Individual bias and fluctuations in collective decision making: analytical results and simulations

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We reconsider the spin model suggested recently to understand some features of collective decision making among higher organisms [1]. Within the model, the state of an agent i is described by the pair of variables corresponding to its opinion $S_i=\pm 1$ and a bias ω_i towards any of the opposing values of S_i. Collective decision making is interpreted as an approach to the equilibrium state within the non-linear voter model subject to social pressure and a probabilistic algorithm. Here, we push such physical analogy further and give the statistical physics interpretation of the model, describing it in terms of the Hamiltonian of interaction and looking for the equilibrium state via explicit calculation of its partition function. We show that depending on the assumptions about the nature of social interactions two different Hamiltonians can be formulated, which can be solved with different methods. In such an interpretation the temperature serves as a measure of fluctuations, not considered before in the original model. We find exact solutions for the thermodynamics of the model on the complete graph. The general analytical predictions are confirmed using individual-based simulations. The simulations allow us also to study the impact of system size and initial conditions in the collective decision making in finite-sized systems, in particular with respect to convergence to metastable states. We discuss advantages and flaws of such an approach as well as its utility to understand impact of population heterogeneity, type of local interaction and fluctuations on the collective decision making. [2].

References

[1] A.T. Hartnett et al., Phys. Rev. Lett. 116, 038701 (2016).
[2] P. Sarkanych, M. Krasnytska, L. Gómez-Nava, P. Romanczuk, Y. Holovatch, Individual bias and fluctuations in collective decision making: from algorithms to Hamiltonians, https://arxiv.org/abs/2302.12945 (2023).