Cooperation, punishment, emergence of government and the tragedy of authorities

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August 2009
Game theory. Nash equilibrium
Deviations from Nash equilibrium in human games
Is strong reciprocity evolutionary stable?
Network dependence of strong reciprocity
Emergence of government
The tragedy of authorities
Game theory. Nash equilibrium

- Game theory: Study of multi-person decision problems influencing one another's welfare

A set of strategies \( (s_1, s_2, \ldots, s_k, \ldots, s_n) \) is a Nash equilibrium if the payoffs satisfy
\[
P(s_1, s_2, \ldots, s_k, \ldots, s_n) > P(s_1, s_2, \ldots, s_0, \ldots, s_n)
\]
for all \( s_0 \).

No player can improve his payoff by changing his strategy, when the strategies of the other players are fixed.

Theorem: (Nash) Every N-player game, with finite strategies, has at least one equilibrium, in pure or mixed strategies.

In economy, Nash equilibrium (Homo Oeconomicus). Provides a sound basis for (almost) the whole of (rigorous) economic theory.
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Deviations from Nash equilibrium in human games

The ultimatum game (monopoly pricing of perishable good)

Acceptance $\rightarrow$ (a,c)  $\uparrow$
Proposer $a$ $\rightarrow$ Responder $\Rightarrow$ Payoff  $\downarrow$
Non-accept. $\rightarrow$ (0,0)

$a + c = 2b$, $a \gg c$
$(a = 99, c = 1, b = 50)$

<table>
<thead>
<tr>
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<th>R0</th>
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<tr>
<td>P0</td>
<td>(a,c)</td>
<td>0,0</td>
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Figure 2 - Cumulative Ultimatum Proposals

Context dependence
Deviations from Nash equilibrium in human games
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Deviations from Nash equilibrium in human games

Fair offers correlate with market integration and cooperativeness in everyday life
Likewise, strong deviations from Nash equilibrium are found in other experimental games:

- The public goods game (with and without punishment)
- Dictator game
- Gift exchange game
- Third party punishment game
- The trust game
Deviations from Nash equilibrium in human games

- Exits *Homo Oeconomicus* (Neo-classical economic theory)

Samuel Bowles, Herbert Gintis

“Homo reciprocans comes to new social situations with a propensity to cooperate and share, responds to cooperative behavior by maintaining or increasing the level of cooperation and responds to selfish free-riding behavior on the part of others by retaliating, even at a cost to himself and even when he could not expect future personal gains”

Strong reciprocity, altruistic punishment (even third-party punishment)

Strong reciprocity is a form of altruism in that it benefits others at the expense of the individual that exhibits this trait.

From the biological point of view, human cooperation is an evolutionary puzzle.
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- genetically unrelated individuals,
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- when reputation gains are small or absent,
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They are cooperative in helping each other, cooperative in achieving material and intellectual achievements unmatched by other species, but also cooperative in war and genocide.
Is strong reciprocity evolutionary stable?

A model (Bowles and Gintis, JTB 2004)

- A population of size $N$ with two types of agents: 
  - Reciprocators (R-agents)
  - Self-regarding (S-agents)
- A public goods activity: each agent can produce a maximum amount of goods $q$ at cost $b$. 

$\sigma$ being the fraction of time the agent shirks 
$b(0) = b, b(1) = 0, b(0)(\sigma) < 0, b(00)(\sigma) > 0$, at every level of effort, working helps the group more than it hurts the worker.

$b(\sigma) = \frac{2\sigma + p}{1 + \frac{4}{b^2(1 + p)}}$ 

R-agents never shirk and punish each free-rider at cost $c\sigma$, the cost being shared by all R-agents.
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  $b(0) = b, \quad b(1) = 0, \quad b'(\sigma) < 0, \quad b''(\sigma) > 0$

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  $$b(\sigma) = \frac{2}{2\sigma - 1 + \sqrt{1 + 4/b}} - \frac{2}{1 + \sqrt{1 + 4/b}}$$
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For an S-agent the estimated cost of being punished is \( s\sigma \). Punishment and cost of punishment are proportional to \( \sigma \). Each S-agent chooses \( \sigma \) to minimize the function

\[
B(\sigma) = b(\sigma) + sf\sigma - q(1 - \sigma) \frac{1}{N} f
\]

\( f = \) fraction of R-agents in the population, \( f\sigma = \) probability of being monitored and punished. The value \( \sigma_S \) that minimizes \( B(\sigma) \) is

\[
\sigma_S = \max \left( \min \left( \frac{1}{2} - \sqrt{\frac{1}{4} + \frac{1}{b} + \frac{1}{\sqrt{sf + \frac{q}{N}}}}, 1 \right), 0 \right)
\]
Is strong reciprocity evolutionary stable?

- The contribution of each species to the population in the next time period is proportional to its fitness,

\[
\begin{align*}
\pi'_S (f) & = q (1 - (1 - f) \sigma_S) - b (\sigma_S) - \gamma f \sigma_S \\
\pi'_R (f) & = q (1 - (1 - f) \sigma_S) - b - c (1 - f) \frac{N \sigma_S}{N f} \\
\pi_{S,R} & = \max \left( \pi'_{S,R}, 0 \right)
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\]

\[\pi_{S,R} = \max\left(\pi_{S,R}', 0\right)\]

- One-dimensional map for the evolution of the fraction \( f \) of R-agents

\[f_{new} = f \frac{\Pi_R(f)}{(1 - f)\Pi_S + f\Pi_R(f)}\]
Is strong reciprocity evolutionary stable?

Figure 1: 
- $f_{new}$ vs $f$ with $q=2, b=1, s=2, c=0.1, \gamma=3.5, N=1000$
- $\sigma_s$ vs $f$
- $\pi_R$ vs $f$
- $\pi_S - \pi_R$ vs $f$
Is strong reciprocity evolutionary stable?

q=2, b=1, s=2, c=0.1, γ=1, N=1000

Fig. 2
Is strong reciprocity evolutionary stable?

- A narrow margin for strong reciprocity, unless one invokes group selection

The idea that group selection might explain human behavior goes back to Darwin himself who, in chapter 5 of the "Descent of man and selection in relation to sex", states that "... an increase in the number of well-endowed men and an advancement in the standard of morality will certainly give an immense advantage of one tribe over another."

However, this idea felt in disrepute because evolution does not pitch groups against groups, nor individuals against individuals, but genes against genes. A "selfish gene" analysis makes the altruistic good-of-the-group outcome virtually impossible to achieve. In particular because the late Pleistocene groups of modern man were not believed to be genetically sufficient different to favor group selection. Therefore, human cooperation is still considered an evolutionary puzzle.
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- However the group selection mechanism might work in the particular environment of the hunter-gatherer groups of the late Pleistocene (corresponding to 95% of the evolutionary time of modern man)

- The cost of the group beneficial behavior of an individual would be limited by the emergence of group-level social norms.

- On the other hand, even in the absence of these group-level norms, group selection pressures would support the evolution of the cooperative-altruistic punishment trait if intergroup conflicts were very frequent.

That is, egalitarian practices among ancestral humans reduces the force of individual selection against altruists, while frequent warfare makes altruistic cooperation among group members essential to survival. Parochial altruism and warfare could have coevolved.
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The work of an S-agent is inversely proportional to the number of reciprocators in his neighborhood. Lack of communication between neighboring reciprocators makes the probability of punishment smaller.
Network dependence of strong reciprocity

The structure of the network plays an important role (clustering). Uses the $\beta$–model of Watts and Strogatz

![Graphs showing network dependence](image)

Conclusion: The reciprocator trait cannot not be maintained in a two-agent model with high $\beta$
Emergence of government

- Three types of agents:
  - R-agents
  - S-agents
  - A-agents

\[
\begin{align*}
\pi'_R &= q \left(1 - f_A - f_S \sigma_S\right) x - b - cp(N) f_S \frac{N \sigma_S}{Nf_R} \\
\pi'_S &= q \left(1 - f_A - f_S \sigma_S\right) x - b \left(\sigma_S\right) - \gamma p(N) f_R + \gamma_A f_A \sigma_S \\
\pi'_A &= q \left(1 - f_A - f_S \sigma_S\right) wx - c_A f_S \frac{N \sigma_S}{Nf_A}
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\]

The factors \(x\) and \(wx\) with \(x = \frac{1}{wf_A + 1 - f_A}\) account for the fact that the amount of public goods given to R- and S-agents is the same, but might be different for A-agents.
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\]
\[
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The factors \( x \) and \( wx \) with \( x = \frac{1}{wf_A + 1 - f_A} \) account for the fact that the amount of public goods given to R- and S-agents is the same, but might be different for A-agents.

- \( p(N) = \) punishment probability by R-agents, decreasing with \( N \).
  - Choose a simple function

\[
p(N) = \sqrt{\frac{1 + \delta}{1 + \delta N / N_0}}
\]
Emergence of government

- Evolution

\[ f_{\alpha,\text{new}} = f_\alpha \frac{\pi_\alpha(f)}{f_R \pi_S + f_s \pi_S + f_A \pi_A} \]

\( \alpha = R, S, A. \)
Emergence of government

Evolution

\[ f_{\alpha, new} = f_{\alpha} \frac{\Pi_{\alpha} (f)}{f_R \Pi_S + f_s \Pi_S + f_A \Pi_A} \]

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Population increasing in time according to a global fitness dependent law

\[ N(t+1) = N(t) e^{\beta \pi} \]

with \( \pi = \sum_{\alpha} f_{\alpha} \pi_{\alpha} \)
Emergence of government

$f_A = 0$, The one-dimensional map for two values of $p(N)$

![Graph showing the one-dimensional map for two values of $p(N)$](image)

- For $p(N) = 1.0$, the map shows a linear relationship with a slope of 1.
- For $p(N) = 0.5$, the map shows a less steep curve compared to the $p(N) = 1.0$ case.

This graph illustrates the emergence of government in a model with the parameter $f_A$ set to 0, and how different values of $p(N)$ influence the system's dynamics.
Emergence of government

$N_0 = 20, f_R^{(0)} = 0.7, f_S^{(0)} = 0.3, f_A(t) = 0 \forall t$

$q = 2, b = 1, c = 0.1, \gamma = 4, s = 3$

Tragedy of the commons
Emergence of government

\[ N_0 = 20, f_R^{(0)} = 0.7, f_S^{(0)} = 0.3, \]

Switching on A-agents if \( f_R < 0.5 \), but keeping \( f_A(t) \leq 0.2 \)
Emergence of government
The tragedy of authorities

\[ N_0 = 20, \quad f_R^{(0)} = 0.7, \quad f_S^{(0)} = 0.3, \]

Same as before but \( f_A(t) \) not constrained
Conclusions

- In a large society, monitoring of public goods behavior cannot be a fully collective activity, rather being the chore of those in close contact with the free-riders.
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- Punishment of free-riders requires a local consensus among reciprocators, therefore, the clustering nature of the society would play an important role in the maintenance and evolution of the reciprocator trait.
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- Large human societies tend to be “small worlds” in the sense of short path lengths, but do not necessarily with a high degree of clustering. Therefore norm monitoring and enforcing requires *new special institutions of governance*. 
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- Punishment of free-riders requires a local consensus among reciprocators, therefore, the clustering nature of the society would play an important role in the maintenance and evolution of the reciprocator trait.

- Large human societies tend to be “small worlds” in the sense of short path lengths, but do not necessarily with a high degree of clustering. Therefore norm monitoring and enforcing requires new special institutions of governance.

- The new institutions bring with them social hierarchies, which imply inequalities. Therefore acceptance of the new institutions must have been possible only if in the majority of the population the reciprocator trait had become an internalized norm.
The evolutionary dynamics of the agents associated to governance, that is *the ruling class*, may, by its proliferation or by assigning to itself a higher share of the production (an high \( w \) factor in the model) provoke a decrease of the average fitness, a crisis or even a collapse of the society. This is what was called the *tragedy of authorities*. 
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- If élite overproduction is the proliferation of an aristocratic class that, under the protection of the ruler, lives from the society production without contributing to it, then it has all the marks of a tragedy of authorities.
However, when élite overproduction is associated, for example, to a greater access of the youth to higher education, this is not a tragedy of authorities. The eventual crisis that may occur in this case results from the fact that the new educated agents are not incorporated neither in the productive sector nor as beneficiaries of the society production. Hence it is not a tragedy of authorities.
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- The existence of authority agents is beneficial to society as long as their number and their share of the goods remains limited. The problem therefore is the old question of *who controls the controllers*. Democracy is in principle a way to implement limitations and accountability of the rulers. But even then, nothing is guaranteed.
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- Economic power easily escapes constraints of democratic control.
Conclusions

- Subtler effects;
  - Exploring the co-evolved parochial feelings of the population, it is easy to erect as a goal the proliferation of local or regional government structures, coordinating committees, etc. Layers and layers of control when there is nothing else to control.
  - Existence of government of central type when community government would be more efficient.

Evolutionary stability of the reciprocator trait depends on social norms and transmission of culture. It depends as much on genetics as on culture. Culturally-inherited traits have a faster dynamics than gene-based ones. Therefore it is critical to understand how modern society might be acting and modifying this trait. A considerable loss of cooperative behavior might change society in many unexpected ways. Could less altruism come along with less hostility to strangers? If contemporary man is becoming more Homo Economicus, maybe it would not be necessary to rewrite the classical economy books.
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R. V. M. and C. Aguirre; *Cooperation, punishment, emergence of government and the tragedy of authorities*, arXiv:0908.4408