Why are some of us opportunists? A computational simulation of N-person prisoner's dilemma

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Introduction

The prisoner's dilemma is a standard example of a non-zero-sum game analyzed in game theory. An extended "iterated" version of the game plays the classic game repeatedly between the same prisoners, who continuously have the opportunity to penalize the other for previous decisions.

Purpose

This study intends to explore the strategic implications that emerge when the world consists entirely of prisoner's dilemma like interactions. We adjust the payoff of strategies in each simulation to observe how cost sizes affect their interaction and population.

Method

- We built a simulation model with Python which is a multiplayer version of the iterated prisoner's dilemma.
- Strategies

truster
exploitative egoist
tit for tat
unforgiving
true believer
win stay lose shift
discriminating altruist
opportunist
recluse
random

- Truster – always cooperates
- Exploitative egoist – always exploits
- Tit for tat – cooperates on the first round and imitates its opponent's previous move thereafter
- Unforgiving – cooperates until an opponent exploits once, then always exploits in each interaction with it
- True believer – cooperates at first, yet exploits if an opponent exploits once
- Win stay lose shift – cooperates if won last round and exploits if lost last round
- Discriminating Altruist – cooperates with any player that has never exploited, and otherwise refuses to engage
- Opportunist – exploits an opponent that cooperates, and appeases an opponent that exploits
- Recluse – doesn't interact with any opponent
- Random – 1/3 chances of cooperating, 1/3 chances of exploiting, and 1/3 chances of playing a recluse

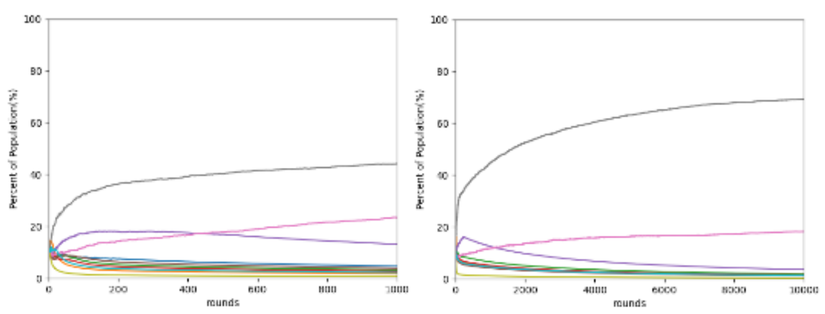
- Payoff (C<R<P, A<1<F)

C	reward gained from cooperation
R	amount received from exploiting/lost from being exploited
P	penalty from being punished
A	fraction offered to appease another player
F	multiplier associated with a punishment escalating into a feud

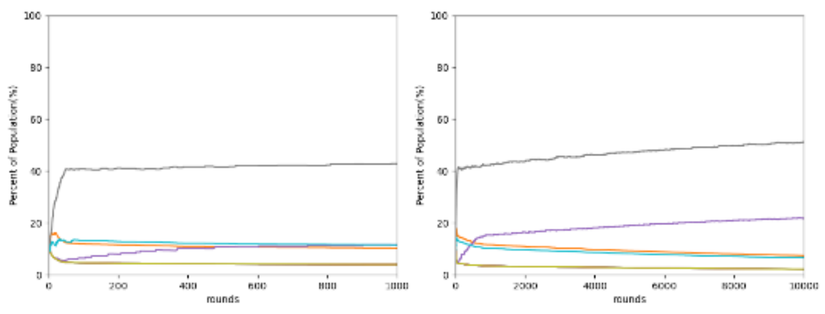
- We set the initial population of each strategy at 10, then let all individuals randomly select a partner to interact with each round. If an individual's payoffs accumulate over a threshold of 100, it gets to reproduce. If its payoffs accumulate below -100, the individual dies off.

Results and Discussion

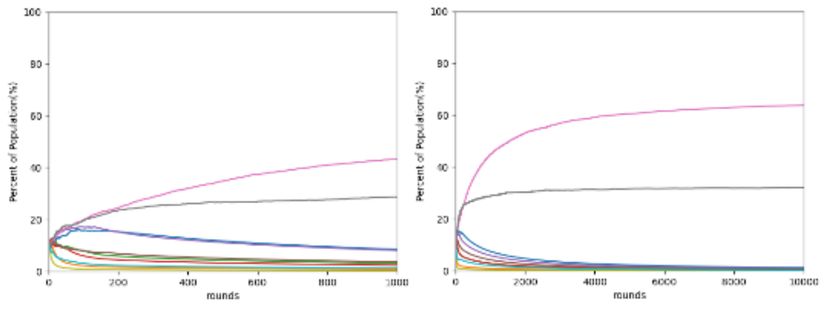
- Control Group (C = 25, R = 50, P = 75, A = 0.5, F = 5)



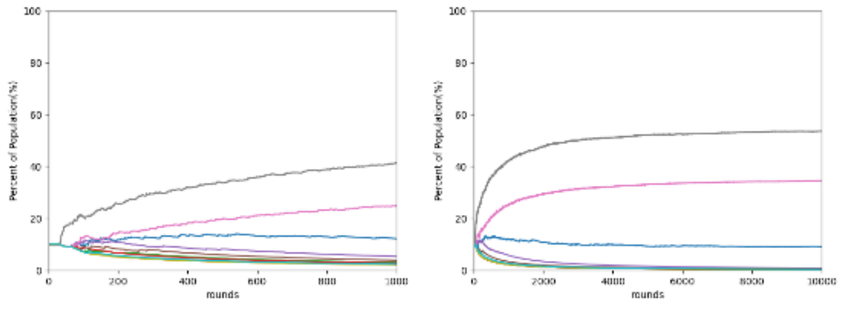
- Decrease C (C = 5, R = 50, P = 75, A = 0.5, F = 5)



- Increase C (C = 45, R = 50, P = 75, A = 0.5, F = 5)



- Decrease Evolution Rate (C = 2.5, R = 5.0, P = 7.5, A = 0.5, F = 5)



Conclusion

- Opportunists profit the most in most situations.
- When reward gained from cooperation increases, discriminating altruists do better. This might be because when the population of opportunists increases, they don't get any payoff interacting with each other. Although opportunists receive payoff from exploiting discriminating altruists on the first round, they don't get any payoff afterwards. Yet discriminating altruists cooperate with each other, and eventually gain reward from cooperating.
- When reward gained from cooperation decreases, opportunists profit more and the population of individuals that cooperate on the first round decreases.
- In contrast to discriminating altruists, the populations of individuals that uses strategies like tit for tat, unforgiving, and true believer don't increase. This might be because these strategies exploit after being exploited by an opponent, increasing the chance of getting penalty from being punished.
- Adjusting the amount received from exploiting/lost from being exploited (R), penalty from being punished (P), fraction offered to appease another player (A), or multiplier associated with a punishment escalating into a feud (F) only has a little effect on the first 100 rounds, yet doesn't affect the final results much.
- Changing the evolution rate only affects the ascending rate of the curves, but still results similar to the control group.

References

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