Social behaviour through emotions in the Iterated Prisoners Dilemma

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Abstract

The abstract should briefly summarize your project in 150–250 words.

1 Introduction

In human decision making, a number of factors influence the process and outcome. As previous research has argued, the more serious the decision at hand, the more it will involve emotion [BB01; ONe00]. This makes emotion an interesting and purposeful topic in research about decision making.

1.1 Problem

By modelling emotions, we can try to acquire insight in real life interactions. In this research we investigate the modelling of emotions, and in what way decisions based on emotions influence global gain. The prisoner's dilemma can be used as a model for many real world situations involving cooperative behaviour. We are using the Iterated Prisoner's Dilemma (IPD) as a framework for our simulation, in which we look for emerging behaviour and the factors causing this.

1.1.1 Prisoner's Dilemma

Suppose, two individuals are suspected for committing a crime. Both are separately interrogated. Each individual can decide to co-operate with respect to the other agent, or he can choose to betray the other agent. To analyse this situation with Game Theory, four situations are defined based on two agents that can either co-operate with, or betray the other. These four situations are then assigned an amount of points based on how favourable each situation is for each agent. In [Axe80], the points are assigned as shown in Table 1.

		Agent B	
		Cooperate	Defect
Agent A	Cooperate	3/3	0/5
	Defect	5/0	1/1

Table 1: The four possible outcomes of the prisoners dilemma. There are two values in the cells. The former value represents the amount of points for agent A, and the latter represents the points for agent B.

1.1.2 Iterated Prisoner's Dilemma

1.2 State of the art

We will be using two major concepts from previous research. The first is [OCC88], which introduces a theory proposed by Ortony, Clore, and Collins (OCC) that allows for reasoning about emotions. The theory proposes a model that is concerned with defining emotions in such a way, that they can be addressed in terms of reasoning. The model allows for influencing behaviour based on emotions.

Recent work is also concerned with formalizing emotions and applying them to decision theory, performed by [GL00]. Their research is concerned with how panic or stress can influence an agent in such a way that it will only look at short term solutions.

In [BB01] a concrete set of rules for simulating emotions is introduced, which can be used as strategies for decision making in the iterated prisoner's dilemma (and possibly other environments). [BB01] compares a simulation with solely defecting and cooperating agents with a simulation including emotional agents, and found that the latter resulted in a higher ratio of cooperation. Strategies like Tit-For-Tat have proven that cooperating can lead to larger overall long-term gain [Axe84], we further investigate the influence of emotions on the cooperation rate, and overall gain in the IPD scenario.

1.3 New idea

The emerging behaviours found in these simulations could help us understand the value of emotions in real life agents. This is why we use the IPD framework in order to extend the research.

In this paper we are initiating separate worlds with both emotional agents and single-strategy agents, and look for different outcomes and converging situations. We look at simulations with interactions between emotional agents and agents who always defect as well as emotional agents and agents who always cooperate. Furthermore we look at emotional agents and agents that use the Tit-For-Tat strategy, and finally the interactions between emotional agents and agents that randomly choose an action.

Instead of using a grid space with hard boundaries as used in [BB01] (i.e. agents at the borders will have less neighbours to cooperate with), we implement a world with continuous borders. This means the agents on the left most column of the grid will interact with agents at the right most column and vice versa, as well as from top to bottom and bottom to top. This results in a more complete simulation, since all agents will have the same number of neighbours and therefore interactions.

Apart from solely evaluating the cooperation and defect rate in order to draw conclusions as was done in [BB01], we also focus on the division and distribution of the different emotions and how it changes over time. With this, we acquire insights on how the different scenarios, such as combinations and variations of agents, influence emotional agents and their strategies.

2 Method

2.1 Implementation of the Model

The model used in this paper, is a simplified version of the model used in [BB01]. The model instantiates a $30 \cdot 30$ grid where every cell is an individual agent. The Iterated Prisoners Dilemma is played by all agents in this grid. Per iteration, each agent plays against its eight neighbours. When all agents have played, every individual agent is considered and replaced by the best scoring neighbouring agent of the current round, i.e. the most successful agent is cloned into the considered cell. Unless the agent is better scoring than all its neighbours, in which case it is not replaced. This makes it possible for non-emotional agents to evolve through the iterative process. The model will report a spatial visualization of the grid, as well as, the proportions of the emotions, and the global gain of the model.

2.1.1 Emotions

There will be four emotions used in this model: Joy, Pity, Distress, Anger. The emotions will be determined, every time two agents will perform the PD. and use this emotion to determine a strategy. The emotions are dependent on the amount of points that are obtained in the IPD, and the emotions of neighbouring agent. Every individual prisoner's dilemma the emotion of an individual agent can change, and therefore it's strategy in the game too.

Our system is heavily influenced by the framework set up in [BB01]. It follows the same concepts and uses the rules set up in [BB01] to determine the emotions of the agents. It is however noteworthy to mention that we could not perfectly emulate the circumstances of the original paper, because the specific implementation and parameters were not given in the paper. After approaching an original autheur, who could not locate the original implementation either, we decided on following the framework as close as we could. Although we cannot reproduce the original paper, the framework that was presented still holds, and we will be using this to set up our own system.

2.2 Implementation details

Our implementation was constructed in python 3. The main drivers of the system are two classes, the first of which is a class for the agents, which handles agent specific functions and the data of the agents. The second class is an overarching world class, which contains the grid of agents and handles the matching of agents, as well as the prisoner's dilemma. It functions as the overarching class which implements the actual iterations and games.

Each iteration the system starts at a random agent, and plays the games against all the neighbours in a random order. It is worth wile to mention that there are no edges and the grid of agents is circular for the purposes of determining neighbours. Both these implementation decisions were made to remove as much effects of location from the system.

Another implementation decision is the place of emotion determination. Because the emotions have an effect on the emotions of the neighbours, the point where you update emotions might have some influence on the results of the simulation. Because some emotions are based on the state of the opponent, specifically pity and angry, we must update the emotions specifically for each opponent. This was implemented by updating the emotions of the agents before they played a game.

The emotional agents are implemented in such a way that they can only have one emotion at a time. The action of the agent in a game is solely dependent on the current emotion of that agent. If it feels joy or pity, it will cooperate, if it feels anger or distress, it will defect.

2.3 Experiment design

We are currently running the simulation for twenty iterations. We use a points threshold value of 20 and a neighbours threshold value of 5 for our simulation. We will fill the grid with variable amounts of emotional and rigid agents(Parameter sweep of threshold values still to be done)

We will collect the gain for each strategy (both emotions and rigid strategies) and report these per iteration. From this data we will plot a stacked graph that shows us what percent of the gain can be attributed to which strategy. We hope to be able to show that the emotions have are influenced by the distribution of other agents.

We will also look at the influence of the distribution of emotional vs rigid agents on the total gain. from this we could see the way the emotional agents influence the gain.

3 Results

The simulation of the IDP is run on different parameters in order to obtain the results. Below, the findings are reported.

3.1 Experiment findings

Table 2 shows the global scores of the simulation. These are the obtained points by all the 900 agents in the grid.

In order to infer on the influence on emotional behaviour on the Iterative Prisoners dilemma, four figures are made with different ratio's of emotional and rational agents. These can be seen in Figures 1, 2, 3 and 4. The ratio's are represented in the format (x, y, z) where they represent the cooperators, defectors and emotional agents, respectively.

Cooperators	Defectors	Emotional agents	Total Gain
0%	100%	0%	432000
0%	50%	50%	495791
25%	25%	50%	527456
0%	0%	100%	537659
50%	0%	50%	558541
100%	0%	0%	576000

Table 2: Total gain for different distributions of 900 agents.

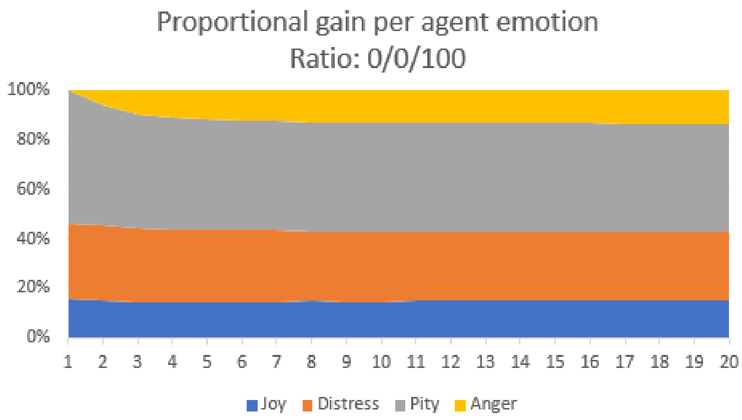

Figure 1: A line plot that shows the how much gain, each emotion adds to the global gain. In this simulation the ratio's of the initial situation is: 0% cooperators, 0% defectors and 100% emotional agents.

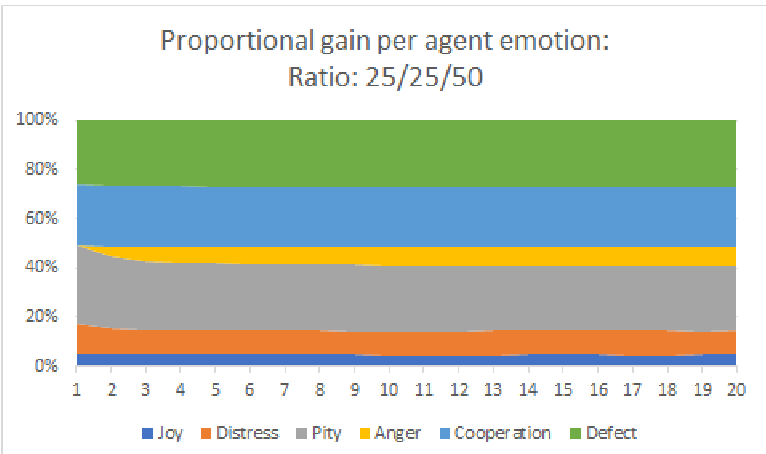

Figure 2: A line plot that shows the how much gain, each emotion adds to the global gain. In this simulation the ratio's of the initial situation is: 25% cooperators, 25% defectors and 50% emotional agents.

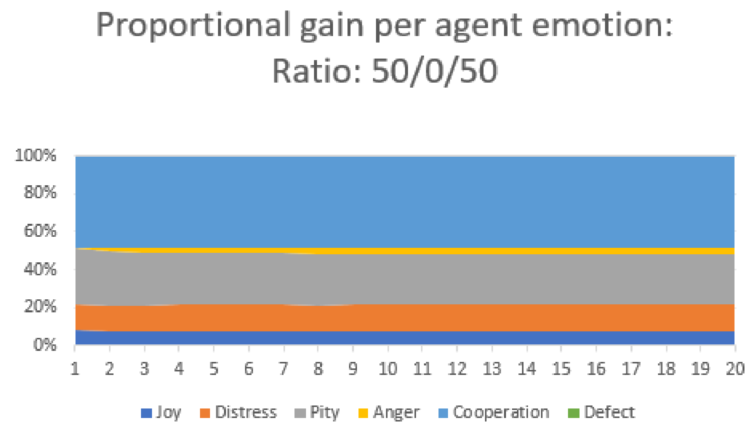

Figure 3: A line plot that shows the how much gain, each emotion adds to the global gain. In this simulation the ratio's of the initial situation is: 50% cooperators, 0% defectors and 50% emotional agents.

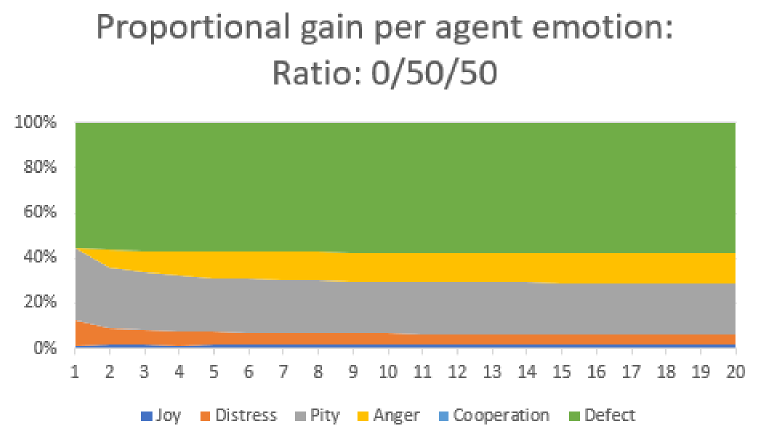

Figure 4: A line plot that shows the how much gain, each emotion adds to the global gain. In this simulation the ratio's of the initial situation is: 0% cooperators, 50% defectors and 50% emotional agents.

3.2 Interpretation of findings

The results show us that the emotional agents stabilise the results of the other agents. We see that they adapt to the other agents. The ratio of anger becomes higher when playing against more defectors, while the gain of joyful agents increase when playing against agents that cooperate. This shows that the emotional agents are responsive to their surroundings.

Another finding is that the total gain of a completely cooperative system is slightly lessened by the introduction of emotional agents, while the gain of a defecting system is increased somewhat more.

We can also see that the gain of the emotional agents is consistently 50% across all situations. The emotional agents seem to be flexible enough to gain at least half of the total gain, independent from the initial ratio's.

4 Conclusion

4.1 Discussion

To be added

4.2 Relevance

To be added

4.3 Future Work

To be added

4.4 Team Work

To be added

References

[Axe80] Robert Axelrod. "Effective Choice in the Prisoner's Dilemma". In: *Journal of Conflict Resolution* 24.1 (1980), pages 3–25. DOI: 10.1177/002200278002400101. eprint: https://doi.org/10.1177/002200278002400101. URL: https://doi.org/10.1177/002200278002400101.

[Axe84] R. Axelrod. *The Evolution of Cooperation.* Basic Books, 1984. ISBN: 0465021220-9780465021222-0465021212-9780465021215.

[BB01] Ana L. C. Bazzan and Rafael H. Bordini. "A Framework for the Simulation of Agents with Emotions". In: *Proceedings of the Fifth International Conference on Autonomous Agents.* AGENTS '01. Montreal, Quebec, Canada: ACM, 2001, pages 292–299. ISBN: 1-58113-326-X. DOI: 10.1145/375735.376313. URL: http://doi.acm.org/10.1145/375735.376313.

[GL00] Piotr J Gmytrasiewicz and Christine L Lisetti. "Using decision theory to formalize emotions in multi-agent systems". In: IEEE. Feb. 2000, pages 391–392. ISBN: 0-7695-0625-9. DOI: 10.1109/ICMAS.2000.858490.

[OCC88] Andrew Ortony, Gerald Clore, and Allan Collins. "The Cognitive Structure of Emotion". In: *Contemporary Sociology* 18 (Jan. 1988). DOI: 10.2307/2074241.

[ONe00] B. O'Neil. "Approaches to modelling emotions in game theory." In: *Proceedings of the Conference on Cognition, Emotion and Rational Choice* (Apr. 2000). URL: http://www.sscnet.ucla.edu/polisci/faculty/boneill/emotions.html.