Reputation-driven interactions influence the emergence of technological innovations

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The development of novel technologies is highly influenced by the interactions between individuals, and one way of studying this interactions is using networked structures to mimic real human societies. With this work [1], we aim to study the importance of reputation-based interactions using a dynamic model which includes an interaction mechanism by which a pair of agents meet and merge their knowledge, having the possibility of discovering a novel technology of higher value. Moreover, we include the concept of reputation to examine the implications of prestige in the processes of human culture accumulation. The results show a notorious effect: while preferential engagement with prestigious individuals speeds up innovation, an excessively exclusive concentration of interactions among them hampers the process of discovering new technologies. Besides, this lack of technological breakthrough results in heterogeneous societies, where few individuals can reach higher-level innovations and the overall skill diversity is diminished.

The model used in the simulations is adapted from the one proposed by M. Derex and R. Boyd [2]. Cultural knowledge of each individual i is defined by a vector $\vec{r}_i(t)$ with binary entries $\left((\vec{r}_i(t))_\alpha = 1\right.$ if ingredient α is known and $(\vec{r}_i(t))_\alpha = 0$ otherwise). Each innovation is associated with an intrinsic fitness f_α, helping in the quantification of the cultural score of individuals at a given time t, denoted as $s_i(t)$. Besides, there are two different lineages and to reach the highest-value innovation, called crossover, the hybridization of both trajectories is necessary (Fig 1.a). To study reputation-driven contacts we make use not only of the score $s_i(t)$, but also the connectivity k_i, which denotes the degree of each individual in the network structure, leading to three possible interactions: random, degree-driven (DD) and score-driven (SD) contact. In addition, we introduce a parameter γ which allows us to tune the driving strength, recovering the random case when $\gamma = 0$.

Finally, we have derived a macroscopic observable that allows us to quantify the degree of bias towards one lineage, denoted as ρ. Hence, the combination of both control parameters, time to crossover t_c and technological bias ρ, provides a good way of characterizing the model and explains the main results, as shown in Figure 1.b.

[1] Gallarta-Sáenz, P., Pérez-Martínez, H., and Gómez-Gardeñes, J. (2023). Emergence of innovations in networked populations with reputation-driven interactions. arXiv preprint arXiv:2312.01812..

[2] M. Derex and R. Boyd, "Partial connectivity increases cultural accumulation within groups," Proceedings of the National Academy of Sciences 113, 2982–2987 (2016).

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Figure 1: (a) Innovation chart of the model with the specific triads of items which lead to new discoveries. (b) Average time to crossover $\langle t_c \rangle$ (left axis) and average unsigned technological bias $\langle |\rho_a| \rangle$ (right axis) as function of γ.