Simulations on the destruction of cooperating conventions

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Abstract

The paper will present the results of simulations of the effect of the invasion of non-cooperating subjects into a community adopting a cooperative convention. The convention is described by an indefinitely repeated prisoner-dilemma game. Presently, we are concerned with the relevance of some aspects of the invaded "community" in what concerns the robustness towards invasion, like the nature of the cooperation-inducing strategy and the number of cooperators. As for the first point, we will investigate whether the robustness increases with the order of a tit-for-tat strategy, where "order" stays for the number of compulsory cooperating moves after a non-cooperating one. However, we deem that the latter is the most interesting topic. We will check whether the robustness increases with the number of cooperators (i.e. with the numbers of players in the p.d. game) and with the structure of cooperation (a single defection may destroy the overall cooperation or may simply reduce the payoff for remaining cooperators). We will use the SWARM simulation language. The relevance for real-world problems will be discussed; presently it is quite low -but not nil. We hope to gain a substantial one through successive complications of the model.

Keywords: simulation, conventions, spatial prisoner's dilemma

1. Introduction

This paper describes a simulation frame to be employed to study the robustness of cooperative conventions. In this section we will discuss three introductory points: the class of real-world problems this approach may be useful to deal with; the limits (some of them) of this approach; and the specific topics we will investigate. Section 2 contains a very brief presentation of the theory of conventions and describes the model. Section 3 shows up-to-date results of our simulations. Conclusions and suggestions for further inquiry follow.

The problem we try to tackle is the following. We assume that *cooperative conventions* play a very basic role in an organized society. When two (or more) societies meet, conventions of both are challenged; when they finally merge, there will be a new society, characterized by a new set of conventions. However, this new set may be of a various nature: with reference to the integration of people forming the societies, the range, both logically and historically, goes from the "melting pot" of Roman, Austrian and (possibly) American empires to the full apartheid of South Africa, ancient India and present day Gypsies. What will be the final result depends upon a lot of factors; the *nature* of the cooperating conventions (the concept will be discussed below) is likely to be a very relevant one. To sum up, what we are trying to study is the *conflict* among conventions.

To our knowledge, up to now there are no experimental or simulative studies on this subject. Probably, Kirchkamp (2000) is the closest one. There is an interesting and growing literature on a related topic, that of the *origin* of a cooperative convention starting from a state of nature. A (very) brief discussion of some pieces of this literature is useful to clarify the limits of our approach.

Vogt (2000) is analytical. He supposes a population where both cooperators and non cooperators are present, and that a mutation allows some subjects to record the nature of the partner. These subjects cooperate with cooperators, and defect with defectors. It results that in equilibrium it is possible that cooperators and defectors coexist.

Eshel *et al.*(2000) and Cooper and Wallace (2000) are simulative. The first shows that cooperation may result (but non necessarily) as a stable strategy (see below) if players interact with neighbours and imitate successfull players. The second shows that cooperation may result if players can choose their partners.

These three papers -and others- make *ad hoc* assumptions, to show that cooperation may result. Their point is that simple (yet unexplained) behavioral assumptions may be sufficient to come out of the state of nature. Their results are theoretical. Our paper is analogous. In other words, we will not try to build a "golem" artificial society to look at what will go on in it. What we will try to do is to investigate what characteristics of cooperation make it robust with reference to some possible setting of the society. As previous ones, our results will be strongly influenced by the simplistic nature of our fictitious world, so it will be impossible to transfer them to the real world. In a sense, they will be in nature of *conjectures.* However, we hope that they may be of interest for two reasons. The first is that, with reference to the important problem of the conflict of conventions, we lack even conjectures. The second is that in an era of globalization the point is of an utmost practical relevance, so conjectures may be useful to on-field inquiries. A (preliminary) list of the topics we think can be investigated with our approach will allow the reader to assess whether their study may actually be useful:

a) How the robustness of a cooperative conventions is affected by the *number* of coperators requested to implement it;

b) *What kind* of cooperative conventions is more robust;

c) To assess the *relative weight* of gain from cooperation and of *learning* in defending cooperative conventions.

Our simulations (up to June 2001) concern point a). However, the program allows already to look for b) and c), and others (some are under discussions) may be added.

2. Method

2.1. Conventions.

The concept of "convention" enjoys a rigorous definition in social sciences. This definition is remarkably powerful, for two reasons. First, it corresponds quite well to the common sense meaning. Second, it is formally identical to the definition of an Evolutionary Stable Strategy used in evolutionary biology. This throws a lot of useful bridges between evolutionary games and sociobiology, or between learning and adaptation. We will not go deeper into this; the final version of the paper will include some references. The definition is the following, according to Sugden (1986):

Given an indefinitely repeated non cooperative game, a strategy I is a convention if all the players adopt I and for every player
(a) E(I,I) = E(J,I)
(b) if E(I,I) = E(J,I), E(I,J) > E(J,J).
for every strategy J?I, where E(a,b) is the expected payoff of a player adopting strategy a against a player adopting strategy b.
(c) There is more than one strategy satisfying conditions (a) and (b).

Conditions (a) and (b) define an ESS too; conditions (c) is peculiar to the social sciences context. What the definition states is that if strategy I satisfies first two conditions, it is *stable*, i.e. *uninvadable*, in the sense that no player may do better adopting another strategy: so it defines a behavioural rule that is self-sustained, with no need of an external enforcement device. This, to say so, is the first half of the common sense definition of a convention. The second half stems from condition (c): a convention is such because there are many possible rules, and to choose one is properly a matter of convention. For instance (and simplifying a little), "stop when the light is red" is a convention: the rule "stop when it is green" would do well the same, provided in both cases that all the players obey to it.

Usually, conventions are studied in the context of a prisoner dilemma game, and here we will do the same. The reason is twofold. On the one hand, the game is very powerful and evocative in describing social dilemmas. On the other, it has been shown that it allows for *cooperative conventions* to take place: in an indefinitely repeated PD there is at least a family of strategies that prescribe cooperation, and that, *once adopted*, cannot be invaded. The family is the famous set of tit-for-tat strategies, albeit without its simplest member. As there are many such strategies, and in addition "never cooperate" is not invadable too, *all* of them qualify as a convention. Note, in addition, that there is no limit to the complexity the definition allows for. For example, strategy I may prescribe "do X if you are in condition a, but Y if you are in condition b". Obviously, not only the number of strategies may be large (or infinite), but the number of players too. This is why it is usually believed that complicated cooperative patterns may be reduced to the basic frame outlined above, or, from another and more suggestive point of view, that whenever there is a cooperative behavior not enforced by an exogenous constraint, there is a cooperative convention at work.

2.2. The model.

There is a "world" populated by a number of *native* (N) subjects that move randomly, and when meet play "coperation" in a PD game. The reason they adopted this strategy is that they get punished if they do not cooperate with a cooperator, so that it pays more to cooperate. This is how cooperative conventions are normally supposed to work. Either a "metanorm" has evolved to punish non cooperators (see Axelrod, 1981) or, as in tit-fo-tat strategies, defectors are forced to suffer one or more defections while cooperating (see Sugden, 1986). A player chooses the strategy providing the highest expected payoff; in this setting, it is always better to cooperate. This world is invaded by new *immigrant* (I) subjects, who adopt a non-cooperative convention: for whatever reason; they never cooperate. They choose what to do according to the expected payoff too.

Now it may become preferable for subjects N *not to cooperate* (if they expect the other player(s) to be I), and for subject I *to cooperate* (if they expect the other player(s) to be N). Both kinds of players evaluate the expected payoffs using the frequencies of previous games as probabilities, so the game evolves. After a while, either all players will have learnt to cooperate, or all will have learnt not to, or some will do and some not. What will happen depends upon the value of the parameters defining the relative number of immigrants, the payoffs, the punishment, the nature of the cooperation, the memory and the pattern of invasion. The effect of these parameters is what will be observed.

2.3. Some details on the simulation

(a) The simulation studies how the society evolves when its member interact via the prisoner’s dilemma game. We observe the resistance of the initial cooperating convention to the arrival of immigrants using various sizes of PD playing groups.
(b) We also vary the benefits of cooperating in the society (see Table 1).

1. *First setting:* cooperating yields benefits (strictly positive payoff) even if some members of the PD group defect, and the size of the maximum payoff obtained when cooperating increases with the size of the group;
2. *Second setting:* cooperating is ineffective (payoff becomes 0) unless all members of a group cooperate, and the size of the maximum payoff obtained when cooperating increases with the size of the group;
3. *Third setting:* cooperating yields benefits, but the size of the maximum payoff obtained when cooperating is fixed .

Table 1 The three payoff settings

Size p.d. groups (max=n)	First setting		Second setting		Third setting	
	Defectors	Cooperators	Defectors	Cooperators	Defectors	Cooperators
0	--	n	--	n	--	2
1	n+1	n-2	n+1	0	3	2((n-2)/n-1))
i	n-(i-1)	n-(i+1)	n-(i-1)	0	3	2((n-(i+1))/(n-1)
n	1	--	1	--	1	--

(c) We model how participants are attached to their traditions and use this to compute the probability that other players may or may not cooperate. This feature is represented by a number of periods in which each type of participant is supposed to have encountered only his `traditional' behaviour situation (all cooperate for natives, all defect for immigrants), before the game starts. The greater the value of the parameter pastTimes, the greater the subjective probability of encountering this situation, and the slower the learning. The value of pastTimes may be different for Natives and Immigrants.
(d) The simulation is based on a spatial prisoner’s dilemma where players meet with their neighbours (forming a chain: all members of a group must touch by at least one point), and move to another part of the space at the end of each round. At each round, some players may not be able to find enough neighbours to form a large enough group: these players are assumed to be “sleeping” for one round. Players are disposed in the space according to two specifications:

1. Ghetto, G: natives and immigrants are segregated each to one part of the space, and can only move in their portion of the space. They can only interact on the boundaries of the ghetto.
2. Random, R: natives and immigrants are mixed in random fashion in the space and can move anywhere.

3. Results

Here follow the results up to June 30, 2001. We hope to have better ones for the IAREP conference of September.

3.1. How the cooperating convention depends on the size of the PD groups (see Figure 1).

The graph plots the time requested for the cooperative conventions to become universal against PD group size. Two features are of interest:

(a) there is an optimal group size. The group size corresponds by large to the "technology" of the cooperation. If too few or too many subjects are requested to implement cooperation, the "victory" of the cooperating convention is slower.

(b) the difference between the third payoff setting and the other ones in promoting cooperation is relevant, as expected; contrary to what was expected, the difference between the first and the second payoff setting is not.

3.2. How the cooperating convention depends on the length of the memory (see Figure 2).

The graph plots the time when the cooperating convention becomes universal against "memory", for a 5-player PD. A high value of "memory" corresponds to a "cultural" rigidity of the conventions (see below). Here the memory of Immigrants is allowed to change, while that of Natives is fixed to 1. Again two results (=features to study) are noteworthy:

(a) There is little difference between settings 1 and 2 (while setting 3 is less effective, as expected);

(b) The rigidity of memory is binding only for very high values, actually out of the observed range.

Figure 1 Diffusion of cooperation with size of groups

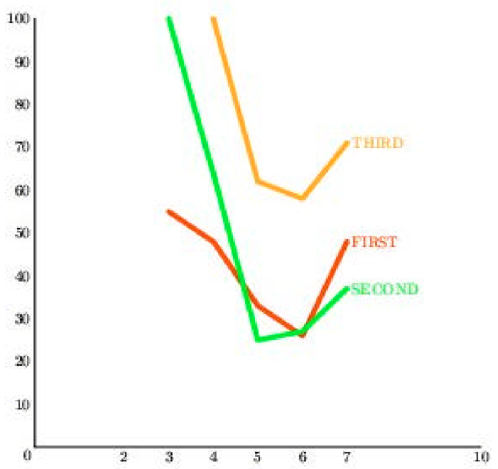
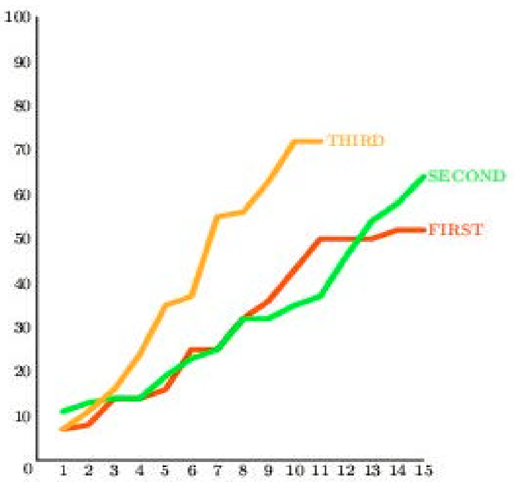


Figure 2 Diffusion of cooperation with length of memory



3.3. Iso-integration curves.

As observed, the effect of all the characteristics (i.e. the parameters) defining the model can be investigated. However, some are more interesting than others. To our opinion two of them mostly deserve attention, i.e. the gain from ccoperation and the learning. They both bear important analogies with the real world. The former may be read as corresponding, in real world, to technology: the more the technology is developed, themore to join efforts in producing is productive. The second corresponds by large to culture weight: the slower the learning process, the more subjects are linked to their original culture.

The combined effect of the two may best be assessed as follows. The two parameters are plotted as the axes of a diagram. A third relevant parameter is assumed as the indicator of the result of their operation: for instance, the time requested by a convention to become universally observed, as in Figure 3 and Figure 4. Every value of the third parameter will then plot as a sort of level (or indifference) curve. The slope of this curve will represent the relative effect of the two main characters. A series of graphs will allow to include the effect of a further relevant parameter/facet, like the number of players needed to implement the cooperation. First simulations appear in Figure 3 and Figure 4. As it may be expected, gains from cooperation are ineffective in promoting integration if tradition is strong, but they become more and more effective as traditions fades (altough there appears to be a minimum time for the cooperating convention to be preserved on which the cooperation gain has no effect).

Figure 3 Iso-integration curves in PD groups with 3 players

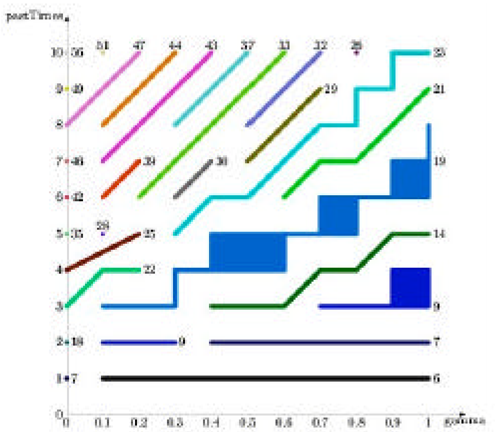
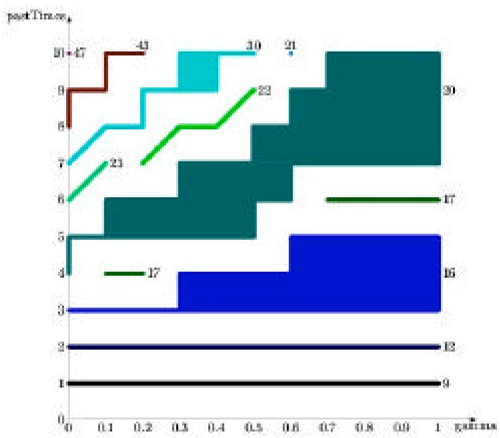


Figure 4 Iso-integration curves in PD groups with 5 players



4. Conclusions.

Our setting is still too rough, so we prefer not to draw real-world indications from it, even if some suggestions are interesting, as seen in the previous section. We plan to make our "world" more realistic through the introduction of new features, like a flexible immigration pattern and the possibility to distinguish the type of co-playing subjects. All these features will be parametrised; it will be possible to assess their effect through successive simulations. Suggestions are welcome.

If you are interested in using the program, please contact the corresponding author.

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