Complex activity patterns emerge from simple underlying laws

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A new study from researchers at Uppsala University and University of Havana uses mathematic modeling and experiments on ants to show that a group is capable of developing flexible resource management strategies and characteristic responses of its own. The results are now published in *Physical Review Letters*.

Group-living animals are led to regulate their activity and to make decisions on how to manage resources, under the action of a variety of environmental stimuli and of their intrinsic interactions. The latter are typically cooperative, in the sense that the activity of a single animal increases nonlinearly with the number of already active ones.

The researchers monitored experimentally and using mathematical modeling the activity profile of food-searching ants in a natural environment. The number of ants entering in or exiting the nest was recorded as well as the local temperature over several days.

The study shows that the group is capable of developing flexible resource management strategies and characteristic responses of its own. This is achieved by operating in an aperiodic fashion close to a regime of chaos, where nonlinearity is especially pronounced and offers the group more options than just following passively the day/night temperature cycle.

Furthermore, the group bursts into its foraging activity rapidly and subsequently relaxes to the inactive mode more slowly. This flexible

behavior is reminiscent of "free will" in the sense that groups' activities are not totally constrained by the environment but on the contrary constitute new, emerging modes of behavior not encoded in the external stimuli or in the activity rhythms of the individuals within the group.

"Our results are likely to account for a wide range of temporal rhythms observed across the animal kingdom as well as in human societies", says Stamatios Nicolis, researcher at the Department of Mathematics, who lead the study.

"For instance, signal processing in the brain typically leads to complex patterns of electrical activity as witnessed by the electroencephalogram whose aperiodic, chaotic-looking structure is not a simple replica of the signal but reflects instead the ability of the brain to store vast amounts information and to process them selectively depending on the circumstances", says Stamatios Nicolis.

More information: Nicolis, S. et al. Foraging at the edge of chaos: Internal clock versus external forcing, *Phys. Rev. Lett.* 110, 268104 (2013). DOI: 10.1103/PhysRevLett.110.268104

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