Bistability and noise improve information propagation in social and biological networks.

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In many social and biological populations, individuals try to infer information about environmental conditions collectively and by sharing information among themselves. Successful accomplishment of this task requires individuals to solve different challenges. Individuals need to combine social information and private information to make optimal decisions. In addition, in a fluctuating environment, they need to make fast decisions but accurate enough. How can these trade-offs be solved optimally?

To address this question, I introduce a model of collective information acquisition. In this model, a population of individuals residing on a communication network can make noisy observations of the environment and communicate their beliefs by production and comprehension of the signals. By analyzing the model using mean-field equations and simulation, I show that the model shows different phases. For a large amount of noise in communication, the model settles in a disordered phase in which consensus is not formed. Consensus is formed for a low amount of noise in communication. However, two different consensus states exist. When the flow of information from the environment to the population through personal observation is small, a misinformed consensus in which the population forms a consensus on a wrong belief about the environmental state is formed. On the other hand, when the flow of information from the environment to the population is large, informed consensus, in which consensus on a correct belief about the environmental state is formed, occurs.

Analysis of the model shows that depending on the model's parameters, different phases can be stable. Given the rich bifurcation diagram of the model, the important question arises: under what conditions can the population make optimal use of information? I show that while communication noise can increase decision-making speed, it also decreases decision-making accuracy. Interestingly, the optimal speed-accuracy trade-off is reached exactly on the edge of bistability, where the system is barely bistable, and both informed and misinformed consensuses are possible. In this region, an optimal amount of noise solves both the speed-accuracy trade-off and the trade-off between the use of social information and personal information.

This analysis thus shows being on the edge of bistability, and an optimal amount of noise in communication is beneficial for the propagation of information in social and biological networks and can increase the responsiveness of the population to environmental fluctuations. This conclusion parallels some arguments according to which noise can improve biological functions and extends such a line of thought to the propagation of information in social networks.

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