Effects of cheaters on altruistic signaling

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Abstract

This report explores some conditions that influence the evolution of cheating individuals in an altruistic signaling society. It explores specifically three kinds of signaling: advertising of food, warning of nearby predators and begging for food. The experimental method considers food distribution, predator density and population size as factors that could influence the evolution of cheating behaviors on these signals.The results of the simulations show that predator density seems to be the most influential factor.

1 Introduction

Altruism is defined as a situation in which an individual acts to promote or enhance the fitness of other members of a group at the same time reducing its own fitness [4]. When all individuals of the group engage (by proving help and/or benefiting from it) on these behaviors we have an altruistic society. This work explores the effects of cheaters (individuals who perform deceiving activities) on an altruistic society.

The first part of this work explores an altruistic signaling society. In an altruistic signaling society individuals emit signals to advertise the presence of food, or to warn about nearby predators, and there can be two main kinds of deceiving activities: one is to emit a false signal (e.g. a bluff), and the second one is to withhold a signal (e.g. a *food* or *alarm call*). This work focus on the latter. There are biological studies [2] that suggest that withholding information can be beneficial to the individual, and can result in a higher fitness. But there is no evidence about which factors constrain or expedite this behavior. The first part of this work explores some conditions that influence the evolution of withholding information on alarm and food calls.

The second part of this work extends the idea of taking advantage of altruism one step further, in this part we explore the effect of individuals who take advantage not from the emission of signals but from even more explicit altruistic behaviors. An example of altruistic behaviors is the reported in [7] about food-sharing in vampire bats, In this part we introduce a beg-for-food call, and the cheating behavior consists of taking advantage of this signal (using it to procure food) but not responding to it. Conditions that can influence the evolution of this cheating behavior are explored.

The final sections consist of the experimental results and discussion of these results.

2 Methods

For this work, a predator-prey simulation framework for evolving a shared communication system was adopted and extended. A brief summary of this framework is provided below and a detailed description can be found in [5].

The world consists in a two-dimensional grid with three kinds of objects: preys, predators and food.

- Food: static food (e.g. "plants") is distributed in a pre-determined number of sites in the world.
- Predators: agents that move around the world looking for preys. They are not able to communicate among them, but they are able to hear prey's communication.
- Preys: agents that move around the world, looking for food and avoiding predators.They are able to emit/hear signals.

2.1 Preys

Preys are the object of interest of the present work; these are the initially altruistic individuals on which the evolution of deceiving behaviors will be studied.

Signals They are able to emit two distinctive signals:

- *Food call*: when they arrive to a food site, they can advertise this food site to other preys by emitting this signal.
- *Alarm call*: when they see a predator, they can advertise its presence to warn nearby preys by emitting this signal.

States They have six possible behavioral states; these behavioral states are activated according to the world perceptions.

- Wander: the prey is just moving around.
- Search: the prey has heard a food call, so it is trying to find it.
- Forage: the prey saw a food site, so it is moving toward it.
- Consume: the prey is at a food site, and consuming the food.

- Avoid: the prey has heard a alarm call, so it is moving away from the signal source.
- Flee: the prey saw a predator, so it is moving away from it.

Kind The kind of a prey is defined by its communicative abilities. These abilities of communicating signals are determined by the genome of the prey, and do not change during its lifetime. The genome is represented as a two-bit string which is interpreted as follows:

- 00 indicates a NC prey (not able to communicate about food or predators).
- 10 indicates a FO prey (able to communicate only about food).
- 01 indicates a OP prey (able to communicate only about predators).
- 11 indicates a FP prey (able to communicate about food and predators).

2.2 Extensions for evolving cheating in *food/alarm calls*

The existent framework was extended with the purpose of studying the influence of multiple factors in the evolution of cheating (deceiving behaviors) in the advertising of food and the warning of predator call.

Added Cheater Gene We modify the genome to include a new gene. This is called the cheater gene. Preys that have this gene activated do not contribute to communication but take advantage of it (if possible). In this case we have two kinds of individual:

- Altruist: advertises food and warn about predators (if able to communicate about them).
- Cheater: hears the advertisements and warnings, and takes advantage of them, but never advertise or warn (similar to altruistic individuals, the ability to hear the signals is determined by the genome).

This gene has no influence with the other two genes described in the previous section; this means that the prey can have this gene activated regardless of the value of the other two, which can give as a result a NC cheater (which won't take advantage of communication since it is not able to communicate in the first place).

Modified behaviors The behaviors of the prey were modified accordingly to consider the new genome; by adding the constraint of advertising food or warn about predators if and only if the cheater gene is not activated.

2.3 Extensions for evolving cheating in *beg-for-food* calls

The original framework was extended to consider a new signal, a *beg-for-food call.* When an altruistic individual hears this signal, it approaches the emitter of the signal and donates some of its own food to him. A cheating individual is an individual who can emit this signal when in need, but ignores the signal when it hears it. In this task we do not consider the *food calls* or *alarm calls* to limit our focus to the relevant information.

Added signal Beg-for-food call: This call is emitted to elicit a donate behavior from fellow preys.

Added behaviors

- Begging: when the prey founds itself with an internal storage of food that is below of a predetermined critical amount then it changes its state to Begging and emits a *beg-for-food call.*
- Approach: when a prey hears a *beg-for-food call*, the it tries to approach to the source of the message to be able to donate him food.
- Donate: when the prey founds the starving fellow, it donates him an amount of it's internal storage of food.

Some constraints apply to these behaviors state transitions:

- The prey can only change to a Begging state if it is currently on the wander state. If the prey is on Forage or Consume state it has more opportunity to get food directly from the food site than from begging, and if the prey is on Avoid or Flee, then these behavioral states get precedence (what is the point of getting food if you are going to be eaten by a predator?).
- The prey can only try to approach to source of the *beg-for-food call* if its internal storage of food is higher than a pre-determined amount. (what is the point of approaching to a starving fellow if you are starving yourself or if donating food can put you in a dangerous situation?). So in a sense, this limits the altruism, the prey can only be altruistic if it doesn't jeopardize its situation.

In this case we have two kinds of individual:

- Altruistic individual: Donate food as a result of *beg-for-food call.*
- Cheater individual: ignore the *beg-for-food calls* it hears, but it could emit this signal if in need.

3 Experiments

Since an approach of systematically varying parameters is not feasible (because of computing-time constraints) we took the parameters that were shown to evolve the shared communication system (as described by the study in [5]) as our reference frame. We considered that parameters that didn't evolve the communication system in the first case, were unlikely to have relevance on this study.

Unless explicitly noted otherwise, all the simulations reported below were done using the following parameters: the environment was 60x60 in size, predators and preys had a vision of three cells, could hear signals at a distance of six cells, and could move in any direction. Preys had a maximum storage capacity of 30 food units and a newborn had an initial storage of 25 units. Spatial constrained selection and placement, and tournament size of two was used. Simulations were run under 100,000 iterations.

The results reported below for each simulation are the averaged values over 10 different runs of the simulation.

The simulator is run using LispWorks 4.2.0 under Windows XP. A single run of one simulation takes approximately 6 minutes on a Pentium IV a 2.4 Ghz and 11 minutes on a Pentium III a 1.0 Ghz.

4 Results

4.1 Evolving withholding of *food/alarm calls*

Baseline simulation For the first part of this work, the focus is in the conditions that influence the evolution of cheating in *food/alarm calls*. To have a baseline to which compare the results of varying several parameters, the first simulation was made set with the default parameters, no food and no predators. The initial population was 200 FO preys, and mutation rate of 0.003 was set for mutating the cheater-gene (other mutations were not allowed). So, our population consists initially of altruistic FO preys, and could evolve to cheater FO preys. The long-term expected fraction of the population in the baseline simulation that is altruistic or cheater is about 0.5, because of the fixed mutation rate. As expected, in Figure 1 we can see this result. This baseline simulation is valid also when considering an initial population of 200 altruistic OP preys, which can evolve to cheating OP preys.

4.1.1 Evolution of cheating in food calls

As mentioned before, a cheating individual will hear and take advantage of *food calls*, but will withhold advertising of food. Two factors that could influence of the evolution of cheating individuals in the advertising of food are studied: the distribution of food and the population size.

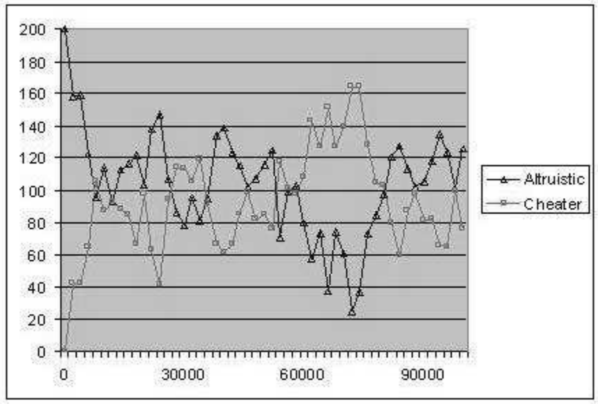
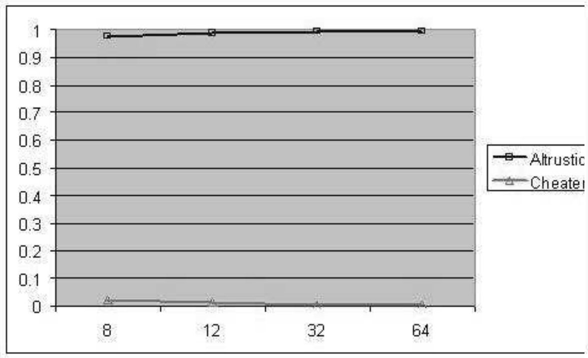


Figure 1: Baseline simulation with no food / no predators. (Time vs Number of Agents)

Varying food distribution In this experiment the amount of food was fixed (1600 units) and the number of food sites was varied. A hypothesis for this experiment is that cheaters would seem more possible to evolve in situations where the resources are scarcer, and advertising of a scarce resource would limit its own fitness due to competition. In this case, cheaters would be more likely to evolve in environments where the amount of the food site is smaller. The results obtained in this simulation do not agree with the hypothesis. In the simulations cheaters were unlike to evolve independently of the distribution of food. An explanation could be that, even though the distribution of food varies, this doesn't put enough pressure over resource competition. Results are showed in Figure 2.

Varying population size In this experiment the population size was varies from 75 to 200 agents. A hypothesis for this experiment is that cheaters would seem more possible to evolve in situations where there is more resource competition. In this case, cheaters would be more likely to evolve in environments where the population size is bigger. Again, the results obtained in this simulation do not agree with the hypothesis. In the simulations cheaters were unlike to evolve independently of the population size. Results are showed in Figure 3.



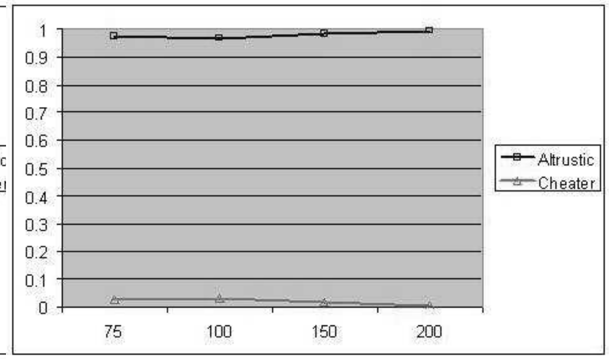


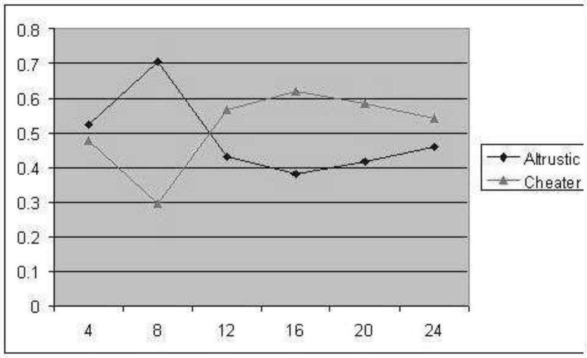
Figure 2: Fraction of population of each type averaged in the last 30,000 iterations. (Axis X shows the number of food sites)

Figure 3: Fraction of population of each type averaged in the last 30,000 iterations. (Axis X shows the population size)

4.1.2 Evolution of cheating in alarm calls

A cheating individual is defined here as an individual that is able to hear and take advantage of *alarm calls*, but withhold warning. Two factors that could influence of the evolution of cheating individuals in the warning of nearby predators are studied: the density of predators and the population size.

Varying predator density In this experiment the predator density varies from 4 to 24 agents. Warning of predators can be costly to the sender, since predators are able to hear these messages and locate a prey that they would have missed before. So, a hypothesis for this experiment is that cheaters would seem more possible to evolve in situations where there the risk of predation is higher. The results of the simulation agree with this hypothesis. We can observe that cheaters get a higher fraction of the population when the number of predators increases. The maximum percentage of the population is 60% , and then it starts to drop. An explanation of these could be the cheaters can not dominate the population because they have a parasite-relationship with altruistic agents (they need to be warned about nearby predators). Results are showed in Figure 4.



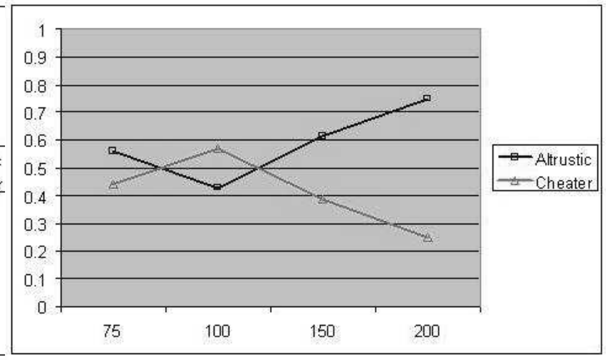


Figure 4: Fraction of population of each type averaged in the last 30,000 iterations. (Axis X shows the number of predators)

Figure 5: Fraction of population of each type averaged in the last 30,000 iterations. (Axis X shows the population size)

Varying population size In this experiment the population size was varies from 75 to 200 agents. A hypothesis for this experiment is that cheaters would seem more possible to evolve in situations where there are more warning agents to take advantage from. So, in this case, cheaters would be more likely to evolve in environments where the population size is bigger. The results obtained in this simulation do not agree with the hypothesis. Increasing the population above 100 seems to have a negative effect on cheaters. Results are showed in Figure 5.

4.2 Evolving cheating in *beg-for-food calls*

Altruistic preys respond to the *beg-for-food call* by approaching to the message source and donating food, while cheaters ignore these calls (but they used them if they need them).

Two factors that could influence of the evolution of cheating individuals in this donating-food behavior are explored: food distribution and predator density.

Baseline simulation In here the simulation was set with the default parameters, no food and no predators. In here we are interested in conditions that influence the

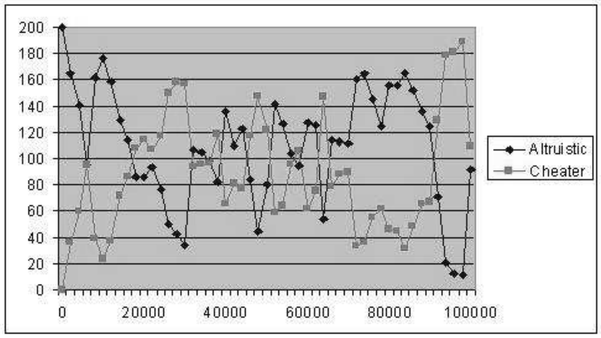


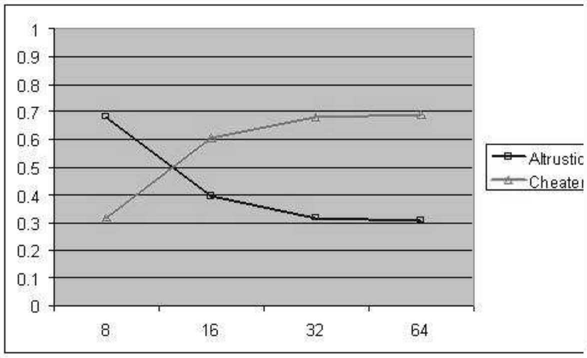
Figure 6: Baseline simulation with no food / no predators. (Time vs Number of Agents)

evolution of cheating in *beg-for-food calls*. In order to explore these we started with a population of 200 altruistic preys, and set a mutation rate of 0.003 for mutating the cheater-gene, other mutations were not allowed. In here we are not considering *food/alarm calls*.

The long-term expected fraction of the population in the baseline simulation that is altruistic or cheater is about 0.5, because of the fixed mutation rate. In Figure 6 we see a mixed result; the altruistic and cheaters agents fluctuate and neither of them can dominate the population and reach an equilibrium point.

Varying food distribution In this experiment the amount of food was fixed (1600 units) and the number of food sites was varied. A hypothesis for this experiment is that cheaters would seem more possible to evolve in situations where the resources are distributed throughout the environment, so they have a bigger opportunity of being approach for an altruistic agent that has access to food (otherwise even if there are altruistic agents, they won't be able to donate food). The results obtained in this simulation agree with the hypothesis. In the simulations the percentage of cheaters increases when the number of food sites is higher than 16. See Figure 7.

Varying predator density In this experiment the predator density varies from 4 to 24 agents. Begging for food can attract predators, which put in danger not only the starving agent, but also any altruistic agent that approaches to the message source to



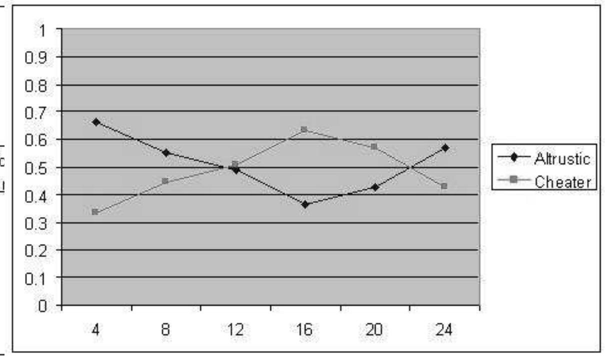


Figure 7: Fraction of population of each type averaged in the last 30,000 iterations. (Axis X shows the number of predators)

Figure 8: Fraction of population of each type averaged in the last 30,000 iterations. (Axis X shows the population size)

donate food. So, the hypothesis here would be that cheaters would be likely to evolve when the number of predators increases. In here the results agree with the hypothesis, we can see a increase of the cheaters population as the number of predators increase, but when the predators reaches 20 the number of cheaters individuals starts decreasing. An explanation for that could be that they reach the critical point at 16 predators, when the percentage of cheating individuals is higher than the altruistic individuals reaching a 60% percentage, and cheater individuals can not dominate the population since they need the altruistic individuals to take advantage of.

5 Discussion

The results of the simulations were mixed, since it didn't always agreed with the hypothesis.Nevertheless, this study gives us an insight of possible conditions affecting the evolution of cheating behaviors in initially altruistic agents.

In the case of the evolution of cheating behaviors for the *food call* it is still unclear which factors can truly influence its evolution, since neither the food distribution nor the population size seem to have affected it.

In both *alarm calls* and *beg-for-food calls*, predator density has a strong influence over the evolution of cheating individuals. In both cases the number of cheating individuals reach their maximum percentage at 16 predators when they have approximately 60% of the population, and then they start decreasing. This decrease could be due to the fact that they have a parasite-relationship with the altruistic individuals (they need altruistic individuals who would emit the *alarm calls* or who will donate food when they hear the *beg-for-food call*) so they can not take over the entire population.

Another factor that influenced the evolution of cheating behavior in the beg-for-food calls is the food distribution. If the food is distributed throughout the environment, then the cheating individual has a bigger opportunity to be approached by an altruistic individual who has access to food (remember that altruistic individuals donate food only if they have enough reserves).

A limitation of this study is the computation-time necessary to run the experiments. This severely constrains the possibilities of varying parameters.

6 Future work

One extension is to enable preys to discriminate between them, so individuals (an not member of an anonymous society) can interact with each other. As pointed out in [1] agents should have histories; they should perceive and interpret the world in terms of their own experiences. This ability to discriminate between individuals would enable an arms-race between cheaters and discriminating receivers, so donors can recognize and expel cheaters (as mentioned in [6]).

References

[1] Dautenhahn, Kerstin. The art of designing socially intelligent agents: science, fiction and the human in the loop. Applied Artificial Intelligence Journal, Special Issue on Socially Intelligent Agents, 1998, 12(7-8):573-617.

[2] Hauser,Marc. Costs of deception: Cheaters are punished in rhesus monkeys (Macaca mulatta), Proceedings of the National Academy of Sciences of the United States of America, 1992, Dec 15;89(24):12137-9.

[3] Lachmann Michael and Bergstrom Carl. Signaling among Relatives, II. Beyond the Tower of Babel, Theoretical Population Biology, 1998 Oct;54(2):146-60.

[4] Lincoln, R., Boxshall, G. and Clark, P. A Dictionary of Ecology, Evolution and Systematics. Second edition. 2001. Cambridge University Press. 361pp.

[5] Reggia James, Schultz Reiner, Uriagereka Juan, and Wilkinson Jerry. A simulation environment for evolving multiagent communication, Technical Report, CS-TR-4182, Computer Science Department, University of Maryland, 2000.

[6] Reggia James, Schultz Reiner, Uriagereka Juan, and Wilkinson Jerry. Conditions Enabling the Evolution of Inter-Agent Signaling in an Artificial World. Artificial Life, 2001, 7(1):3–32.

[7] Wilkinson, Jerry. Food Sharing in Vampire Bats, Scientific American. February, 1990:76-82.