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Evolution of self-organized division of labor
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Division of labor (DOL) is characterized by the coordinated interaction of individuals that collectively achieve a common goal by specializing on certain tasks. It is undisputed that DOL is a key feature for the ecological success of social insects. Yet, the evolution of DOL is not well-understood. Natural selection on DOL is indirect, since DOL is not a heritable property in itself but the result of self-organization. The challenge is to understand how selection acting on individual behavior results in the evolution of well-organized collective behavior. To meet this challenge, we develop and analyze models for the evolution of heritable neural networks that determine the response of individuals to external stimuli. Within a colony of insects, all workers are endowed with a neural network that reflect the genetic information inherited from their parents. These networks steer the behavior of individual workers and collectively the functioning and productivity of the colony. Colony performance determines the rate at which reproductives are produced and, hence, colony fitness. Well-performing colonies (where the neural networks of the workers lead to the emergence of DOL) transmit the genes underlying the neural networks at a higher rate than less well performing colonies. Previous studies revealed that this process can lead to the evolutionary emergence of efficient DOL from scratch. The models developed thus far are not fully satisfactory, since they focus on DOL under constant conditions, where a fixed distribution of tasks is selectively favored. In contrast, the flexible rescheduling of tasks in response to a changing state of the colony or to changing environmental conditions is a hallmark of DOL in social insects. Here we present some first results on the evolution of flexible DOL, which illustrate both the scope and the limitations of neural network models for understanding the evolution of self-organized DOL.