Term Paper

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Group Selection (The co-evolution of individual behaviors and social institutions, Bowles et al 2003)

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Introduction:

The agent-based model introduced here determines the parameter space of an environment where a trait can become more numerous in the deme-structured population. The individual agents of this model are the bearers of genes (behaviors) that are genetically transmitted: altruistic and non-altruistic. The genetically transmitted altruistic trait (group-beneficial behaviors) evolves under group selection pressures (between-group selection) and becomes popular (growing in size) in the population. On the other hand, the non-altruistic agents will be the majority of the population without group selection pressures (within-group selection).

Model:

The two features of this model are inter-group conflicts and culturally transmitted group differences. Agents living in groups can have one trait at a time: altruistic or non-altruistic. Altruism is group beneficial where altruistic behavior costs the individual agent c and confers a benefit of b (b>c, measured in units of some material resource). Within-group selection, payoffs or fitness of non-altruists will be higher than altruists.

Row's Payoffs

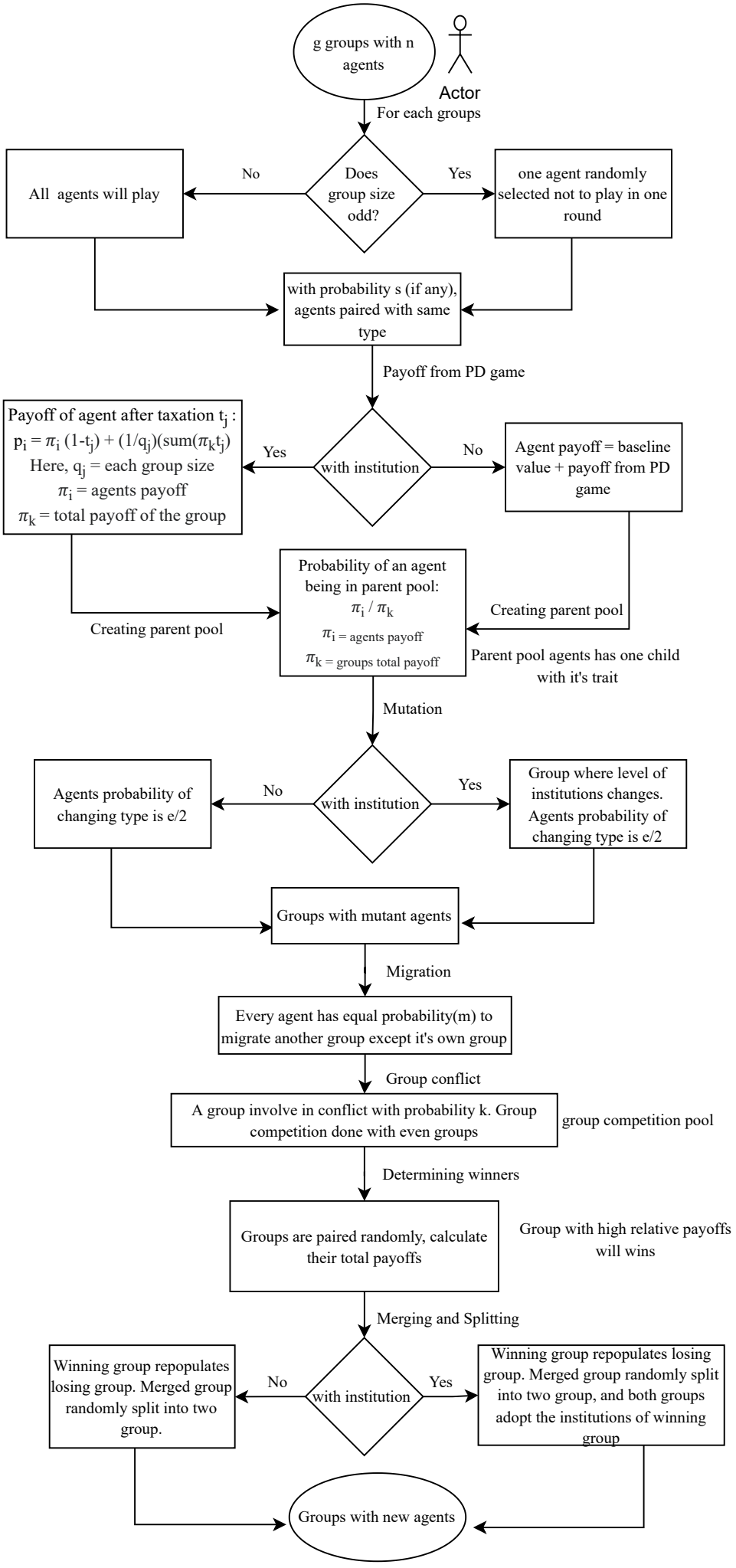
	A	N
A	b-c	-c
N	b	0

Column's Payoffs

	A	N
A	b-c	b
N	-c	0

Fig-1: the altruism game, where A means altruists and N means non-altruists

The flowchart of the computational algorithm of this model shown in the following page:


g groups with n agents
Actor
For each groups
Does group size odd?
No
Yes
All agents will play
one agent randomly selected not to play in one round
with probability s (if any), agents paired with same type
Payoff from PD game
Payoff of agent after taxation t_j : $p_i = \pi_i (1-t_j) + (1/q_j)(sum(\pi_k t_j)$
Here, q_j = each group size
π_i = agents payoff
π_k = total payoff of the group
with institution
Yes
No
Agent payoff = baseline value + payoff from PD game
Creating parent pool
Probability of an agent being in parent pool: π_i / π_k
π_i = agents payoff
π_k = groups total payoff
Creating parent pool
Parent pool agents has one child with it's trait
Mutation
Agents probability of changing type is e/2
with institution
No
Yes
Group where level of institutions changes. Agents probability of changing type is e/2
Groups with mutant agents
Migration
Every agent has equal probability(m) to migrate another group except it's own group
Group conflict
A group involve in conflict with probability k. Group competition done with even groups
group competition pool
Determining winners
Groups are paired randomly, calculate their total payoffs
Group with high relative payoffs will wins
Merging and Splitting
Winning group repopulates losing group. Merged group randomly split into two group.
with institution
No
Yes
Winning group repopulates losing group. Merged group randomly split into two group, and both groups adopt the institutions of winning group
Groups with new agents

Simulations and Results:

I have assigned 400 agents in 20 different groups: initially, all groups had the same number of agents. If an odd number of agents are assigned to even groups, then one group will have an extra agent. Random migration and the outcomes of group conflicts are responsible for each group changing its size. Agents are randomly paired within their group to play a prisoner's dilemma (PD) game once in each generation. I have used the benchmark values from the original research paper for migration rate (m) = 0.2 , mutation rate (e) = 0.001, probability of group conflict (k) = 0.25, benefit (b) =2, cost (c) = 1 and baseline payoffs = 10.

I have done two simulations: 1.within-group selection

2. between-group selection

1. Within-group selection (without group conflict/without war):

I have simulated the model for different time ranges, where the non-altruistic population always performs better. The total number of agents will remain constant in the within-group selection, but each group may not have the same number of agents due to the random migration.

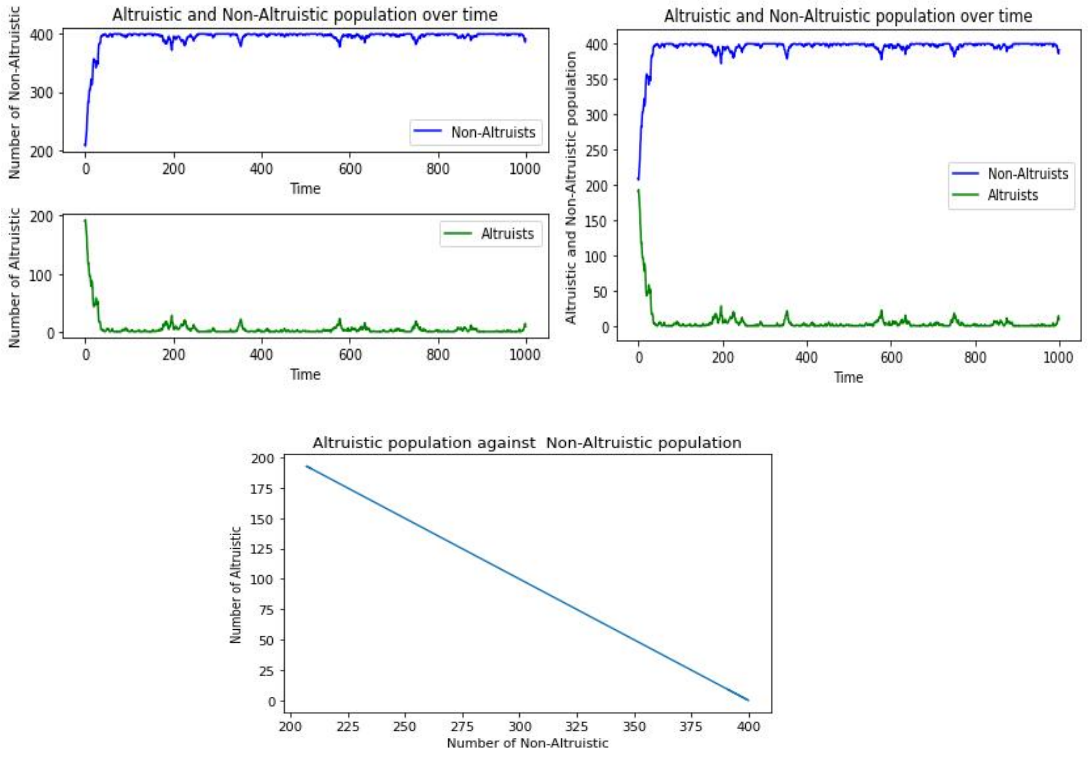


Fig-2: outcomes of the evolution for 1000 time periods (without war/without groups conflict)

2. Between-group selection (with group conflict/with war):

The sole purpose of this model is to find an environment where group-beneficial behavior will grow in size over time in the population. Group beneficial behaviors can be evolved and increase in numbers without group-level institutions: when inter-group conflicts happen more frequently. In this case, the migration rate should be small. In the process, every group experienced mutation and migration before joining the war with probability k. Groups are paired randomly for conflict. The number of groups going to compete in total has to be even.

If we use the absolute payoff of groups to determine the winner, then non-altruistic agents will increase in population over time. There is always an advantage for the larger groups.

To determine the winner, I used the relative payoffs of groups: those groups with the highest relative payoffs will win, repopulating the losing groups.

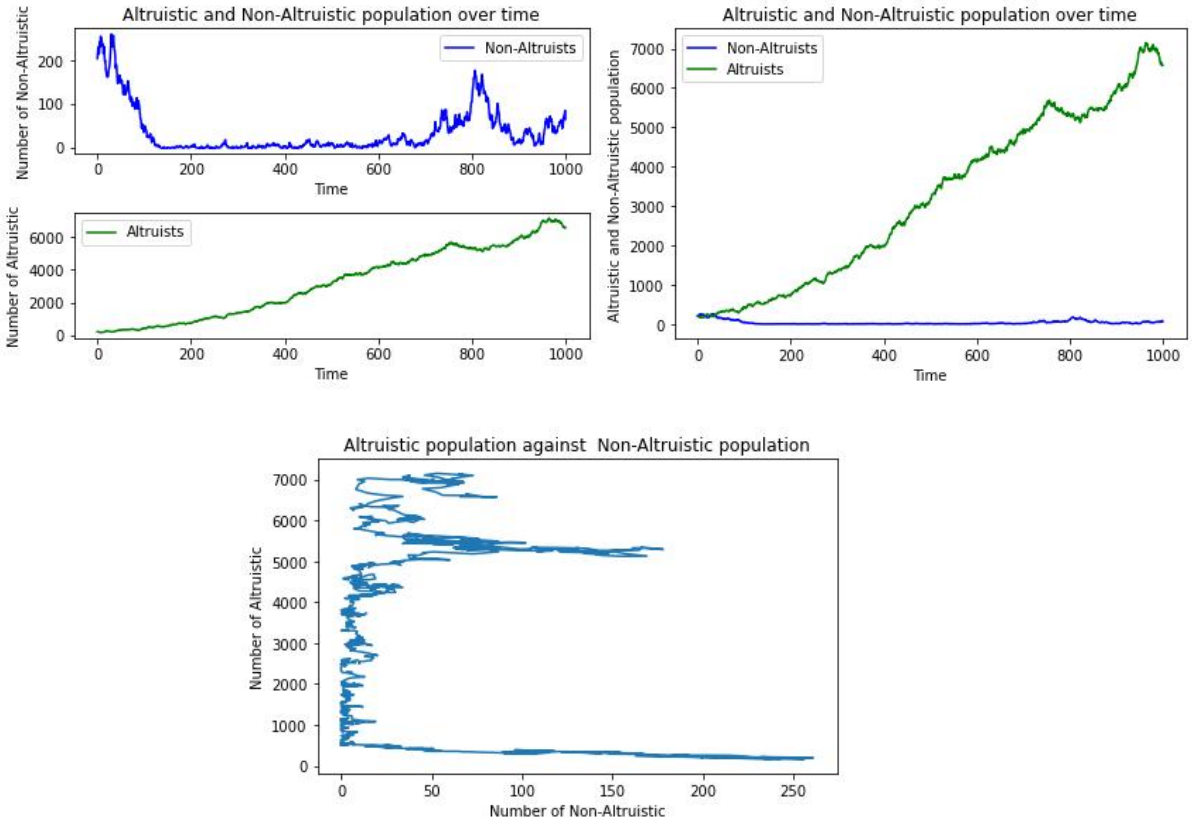


Fig-3: outcomes of the evolution for 1000 time periods (with war/groups conflict)

The figure shows that altruistic agents gradually grow in numbers. The total number of non-altruistic agents increases sometimes, but it is very less compared to altruistic agents.

Conclusion:

Here it has described and simulated an evolutionary process where an individually costly group beneficial trait evolves. The model can have different kinds of institutions to support altruistic behavior to grow in size in a given population. Altruistic behavior can grow in size within the given population without any group-level institutions under some conditions. According to this agent-based model (multilevel selection), group selection pressures (between-group competition) are essential for creating an environment where a group-beneficial trait becomes more popular over time.

This artificial environment works against altruism in within-group selection. On the other hand, altruism performs better where group conflicts exist.