Sensory Networks and Distributed Cognition in Animal Groups

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ABSTRACT

Understanding how social influence shapes biological processes is a central challenge in contemporary science, essential for achieving progress in a variety of fields ranging from the organization and evolution of coordinated collective action among cells, or animals, to the dynamics of information exchange in human societies. Using an integrated experimental and theoretical approach, I will address how, and why, animals coordinate behavior. In many schooling fish and flocking birds, decision-making by individuals is so integrated that it has been associated with the concept of a "collective mind". As each organism has relatively local sensing ability, coordinated animal groups have evolved collective strategies that allow individuals, through the dynamical properties of social transmission, to access higher-order capabilities at the group level. However we know very little about the relationship between individual and collective cognition. A major limitation is that it has not been possible to observe directly the pathways of communication, and social networks are typically based on proxies such as spatial proximity among organisms. I will demonstrate new imaging technology that allows us to reconstruct (automatically) the dynamic, time-varying networks that correspond to the visual cues employed by organisms when making movement decisions. Sensory networks are shown to provide a much more accurate representation of how social influence propagates in groups, and one that cannot be captured correctly by social networks based on spatial proximity (regardless of how they are parameterized). I investigate the coupling between spatial and information dynamics in groups and reveal that emergent problem solving is the predominant mechanism by which mobile groups sense, and respond to complex environmental gradients. This distributed sensing requires rudimentary cognition and is shown to be highly robust to noise. I will also demonstrate the critical role uninformed individuals (those who have no information about the feature upon which a collective decision is being made) play in fast, and effective, democratic consensus decision-making in collectives.

Categories and Subject Descriptors

H.5.m Miscellaneous

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Bio

Iain Couzin is a Professor in the Department of Ecology and Evolutionary Biology at Princeton University. Previously he was an Assistant Professor at Princeton University, a Royal Society University Research Fellow in the Department of Zoology, University of Oxford, and Junior Research Fellow in the Sciences at Balliol College, Oxford. His work aims to reveal the fundamental principles that underlie evolved collective behavior, and consequently his research includes the study of a wide range of biological systems, from cellular collectives to insect swarms, fish schools and human crowds. In recognition of his research he was recipient of a Searle Scholar Award in 2008, the Mohammed Dahleh Award in 2009, Popular Science Magazines "Brilliant 10" award in 2010, PopTech Science and Public Leadership award in 2011 and National Geographic Emerging Explorer Award in 2012.