A 2D Simulation of Paleolithic Cooperation

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Introduction

This simulation investigates how cooperative behaviour can prevail in human societies, despite coming at a higher cost than selfish behaviour.



Social dilemmas

- Without punishment, **defection** would be the **best strategy** (leading to reward without risk)
- Widespread defection leads to exctinction
- **Punishment** solves the problem, but has a high cost
- => How can cooperation evolve and prevail?

Results

1) Compulsory cooperation leads to a population **dominated by defectors**² (and, ultimately, **extinction**)



Human agents can act in a **2D stone age environment** containing **plants** for foraging, **mammoths** as hunting prey and stones obstructing sight. All **humans** have **strategies**:

- Cooperators help during a hunt, and receive large rewards if the hunt is successful, but also take damage and can even die
- Defectors participate and receive rewards, but do not cooperate and thus are not in danger of injury or death
- **Punishers** cooperate in hunts, and also punish Defectors upon catching them, putting themselves at further risk
- Loners abstain from hunting and survive by foraging A human can **adopt** foreign **strategies** if it perceives them to be more successful, and can sometimes randomly switch strategies (mutation). Humans can **reproduce** if they have accumulated enough rewards, and can die of injuries, malnourishment, or age.

2) Voluntary cooperation (with the **option** to **abstain**) leads to a reliably stable **majority** of **cooperators**²



Since a part of the population abstains, defector group sizes are smaller against which punishers have a chance²

3) With **insufficient information** and **coordination** (many obstacles), **cooperators** can **prevail** and the population can survive even with **no option** to **abstain**



Conclusion and Implications

Among selfish individuals, **cooperation** can only emerge

Simulation mechanism

The **simulation environment** is a two-dimensional grid with periodic boundary conditions (torus surface), the cells of which contain the entities (plants and stones) and agents (humans and mammoths). In every step of the simulation, the agents can choose an action which will preferably lead to a large reward. **Mammoths** have a limited set of actions - they move toward the nearest plant and feed upon reaching it, until it is depleted, then they move on. They also try to run from larger groups of humans, unless they are too hungry to flee. **Humans** try to maximize their rewards according to their current strategy. These are randomly assigned upon starting the simulation, and can change through imitation or mutation. Hunters approach and join a hunt if they see one (coordination).

with sufficient **punishment**.

Punishment can easily **prevail** and save the population if cooperation is **optional** (there is an option to **abstain**) If cooperation is **compulsory**, stable cooperation is only possible with **insufficient coordination**, which leads to smaller group sizes and thus less cost for punishers.

Individuals in many **hunter-gatherer societies**^{2,3} have a great deal of **freedom** -> voluntary participation -> stable majority of **cooperation Climate preservation**: requires cooperation, which is **compulsory** -> widespread **defection**

References

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