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RESEARCH ARTICLE

Using Game Theory to Reduce Climate Change

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ABSTRACT: A significant issue in our world right now, among all others, is climate change. While we are very aware of this issue, our progress toward reducing climate change has been slow. Using game theory, we could make a solid prediction on what we are doing wrong and what we'd need to improve on. But instead, what we want to focus on right now is what the ideal environment would be for the most efficient path to adapting to climate change by using game theory. We found out through simulations that if people cooperate, form strong networks, and work together to find and incorporate solutions, they can prevent and reduce climate change faster.

KEYWORDS: Game Theory; Tragedy of the Commons; Climate Change; Global Warming; Reduce and Adapt; Networking; Infinite Game; The Evolution of Trust.

Introduction

Our efforts in reducing and mitigating climate change right now can be described with an analogy - a massive boulder rolling down a mountain. It will eventually reach the bottom but it can still be slowed down enough that it will take hundreds of years to get to the bottom - that much is obvious. However, with only a few people that care about this boulder and try to stop it, it won't slow down by much. Some people may disregard it or even make it roll down faster until it is too late, such as large oil and fossil fuel companies turning away climate change and dismissing it as an unimportant issue.

This is a convoluted translation of a Tragedy of the Commons game. The Tragedy of the Commons is a situation where every being in a population tries to strive for their own personal gain, which negatively affects the entire population. This is due to the extensive hoarding of resources and wealth for the self instead of the collective.[1,2]

Global warming is a major issue right now that, despite most efforts to reduce and mitigate it, isn't going to change quickly anytime soon. But this isn't because of the effectiveness of the efforts and methods used, but instead because of how they are executed. Not everyone is trying their best to deal with climate change. While many people use different methods to reduce and adapt to climate change, some people and large companies completely brush climate change aside or even point fingers. Because of this spread-out view on climate change and global warming, progress to mitigating and reducing this global threat has been slowed down drastically. This is our Tragedy of the Commons game. Despite the efforts to reduce climate change, there are still people striving for their own benefit that make these efforts, overall, less effective.[3-5]

Game theory involves the mathematical analysis of strategies in competitive scenarios. We can utilize this to figure out why these slowdowns are happening and what a perfect environment to reduce climate change is.[2]

Infinite games[6] are crucial to solving the Tragedy of the Commons. An example of an infinite game is if two people were to play tic-tac-toe and repeatedly play games with the other player. Over time, they'll learn each other's strategies and will adapt accordingly. Infinite games are indeed important, but in our modern world, we do not utilize this. With such an increase in speed, communication, and capability, humans do not have to play an infinite game with a long-term goal in mind. So, we will center some of our experiments not around infinite games but instead on forming strong networks.[7]

Powerless speech is usually seen as a bad sign when presenting, as stuttering and showing signs of humility is often a sign of unsureness. However, in the context of our situation, as well as many others, this "strategy" – often seen as a bad habit – can be utilized to from and further strengthen further and form our networks and handle uncertainty.[7]

The population is full of many different types of people, so we will simplify the population's roles into three categories; Cooperators (Givers), Cheaters (Takers), and Copycats (Matchers). These roles will represent the different types of people that are involved in climate change and how they usually act.[7,8]

We used a website by Nicky Case, *The Evolution of Trust* [8], to simulate a Tragedy of the Commons game with the three roles and determine which outcome(s) will benefit the group as a whole and which one(s) will not. In our situation, a beneficial outcome would mean reducing and mitigating climate change and forming strong, positive networks. In addition to creating the "most beneficial Environment(s)," we will also explore ways to mitigate and adapt to climate change used in our real-life model and how these solutions align with our simulation results. Finally, we will define the strategies that give us the best outcome.

In the first part of the paper, we will go over the tools used in the experiment and the process used to collect the data. Then we will review the results and discuss precisely what they mean. Finally, we will create a conclusion on what our data entails.

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■ Methods

This paper uses *The Evolution of Trust* by Nicky Case, an "interactive guide to the game theory of why & how we trust each other." The website has a sandbox mode, which allows you to set your own rules and payoffs to simulate a game between specific people, as shown in Figure 1.

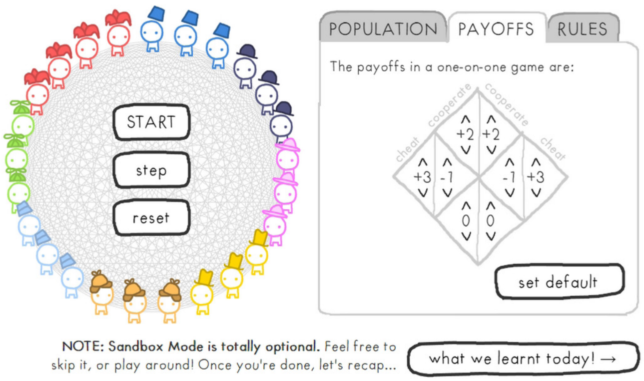


Figure 1: Sandbox Mode in The Evolution of Trust by Nicky Case.

While there are a total of 8 different types of players, as shown in Figure 1, we will be focusing on three specific ones, shown in Figure 2: The Cooperator, The Cheater, and The Copycat.

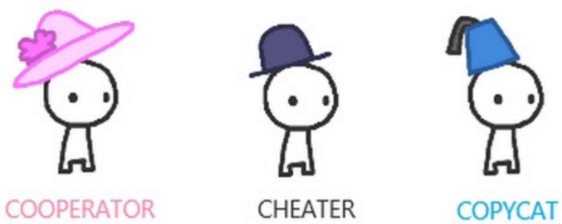


Figure 2: The three leading roles: Cooperator, Cheater, and Copycat.

These roles fill up a population and play the game. They are paired up to face each other, one-on-one, and will either cooperate or cheat to gain and lose points (In real life, these points will represent resources that our world can use). There are three distinct possible outcomes: Both players cooperate, both players cheat, and one player cheats while the other player cooperates.

The Cooperator, as the name suggests, cooperates with the other player. Always, no strings attached. The Cheater does the exact opposite, always cheating. The Copycat, however, is unique. Depending on their opponent's last move, the Copycat changes their move to match it. If their opponent cooperated in the previous round, they would cooperate in the current round. If their opponent cheats in the previous round, they will cheat in the current round. This makes the Copycat "easy to influence" and are followers.

Because *The Evolution of Trust* can only hold 25 players, no more, no less, the three roles will be divided "equally" to a degree; 8 Cooperators, 8 Cheaters, and 9 Copycats.

As mentioned previously, the state of our climate change reduction efforts is stuck in a Tragedy of the Commons game, a short-sighted resource-driven strategy that eventually exhausts resources, making the whole population suffer. So, our game will be arranged so that the payoffs for both players striving for personal gain (both cheating) are much worse, while profits for the group (both cooperating) are better collectively. However, as it is, if a person decides to cheat instead of cooperating while the other does the latter (one cheats, one cooperates), the cheater will gain more points for themselves. If one player cooperates and one cheats, the cheater will earn three points, and the cooperator will lose one point. If both players cheat, they gain nothing; if both players cooperate, they gain two points. This payoff matrix is shown in Figure 3.

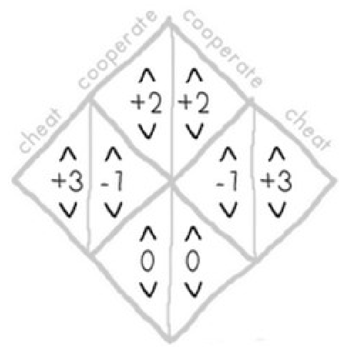


Figure 3: *The tragedy of the commons payoff matrix.*

The issue with this payoff matrix is that no matter what, cheating always seems to be the dominant strategy. This is because when considering the self, individual players gain more, and since they cannot predict other player's choices, it isn't worth trying to cooperate. Both players are eventually so intent on cheating that they gain nothing. But, it turns out that when considering the group as a whole, it's much better to choose to cooperate, which will be the better option. Cooperators gain more in the long run, helping other players and, as a result, staying in the game longer. But a cheater makes all their competition lose, consequentially replacing them with more cheaters, creating a negative feedback loop with everyone gaining nothing. However, if a game is finite like it is now in real life, people are less likely to realize that cooperating is better than cheating. This is where infinite games, or in our case, networking and forming strong networks, comes in. By making people constantly interact with other people regularly, perhaps by encouraging daily or weekly interactions, this compels all involved to agree to cooperate with each other in subsequent games, so both players can always gain, not lose.

After establishing the players and payoffs, we can decide the rules, which will be our independent variables. There are three rules, adjusted via. slider, which can change how the game plays out. Preferably we want the Cooperator to win since they represent those involved with the reduction and adaptation of climate change in real life. If the Cheaters win, this will most likely mean that in real life, they will expend the Earth's resources and maintain climate change's steady incline.

Games in *The Evolution of Trust* are in a tournament format, where there will be a specified number of rounds in a match. Once each match is done, a specified number of losers will be eliminated, and the same number of winners will be reproduced, so usually, either one type of player comes out on top, or the game reaches an equilibrium, where two or more populations coexist in balance. In addition to that, to create a degree of randomness, there is a specified percentage that a player could make a mistake, depending on their role, selecting the opposite option of what they intend to make.

All three factors, number of rounds, number of players eliminated/reproduced, and mistake percentage, can all be adjusted to significant effect. The adjustable rules are shown in Figure 4. Note that the values shown are the default when entering Sandbox Mode in *The Evolution of Trust*.

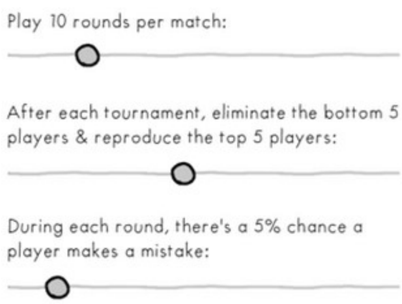
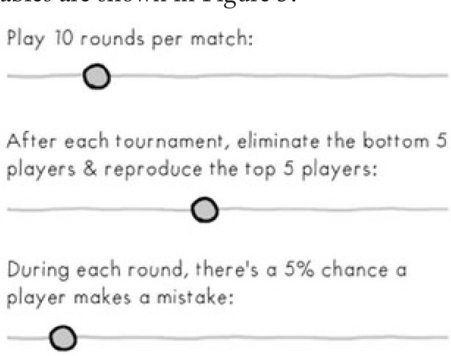


Figure 4: The rules that can be changed with the sliders.

For our experiments, we will keep the chance of mistakes at the default of 5%. It will remain unchanged for the entirety of the experiments.

For the first part of our experiment, we want to change the first two variables, rounds per match and the number of eliminated/reproduced, to test networking between people. A strong network of people means tight and trusted connections that can be relied on, and vice versa for a weak network. Cooperating is common in strong networks.

In the first run, we'll adjust the rounds per match to decrease the "interactions per match" (IPM) and also adjust the elimination and reproduction numbers to increase the "temporariness of interactions" (TOI) for testing fast temporary networks. In the second run, we'll adjust the rounds per match to increase the IPM and adjust the elimination and reproduction numbers to decrease the TOI for testing slow permanent networks. In the third run, we'll adjust the rounds per match to reduce the IPM and adjust the elimination and reproduction numbers to decrease the TOI for testing slow temporary networks. Finally, in the fourth run, we'll adjust the rounds per match to increase the IPM and adjust the elimination and reproduction numbers to increase the TOI for testing fast permanent networks. Each runs' variables are shown in Figure 5.



Results and Discussion

IPM = **I**nteractions **P**er **M**atch
TOI = **T**emporariness **O**f **I**nteractions

The results for the first part of the experiments are shown in Figure 6.

Figure 6: The results of the first part of the experiments.

As shown by the results, the scenario that allows the Cooperators to win is Run #2, when the player forms a strong network that favors large amounts of interaction and long-lasting connections. This means that in our real-life climate change scenario, people need to form strong connections with each other to mitigate and adapt to climate change.

During Run #2, the "successful run," the Cheaters initially beat the Cooperators because the payoff for cheating when the other cooperated was in favor of the Cheaters. But the Copycats, who reciprocated with Cooperators and Cheaters, slowly increased in numbers, weeding out the Cheaters. This allowed the Cooperators to convert the Copycats to Cooperators gradually. This process is shown in Figure 7.

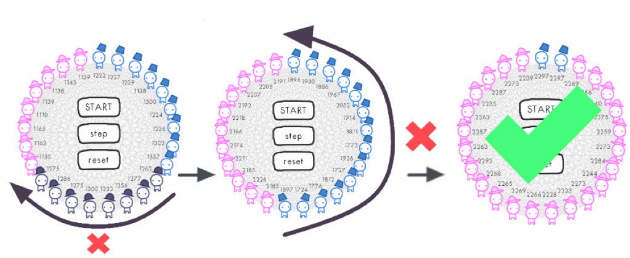


Figure 7: The progression of Run #2.

Cooperators strive for a robust networking environment simply because they will always be able to strengthen their network. At the same time, Cheaters, who try to exploit and quickly use up connections, will often struggle in the robust networking environment because they do not attempt to strengthen and maintain their networks.

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What makes the game a networking game to begin with, is IPM. They have more interactions that allow people to form networks. Cooperators want to maximize the number of interactions with others and create a sort of permanence within networks. Cheaters want to minimize the number of interactions with others and keep them as temporary as possible.

What makes a network strong is the TOI. A Cheater at the center of a network will commonly throw away the people with less power, while a Cooperator will keep them in for as long as possible. That is why less TOI allows Cooperators to win.

When a Cooperator is on top of a hierarchy, they will only remove a contact when they absolutely need to. When a Cheater is on top, they will release a contact if they no longer have any power they can use. In our climate change scene, Cooperators need everyone they can get to prevent climate change, unlike Cheaters. The latter will use powerful people to gain temporary power before eventually giving them up for someone else more powerful.

In our real-life climate change scene, people need to share ideas but also to accept others and relate to others as people to strengthen their network further. This is powerless speech, which though often viewed as a weakness in public speaking, will provide benefits when trying to connect with an audience, or strengthen networks. Powerless speech ties directly to stronger networking and, by extension, having a lower TOI. This means that powerless speech will help Cooperators and not Cheaters.

Conclusion

In summary, by utilizing the tools given by game theory, it is shown that cooperating and communicating is crucial to mitigating and adapting to climate change and the "Tragedy of the Commons" game.

As the results show, the perfect scenario is deceptively simple: Create an environment where Cooperators can thrive and form networks, strengthening them to further encourage the sharing and acceptance of strategies and ideas. If a group of Cheaters is presented, introduce Copycats that will flush out the Cheaters by penalizing them for cheating.

This scenario is possible to achieve but difficult in its process; as in real life, the Cheaters will represent, for example, large fossil fuel manufacturers whom benefit from the selling and use of fossil fuels. These companies and groups often ignore climate change rules to expand their business.

While the Cheaters may be difficult to change, the Cooperators have already acted and have made many steps forward. One example is the two cities, Seattle and New York City. Big cities house a large population and consume large amounts of energy. In addition, the 40 largest cities in the world combined are classified as the third largest emitter of carbon dioxide. This means that cities are a notable contributor to climate change. However, Seattle and NYC have utilized different methods of adapting and mitigating climate change. One thing to note about both cities is that they are part of the Climate Impacts Group, which means both cities can share ideas and strategies to mitigate and adapt to climate change.[9,10]

This simple example showcases how vital cooperation and communication are to face the global threat of climate change. By utilizing game theory, we can face this issue head-on, not as individuals, but as a whole, with one single objective: To stop climate change in its tracks.

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Richard L. Wan is a coming 8th grader at Holicong Middle School. His CTY Game Theory course inspired this research paper, where he used game theory to create a sequential game for increasing the player's "fun" in video games.