Networks and people (in)effficiency

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1 Purpose/aim & Background

Many organizational outcomes rely on a group of individuals trying to find the best idea, innovation or solution to a problem. Research on problem-solving and group performance has largely been shaped by the discussion about networks efficiency. From the classic experiments [1, 2] to the more recent computational approaches [3, 4], many publications have tried to determine how the structure of the communication network between individuals affects group-performance [5]. The logic behind the focus on network efficiency is simple: in collective problem solving, individuals can obtain information and learn from the solutions/performance of other individuals. If the performance/behavior of an individual is affected by access to the information of others, group-performance is dependent on the structure of the network of connections between these individuals, specifically, to the efficiency with which that the network can facilitate this access. The most efficient networks (e.g., a fully connected network) facilitate the transmission of information between group members, while less efficient networks mean slower access to other solutions available in the system.

While the logic seems straightforward, reconciling different results regarding the relationship between group performance and networks efficiency has turned out to be a difficult task. Until now, scholars have not been able to provide a clear explanation as of why regardless of the methodology (experimental or computational) some authors have found that inefficient networks outperformed efficient networks [3, 4, 6, 7], while others have found evidence for the contrary [3, 8, 9]. Hereby, I claim that mixing networks and people (in)efficiency is at the core of these conflicting results. In short, inefficiencies in collective problem-solving led to better group performance. When people act as efficient decision makers good performance can be achieved by introducing inefficiencies at the level of the network. On the contrary, when people act as inefficient decision makers better performance is achieved through having a efficient network.

A previously absent detailed look into the literature about group performance and networks efficiency gives theoretical support for this claim. On the one hand, research in which computational agents are guided by the best available solutions [3, 4] or in which experimental subjects are incentivized to hold a good solution as long as possible [6, 7], are driven by efficient-like decision makers who very quickly copy the best solutions available in the system. In this research, inefficient networks outperformed efficient networks. On the other hand, experiments where individuals are not "forced" to hold good solutions as soon as possible [8, 9] or computational models where the inefficiencies of individual decision-making are included [3, 9] suggest efficient networks perform better. Therefore, what we should be asking is not ¿which type of networks are better?, but ¿where and how do inefficiencies in group problem solving occur?. Networks can be inefficient, but people are also inefficient decision makers with both types of (in)efficiencies shaping group-performance (see Figure 1)

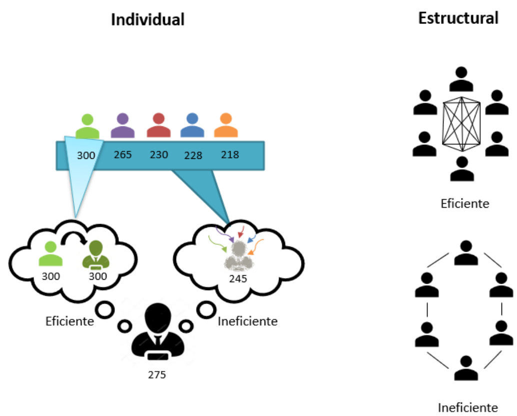

Fig. 1. At the individual level (left) decision-making determines the efficiencies/inefficiencies. Decisions are efficient when focused on copying the best solutions available in the system; on the contrary, they are inefficient when good solutions are ignored by giving preference to re-combinations, the design of new solutions or by following decision heuristics. At the structural level (right), efficient structures facilitate the transmission of information between the members of the group (e.g., a fully connected network); on the contrary, inefficient networks are those in which the information requires several steps to be distributed (e.g., a circular network). The introduction of inefficiencies at any of these levels results in better group performance in collective problem solving.

To further support that claim, in this paper I build a computational simulation to test the effects of (in)efficiency at the individual and network level on group performance. In that sense the model aims to be a computational probe of the theorethical claim and the need to modify the network paradigm in the understanding of group performance.

2 Methodology

An agent-based model to simulate a search process in which n number of agents connected through a network try to find the best solution to a problem. The model shares the logic of experimental and computational research on collaborative problem-solving: (i) the problem is represented as a solution landscape with peaks and valleys of performance. (ii) the ruggedness of the lanscape accounts for the complexity of the problem (iii) agents aim to find the best solution to the problem by "walking" through the landscape (iv) at any given point in time, each agent holds a solution (position) in the landscape. The performance of each solution is measured by the *fitness-value* of that specific position in the landscape (v) agents can see the performance of the individuals to whom they are connected.

(In)efficiencies at the network level are introduced by controlling the density of the communication network between the agents. Combining the computational model with experimental work, (in)efficiencies at the individual level are introduced by controlling the frequency of the "copy of the best solution" mechanism and replacing it with an experimental result showing that individuals decisions on how far to search in a landscape are affected by the number of repeated fitness values they observe in their network (see figure 2).

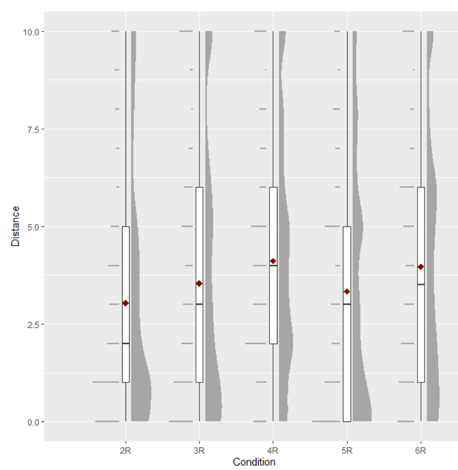

Fig. 2. Experimental results showing how far from their current position individuals search according to the amount of repeated values they see in their alters (from 2 to 6)

3 Originality/Value

While the proposed model shares the logic of other collaborative problem-solving simulation models, the main value of this paper lies on its aim to give a theorethical and computational probe on the importance of accounting for the intersection of network and people (in)efficiencies in the understanding of group problem solving. Obsessed with concluding which type of networks were better, previous literature have focused on establishing whether certain results give support or contradict the general claim of inefficient networks outperforming their efficient counterparts. However, none of them had given a comprehensive explanation to reconcile this different results. I claim efficient networks can be better on worse depending on whether individuals are efficient or not.

4 Results

According to the theorethical claim, results show that, in general, inefficient problem-solving leds to better group performance. This inefficiency can be achieved through two ways, having inefficient networks or inefficient decision makers. When the network is efficient, efficient individuals perform worst than inefficient groups. However, when the network is inefficient, efficient individuals perform better than inefficient ones. Together, these results suggest group problem-solving should balance the (in)efficiencies of networks and people. Surprisingly, inefficient individuals in inefficient networks do not perform better than individuals in the "balanced" combinations suggesting that too much inefficiency leds to worse performance. These results are consistent with the general claim of keeping variety of solutions in a the system to benefit team perfomance [4]. Results are also consistent with the previously discussed papers showing that efficient networks are better and worse for group performance and with many other publications whose findings can be classified either as (in)efficiencies at the individual [10–12] or network level [13, 14].

5 Conclusions

While at first glance research on collective problem solving, networks and group perfomance seems contradictory, I suggest the problem lies at mixing two levels of analysis: the individual informational level and the structural one. Inefficiencies in collective problem-solving processes lead to better performance outcomes. However, these inefficiencies may not only exist at the network level, hindering the rapid transfer of information, they may also exist at the level of the search decisions of individuals who, by following "imperfect" decision heuristics, produce delays in the mechanisms of copying and in the early disappearance of diverse solutions in the system. In other words, when the structure of connections between individuals is inefficient (e.g., individuals are connected through a network in which there is no direct access to everyone's information) or when individuals make imperfect decisions (e.g., search solutions ignoring the availability of a superior solution) an inefficient solution search process results in better overall system performance. Thus, differentiating the individual level from the structural one can reconcile two branches of results they seemed separate.

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