Talking loud or talking often: How the interplay between network structure and agent influence affects the time to reach consensus in collective decision-making

Cedric Perret,[1] Guillaume St-Onge,[2] Zohar Neu,[3] and Andrea Santoro[4,5]

[1]*School of Computing, Edinburgh Napier University, Edinburgh, EH10 5DT, United Kingdom*
[2]*Département de Physique, de Génie Physique, et d'Optique,*
Université Laval, Québec (Québec), Canada G1V 0A6
[3]*Department of Engineering Mathematics, University of Bristol, Woodland Road, Bristol, BS8 1UB*
[4]*School of Mathematical Sciences, Queen Mary University of London, Mile End Road, E1 4NS, London, UK*
[5]*The Alan Turing Institute, The British Library, London NW1 2DB, UK*
(Dated: November 2, 2018)

Consensus-seeking processes are core mechanisms for social organization in non-human animal groups, human societies, artificial and multi-agent systems. Such processes consist of a series of negotiations between individuals, which ultimately aggregate different individual opinions into one common agreed decision. Related works have shown that a small number of influential and highly centralized agents i.e. leaders, considerably speed up the consensus-seeking process. Yet the important features of hierarchy and leaders have not been clearly identified and their investigation in experiments provide contradictory evidence. To disentangle these effects, we separate two features of hierarchy (i) the level of centralization ν and (ii) the number of leaders N_L, i.e. influential individuals. We therefore developed a continuous opinion formation model to explore the effect of each feature and their interplay on the time to reach a global consensus. The results show that the most important feature is the topology of the network structure, with higher centralization always decreasing the time to reach consensus. In addition, it also demonstrates that the effect of influential individuals are deeply entangled with the underlying network structure. Indeed, it can be beneficial to have a few leaders if the structure is centralized, but surprisingly it can also be detrimental if the population is homogeneous. Our results provide a mechanistic explanation of the "babble" hypothesis which stresses the importance of talkativeness and extraversion of leaders. Further directions involve a full characterization of the main mechanisms leading to polarization or fragmentation as final states in more complex network structures, such as modular structures with nested hierarchies.
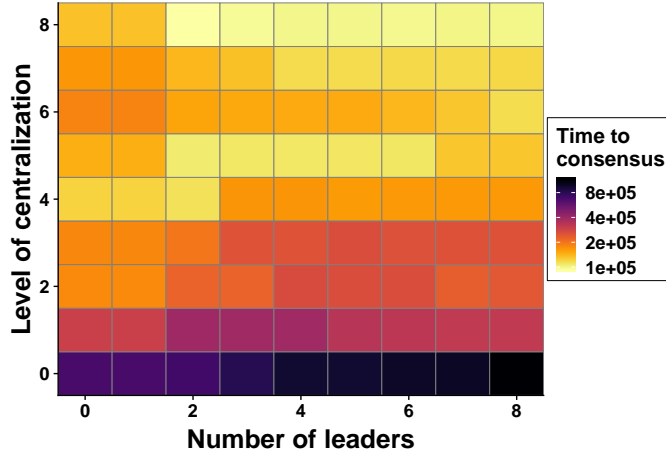
FIG. 1.   Time to reach consensus τ as a function of the number of leaders N_L in the network and the level of centralization ν, which dictates the heterogeneity of the network. Simulations are averaged over 200 realizations, with networks having $N = 200$ node, an average degree $\langle k \rangle = 4$ and influence parameters $\alpha_L = 0.9$, $\alpha_F = 0.1$ for the leaders and the followers respectively.