Path Integration in Desert Ants Controls Aggressiveness

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When close to the nest, Saharan desert ants, *Cataglyphis fortis*, are extremely aggressive toward members of other conspecific colonies, but their aggression fades away whenever they are farther from the nest than a few meters, while on their foraging journeys, for instance, which can take them up to 100 m away from the nest (*1*). Here we show that the state of the ant's path integrator, a navigational toolkit that tells the ant how far it is away from home (*2*), is sufficient to control the animal's level of aggression, independently of the actual presence of the nest, its odor cues, and landmark surroundings.

We trained foragers of four colonies to four different feeding sites, each 20 m north of their nest entrance. On reaching the feeder, the ants were marked with colony-specific color dots and transferred to a remote test field. On release, they immediately head south and run for a distance (their home vector) equivalent to their predisplacement distance to the nest (20 m). They then break off their straight homeward run and start a systematic search for the nonexistent nest.

In this experimental paradigm, we tested two groups of ants: zero vector ants, which had run off a home vector in the test field and were recaptured just after they had started to search at the fictive position of the nest, and 75 percent vector ants, which had run off only 5 m of their home vector, i.e., still had 15 m (75% of the feeder-to-nest distance) to go. The four colonies contributed equally to both groups (zero vector and 75 percent vector ants).

Both groups were then transferred to the laboratory and subjected to videotaped aggression tests. Individual members of either group entered the battlefield, a Perspex box 8 cm by 10 cm, within which they were confronted with each other for 1 min. Later, their videotaped aggressive interactions were analyzed by an independent observer, who could tell the two ants apart by their color labels but who was not informed of the state of either ant's path-integration vector. Two measures were taken: which ant started aggressive behavior (threatening with open mandibles) and which ant attacked by escalating fights (biting or spraying formic acid) (Fig. 1). Twenty-

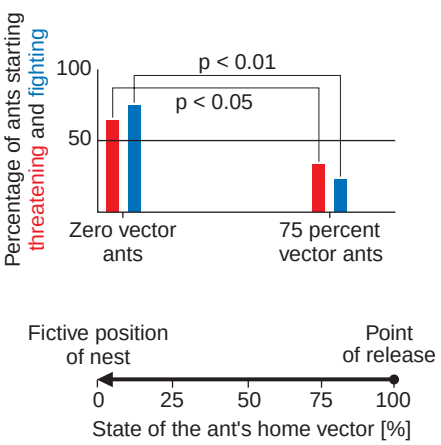

Fig. 1. Ants tested in unfamiliar terrain far off their nesting site exhibit significantly different levels of aggression depending on whether they have already run off their home vector (zero vector ants) or whether they have still three quarters of it to go (75 percent vector ants).

nine of 34 confrontations resulted in at least threats with open mandibles (85.3%, corresponding well with the 84.0%, $n = 70$ encounters, recorded in ants taken from the nest directly), and 21 of 34 led to escalated fights. The zero vector ants started the aggressive encounters (one-tailed χ^2 test, $n = 29$ encounters, $P < 0.05$) and provoked escalating fights ($n = 21$ encounters, $P < 0.01$). Because both groups of ants underwent identical experimental treatment, with the only exception that the zero vector ants had already run off their full home vector whereas the others had not, it was the state of the path integrator that influenced the ant's level of aggressiveness, with the zero state causing maximal aggression.

Rapid changes in the readiness to fight have been observed in territorial butterflies (*3*) and crayfish (*4*), but our report shows that short-term changes in the level of aggression can depend exclusively on an internal (navigational) state of the animal rather than on external cues such as the surrounding territory or the size of an opponent. Because serotonin and octopamine play key roles in insects (*5*, *6*) and crustaceans (*4*) in balancing the motivations to fight and to retreat, our finding might suggest an involvement for these biogenic amines in the neurobiology of the insect's path integrator as well.

References and Notes

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