How ‘First Carrot, Then Stick’ Incentives Promote Cooperation

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We assume the existence of institutions that can provide incentives on a limited budget. The policy switches the incentive from rewarding to punishing when the frequency of cooperators exceeds a threshold. The amount of rewards (or penalties) per target is equal to the incentive budget divided by the number of cooperators (or defectors). We find that this policy establishes and maintains full cooperation at lower cost and under a wider range of conditions than either rewarding or punishing alone, in infinitely large, well-mixed populations, as well as in spatially structured populations.

Adaptive hybridization of carrots and sticks

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Widely applicable and surprisingly inexpensive

Individuals play the game with the nearest four neighbors on the 100 × 100 square lattice, in which a single cooperator is initially given among a defector population. Specifically, the domain of applicability of the adaptive hybrid policy is the widest among the three incentive strategies (a–c). Once full cooperation has been established, the adaptive hybrid policy and pure punishing are equally successful in preventing the emergence of defectors. The adaptive hybrid policy is also the least expensive method of establishing cooperation among the three incentive strategies (d–f).

Once a state of full cooperation has been reached, the adaptive hybrid policy, as well as pure punishment, is cheaper as a means of maintaining cooperation since it needs to be used only occasionally.

Best of both worlds

In the structured population, cooperators thrive under a policy of pure rewarding (g), forming local mixtures with defectors, but ultimately fail to establish a cooperative norm for the incentive strength considered. With pure punishing (h), an invasion which begins with a single cooperator always results in a cluster of cooperators that grows and eventually displaces all defectors. The adaptive hybrid policy (i), on the other hand, exhibits an intriguing phase transition. Punishment acts as a ‘booster stage’ that capitalizes on and amplifies the pro-social effects of rewarding.