Asymmetry, Cooperation, and the Emergence of Social Norms. Experiments with the Volunteer’s Dilemma Game

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„Sozialwissenschaftlicher Ausschuss“
Erfurt, May 5-7, 2011
Volunteer’s Dilemma

The Volunteer’s Dilemma is a N-player binary choice game (for \( N \geq 2 \)) with a step-level production function. A player can produce a collective good at cost \( K > 0 \). When the good is produced, each player obtains the benefit \( U > K > 0 \). If no player volunteers, the good is not produced and all players receive a payoff 0.

N-Player Game:

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>...</th>
<th>N - 1</th>
<th>Other C-Players</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>U - K</td>
<td>U - K</td>
<td>U - K</td>
<td>...</td>
<td>U - K</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>0</td>
<td>U</td>
<td>U</td>
<td>...</td>
<td>U</td>
<td></td>
</tr>
</tbody>
</table>

→ No dominant strategy, but \( \text{N asymmetric pure equilibria in which one player volunteers while all other defect. Cf. Diekmann (1985)} \)

Formal Models & Extensions, e.g.:

§ Volunteer’s Dilemma (Diekmann 1985)
§ Asymmetric VOD (Diekmann 1993, Weesie 1993)
§ Timing and incomplete information in the VOD (Weesie 1993, 1994)
§ Cost sharing in the VOD (Weesie and Franzen 1998)
§ Evolutionary Analysis of the VOD (Myatt and Wallace 2008)
§ Dynamic Volunteer’s Dilemma (Otsubo and Rapoport 2008)
§ Volunteer’s Dilemma and Optimal Size of Social Group (Archetti 2009) etc.
Examples of VOD

- Helping. Problem of diffusion of responsibility
- Alarm calls of animals if a predator is approaching
- Olson, Logic of collective action: “privileged actors”
- Investment in R&D or waiting for other firm’s innovation (Eger et al. 1993)
- Committee with veto. Expecting a colleague’s veto if a decision is unpopular.
- Two lazy professors responsible for a joint seminar
- Sanctioning dilemma.
- Lee et al., 2007, Backbone construction in selfish wireless networks.
- E-mail help requests (Barron and Yechiam 2002)
- Emperor penguin’s dilemma
- Mahmihlapinatapai (Tierra de Furgo, Rapoport 1988)
Choose the probability of defection \( q \) such that an actor is indifferent concerning the outcome of strategy C and D

\[
U - K = U (1 - q^{N-1})
\]

\[
U - K = U - U q^{N-1}
\]

\[q^{N-1} = \frac{K}{U}\]

- **Defection**  \( q = \frac{N-1}{N} \sqrt{\frac{K}{U}} \)
- **Cooperation**  \( p = 1 - \frac{N-1}{N} \sqrt{\frac{K}{U}} \)

“Diffusion of Responsibility” derived from a game model
Experiment with repeated symmetric volunteer's dilemma, \( U = 80, K = 50 \)  
(0.80 versus 0.30 CHF per round)  
Group size \( N = 3 \)
Asymmetric Volunteer’s Dilemma
Mixed Strategy Equilibrium

(i) Strategy $C_i$ yields $U_i - K_i$,

\[
\begin{cases} 
U_i & \text{is obtained if there is at least} \\
0 & \text{otherwise.}
\end{cases}
\]

(ii) while, for $D_i$ one other actor choosing $C$, 

If $D_i$ is chosen with probability $q_i$, actor $i$’s expected utility $E_i$ is

\[ E_i = q_i U_i \left(1 - \prod_{j \neq i} q_j\right) + (1 - q_i)(U_i - K_i). \]  

(1)

Partially differentiating with respect to $q_i$ yields

\[ \frac{\partial E_i}{\partial q_i} = -U_i \prod_{j \neq i} q_j + K_i. \]  

(2)

The following system of $N$ equations results if the derivatives are set equal to zero:

\[
\prod_{j \neq i}^N q_j = \frac{K_i}{U_i} \quad i = 1, 2, \ldots, N
\]  

(3)

The solution of (3) is

\[ q^* = \frac{U_i}{K_i} \left( \prod_{j=1}^N \frac{K_j}{U_j} \right)^{\frac{1}{N-1}} \]  

(4)

Diekmann (1993)
Asymmetric Volunteer’s Dilemma
Nash-equilibrium in pure strategies

• Heterogeneity of costs and gains: $U_i, K_i$ for $i = 1, \ldots, N$; $U_i > (U_i - K_i) > 0$

• Special case: A “strong” cooperative player receives $U_k - K_k$, N-1 symmetric “weak” players’ get $U - K$ whereby:
  
  $U_k - K_k > U - K$

• Strategy profile of an “asymmetric”, efficient (Pareto optimal) Nash equilibrium:

  $s = (C_k, D, D, D, D, \ldots, D)$

• i.e. the “strong player” is the volunteer (the player with the lowest cost and/or the highest gain). All other players defect.
  
  - In the asymmetric dilemma: Exploitation of the strong player by the weak actors.
  - Paradox of mixed Nash equilibrium: The strongest player has the smallest likelihood to take action!
Whelan (1997) provides an example from ancient politics which is analyzed in terms of collective good theory. As the Greek polis’ had been under threat by the Persian emperor Darius in the fifth century B.C. Athens was the volunteer to resist the Persian attack while other Greek states such as Sparta defected. The collective good of Greek independence was preserved by the victory of Athens at Marathon. In this historical example, the strategic interactions of states resemble an asymmetric volunteer’s dilemma. About sixty polis had an interest not being colonized by the Persians. Most of them defected while Athens, the most powerful state, was almost alone to act in the common interest.
Evolution of Social Norms in Repeated Games

**Asymmetric VOD.** There are two types of Nash-equilibria in an asymmetric VOD. The mixed Nash-equilibrium and the asymmetric pure strategy equilibrium.

We expect the asymmetric equilibrium to emerge in an asymmetric game. In our special version, we expect a higher probability of the “strong” player to take action, i.e. to cooperate than “weak” players. (Exploitation of the “strong” by the “weak”)
Design Experiment I

Group size $N = 3$, series of interactions with 48 to 56 repetitions, 120 subjects, partner matching

1. Symmetric VOD (control): $U = 80$, $K = 50$

2. Asymmetric 1: Weak players: $U = 80$, $K = 50$, Strong player: $U = 80$, $K = 30$

3. Asymmetric 2: Weak players: $U = 80$, $K = 50$, Strong player $U = 80$, $K = 10$

4. Focal player condition

The collective good has always the same value $U = 80$. Strong players have lower cost to produce the collective good.
Results Experiment I: The Importance of Learning

Probability of efficient public good provision

(N=120)
Results Experiment I: Dynamics of Behaviour

Decision patterns over time by super-game
(asymmetric 1, session 3)
Results Experiment I: Exploitation of the strong player
Average number of volunteering decisions

![Bar chart showing the average number of volunteering decisions for different conditions: symmetric, asymmetric 1, asymmetric 2, and focal point. The chart compares weak player, strong player, and focal player conditions, with 95% confidence intervals.](image)
However, no efficiency gain in asymmetric situation
Design Experiment II

Group size N = 3, series of 56 interactions, 87 subjects, „stranger matching“ (series of „one-shot“ games), rotation of role of strong player

1. Symmetric VOD (control): U = 80, K = 50

2. Asymmetric 1: Weak players: U = 80, K = 50, Strong player: U = 80, K = 30

3. Asymmetric 2: Weak players: U = 80, K = 50, Strong player U = 80, K = 10

The collective good has always the same value U = 80. Strong players have lower cost to produce the collective good.
Proportion of interactions with exactly one volunteer (Efficient, Pareto optimal outcome)
Average Payoff per Round Across Treatments and Player Types (in Rp.)

1. Strong player volunteers in the asymmetric game, weak player is freerider
2. Efficiency gains in the asymmetric game.
Experiment III: Sanctioning as a Volunteer’s Dilemma

108 subjects, groups of N = 4: 1 sender, 3 recipients, 24 rounds, stranger matching, in every round role of sender or recipient assigned by random.
Recipients had an endowment of 80 Rp., sender decides whether to share 400 Rp. A fair sender keeps 160 and sends 240 (fairness norm).
Round 1 - 8: Recipients had no veto power
Round 9 - 24: Any recipient had the opportunity to reduce sender’s income to 160 on cost K if the sender had violated the fairness norm.

<table>
<thead>
<tr>
<th></th>
<th>Symmetric</th>
<th>Asymmetric</th>
<th>Symmetric, binary choice</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sender Transfer</strong></td>
<td>0 – 400 Rp.</td>
<td>0 – 400 Rp.</td>
<td>0 or 240 Rp.</td>
</tr>
<tr>
<td></td>
<td>(VOD: Sender</td>
<td>(VOD: Sender</td>
<td>(VOD: Sender</td>
</tr>
<tr>
<td></td>
<td>keeps &gt; 310)</td>
<td>keeps &gt; 280)</td>
<td>keeps 400)</td>
</tr>
<tr>
<td><strong>Recipient sanction cost</strong></td>
<td>$K_{1,2,3} = 50$</td>
<td>$K_{1,3} = 50$;</td>
<td>$K_{1,2,3} = 50$</td>
</tr>
<tr>
<td></td>
<td>$K_2 = 40$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
In dieser Runde sind Sie ein Sender und Ihr Guthaben beträgt 400 Rp. Das Guthaben der drei Empfänger beträgt je 80 Rp.

Sie können sich jetzt entscheiden, ob Sie einen Teil Ihres Guthabens an die drei Empfänger überweisen wollen oder nicht.

Sie können jeden ganzzahligen Betrag von 0 Rp. bis 400 Rp. an die Empfänger überweisen. Der überwiesene Betrag wird Ihnen von Ihrem Guthaben abgezogen und zu gleichen Teilen an die drei Empfänger verteilt.

Beträgt in Rp. 0

überweisen
Der Sender hat 0 Rp. an die Empfänger überwiesen. Das Guthaben des Senders beträgt jetzt 400 Rp. und das Guthaben der Empfänger beträgt jetzt je 80 Rp.

Sie sind ein Empfänger und können sich für "oben" oder "unten" entscheiden indem Sie mit der Maus in das entsprechende Feld klicken.

Entscheiden Sie sich für "oben", werden dem Sender 240 Rp. abgezogen und zu gleichen Teilen auf die drei Empfänger verteilt (je 80 Rp.). Ihnen werden aber für diese Entscheidung ...
...40 Rp. abgezogen wenn Sie Empfänger 2 sind.
...50 Rp. abgezogen wenn Sie Empfänger 1 oder 3 sind.

Entscheiden Sie sich für "unten", hängt Ihr Gewinn von den Entscheidungen der anderen Empfänger ab.
Entscheidet sich mindestens ein anderer Empfänger für "oben", werden dem Sender 240 Rp. abgezogen und zu gleichen Teilen auf die drei Empfänger verteilt (je 80 Rp.). Wenn sich alle Empfänger für "unten" entscheiden, wird dem Sender nichts abgezogen und alle Empfänger erhalten 0 Rp.
Asymmetric $K_{1,3} = 50$, $K_2 = 40$

Symmetric $K_{1,2,3} = 50$

Sender has binary choice, symmetric $K_{1,2,3} = 50$
Average sender transfer in first and second part across treatments

![Graph showing average sender transfer across treatments](image)
Recipients cooperation rate across treatments and recipient types
(rounds 9 – 24)
Frequency distribution of average sender transfer

- symmetric
- asymmetric
- symmetric 2 (binary choice game)
Proportion of transfers establishing VOD across treatments

Recipients cooperation rate in second part across treatments and recipient types in VOD condition
Conclusions: Asymmetric Volunteer’s Dilemma

1. Group size (symmetric game):
   **Complexity of coordination.** The efficient provision of the public good decreases with group size.

2. Learning:
   **Evolution of norms.** The efficient provision of public good and successful coordination is increasing with the number of repetitions of the game.

3. Repeated versus one-shot games:
   **In both versions** the strong player is more likely to volunteer.
   **Repeated:** The probability of efficient public good provision in the asymmetric game was not larger than for the symmetric game.
   **One-shot:** The probability of efficient public good provision in the asymmetric game was clearly larger than for the symmetric game.

4. Sanctioning as a volunteer’s dilemma:
   **Cooperation increases and the strong player is more likely to veto.**

5. Player’s strength:
   **Exploitation of strong players.** In the asymmetric VOD, the public good was provided to a much higher degree by the strong player compared to weak players
   **Strong player’s higher likelihood of action is expected by the Harsanyi/Selten theory of equilibrium selection.**