (top row) or eastward (bottom row) wind-blown passive displacement.
The scheme and histograms are all oriented with the north towards the right. (A) Schematic aerial view of the experimental set-up. Small grey dots near the nest indicates the location of cookies from which ants were blown away westwards or eastwards until hitting a vertical barrier and falling into one of the pits. (B–G) Subsequent heading direction of individual ants carried in darkness and released in a windless unfamiliar environment. (B) Ants subjected to a wind-blown passive displacement. Replications of the experiment with a different unfamiliar release location (C) and with ants from another nest (D). (E) Ants with artificially covered ocelli during both wind-blown passive displacement and subsequent release in an unfamiliar location. (F) Ants could perceive the sky during the passive displacement but not during the preceding clutching behaviour. (G) Ants not subjected to a passive displacement but to moderate wind and captured directly at the cookie pile while displaying the clutching behaviour. (H) Ants were not subjected to wind passive displacement but captured directly at the cookie pile in the absence of wind (P value results here from the Rayleigh test). (B–H) Each dot represents an individual heading direction at 30 cm (inner circle) and 60 cm (outer circle). Arrows indicate the mean vector of the group distribution. P values result from a V-test for the direction opposite to the wind direction (black arrowheads).

with ants having their ocelli covered with opaque paint all along the procedure. Despite covered ocelli, ants were equally accurate at heading in the direction opposite to the displacement when released on unfamiliar terrain (Figure 1E; K-test covered ocelli versus non-covered ocelli: P values > 0.311). Therefore, collecting such compass information does not require the fast processing of ocellar input, and presumably involves the perception of celestial cues via the compound eyes, with or without ocellar contribution.

Careful observations revealed that *M. bagoti* ants systematically display a particular behaviour before getting blown away. When sensing a wind gust the ants spread their legs and lower their body close to the floor, clutching the surface to resist the wind (see Supplemental Movie S1). Could this be the moment when ants collect directional information? To answer that question, we performed two complementary conditions.

In a first group, we used an opaque screen (40 × 40 cm) to prevent ants from perceiving the sky during clutching but not during the actual passive displacement. When released on unfamiliar terrain, these ants displayed undirected

headings (Figure 1F), showing that access to the sky during clutching is essential. In a second group, ants picking up a cookie crumb were exposed to moderate wind intensity and captured while still displaying the clutching behaviour. These ants could perceive the sky while clutching but did not get blown away. When released on unfamiliar terrain, they headed opposite to the wind they had experienced (Figure 1G), as if they had been blown away. This shows that actually getting blown away is not necessary for this kind of orientation. Instead, ants prepare themselves for displacement by measuring wind direction and obtaining celestial compass information before the passive displacement — while clutching the ground — and then respond appropriately whether they are displaced by the wind or by an experimenter.

The ecological function of collecting the wind direction is clear, as ants that get blown away increase their chances of returning to visually familiar areas quickly, sparing the cost of longer undirected searches. Mechanistically, this behaviour is intriguingly sophisticated as ants must somehow encode the

compass direction of the wind during clutching. Several sensory organs may be involved in monitoring wind direction. The most likely are the pedicellar Johnston organ of the antennae, as in *Cataglyphis* ants [6]. However, by itself any purely egocentric perceptions of wind direction would be useless after turbulent passive displacements (see Supplemental Movie S2) and in the subsequent absence of wind. Given that access to the sky during clutching is crucial (Figure 1F), ants must compute the wind's compass direction (for example, wind from west) by integrating the egocentric perception of the wind direction relative to their body axis (for example, wind from left) with celestial compass information from the eyes acquired during clutching (for example, body facing north) (see supplemental movie S1). The clutching behaviour clearly provides a time window for this computation, but whether clutching behaviour explicitly modulates or triggers it remains to be seen.

Insects can orient by combining sensory wind information with scents to track odour plumes [7], with vision to maintain a straight flight direction [8], or with compass information to optimise their trajectories during high-altitude migration [9]. *Cataglyphis* ants of Saharan salt-pans — where wind typically blows from a constant direction over considerable time — use a wind compass to bias their heading direction [6,10]. In these cases, however, orientation responses can be achieved via a continuous feedback system, in which the outputted direction is constantly calibrated against the currently perceived wind direction. In contrast, our results imply: first, that wind direction is encoded into a celestial compass reference; and second, that computations have to be made in advance, be stored and used afterwards. The use of celestial compass information in ants is not limited to path integration, but processed along multiple pathways to serve different navigational purposes.

We have shown that *M. bagoti* ants possess an elegant heuristic to cope with true passive displacements caused by wind gusts. By clutching the floor, they create and exploit a

small window of opportunity just before getting blown away, where information is available to compute the direction of the impending passive displacement. The solution does not reside in the ant itself, but arises from its interaction with the environment. This illustrates the inseparable relationship between organisms and their environmental niches.

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[1]School of Life Sciences, University of Sussex, Brighton, BN1 9QG, UK. [2]Department of Psychology, McMaster University, Hamilton, Ontario L8S 4K1, Canada. [3]Both authors contributed equally to this work.
*E-mail: a.wystrach@sussex.ac.uk

Parental misperception of youngest child size

Jordy Kaufman*, Joanne C. Tarasuik, Leila Dafner, Judy Russell, Sandra Marshall, and Denny Meyer

After the birth of a second child many parents report that their first child appears to grow suddenly and substantially larger. Why is this? One possibility is that this is simply a contrast effect that stems from comparing the older sibling to the new baby: "everything looks big compared to a newborn". But, such reports could be the result of a far more interesting biopsychological phenomenon. More specifically, we hypothesized that human parents are subject to a kind of 'baby illusion' under which they routinely misperceive their youngest child as smaller than he/she really is, regardless of the child's age. Then, when a new baby is born, this illusion ceases and the parent sees, for the first time, the erstwhile youngest at its true size. By this account the apparent growth results from the mismatch of the parent's now accurate perception with the stored memories of earlier misperceptions. Here we report that the baby illusion is a real and commonly occurring effect that recasts our understanding of how infantile features motivate parental caregiving [1].

Our study began with an online perceptual recollection survey of 747 mothers to validate the anecdotal reports of this perceptual experience. Over 70% of respondents indicated that the erstwhile-youngest child suddenly appeared bigger after the new infant's birth (for details see the Supplementary Information available on-line with this issue).

While the survey data are suggestive, it does not definitively inform us as to whether mothers routinely misperceived the sibling's size before the birth or were temporarily subject to a contrast effect afterwards. To more directly assess the baby illusion hypothesis we asked: do parents routinely misperceive their youngest child as smaller than he/she truly is?

To answer this question we conducted a height estimation experiment in which mothers estimated the height of one of their children (aged 2–6 years) by marking a featureless wall in the presence of an investigator. This estimation was then compared to an actual measurement of the child's height to calculate an estimation error.

Children were considered to belong to one of two birth order groups: Elder-children, who have at least one younger sibling; and Youngest-children, who have no younger siblings. The Youngest-children group includes 'only children', as there were no meaningful differences in estimates of Youngest-children who did and did not have an older sibling (see Supplementary Information).

The results of this experiment were striking: Youngest-children's heights were significantly underestimated by an average of 7.5 cm (SD = 7.2; t(38) = –6.44, p < 0.0001), whereas Elder-children estimates were basically accurate (average overestimation of 0.4 cm; SD = 5.6, t(37) = 0.48, p = 0.64) (Figure 1).

To assess any effects of child age, child sex, and actual child height, a subsequent full-factorial regression analysis used birth order, child age, child sex, and z-score for actual child height (i.e., statistical deviance from the population mean height of children of the same age and sex) to predict height estimation errors. Birth order was a significant predictor (F(1, 61) = 36.18, p < 0.0001, η^2 = 0.39), demonstrating that estimation errors differed significantly for Youngest-children compared with Elder-children.

The representational shift occurring when a new baby is born seems to happen suddenly rather than gradually. A gradual shift account would predict some residual underestimation to new Elder-children because they had recently been the youngest themselves. However, estimations of Elder-children (with one younger sibling) were not influenced by the age of the younger sibling (r(36) = 0.17, p = 0.30). A regression on Eldest-child estimation errors with Eldest-child and younger sibling age as predictors also failed to demonstrate any role of younger sibling age in the baby illusion (F(1,37) = 0.18, p = 0.67, η^2 = 0).