Cooperation and individual strategy in social science

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Abstract

Cooperation is the process of organisms working or acting together for common, mutual, or some underlying benefit, as opposed to working in competition for selfish benefit. Many animals and plants species cooperate both with other members of their own species and with members of other species. The reasons, which make a herd or a group of people reach a cooperative state of mind, are still not clear; the main goal of this work is analyzing some possible ways the cooperation may arise through. These possible ways belong to the individual survival strategies (ISS) class and they show us that cooperation can arise only under specific choises of global parameters values.

Introduction The *cooperation* and *survival strategy* concepts play a huge role in this work, so that I have to discuss them and explain their meaning before showing any parts or results of this work.

Let us explain first what a survival strategy is [1]; to survive and reproduce an individual must possess resources which have to be available for use. A resource can be defined as anything which, when it is used by an individual, directly or indirectly causes an increase in the individual's reproductive chances (like food, artefacts, knowledge, money, etc.). Survival strategies assumed by each member of population depend on how this member decides to collect or share some of his resources; there are two main servival strategies classes: the *individual survival strategy* (ISS) or the *social survival stategy* (SSS). The ISS makes each member of the population be selfish and not allowed to share its resources with anybody else; instead, when a SSS is adopted by the population, resources can be collected through cooperative way and they are shared from a member to another when someone is in need. Let us now introduce the role of cooperation; cooperation plays some role in any social system detectable in nature and it can be classified as the state of mind the population has when it adopts a SSS.

Because of cooperation importance in social science, a huge research effort has been made in order to clarify the genesis of cooperation; two big branches of research exist: the neurologic and evolutionist one [2, 3, 4, 5]. Sociologists, biologists and neurologists don't agree on every aspects of the research but they are convinced that each event (involving cooperation) belongs to one of these classes:

- **Parental selection**
  Every altruistic behaviours, having to goal of protecting members of the family, belongs to this class. The first researcher that took into consideration this approach was C. Darwin and then it was studied in deep by W. D. Hamilton in 1963.

- **Direct Reciprocity**
  The meaning of direct reciprocity is really simple and it can be sum up in the following sentence:"*The individual A helps another individual B if and only if B will help A* "

- **Not direct Reciprocity**
  It can be sum up in the following sentence:"*The individual A helps*

another individual B if and only if a third individual C will help A or it will increase gain of A"

- **Network Reciprocity**
  The network reciprocity takes into account specific cases of Not direct Reciprocity; in fact it tries to explain cooperation in ecologic system where only a part of the population can know that an individual has had an altruistic behaviour, so that the system creats spontanuesly an information network in order to inform all the population about altruistic behaviour.

- **Multilevel selection**
  This branch tries to explain how cooperation work when there are different species involved in a cooperation event.

This work counts two different parts called **"direct reciprocity"** and **"direct reciprocity and sympathy"**

Direct reciprocity I focused on **direct reciprocity** showing that this kind of events can be modeled using an agent based model and discussing the boundary induced transition toward a cooperation state. Basically a population of certain number of humans (or animals, this choice is up to the reader) has to collect resources spread on the environment. When a member of the population works by itself in order to collect them, it earns a certain gain (called α). On the contrary, when two individuals try two collect some resources, they can fight (so that the fight-survival gets a gain β) or cooperate (getting gain γ); the only constrain imposed is $\alpha < \beta < \gamma$. After a certain number of meetings near a resource storage, each member of the population evaluates the total resources gained during its history and it can decide to cooperate all the time (increasing its risk). Choosing certain values for the boundary parameters, a Non Equilibrium Steady State (NESS) is reached and a cooperative society arises.

ciprocity and sympathy This model is different from the **direct reciprocity** case. In fact the turtles presents the direct reciprocity behaviour described above but they can't decide to cooperate all the time they only in crease the probability of a cooperative behaviour. In addition to that, they can fell symphaty so that turtles can increase the probability of a cooperative

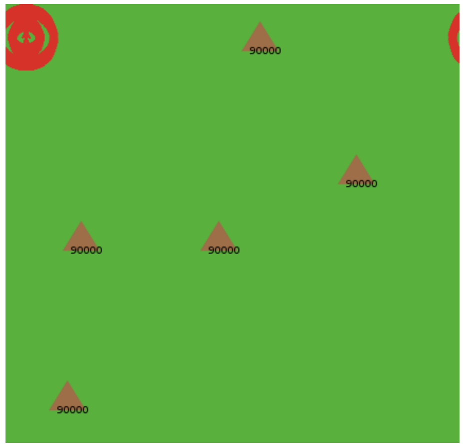

Figure 1: Setup of the model: `NumberOfPeople`= 4000 turtles are created in a specific point (4^{th} quadrant) and the resources storages are spread in the environment

behaviour if they face other turtles that already cooperated a certain amount of times. Choosing certain values for the boundary parameters, a Non Equilibrium Steady State (NESS) is reached and a cooperative society arises in this case too.

Direct reciprocity

1 Dynamic of the system and Code

The basic structure of the model is pretty simple in fact the system is initialized creating a group of `NumberOfPeople` turtles (colored red) in a specific point of the environment where some resources storage (yellow triangles) are spread on (Fig.11). Then the turtles start moving randomly and they collect resources when they are near enough (`in-radius 3`) a resource storage all alone (turtles get black colored when they are close to the storage enough to collect resources) Fig.2

The turtles main attributes are `attitude`, `gain` and `experience` (whose meaning will become clearer in the following) while the most important attribute of the storages describes how many resources are still collectable and it decreases when a turtle collects some of them. A huge role is played, in

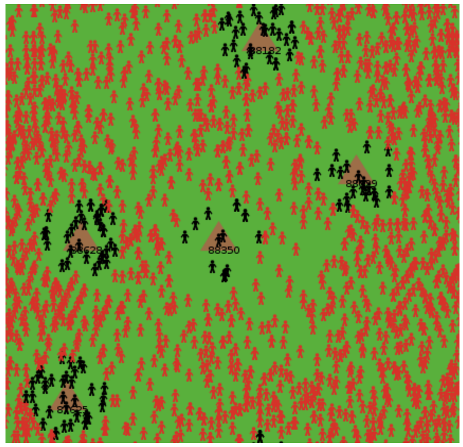

Figure 2: `Numberofpeople`= 4000 turtles move randomly in the environment and they get black colored if they are collecting resources near a storage.

the dynamic of the system, by two turtles meeting near a storage. In fact the `attitude` attribute is a boolen variable that is 1 if the turtle fights other turtles near the storage to steal its `gain` (attribute of the turtles that describes the gain obtained collecting or stealing resources) or 0 if the turtles try to cooperate with another turtle in order to collect more resources.
The global variable, called `fightingprobability`, describes the probability that each turtle attitude is 0 (or 1 otherwise). Therefore let us itemize the possible situations which a turtle (**A**) may face when it gets near a storage and there is (or not) another turtle (**B**):

(1) The turtle **A** is alone (there is not turtle **B** `in radius-3`) and it is close to the storage: the turtle gain is increased by 1

(2) [`attitude-`**A**=0, `attitude-`**B**=0]
The turtles (**A** and **B**) cooperate in order to collect resourses and the gain of both is increased by 3

(3) [`attitude-`**A**=0, `attitude-`**B**=1]
The turtle-**B** kills turtle-**A** and the gain of turtle-**B** is increased by the gain that turtle-A collected before.

(4) [`attitude-`**A**=1, `attitude-`**B**=0]
The turtle-**A** kills turtle-**B** and the the gain of turtle-**A** is increased by the gain that turtle-**B** collected.

(5) [attitude-**A**=1, attitude-**B**=1]
Two outcomes are possibile: [attitude-**A**=1, attitude-**B**=0] and [attitude-**A**=0, attitude-**B**=1] and the happening of both has the same probability.

The reader can check the code (”fightmining” method) used in order to characterize the possible outcomes of a turtles meeting (mines are the storage agents and humans are the turtles agents)

```
to fightmining
let dude one-of mines in-radius 3
let hum one-of other humans in-radius 3
if dude != nobody [;se c'è  miniera vicino
ifelse hum = nobody [set gain  gain + 1 ask dude [set gold gold - 1]][
let alpha [closemine] of hum
ifelse alpha = 0 [set gain gain + 1 ask dude [set gold gold - 1]]
[
ifelse attitude = 0 [
ifelse [attitude] of hum = 0 [set gain  gain + 3 ask dude [set gold gold - 3] set
ifelse [attitude] of hum = 0 [ask hum [die]][ifelse random(10) < 5 [set gain gain
]
]
]
]
end
```

The turtles behaviour (described above) can change after Numberofexperiences(global variable) meetings near a storage; in fact the experience attribute is an array that counts how many meetings the turtle has faced; if the array length is higher than Numberofexperiences and if the turtle gain is higher than Numberofexperiences length then (when the turtle gets close the storage) the only possible outcomes are **(1)** and **(2)**.

```
to go
ask humans [
forward random 3
closetomines
ifelse length experience > Numberofexperiences [if gain > Numberofexperiences [set
```

interface.png

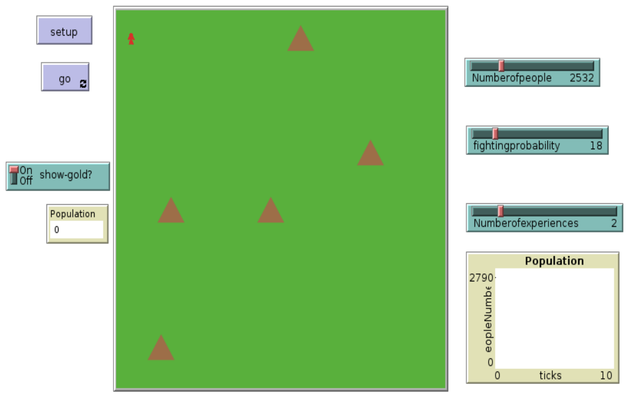

Figure 3: The program interface.

```
fightmining
]
ask mines [if gold < 0 [die]]
number
display-gold

tick
end
```

The reasons behind this change of behaviour became clear when we imagine a turtle deciding to accept a higher die-risk if a possible cooperation might make it collect a greater amount of resources. Moreover the fact, that its gain must be higher than the experience length, means that it faced at least another turtle trying to cooperate with it; so that it already saw cooperation and it understood what cooperation is.

2 User instructions and results

Let us explain the interface of this program (Fig. 3). Using the sliders, the user can notice that the choice of the `fightingprobability`, `Numberofpeople` and `Numberof experiences` values strongly affects the achievement of a co-

operative state.
The fightingprobability slider allows us to choose the probability for fighting or cooperative behaviour of turtles during a meeting near a storage.
The Numberofpeople slider allows us to decide how many turtles will be created inizializing the system.
The Numberofexperiences slide monitors the number of meeting which each turtle has to face in before adopting a cooperative behaviour.
Checking the number of turtles alive is also possible and the user can switch on or off the resources left monitoring too.
The SETUP button has to be pressed in order to create the system and then the user can run the model by pressing GO. The possible model asymptotic outcomes are two different NESS: **reaching-cooperation-NESS** or **alone-survivor-NESS**.
The **reaching-cooperation-NESS** shows that the turtles (not died during the transition toward the NESS) chose cooperation and they will cooperate since then. The **alone-survivor-NESS** shows that only one turtle survived after transition toward the NESS; obviously the number of still alive after the transition turtles depends on the values of fightingprobability and NumberOfExperience. Clearly a high value of NumberOfPeople and low values for fightingprobability and NumberOfExperience promote the **reaching-cooperation-NESS**; this kind of behaviour can be easily shown taking into consideration the role of the global variable: NumberOfExperience (pretty much the same for fightingprobability). We can see the transition toward the NESS in Fig. 4-5 . The mean life τ describes how the exponential decays and it is possible to see how the number of turtles still alive after the transition is much lower if the NumberOfExperience is higher.

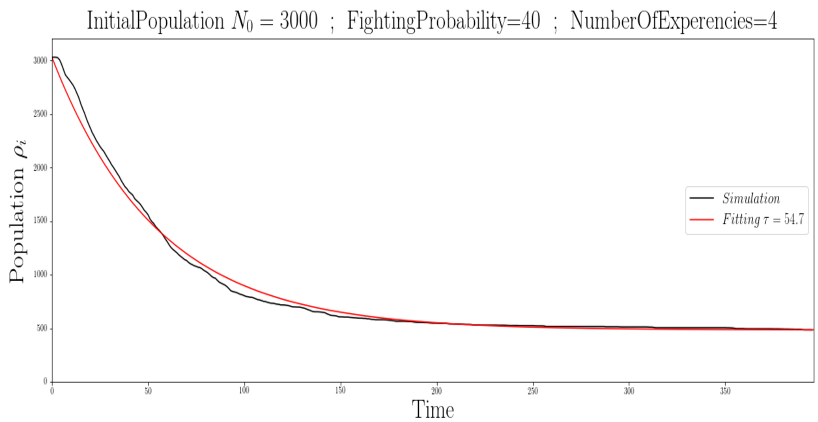

Figure 4: Black line describe the population decay during transition toward NESS. Red line rappresents the exponential fitting.

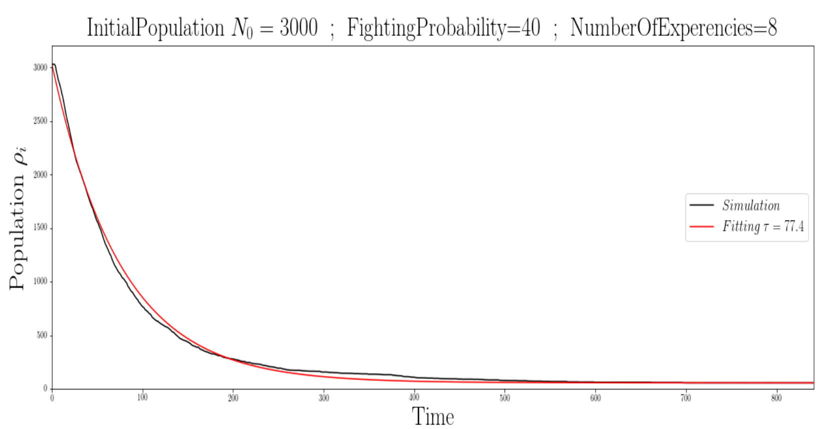

Figure 5: Black line describe the population decay during transition toward NESS. Red line rappresents the exponential fitting.

3 Dynamic of the system and Code

The basic structure of this model, as already said, is similar to the **Direct reciprocity** case; in fact the system is initialized creating a group of `NumberOfPeople` turtles (colored red) in a specific point of the environment where some resources storage (yellow triangles) are spread on (Fig.1). The turtles can't decide to cooperate all the time they only increase the probability of a cooperative behaviour. In addition to that, they can feel symphaty toward other turtles in order to increase the probability of a cooperative behaviour if they face other turtles that already cooperated a certain amount of times.

Let us now discuss the turtles main attributes; each turtle owns the following attributes: `closemine`, `gain`, `attitude`, `experience`, `fightingprobability` and `cooperated`. The attributes `closemine`, `gain`, `attitude`, `experience` have been already introduced in the first part while the attribute `fightingprobability` and `cooperated` represent the big difference between this model and the Direct reciprocity model. In fact `fightingprobability` is no more a global variable but it is an attribute so that each turtle fighting tendecy can be affected by the events which it face. On the other hand the attribute `cooperated` is an attribute that plays a huge role in the symphaty behaviour, in fact `cooperated` is an array attribute that counts how many time the turtle cooperated.

Each turtle faces four possible (see the Direct reciprocity model) situations when it meets another turtle but, in this case, the turtles behaviour (after `Numberofexperiences` meetings near a storage) changes differently respect to the the Direct reciprocity model; if the `experience` length is higher than `Numberofexperiences` and if the turtle gain is higher than `Numberofexperiences` length then each turtle `fightingprobability` attribute dicreases of `Decrease`(global variable). In addition to that, if the turtle gets near another turtles that has a `cooperated` lentgh higher than 3, the turtle decreases its fighting probability of `Decrease`. In the following it is possible to see how the method `fightmining` is modified and the addition of `think` method:

```
to fightmining
let dude one-of mines in-radius 3
```

```
let hum one-of other humans in-radius 3
if dude != nobody [
ifelse hum = nobody [set gain  gain + 1 ask dude [set gold gold - 1]][
let alpha [closemine] of hum
ifelse alpha = 0 [set gain gain + 1 ask dude [set gold gold - 1]]
[
ifelse attitude = 0 [
ifelse [attitude] of hum = 0 [set cooperated lput 1 cooperated set gain  gain + 3
ifelse [attitude] of hum = 0 [ask hum [die]][ifelse random(10) < 5 [set gain gain
]
]
]
]
end


to think
let hum one-of other humans in-radius 3
if length [cooperated] of hum > 3 [ set fightingprobability fightingprobability -
end


to go
ask humans [
forward random 3
closetomines
if length experience > Numberofexperiences [if gain > Numberofexperiences [set fig
changingprob
fightmining
if fightingprobability < 0 [ set fightingprobability 0]
]
ask mines [if gold < 0 [die]]
number
meanattitude
display-gold

tick
end
```

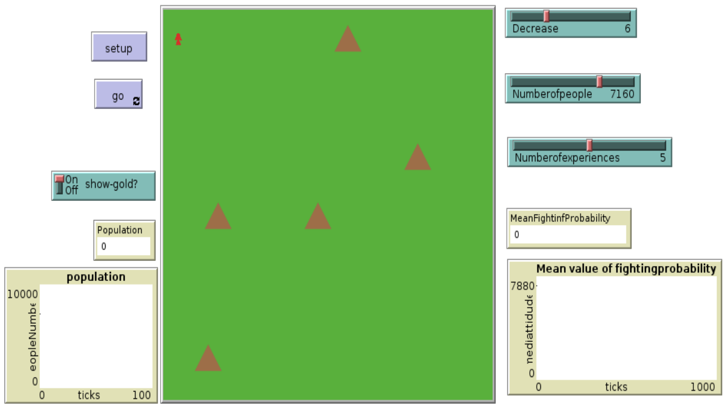

Figure 6: The turtles start moving randomly and collecting resources when they are near a resource storage all alone (turtles colored black) when they are close to the storage enough to collect resources

4 User instructions and results

The NetLogo interface (Fig.6) is similar to the first model interface; there is the `Numberexperience` and `Numberofpeople` sliders which play the same role discussed in the fisrt part. Instead the `Decrease` slider allows the user to decide how much the sympathy or the memory/experience can affect the the turtles cooperative behaviours; in fact the user can choose through the `Decrease` slider how much his `fightingprobability` decreases after a certain number of experiences and after a certain number of meeting a turtle with a cooperative history. The user can also check how many turtles are still alive and how much is the mean value of the fighting probability.The `SETUP` button has to be pressed in order to create the system and then the user can run the model by pressing `GO`. The possible model asymptotic outcomes are two different NESS in this model too: **reaching-cooperation-NESS** or **alone-survivor-NESS**.

The **reaching-cooperation-NESS** (Fig.7-8)shows that the turtles (not died during the transition toward the NESS) chose cooperation and they will cooperate since then.Numberofpeople Clearly a high value of `NumberOfPeople` and of `Decrease` and a low value for `NumberOfExperience` promote the **reaching-cooperation-NESS**. Obiously the setup value of the `fightingprobability` attribute is really important too.

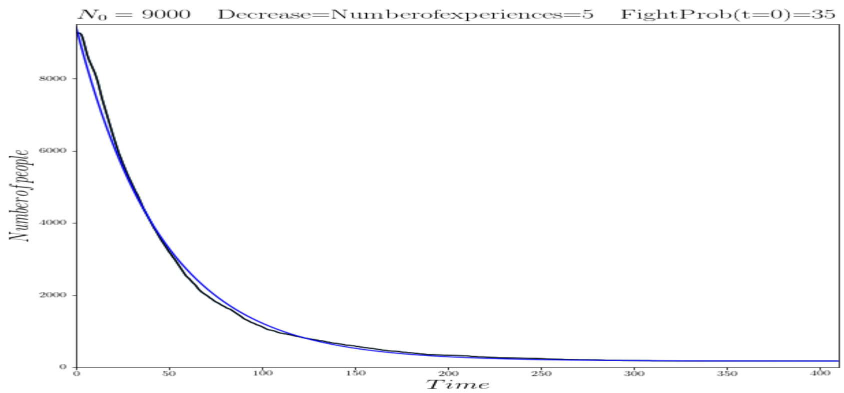

Figure 7: Black line describe the exponential decay of the population; while the blue line show the exponential fitting whit $\tau = 46.33$

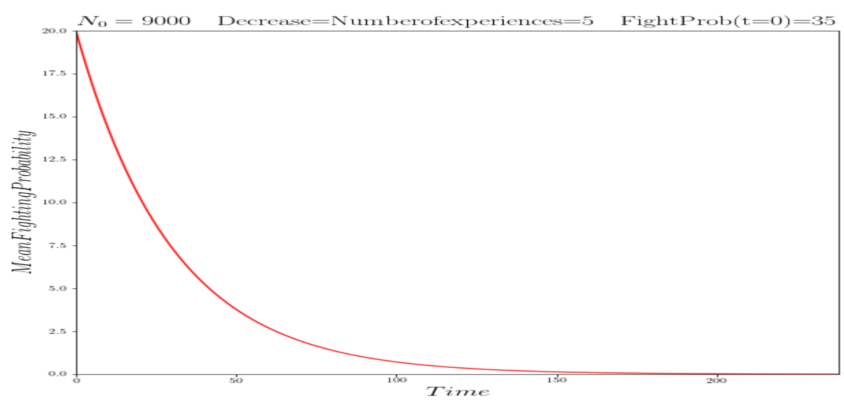

Figure 8: Exponential decay of the `fightingprobability` mean value

Conclusions
Both of the models show really interesting properties and they corroborate some papers results. In fact the main results of the models can be counted in the following:

- **Exponential decay** Exponential decay is a really common behaviour in social system. It shows up in both models, it allows us to define a meanlifetime and it may suggests to us that such complex scenario could be modelized through SDE(Stochastic Differential Equations).

- **Direct reciprocity** Direct reciprocity can be modelled by agents based model. Cecconi and Parisi already attempt this way [1] but they fix the following constrain: turtles must reproduce themselves, instead I showed that this constrain is not necessary to show cooperation in direct reprocity society

- **Sympathy** Sympathy can be a good candidate in order to show how cooperation arises. Sympathy has been studied in many real situations [3] and it is way more realistic than Direct reciprocity.

- **Sympathy and direct reprocity** The combination of Sympathy and direct reprocity allows to show a very realistic system and they both make a population reach a cooperative status for a large range of boundary parameters.

In conclusion these models show two possible way which the animals or humans could go through in order to make a cooperative society. These models could be update introducing a grown-birth behaviour that would make the system more realistic and it could allow a more interesting matching with Cecconi and Parisi [1] results.

References

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