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I Rights Formalized in Game

The game form construction of rights originates from Sen's problem of the "Impossibility of a Paretian Liberal" [1-4]. The basic idea underlying game-theoretic approaches in analyzing rights is that rights are ultimately about actions that individuals are and are not allowed to do[5], and this can be termed as admissible strategies in game theory. [6] Early writers responded to Sen by discussing preference ordering and social states[7], and established the game form structure to the analysis of rights. Later game theoretic approach relies more on the notion of effectivity functions [8-11], in which rights are defined by the sets of outcomes that the right holder can secure. For example, A's right to wear a blue shirt is defined by the set of outcomes within which A is actually wearing a blue shirt, and she is effective in securing such a set of outcomes. Fleurbaey and Van Hees developed a very detailed description of rights with distinction between active-passive and negative-positive rights. [12] But, after Dowding and Van Hees' review[13], writers stopped contributing new ideas on this topic. This reveals that this approach has its limits. As Dowding pointed out, by ignoring the moral grounds of rights, formal writers seem to have gone astray [14]. Another approach worth noticing is the application of Hawk-Dove game in explaining the private property rights. [15-17]

The approach adopted here, is distinctive in several aspects: 1) the rights are formalized in a complete normal form game with specified strategy space and payoff matrix; 2) a distinction between negative and positive rights is recognized as they involve different sets of actions; 3) the inner structure of rights is admitted, which means rights involve different types of actions related to the interactions between individuals. These can be demonstrated in the three steps in the formalization of rights.

The first step is to select a set of rights. It is by no mean here to exhaust all rights, and what we need to do is come up with a somehow representative and widely acknowledged collection of rights. So, our choice here is the *Universal Declaration of Human Rights* 1948. And we will extract all those negative and positive rights declared in this document into a set. The set looks like this:

> {the right to life, the right to liberty, the right to safety, the right free from slavery, the right free from torture, the right free from discrimination, the right free from arbitrary arrest or exile, the right to privacy, the right to marriage, the right to own property, the right to freedom of thought conscience and religion, the right to freedom of opinion and expression, the right to peaceful assembly and association …the right to asylum, the right to nationality, the right to fair trials, the right to hold office, the right to social security, the right to work, the right to leisure and payed holidays, the right to decent living condition, the right to education, the right to cultural life…}

The second step is to categorize all actions related to those rights in the set into three groups and thus three sets of actions which consist the strategy space for the game of rights in the same time. The above set of rights in the 1948 declaration can roughly be categorized in two groups: negative rights and positive rights. In order to categorize actions related to negative and positive rights respectively, we should consider two kinds of different actions: actions satisfying and violating those rights. Briefly, a negative right is satisfied by omission of actions, and violated by interference; a positive right is satisfied by offering benefits and violated by omission. Thus, there are three kinds of actions involved here: actions of interfering, actions of omission and actions of offering benefits. As those interfering actions often involve harmful consequences, we can call it "Attack" for convenience; meanwhile, we can call those actions offering benefits "Playing Good". So, there are three groups of actions involved here: Attack, Omission, Playing Good. For example, if perceived as a negative right, the satisfaction of the right to life is omission which is doing nothing to the right holder, and the violation of it is to kill or injure him; in contrast, the satisfaction of the right to leisure and payed holidays as a positive right is to offer leisure and payed holidays, omission here is a violation of it.

So, now we can categorize actions related to the set of rights into three subsets: Attack, Omission and Playing Good:

> {**Attack**| killing or injuring, constraining liberty, endangering, enslaving, torturing, discriminating, arresting or exiling arbitrarily, invading privacy, depriving marriage, depriving the right to own property, depriving the right to freedom of thought conscience and religion, depriving the right to freedom of opinion and expression, depriving the right to peaceful assembly and association…}
>
> {**Playing Good**| offering asylum, giving nationality, offering fair trials, letting hold office, offering social security, offering jobs, offering leisure and payed holidays, offering decent living condition, offering facilities of education, offering facilities of cultural life…}
>
> {**Omission**| omission from killing or injuring, omission from constraining liberty, omission from endangering, omission from enslaving (omission from all Attack actions) ... omission from offering asylum, omission from admitting nationality, omission from offering fair trial, (omission from all Playing Good actions) …}

Again, it is by no means aimed to exhaust all actions related to rights in these three sets other than delivering a very brief demonstration about what kinds of actions are involved in the game of rights. Furthermore, very element in the above sets can be perceived as a subset of actions. For instance, torturing can be conceived as a set including actions such as whipping, waterboarding, boiling, rat torturing … etc.

The third step is to give a preference ordering of the outcomes. For negative rights, the ranking is:

1. The most preferred outcome is that, I Attack and you play Omission, so that I got a Temptation payoff T;
2. The second optimal is we both playing Omission, so that I got a Reword payoff R;
3. The third option is that we both Attack, so that each receives a Punishment payoff P;
4. The last option one would desire is that I play Omission and you Attack, so that I get a Sucker's payoff S.

Putting this preference ordering into a normal form, we have:

Player 2 / Player 1	Omission	Attack
Omission	R=1	S=-20
Attack	T=10	P=-10

(Payoff denotes row player,where T>R>0>P>S and R>(S+T)/2)

So, in the above form we have a complete normal form game of negative rights. And negative rights are established and defined by the fact when both players choose the {Omission, Omission} profile.

Similarly, with positive rights:

1. The most preferred outcome is that, I play Omission and you choose Play Good, so that I got a Temptation payoff T;
2. The second optimal is we both choose Play Good, so that I got a Reword payoff R;
3. The third option is that we both Omission, so that each receives a Punishment payoff P;
4. The last option one would desire is that I choose Play Good and you choose Omission, so that I get a Sucker's payoff S.

Thus, we have the following normal form game:

Player 2 / Player 1	Playing Good	Omission
Playing Good	R=3	S=-2
Omission	T=5	P=0

(Number denotes row players' payoff, where T>R>P>S and R>(S+T)/2)

It should be noticed here that, positive rights are defined by the profile of {Playing Good, Omission}. Professional game theorists often call these kind of profile exploitation, because, it is an asymmetric interaction that one player offered some benefits to the other, while the other player never pays back. There are not much significant conclusions drawn on this asymmetric relationship, so here after I will drop out positive rights, and concentrate on the discussion of negative rights.

So, when formalized in game form, both negative rights and positive rights turn out to be typical Prisoner's Dilemma. This means, when facing the situation of negative and positive rights, and game is played only once, if the players both choose nice cooperative actions they will both better off; but, as there is always a temptation to choose mean defective actions, they will inevitably choose mean defective actions and thus stuck in the Prisoner's Dilemma.

As the study of Prisoners' Dilemma has been the focus of game theory for decades, it is a very matured area. And there are plenty of excellent works done on this topic which are quite ready for us to apply to shed some light on the study of rights. Thus, here below, I will treat the following terms as interchangeable: Cooperation equals to Omission, Defection equals to Attack and the evolution of rights equals to the evolution of cooperation.

II The Evolution of Rights

If rights turn out to be Prisoners' Dilemma in game theory, it is known that neither a single play of a one shot game nor any finite number of repetitions can escape this situation.[18] There are several ways to escape this dilemma, for example, when it happens among close relatives, by the mechanism of reputation or by the competitive pressure between groups to promote in-group cooperation. [19] While for rights, the most relevant approach to escape from this dilemma is through repeated encounters, especially through evolutionary context.

When facing such a situation of infinitely iterated Prisoners' Dilemma, the first question one should ask is, what strategy one should adopt? Although there are only two options every round, either to choose Omission or Attack, if the game is iterated for n round, the number of possible strategies amounts to 2^n. With such a boundless choice of strategies, it is not easy to figure out what kind of strategy will work.

In some simple cases, we can calculate the expected payoff for a specific strategy. Let V (A | B) denote the expected payoff of strategy A playing against strategy B, and let w denote the possibility that A and B will encounter again. Then, for example, if All Omission player (always choose Omission whoever he meets) meet another All Omission player with a w probability of encountering each other in the future, the expected payoff can be calculated as:

$$V\text{ (All Omission | All Omission)} = R + wR + w^2R + w^3R \ldots w^nR = R/(1-w)$$

Similarly, if two All Attack players meet each other, their expected payoff is:

$$V\text{ (All Attack | All Attack)} = P + wP + w^2P + w^3P \ldots w^nP = P/(1-w)$$

While in the real world, whether it is the biological world or in the society, the situations are a lot more complicated. The above All Omission and All Attack strategies seem like simpleton. No one behaves that way. Even in a small community, where people are more likely to meet each other frequently, which makes a large enough w possible, it is still hard to tell what kind of strategy will exceed. As in the real dynamic world, besides the hugely diversified strategies, it is also impossible to predict who one will meet in the next encounter, thus we cannot calculate expected payoffs in advance, even for simple strategies.

In the 1980s and 1990s, as computers became more available, scholars can take the advantage of computer simulation to tackle the complicated problem of iterated Prisoners' Dilemma. In a tournament sponsored by Robert Axelrod, where computer hobbyists, biologists and professional game theorists are encouraged to hand in strategies to play the game of iterated Prisoners' Dilemma, a simple and extremely successful strategy called Tit For Tat emerged. What Tit For Tat does is very simple: it will always cooperate in the first round (for rights, it is to choose Omission), and then it will simply copy the other players' strategy in the last round to play in the current round; for example, if the other player chose to cooperate in the last, Tit For Tat player will also cooperate this round, and if the other player chose to defect in the last round, Tit For Tat player will also defect in this round. Among the many strategies handed in, Tit For Tat scored highest on average. This simple strategy was so successful that the study of Prisoners' Dilemma in the 1980s was almost a story of Tit For Tat. [20-23]

	OO	**OA**	**AO**	**AA**
All Omission	1	1	1	1
All Attack	0	0	0	0
TFT	1	0	1	0
GTFT	1	0.25	1	0.25
Pavlov	1	0	0	1
GRIM	1	0	0	0

(This form is a way to sketch the infinitely diversified strategies in Iterated Prisoners' Dilemma. The top row represents the outcome of last round: OO represents both played Omission (or, Cooperate); OA represents player A chose Omission and player B chose Attack (Defect); AO represents Player A chose Attack and player B chose Omission; AA represents both played Attack. Numbers in the form denote player A's probability to choose Omission in the current round. Notice that, for deterministic strategies where the probabilities is fixed numbers, such as All Omission and All Attack, those 0 and 1 are exactly 0 or 1; while for stochastic strategies, such as GTFT, Pavlov and Grim, numbers are roughly around 0, 1 or 0.25, for example 0.997, 0.998 or 0.999)

Later on in the 1990s, some even more successful strategies that outperformed Tat For Tat was found, and Martin Nowak's simulation revealed a larger picture. There are several strategies were reported to outperform the original Tit For Tat with even higher scores when played against it, for example, Generous Tit For Tat,[24] Pavlov [25] and Grim [26]. A detailed description was included in the following figure. In the computer simulation conducted by Martin Nowak with an evolutionary context, where the mechanism of natural selection is simulated in a way that strategies with higher scores reproduce faster and strategies scored lower than a threshold die out, the evolution of cooperation turns out to be a cycle. Started by a randomly diversified population adopting all kinds of possible strategies, All D players (always Defect, which is to choose All Attack in rights) soon whipped out players with other strategies, turning the whole population into All D. Then, by the introduction of mutant strategies with a small possibility, Tit For Tat players starts to invade the All D population, and within a period of only 4-5 generations Tit For Tat players drive out the All D players and take hold of the population. After that, those even more successful strategies like Generous Tit For Tat, Pavlov emerge and as they can outperform Tit For Tat, they invade the Tit For Tat population and take hold. Finally, the All C players (always Cooperate, which is to choose Omission in the game of rights) will exceed and occupy the population. Unfortunately, when the whole population turns into nice All C players, the mean All D players get plenty suckers to prey upon, and they will turn the population into a chaos again. This is not a happy ending. But, there is still good news: Tit For Tat, Generous Tit For Tat and Pavlov together will occupy the majority of the time in the cycle. [28]

One conclusion we can draw from these excellent works is that negative rights can emerge from the evolutionary process among rational individuals who will maximize their preference even without a central authority. The key step in the above cycle of evolution of cooperation and rights is how TFT players will invade the All Attack (All D) population. In the simpler case discussed by Axelrod, where a situation of no "noise" (the odds that humans and animals can make mistakes according to "fuzzy mind" and "trembling hand", as in Axelrod's tournament, strategies like TFT are executed by computer program which does not make any mistakes, such "noise" is not present) is assumed, a simple mechanism can be revealed. As a TFT player always choose to play Omission in the first move, when two TFT players meet, their expected payoff can be calculated as:

$$V\text{ (TFT | TFT)} = R + wR + w^2R + w^3R \ldots w^nR = R/(1\text{-}w)$$

This is the same as V (All Omission | All Omission) = R/(1-w). While the average expected payoff of an All Attack population is V (All Attack | All Attack) = P/(1-w). Provided w is large enough, All Attack population is much disadvantaged as they have a much lower expected payoff. As long as TFT players invaded in a cluster above the required threshold value, TFT players can invade the All Attack population. (Axelrod, 21, p. 1394) While the opposite is not true. When, TFT players take hold and occupy the majority of the population, it cannot be invaded by the All Attackers. When an All Attack player is playing against a TFT player, he gets a T in the first round, and P for all the rest of the game; so, his expected payoff is:

$$\text{V (All Attack | TFT)} = T + P + wP + w^2P + w^3P \ldots w^nP = T + P/(1\text{-}w)$$

As long as w is large enough (w >= (T-R)/(T-P) and w>=(T-R)/(R-S)), we have V (All Attack | TFT) <= V (TFT | TFT). Thus, provided that two players will encounter each other with an enough high probability, TFT can invade All Attack population, while All Attack cannot invade TFT. (Axelrod, 20, p. 311)

While "noise" is integrated, thus making the evolution into a stochastic process, the analysis becomes much more complicated; but, when some moderate conditions are satisfied, evolution still favors TFT to invade and replace All Attack populations. [29] However, explaining these mechanism is quite beyond the aim of this paper.

If we take these above works seriously, they can be turned into some down-to-earth predictions: that negative rights will emerge sooner or later, that negative rights are more likely to flourish in small communities where individuals have iterated encounters. Certainly, the thing we should keep in mind is that, the concept of negative rights here is somehow reductionist: it is not the full-feathered normative concept we use in philosophical discussion, but a minimal concept reduced to the satisfaction of the action sets of {Omission, Omission}.

These conclusions are close to our intuition and experience from everyday life, and the evidence in social life and history is abundant. We have the daily experience that, people will be nicer to someone who they are going to meet again, that people in small town are more likely to say hello to each other than in big city. These patterns of the behavior are related to the frequency and probability of reciprocating in the future. Although we cannot offer statistical evidence, violations of negative rights are more likely to happen between strangers than among acquaintance; even a gang member is less likely to rob a neighbor than strangers.

If what the above-mentioned literatures have revealed is true, that negative rights can emerge among small communities and thus reduce intragroup conflicts, one prediction to make is that there will be much less intragroup conflicts than that of the intergroup conflicts in a primitive "state of nature" where the central authority is absent. And this can be confirmed by evidence from human history. "The picture that has emerged from these studies is of neither a Hobbesian hell nor a Rousseauite paradise of pre-sin innocence, but a more mundane complex … Hobbes's image of an endemic state of 'warre' and lack of security in the absence of state authority has been found to be perhaps somewhat overdrawn, but not by that much. Quarrels were rife among hunter–gatherers as among the rest of humankind, resulting in very high homicide rates among most hunter–gatherer peoples, much higher than in any modern industrial society. And yes, **intergroup** fighting and killing were widespread among them… According to another study, in 90 per cent of hunter–gatherer societies there was violent conflict, and most of them engaged in **intergroup** warfare at least every two years, similar to or more than the rest of human societies." [30]

III Evolutionary Stable Strategy and Long Term Nash Equilibrium

By far, we have mentioned quite a bit about the expected payoff or scores in the iterated Prisoners' Dilemma. Then, what does these scores mean, and why we care about them so much? Certainly, as we assume a "rational man" assumption, individuals are supposed to care about their payoff and try to maximize it. However, in an evolutionary context, these scores have some deeper meanings. They can be explained in two different ways: in biological world, these scores represent different levels of fitness; higher scores mean a high level of fitness and higher level of fitness results in more offspring; in the social context, as individuals can copy one another's strategy, those scores represent the frequency of the corresponding strategies; a more successful strategy with a higher score will result in more people in a population to adopt that strategy.

Also, those scores are related to another concept that are originally raised by biologists, [31-32] and now widely adopted in many other fields. And that is the concept of Evolutionary Stable Strategy (ESS).

The definition of a ESS is straight forward. In the original version offered by John Maynard Smith, it is defined as (translated into the form we use above): Strategy i is evolutionary stable if, for all strategies $i \neq j$,

$$V(i \mid i) >= V(j \mid i), \text{ and if } V(i \mid i) = V(j \mid i),$$
$$\text{then, } V(i \mid j) > V(j \mid j).$$

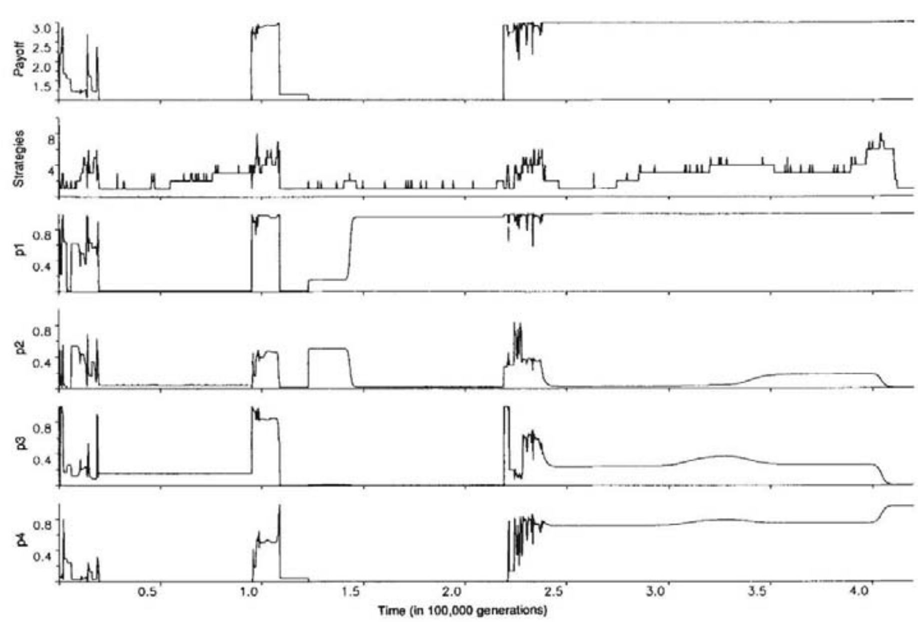
What this definition of ESS means is that, when the other player is playing strategy *i*, the best strategy you can adopt is also to play *i*; and if there is an alternative strategy yields an equal score, strategy *i* must have a better score playing against strategy *j*, than *j* is playing against itself. There are several versions of ESS, [33] and Axelrod used another concept called "Collective Stability" rather than ESS which requires only that $V(i \mid i) >= V(j \mid i)$. But for our purpose here, this version is enough.

Drawing some textbook conclusion, we can see that ESS is a refinement of another important concept used in social science: Nash Equilibrium. Because, if we formulate Nash Equilibrium in the form we use here, it will be: a strategy *i* is in Nash Equilibrium with itself, if for all strategies $i \neq j$,

$$V(i \mid i) >= V(j \mid i)$$

So, ESS is a stricter refinement of Nash Equilibrium, every ESS is a Nash Equilibrium while the *vice versa* is not true. Even the less strict form, Axelrod's "collective stability", is the same as that of a Nash Equilibrium.

Having this in mind, we can articulate the relationship between negative rights and Nash Equilibrium more accurately. As those successful strategies, such as TFT, GTFT, Pavlov and Grim, are ESS or at least "collective stable" strategies; also, these strategies can evolve through the evolutionary process and occupy the majority time in the cycle; then, **in the long term, when facing the affairs related to negative rights, the long term Nash Equilibrium resides in strategies that give a high probability to play Omission**. And just how high a probability a rational man should give? Take Pavlov for example, in the above form, this strategy will give a probability of close to 1 to play Attack when either it got a T or S payoff in the last round; does this mean that it will give a near 1/2 probability to play Attack? Certainly not. Because, there is very rare opportunity to trigger the mean defective action of Attack in a Pavlov population. We can see this from Nowak's simulation. (Nowak, 25, p. 57) From the average payoff, we can tell that, provided it is at least after the TFT stage, the average payoff converged to R (which is 3 using Axelrod's payoff matrix), meaning that in a Pavlov population, mean defective action of Attack rarely happened.



Meanwhile, the dark side of the story is that, the nicest strategy-- All Omission, is not a ESS. All Omission can be exploited by All Attack. This can be revealed straight-forwardly by some simple calculations. So,

$$V\text{ (All Omission | All Omission)} = \text{R}/(1\text{-}w)$$

$$V\text{ (All Attack | All Omission)} = \text{T} + w\text{T} + w^2\text{T} + w^3\text{T} \ldots = \text{T}/(1\text{-}w)$$

As R < T, the following does not hold

$$V\ (\textit{All Omission | All Omission}) >= V\text{ (All Attack | All Omission)}$$

This means that even the “Golden Time” of All Omission can evolve, it cannot hold very long.

The above conclusions seem to be too easy to be true, and intuitively, they are not quite surprising ones. After all, nowadays there are billions of people living under the institution of negative rights, it will be a shocking news if negative rights turn out to be way departed from the equilibrium point. But, for the first time, we have affirmative proof.

IV Conclusion

Back to the question I raised at the beginning of this paper: why rights are such a powerful discourse? One reason among others is that, negative rights are long term Nash Equilibrium; and this mechanism will make negative rights a self-enforcing and self-realizing social institution. Furthermore, let’s make some falsifiable predictions: given enough time, all oppressive social institutions which deviate from the equilibrium set by negative rights will collapse. So, in the human history, we have cracked down the off-equilibrium institutions such as slavery, feudal privileges, racial segregations, oppression against homosexuals; and after the milestone of the right to same-sex marriage, what is the next?

Also, there is a possibility of constructing a Contractarian theory of rights if the conclusions in this paper can be established. Contrasted to the other tradition in contract theory—Contractualism, which is handed down from Kant to Rawls and Scanlon, the motive to reach a social contract in a contractarian theory is the maximizing rationality that can be traced back to Hobbes. Very briefly, a contractarian theory of rights distinguishes itself at least in three aspects: 1) it can take advantage of modern knowledge such as economics, game theory with which it shares the common assumption of human rationality; 2) compared to that of the natural rights theory which is the birth place of contemporary rights discourse, the ultimate authority of a contractarian theory of rights that bears the persuasive power resides in science rather than God; hopefully, this can give rights more transcultural normative power; 3) the normativity of rights come from rational individuals’ unanimous consensus—a social contract.

Certainly, there is much more to be explored than what we know by now. For example, the major limit of the current literature is that nice cooperative actions emerge from reciprocity or repeated encounters; it means that this mechanism can only work in small communities (optimal size of population ranges from several hundreds to 2 or 3 thousands: Nowak, finite populations) where individuals have opportunity to meet each other repeatedly. But rights are supposed to work among total strangers, in a super large modern state where millions of people are living together. Perhaps, this problem can be called "the challenge of scale". Whether the introduction of a government is inevitable to tackle these kinds of problem? Questions like these await to be answered.

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