Time scales in evolutionary dynamics

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Abstract

A fundamental, profound and broad-ranging unsolved question is how cooperation among animals and humans has evolved. Evolutionary game theory is the mathematical framework that has provided the deepest insights into this issue. Simple games such as the Prisoner's Dilemma, the snowdrift game or the stag-hunt game have been the subject of intense experimental and theoretical work along this line. The emergence of cooperation has been shown to be sensitive to whether populations are well-mixed, such as in replicator dynamics evolution, or spatially structured. Co-evolution of agents and networks and finite population effects are also relevant factors. None of these approaches has considered the influence of different evolution rates. Here we show that the pace at which selection acts on the population is crucial for the appearance and stability of cooperation. Even in non-dilemma games such as Harmony, where cooperation is the only possible rational outcome, defectors may be selected for if population renewal is very rapid. Similar results are found for coordination games such as the stag-hunt, where the basins of attraction of cooperation and defection depend on the evolution rate. Our results point out the necessity to include a discussion of the time scale of evolution in any study about cooperation.