From Cells to States: A Unifying Framework of Social Relativity

Shade T. Shutters1 & Matus Halas2

1School of Sustainability, Arizona State University, Tempe, AZ, USA
2Faculty of Social Sciences, Charles University, Prague, Czech Republic

Abstract: One of the greatest tasks facing both biologists and many social scientists is explaining the evolution of cooperative behavior. Cooperation has been cited as the key to all major transitions in the history of life, from the advent of multicellular creatures to the development of complex societies in certain insect species. Yet similar examples of cooperative behavior can be easily found in other societies, and they also include emergent phenomenon like that of long-lasting peace, functioning of international institutions, or even interactions at the students’ dormitories. All these examples at the same time share a common attribute in that they can be represented as situations in which agents’ individual goals are seemingly at odds with those of a larger group or collective. Because of this commonality, game theory is increasingly being used to understand social dilemmas and social behavior in general. Nevertheless, the fundamental aspect of social evolution of cooperative behavior often remains unaddressed – regard for relative position vis à vis other players. Among biologist it is a matter of fact that only relative fitness matters when explaining evolutionary processes. In other words, the absolute payoff for a particular behavior cannot be assessed properly in isolation from what others get. However, taking into account not only individual benefits but also ones own position with respect to other individuals or agents has been slow to be incorporated into social sciences. Concepts such as interdependent preferences in microeconomics and relative gains in international relations do exist but there still remains a need for a unifying framework across disciplines that can incorporate social relativity into game theoretic explanations of behavior. We present a simple abstract model applicable to multiple disciplines and show how it may better guide research on the evolution of social behavior.

Keywords: Conflict Resolution, Political Theory, Environmental Policy

1. Introduction

It is not only human behavior that is characterized by social interactions. One can find abundant examples of social relations throughout the animal world. Similarly, in both worlds there exists the unsolved puzzle of how cooperative behavior can be evolutionary prosperous in a competitive environment of survival of the fittest. In this paper we examine links between these two issues, through gradually increasing complexity of social interactions on one hand, and analyzing how individual actors (human beings, sovereign states, or animals) evaluate possible cooperative outcomes of their actions on the other.

When trying to understand the problem of cooperation among players, scholars typically turn to game theory, particularly the Prisoner’s Dilemma. We do the same and moreover attempt to cope with questions related to how actors regard not only their own payoffs from a strategic decision, but their opponent’s gains as well. We develop a model in which the more developed cognitive functions actors possess and the more complex social relations players are engaged in, the more regard they have during these interactions to relative gains and to the position of individuals within the corresponding social hierarchy. Such hierarchical social structures can be manifested in groups of animals, the system of sovereign states, or as a human society itself.

In general we show that when there are no stable and repeatedly occurring interactions, and a lack of information as well as of cognitive abilities of participants is
omnipresent, player decisions are generally motivated only by absolute gains. Cooperation is possible only if the payoff matrix favors mutual cooperation over defection as demonstrated by many mutualist relationships between animals. Otherwise players defect and try to simply maximize their absolute gains in a competitive environment where evolution favors those with the highest relative fitness. This is addressed in the first part of the paper. In the second part, we shift emphasis to relative gains as the complexity of the social environment increases and individuals interact more frequently either in non-hierarchical, single-species animal groups or in other rare but repeated encounters without information about the social status of interaction partners. Cognitive functions of individual players improve and enable cooperation even in the Prisoner’s Dilemma. At this stage we formalize relative gains accordingly without attention to position of players within the system. In the third section, as groups become hierarchical and relations much more complex, we examine behavior as players are sensitive to their initial positions as they contemplate strategic decisions. This is also related to higher cognitive abilities and a capacity to recognize members of a group who encounter each other repeatedly. Finally, we introduce a formalization combining all three approaches to the Prisoner’s Dilemma payoff matrix so that overall gains of a player may be computed, allowing predictions about expected behavior. In general, we conclude that higher cognitive functions, more complex social relations, and more frequent interactions with the same players enable actors to effectively mitigate the natural selection process driven by competitive accumulation of absolute gains. This is enabled by the mutually cooperative behavior that pays due attention to relative gains.

2. Absolute Gains

The Prisoner’s Dilemma became in the second half of the 20th century a common tool for analyzing many social situations, in which individually rational behavior led to collectively suboptimal outcomes. This was partly due to the adoption of game theory from economics (von Neumann – Morgenstern 1944) by other social sciences and evolutionary biology (Maynard Smith 1982). The essence of the dilemma is represented by a situation in which two players can choose between cooperation (C) and defection (D), giving rise to four possible end states (2x2) with attached payoffs. These are temptation (T) for unilateral defections, reward (R) for mutual cooperation, punishment (P) for mutual defection, and being a sucker (S) for unilateral cooperation. For a game to be considered as an instance of the Prisoner’s Dilemma, its payoffs must be ordered so that T > R > P > S. Moreover, in order to secure that mutual cooperation is really collectively optimal solution and thus better than alternating unilateral cooperation and defection, it is also necessary that 2R > T + S. In any game that fulfills these conditions, it is better for both actors individually to defect irrespective of the other player’s decision. Real world international politics examples of a decision between high and low tariff levels, or between increasing arms spending and its alternative of disarmament, correspond to this logic. In biology cooperative behavior is necessary at the level of molecules to form cells, at the level of cells to form multicellular organisms, worker bees cooperate with the queen, animals cooperate and form social structures or help feed the offspring of other individuals etc. (Nowak 2006: 72). Yet it is the individually rational defective behavior that leads to the Pareto suboptimal payoff as a result of mutual defection, which is the only Nash equilibrium of the game. Being the only Nash equilibrium means that no player can improve its own position (increase the payoff received) through a unilateral change in strategy. The dilemma then rests in the fact that there is another collectively more beneficial outcome, that of mutual cooperation, which can provide higher payoffs for both players.
a) Ordered Utilities

\[
\begin{array}{c|cc}
\text{Player A} & \text{Cooperate} & \text{Defect} \\
\hline
\text{Cooperate} & R(3), R(3) & S(1), T(4) \\
\text{Defect} & T(4), S(1) & P(2), P(2) \\
\end{array}
\]

b) Gains

\[
\begin{array}{c|cc}
\text{Player A} & \text{Cooperate} & \text{Defect} \\
\hline
\text{Cooperate} & 3, 3 & 0, 5 \\
\text{Defect} & 5, 0 & 1, 1 \\
\end{array}
\]

c) Alternative Distribution of Gains

\[
\begin{array}{c|cc}
\text{Player A} & \text{Cooperate} & \text{Defect} \\
\hline
\text{Cooperate} & 3, 5 & 0, 8 \\
\text{Defect} & 5, 0 & 1, 1 \\
\end{array}
\]

The important aspect of the Prisoner’s Dilemma, in a game theoretic framework, is the order of utilities (Figure 1a), so that for both players payoffs correspond to the Prisoner’s Dilemma condition. Neither condition mentioned above is concerned with payoffs of the other player and thus the matrix can easily look like Figure 1c.

When trying to explain cooperative behavior of animals, including humans, scholars typically make two simplifications. First, they generally assume symmetric payoffs as in Figure 1b. Second, they replace ordered utilities by ordered gains so that they will be able to sum up payoffs from repeated interactions and/or compare the performance of individual players in computer simulations or laboratory experiments (see Axelrod 1980a and 1980b for how this is implemented). The second assumption is just an analytical convenience, but the first one has implications for the nature of the game as such and is related to the problem of relative and absolute gains present both in biology and social sciences (for international relations see Grieco 1988). Simply stated, it deals with the extent to which the players pay attention to received payoffs and general well being of other actors around them. It is about comparing one’s own payoffs with those of others. In many cooperative situations it is not enough to simply maximize one’s own payoffs or fitness, it is also necessary to ensure that you will have at least as many offspring as other members of the same species or that you will get at least as large benefit from international cooperation as your partner (Waltz, 1979: 105).

Consider a situation in which it is not possible to talk about society in any meaningful way. Interactions of players are non-repetitive. They are mostly single-shot encounters and actors are either not able to recognize each other or they assume that such information is worthless with respect to the probability of any future interactions. Cognitive functions are very limited. Social relations between interacting individuals
(animals, humans, states) are at the lowest possible level and some scholars may even dispute the use of the term social in these situations. It is a situation commonly present in nature when only absolute gains matter. In such a situation, animals try to maximize their own gains without regard for the payoffs of an opponent. Other players’ payoffs do not matter partly because they have no method of knowing their opponent’s payoff. Many times they cannot even recognize their opponent personally after the encounter. In such a situation, cooperation in the Prisoner’s Dilemma is theoretically not plausible. Players maximize their absolute gains and the process of natural selection driven by competition that evaluates final relative fitness of the actors.

Here cooperation is only likely if actors concerned do not compete with each other for resources or offspring. If the increase in fitness of other players is greater than yours, it must not have an impact upon your probability of survival or your evolutionary success. If other actors get more than you from your mutually cooperative interaction, it cannot pose a risk with respect to the future when the partner might turn enemy with greater power. Only then the underlying process of natural selection based on relative fitness does not come into force. Actors can cooperate and maximize their gains (fitness, level of capabilities) only if they do not compete. Such situations are truly rare. Examples can be found in some seemingly mutualistic relationships between animals of different species. Often, a mutualism is a long lasting relationship between species but the ability to recognize cooperating players is close to zero. Yet encounters of impala and red-billed oxpecker are for example typically single-shot interactions. These cooperating animals from different species do not compete with each other and they only care for maximizing their individual benefits. Thus they can cooperate.

Biologists, and ecologists in particular, are nevertheless much more focused on individuals and species that do compete with other living things. Darwin’s theory of evolution by natural selection is generally acknowledged as the unifying theory of biological sciences (Darwin [1859] 1996) and in layman’s terms is often summarized as the idea of “survival of the fittest”. As the description implies, survival is a function of fitness relative to others in the environment. The concept of absolute fitness has little or no meaning in biological sciences. Yet there is little evidence that species make decisions based on advancing their relative position. Instead species of lower cognitive ability can be thought of as having a utility function based solely on the absolute gains they may achieve from a given course of action. The issue gets more complicated as we analyze cooperative behavior within the same species, since such a behavior should be impossible when maximizing absolute gains in situations described above.

An example of purely absolute gains concern from international relations might be a trickier issue since when states start interacting they usually interact repeatedly and not in a single-shot pattern. They are also rarely completely isolated and can recognize each other more easily. But think of the West German Ostpolitik from the late 60s to the early 70s. There were no diplomatic relations between West Germany and the Ostblock at that time. And Bonn was, unlike Washington, hardly competing with Moscow, not to mention Prague, Warsaw, or East Berlin. Treaties were moreover not examples of mutual accommodation of interests, but of fulfilling one’s own goals (Bahr 1985, 1996). Both sides of all treaties strived for their own interests and maximized their gains, which were hardly commensurable. West Germany achieved normalization of relations with Moscow, the possibility of further progress with respect to East Germany and the traffic within the divided Berlin, as well as with respect to other communist countries, but also the promise to improve human conditions (culture, sport, education, divided families etc.). Finally both sides pledged to restrain from using the force. On the other hand the Soviet Union achieved recognition of the status quo in Europe, post-WWII
borders including those of Poland and East Germany, and also de facto recognition of East Berlin government (Bundesregierung 1990). Both parties thus cooperated because deal was more beneficial for both sides than defection. They achieved their own goals in a single-shot encounter in which they do not competed but only recognized the status quo. What they cared for were absolute gains. As far as these gains were met, both sides were able to strike a deal with the other side and grant the opponent what he demanded. Division of gains was neither symmetric, nor proportionate, since both sides get completely different payoffs.

The problem is that to achieve such a level of cooperation one must transform the Prisoner’s Dilemma payoff matrix in a way that will favor the mutually cooperative outcome over defection. Such a matrix is no longer a Prisoner’s Dilemma. Without transformation of the matrix, cooperation is not possible, as the only Nash equilibrium is mutual defection. Scholars have attempted to solve this problem with help of repeated games. Yet this leads to the key problem of relative gains.

3. Relative Gains
Cooperation becomes plausible when interactions in the Prisoner’s Dilemma are repeated (Axelrod 1984, Axelrod and Hamilton 1981), but given typical simplifications discussed above, one must address not only absolute gains but also relative gains. This is so even if we only enable adding up the gains from individual repetitions of the game without the assumption of symmetry of payoffs. If gains are divided as in Figure 1c, both players gain from mutual cooperation and thus the requirement of absolute gains would be fulfilled. However, their gains would be different and their position in the social environment would change. Then imagine an example in which two interacting states or two animals have overall capabilities or overall fitness at the level of 100 units in case of the first actor and 50 units in case of the other one. If we assume symmetry of payoffs as in Figure 1b and also players’ concern only for absolute gains that are summed up after each game, then repeated interactions gradually diminishes any initial difference in social positions of the given actors. This kind of mutual cooperation and division of gains is beneficial to one player and contrariwise for the other. Relative gains therefore constitute a problem that must be dealt with when considering repeated interactions of player in the Prisoner’s Dilemma.

![Figure 2: Parameters Influencing Perception of Gains](image)

Relative gains can, however, be formalized in two different ways as we tried to suggest with help of above mentioned example. The best way how to identify the proper formalization of relative gains is to focus upon frequency of interactions, social
structure of interacting players, and their cognitive abilities (see Figure above). To express our argument more clearly, we picked up three parameters that can help us understand three different situations under which players can find themselves while trying to reach mutually cooperative outcomes. These situations are defined by parameters of interaction frequency, cognitive ability, and social structure.

As stated previously when players simply maximize their absolute gains irrespective of other actor’s payoffs, the situation is characterized by non-cooperative asocial relations between individuals, rare or non-repetitive interactions, and inability to recognize and remember possible cooperating partners in the environment. Cooperation here is often possible only after modifying the Prisoner’s Dilemma payoff matrix itself and only in form of interspecific mutualisms where relative and absolute fitness are equivalent. If the cooperation is to occur within a single species, then it becomes necessary to deal with the question how gains are divided and thus address the issue of relative gains.

Among humans, this situation of purely absolute gains concern is probably characteristic of racial segregation where the actors are groups. Two groups do not compete with each other because of their separation. They rarely, if ever, interact with each other and it is more appropriate to speak about two independent societies rather than about a single society composed of two segregated groups. Cultural prejudices and psychological shortcuts then also disable distinguishing individual members of the other group thus facilitating overgeneralizations to all members from individual cases. Cooperation is possible only when it benefits both parties even in the single-shot game. With respect to members of the other group player tries only to maximize his/her absolute gains.

But as the interactions become more frequent, cognitive abilities more developed, and social structure more stable and complex, the situation changes with respect to cooperation and hence necessarily also with respect to the regard players have for other actors’ gains.

3.1. Regard for Relative Gains but not Initial Position

The first step towards attention to relative gains is an effort to get no less than an opponent. This leads to the idea of interdependence with respect to gains from strategic interactions. The idea that individual choices are based in part on the behavior of others was advanced as early as the nineteenth century (Veblen [1899] 2007), but was slow to be incorporated into mainstream social theories.

Yet examples abound of such behavior not only from the human world but also among other animals. As interactions become repeated within a specific usually non-hierarchical group or among members of the same species, and as cognitive functions become more developed, thus facilitating recognition of cooperating partner, symmetry of gains (Figure 1b) becomes gradually more important. By securing equal payoffs from mutually cooperative outcomes, interaction partner try to avoid loss of their relative fitness after several repetitions. In this case the relative gain can be formalized as:

\[
(1) \text{ Relative Gain } = \frac{(G_i - G_k)}{2}
\]

where \(G_i\) and \(G_k\) represent absolute gains of player \(i\) and \(k\), respectively. Relative gain is then the simple difference between absolute gains divided by the number of interacting players, so that the negative relative loss of one actor would always be the same as the positive relative gain of the other. One precondition for paying attention to this kind of relative gains and for the possibility of cooperation in the Prisoner’s Dilemma is the
higher probability of repeated interactions within given group or with the same opponent that opens up the space for reciprocity (Trivers 1971). The other condition is higher cognitive function, which enables recognition of unequal payoffs and identification of cooperators (but for cellular automata see Nowak – May 1992).

Species with higher cognitive ability and more complex social interaction have demonstrated the capacity for evaluating relative gains achieved through cooperative interactions with others. Ability to compare one's own fitness with that of others is demonstrated both by lions as well as langur monkeys (Trivers 1985). When a male lion (or new alpha male langur monkey) takes over an existing pride of female lionness he almost immediately kills all existing cubs. This infanticide ensures that, relative to previous males in the pride, the new male will father a much higher proportion of the pride’s offspring. In evolutionary terms, the new male is actively increasing his relative fitness. Brosnan and de Vaal (2003) found that brown capuchin monkeys (Cebus paella) display significant levels of inequity aversion typical of actors that are concerned with relative payoffs as formalized above. Researches placed a subject monkey so that it could observe a fellow monkey earning a reward for performing a task. Subject monkeys were then offered a lesser reward for performing the same task. Instead of accepting the reward, an action that would have indicated regard for absolute gains, subjects responded negatively, often refusing to perform the task for the lesser reward than offered to others. Yet the extent of this behavior among non-humans is still widely debated and studies of chimpanzees playing a bargaining game suggest that such aversion to inequitable payoffs is not always exhibited (Jensen et al. 2007).

But several other examples of equal division of gains from cooperation in non-hierarchical groups in the animal world exist. Cooperation in the Prisoner’s Dilemma as facilitated by the indirect reciprocity is exemplified by the bats (see Nowak – Sigmund 1994) as well as red-cockaded woodpeckers. These are examples of food sharing and cooperative breeding within stable conspecific groups. Such cooperative behavior leads after several iterations of the game to an increase in fitness of all members. Reciprocal and alternating pattern of food sharing and cooperative breeding ensures that no group member receives more than others.

There is evidence that humans too base strategic decisions on their expectation of relative payoffs. Extensive research has been conducted using a framework known as the ultimatum game. In such a situation two actors A and B must decide how to split resource delivered by the experimenter to one of the players (in this case player A). The proposer A initiates the game by offering a portion of the resource to the responder B. B then either accepts the division, in which case each actor collects its agreed upon share, or B rejects the division, and both participants receive nothing. In either event the game ends. Economic theory predicts that, given rational agents motivated by absolute gains, B will accept even the smallest positive offer and that A, knowing this, will therefore offer the smallest amount possible. Yet contrary to this expectation, in controlled experiments using money as the resource, human subjects across many cultures have shown a strong propensity to offer ~ 40-50% of the resource to the other player. In addition, subjects very frequently reject offers that deviate from a roughly equal division (Roth et al. 1991, Nowak et al. 2000, Henrich et al. 2001). Humans are generally so unwilling to allow an interaction partner to make significant relative gains formalized according to (1) that they would rather walk away empty-handed, foregoing all absolute gains, than to gain less than others. Another thought experiment was proposed by John Rawls (1971) too. According to his argument people in the original position and under the veil of ignorance would split the gains equally and any inequality would have to benefit those worst off in society. In other words, if the players have
limited information about the social position of the others (veil of ignorance in the state of nature) they will naturally opt for maximin strategy and equal division of public gains from cooperative interactions as a fair principle of justice.

Symmetry of cooperative gains as required by this formalization of relative gains was the cornerstone of the whole relative/absolute gains debate from the early 1990s in theory of international relations as well (Grieco 1988, Snidal 1991, Grieco – Powell – Snidal 1993, Jervis 1999). After all design of the majority of international organizations in which equal voting rights are allocated to all member states corresponds to this division of gains as well. Technical matters constitute most of the agenda of international institutions like Universal Postal Union and interactions of members states after setting up the regime in the first years remain repeated but of maintenance character in general. Also consider four sectors of the post-WWII Berlin division despite greatly uneven power of the Allies, or strict reciprocity in disarmament measures between the Superpowers during the Cold War despite different numbers of missile and different strength of corresponding economies.

Thus we can say that when there is perceived equality of participating members in all relevant aspects, then there is no need for differently formalized relative gains than proposed in (1). Non-hierarchical single species groups, humans under the veil of ignorance, or states perceiving each other as equal partners guarantee that equally split gains from mutual cooperation do not change the status quo within the group or in the system. Yet as the cooperation proceeds and as the participating players get more information about the other players, social hierarchy emerges or becomes more apparent and individual players gradually have to pay more attention to their position within the group or the system in order to avoid relative loss of power/fitness through the equal division of gains from cooperative interactions.

3.2. Regard for Initial Position
Stable repeated interactions, ability to recognize social status within given group or system, and available information about other players is the reason why it is necessary to modify the computation of relative gains. In non-humans, concern for initial position is best exemplified by animals involved in dominance hierarchies. Typically found among animals of higher cognitive ability, dominance hierarchies can be defined as a long-lived set of dominant-subordinate relationships among members of a social group. Those at the dominant end of this hierarchy typically wield the most power within the group and enjoy the greatest access to resources and reproductive opportunities. Importantly for our purposes is that behavior of individuals depends on position in the hierarchy. Those with the most power also exert considerable energy to maintain their dominance, clearly indicating an understanding of and regard for their position. Those among the most subordinate in a hierarchy also exhibit behavior consistent with regard for their position – they often emigrate to other groups as their only hope of improving their relative standing (Wilson 2000). Among humans many social institutions such as monetary exchange, proportional division of votes (in the World Bank or in the Council of the European Union), point in the direction that sustained and intense cooperation must be secured against relative loss of power with help of properly divided gains that proportionally correspond to the position of individual actors in society.

Suppose for example that state A or any other social entity has 100 tanks while state B has only 50 (note that from an analytical point of view it doesn’t matter what units of capabilities we use). They agree to produce 2 new tanks together per year and to divide the production equally. According to equation (1), there would be no relative gains for either state since the gains (new tanks) of states A and B are equal. Consider,
however, the initial and the final distribution of capabilities. The former is [100; 50]. The latter is [101; 51], which is clearly beneficial for state B, but counterproductive for state A. After 100 iterations the capabilities distribution will be [200; 150] (or 4:3), which is quite different than the initial ratio of 2:1 (or [100; 50]). Thus there is a need for reformulation of relative gains computation if the players’ positions within the system or group is unequal. Otherwise the equal division of gains would change the status quo and cooperative behavior would ultimately lead to lower relative fitness or power of at least some players.

The problem behind relative gains is basically that of proportionality and symmetry of payoffs (see Halas 2009). As far as the actors are equal, and as far as there is no hierarchy in the group, simple difference of absolute payoffs suffices for computation of relative gains. Cooperation is possible under symmetric division of gain. But as inequality emerges, we must address relative position within the system. As long as we intend to compute relative gains and emphasize relative fitness together with the relational character of power, we must stress the proportionality of the division of cooperation benefits. We propose a revision of the relative gains computation (and ultimately of the utility equation) in a way that mirrors required proportionality of absolute gains division:

\[
(2) \text{Relative Gain} = \frac{(G_i W_k - G_k W_i)}{(W_i + W_k)}
\]

In equation (2) \(W_i\) and \(W_k\) represent initial sum of all absolute gains \((G_i\) and \(G_k\)) players \(i\) and \(k\) received in previous rounds before the examined interaction takes place. The position vis-à-vis the other player is then given by the ratio of \(W_i\) to \(W_k\). The logic behind this equation is that the initial and the final position of the players within the group or society must remain the same in order for cooperation to remain possible. Otherwise the relative loss of power or fitness by at least one player could inhibit cooperative behavior in the case of pure relative gains concern. This further implies that the hierarchical status after the encounter must correspond to the initial one, provided that there were no relative gains. Since the final level of gains \((W_{\text{END}})\) of any player is determined by simple sum of the initial position \((W_{\text{START}})\) plus absolute gains \(G\), one can compute relative gains \((G_{R})\) as expressed above after simple adjustment of the equation below:

\[
(3) \frac{(W_{i}^{\text{END}} - G_{R})}{(W_{k}^{\text{END}} + G_{R})} = \frac{W_{i}^{\text{START}}}{W_{k}^{\text{START}}}
\]

An increase in the capability level of one player by a given relative gain must correspond to precisely equal relative decrease in the capabilities of the other player, which is the central characteristic of the relational nature of power and also the focal point when talking about relative fitness. Simply stated, when we subtract relative gains, expressed in absolute terms, from the final capabilities of one actor and add the equal but negative relative loss to the final capabilities of the other player, we must arrive at the initial ratio of the actors’ capabilities. Without relative gain/loss, there cannot be any shift in power position or fitness. Cooperation is possible in the repeated Prisoner’s Dilemma when the gains are divided proportionally so that relative fitness or power remains unchanged.

In fact, this reasoning closely corresponds to the neorealist argument in international relation, in which ‘states define balance and equity as a distribution of gains that roughly maintains pre-cooperation balance of capabilities’ (Grieco, 1990: 47).
Thus if gains from mutual cooperation are divided fairly, the power distribution does not change. One reason why the United Nations is less effective than it might be can, for example, be that positions of individual states within this organization do not mirror their true power positions and shifting capabilities. Apparent disregard of (or shifts in) systemic status quo suggests that it would deal most effectively with technical matters. Yet very frequent interactions across every imaginable issue area make it in fact ineffective in all other significant respects. Proportional division of cooperative gains would be much more appropriate for institution like United Nations. On the other hand, European integration process witnessed effective shift from equal voting rights towards proportional division of votes as the integration deepened. EC/EU thus remained effective in coping with great variety of problems. States continued frequent and close interactions and have abundant information about one another. Proportional division of gains and votes as well as recognition of different weights of individual countries in the Council of the EU further facilitates continuous cooperation. Nobody gains anything on account of others. Similarly as long as the cooperation benefits within highly structured and complex groups in nature are divided proportionally, there is no shift in social hierarchy and in the status of individual animals such as for example alpha males.

We should note also that another emergent feature among those concerned with relative gains and initial position is a division of labor. Though we do not speculate here on a causal relationship between this phenomenon and the sensitivity to relative standing, it is important to know that such division often accompanies hierarchical social groups. This is true not only in non-human social animals and human groups (Page and Mitchell 1998, Anderson and Franks 2001, Beshers and Fewell 2001, Gibbs 2003), but also among national actors, where the idea of comparative advantage has long been acknowledged (Ricardo [1817] 2001).

3.3 Overall Gains and the Utility Function
Above we show three different stages of sociability both in nature and with respect to humans and their institutions. The degree of social complexity and development of cognitive functions is interconnected with prospects of cooperation and the level of regard given to various kinds of gains. Yet these stages are not separate entities. They are better described as roughly defined points on a continuum from asocial competitive environments of absolute gains seekers without real possibility for mutual cooperation to highly structured and cooperating groups or societies whose members secure relative gains by paying due attention to their position in a hierarchical group, society, or system. Represented as points on a continuum, it is thus natural that players can strive for absolute and relative gains at the same time, with different emphasis placed on each component. This emphasis becomes important when computing the utility function of any particular division of gains. Shift from absolute gains towards relative gains without attention to initial position, and ultimately further on to relative gains with appropriate attention to social position is depicted below. It is determined first by the coefficient $w$ of the sensitivity to relative gains and then also by the coefficient $z$ of the sensitivity to initial position. Changes of these parameters are yet to be formalized. On the figure below one can see both parameters as they shift together with the changing factors depicted on the Figure 2 above.

**Utility function influenced by**

- absolute gains
- relative gains without attention to social position
- relative gains with attention to social position
Parameter \( w \) (sensitivity to relative gains)

~0 (low)  ~1 (high)

Parameter \( z \) (sensitivity to initial position)

~0 (low)  ~1 (high)

Examples

- mutualist relations
- social amoeba
- impala-bird, Ostpolitik
- bird colonies
- United Nations
- Rawlsian societies
- chimpanzees
- IMF, World Bank, EU

**Figure 3: Formalization of the Utility Function**

What is already clear at this point is that player cannot pay full attention to both absolute as well as relative gains because it would lead to counting the payoffs twice when computing actor’s utility function. Moreover, at least in international relations theory there were a minor problem, whether to express relative gains in some specific units and computed as a simple difference of two numbers, or rather as a ratio of the given payoff to average payoff in the system (Mosher 2003). The shift from units to the ratio as the best form of relative gains computation, however, turned up to be the cul de sac. We switch back and calculate the value of relative gains in units in order to enable summing up absolute and relative gains as proposed below when computing final utility of actor’s gains.

\[
(4) \quad U = (1 - w) \times \text{Absolute Gain} + w \times \text{Relative Gain}
\]

The final step in proposing the utility formula (5) is then to include the coefficient \( z \) determining the weight laid upon relative gains that take into account initial status of actors as opposed to the one without attention to position of players in the system. Simply stated, the more complex are social relations, the more frequent are interactions, and the more developed are cognitive functions of participating individuals; the greater emphasis is then also laid upon relative gains as opposed to absolute ones, and also upon initial positions of actors as opposed to situation in which they are disregarded.

\[
(5) \quad U_i = (1 - w)G_i + w \left[ (1 - z)(G_i - G_k)/2 + z(W_iW_k/(W_i + W_k)) \right]
\]

Of course emphasis upon absolute or relative gains and upon individual types of relative gains as well might differ according to particular situations. Even humans try to maximize their absolute payoffs in one context, secure equal relative gains in other one, and refuse to cooperate unless offered proportional benefits in still another. What is important is that only organisms with highly developed social structure and cognitive functions are capable of recognizing relative gains and status quo together with their position in the group and act accordingly when pursuing cooperative behavior.

One of the interesting results of utility function formalized in a way proposed in (5) is the impact upon the player’s willingness to cooperate in the single-shot game. It is usually supposed that simple modification of the Prisoner’s Dilemma payoff matrix in a
way that reward for mutual cooperation becomes more beneficial than temptation for unilateral defection suffices to secure cooperative outcome of interaction. We decided to examine this assumption. In order to do that we used all possible combinations of parameters $w$ and $z$ with their gradual shift from 1 to 0 and back by the amount of 0.05. We chose a situation in which player A had at the beginning of the game 1 000 units and player B had only 500. This enabled us to properly examine not only absolute gains and relative gains that disregarded initial position, but also relative gains that paid full attention to the social structure of the interacting pair. In the first examined situation we computed differences between reward and temptation payoffs using Axelrod’s payoff matrix (Figure 1b). In the second situation we increased reward payoff to 6 so that mutual cooperation will be more promising than unilateral defection. And finally in the third situation we modified reward payoffs of two interacting players from $3 : 3$ to $4 : 2$ in order to make payoffs proportional to the initial distribution of capabilities.

Our results show that even after modifying reward payoff to be higher than the temptation, only 25% of the examined combinations of $w$ and $z$ parameters favored mutual cooperation over unilateral defection. To no surprise, those combinations were the ones with very high values for absolute gains concern and almost no interest in relative gains. In other words, even modification of the Prisoner’s Dilemma by increasing the reward payoff above the level of temptation does not have to secure mutually cooperation outcome, if for example ratios of initial positions and of absolute gains are not similar. Furthermore, in 17% of the parameters’ combinations the situation even worsened so that before modification the obstacles to cooperative behavior were less restrictive. On the other hand, when we replaced cooperation gains division $3 : 3$ with an alternative (and proportional) one of $4 : 2$, situations improved in all possible combinations of parameters $w$ and $z$. Yet since reward of 4 points was still lower than unilateral defection payoff, none of the situations favored cooperation as happened with 25% of the examined combinations under the first modification. To sum it up, contrary to common belief, even modification of payoffs does not secure cooperative outcomes of interactions. Paying due attention to relative gains only facilitates better understanding of how cooperation can supplant natural selection competition by trying to maintain relative fitness instead of letting the invisible hand rule the game.

4. Conclusion
In this paper we try to fill in one gap in the research on evolution of cooperation in games like the Prisoner’s Dilemma. This gap relates to the fact that most of the articles on cooperation work with simple assumption of pure absolute gains concern. Yet not only in international relations but also in biology it is relative gains concern that really matters when dealing with cooperative behavior. Power is a relational concept (Gilpin, 2002: 158) having no meaning without taking into account position of the other sovereign states. Similarly using the term fitness makes sense only when we talk about relative fitness and compare the performance of different individuals in a common environment. Division of gains from cooperative encounters matters also for questions of justice and fairness relevant in debates about natural state and social contract. In other words, relative gains as a term is important both in biology as well as in social sciences and political science in particular.

We tried to show that situations in which individual players pay attention only to absolute gains offer very little space for cooperative behavior. Such situations are characterized by rare or single-shot interactions, lacking cognitive capabilities to
recognize and identify cooperators, and low or non-existent social relations among actors. If cooperation occurs in such an environment, it is usually of interspecific mutualist nature where animals maximize their individual payoffs and pose no competitive threat to each other. Rare examples from human societies or international politics include strictly separated communities and situations in which previously isolated entities (states) strike a deal that fulfills gain maximizing goals of both parties.

Yet as the social structure becomes more complex, with repeated interactions, non-hierarchical group relations, and all that further strengthened by the improved cognitive functions, then actors gradually get more cooperative opportunities (precisely thanks to iterated encounters). In order to avoid decline of relative fitness thanks to repeated cooperation with unbalanced division of gains, players start to pay attention to relative gains formalized in a way to emphasize desired equality of received payoffs. And again, strive for equality among humans in ultimatum games or in original position under the veil of ignorance with no information about the social position of the other actors is not something specific to human beings. Indirect reciprocity in non-hierarchical groups is demonstrated by bats with respect to food sharing or in various bird species showing cooperative breeding. Most of the international institutions similarly employ equal voting power for all member states irrespective of their power and disarmament during the détente exhibited very similar tendency for symmetry.

At the final stage of both the cognitive function development as well as social complexity increase, players interact frequently with the same members of their group and clearly recognize their position in the society, system, or hierarchy. Even equally divided payoffs can cause shift of relative power or fitness provided that the interacting players have different starting position before encounter occurs. The only remedy for this obstacle of the cooperative behavior is proper attention devoted to relative gains understood in a way that takes into account initial position of actors. And corresponding thinking and behavioral patterns are not characteristic only of humans whose cooperative interactions is often facilitated by monetary exchange that is probably the best medium for securing relative gains proportionate to invested wealth. Hierarchical structure of groups in nature similarly indicated concern for relative gains as manifested via access to food and reproduction opportunities. Last but not least, those international institutions and organizations that exhibit the most frequent interactions in different areas at the same time or in the financial sector particularly remain effective and functional as far as they adhere to proportionate division of voting rights.

Hopefully we managed to show that when considering cooperation in the Prisoner’s Dilemma, it is relative gains that really matter. And also that it is not sufficient to modify the payoff matrix so that reward is more beneficial than temptation and simply expect that cooperation becomes inevitable. Quite the contrary, matrix has to be modified in a way that respects relative gains concern at the given stage of social differentiation and development of cognitive functions of participating players.
5. References


