

# Consequential Rationality, Procedural Rationality, and Optimal Nash Equilibrium<sup>□</sup>

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## Abstract

Two perspectives on individual rationality in a social context have been traditionally considered : individuals act according to what they prefer, and individuals act according to rules. This paper is an introductory and theoretical step towards the integration of these two approaches within a formal framework. We propose a definition of rationality that combines preferences for consequences with preferences for procedures. We can then consider individuals maximizing their utility for acts, as separated into utility for consequences (consequential rationality) and utility for actions themselves, as means or processes towards consequences (procedural rationality). The underlying qualitative structure of this definition enables simple and formal enhancement of Game Theory to allow interpretation of procedural concerns. After having formulated a solution concept of Nash Equilibrium with procedural concerns, we provide a refinement called an Optimal Nash Equilibrium. Such an equilibrium corresponds to the selection of the equilibrium whose acts are consequentially and procedurally preferred. When it exists, such an Optimal Equilibrium is unique. Hence, integrating the procedural dimension in rational behavior leads to a simple and rigorous solution for the selection of the 'focal' or 'salient' equilibrium in case of coordination, a difficult and outstanding issue with pure consequential approaches of rationality. An application to the Prisoners' Dilemma is proposed, where empirical observation of mutual cooperation does not reveal irrationality, but rather the influence of procedural preferences for cooperation, even if utility for consequences has been properly measured beforehand.

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## 1. Introduction

Two perspectives on individual rationality in a social context have been traditionally considered: individuals act according to what they prefer, and individuals act according to rules (Elster, 1979: 137). This paper proposes a first step towards integrating these two perspectives within a single conceptual and formal framework. The benefits of such an integration would be to provide a link between economic and sociological analysis of rational behavior, and thus to expand the scope of its formalization. Two main difficulties seem to have impeded such integration. First, the necessity of combining Utilitarianism with procedural concerns (Sen, 1995) and second, the possibility of constructing an interesting mathematical formalization of rational behavior that would respect its volitional character (Sen, 1997). Our integrating approach to this problem relies on an extended definition of rationality, where consequential and procedural dimensions are separated and then combined so as to maintain the representation of rational behavior as a maximization. A modification of the object of choice is necessary so as to account for the nature of the relation between these two dimensions. It leads to a distinction between maximization and optimization, where the latter restricts to situations where no ethical dilemmas occur. As a first development, we show that integrating procedural concerns in Game Theory sheds light on equilibrium selection, a difficult and outstanding issue with pure consequential approaches of rationality. Before entering into the details, we briefly expose how this work relates with fundamental notions that have been used to analyze rational behavior in Economics and Sociology, as well as review the key literature on which it builds.

Primarily, we consider individuals as the elementary level of analysis. We follow therefore a tradition of Methodological Individualism. We consider however that individuals can be influenced by the social context. They may have internalized social norms through their preferences (Elster, 1979: 141) and possess social knowledge of their environment (Arrow, 1994). This integration of the context through preferences enables us to keep considering rational individuals as individuals who do what they prefer to do, which is the cornerstone of Utilitarianism. However, we consider what individuals prefer to do as composed of two irreducible dimensions: what the individual actually does: an action, and what the individual anticipates: a consequence, the two being related through a consequence function.

Because individuals have the ability to be conscious of both these dimensions, we consider that rational individuals are able to carry out independent evaluations of both of them. A consequence is merely the anticipation of the result of an action, and an action itself might also be subject to evaluation, for its own sake and independently of its consequence (Weber, [1956]1978: 24-26). Reducing preferences to preferences for consequences leads to Consequentialism. We argue that

it is not necessary to carry out such reduction -that is to reduce Utilitarianism to Consequentialism, in particular if we want to embed the influence of the social context in the analysis. We therefore acknowledge the distinction between consequential and procedural dimensions of rational behavior and consider rational individuals as having both consequential and procedural preferences. Independent of consequential preferences, procedural preferences reflect a conformity between the action and a procedure, a rule of behavior, or more generally a social norm that is internalized by the individual. Typical examples are the reluctance to lie, choosing to vote, or simply choosing to leave a tip in a restaurant you know you will never visit again. In other words, procedural preferences reflect a propensity to act independently of the consequences.

Having acknowledged the irreducible distinction of consequential and procedural preferences, the key of our approach is then to build on their structural relation. Although consequences are related to actions through a consequence function, we consider their valuations independent and thus related in a monotone way<sup>1</sup>. As we will see, procedural and consequential preferences then become subject to a trade-off when reaching the most preferred consequence requires the individual to take an action that is not the most preferred one. Such conflicts -referred to as ethical dilemmas, are deemed to be solved empirically by the individual at the very moment he or she takes an action<sup>2</sup>. However, this separation between consequential and procedural preferences also creates a qualitative characterization of optimality, when the action that leads to the preferred consequence is itself the procedurally preferred action. The simultaneous presence in the structure of an indeterminacy -in the case of ethical dilemma, and of a qualitative property -in the case of optimality, might therefore provide an interesting formal approach to human behavior that respects its volitional character. Indeed, it provides a simple distinction between maximization and optimization. As in the work of Sen (1997), optimality implies maximization but the reverse is not true, since situations are not always exempt of ethical dilemmas. However, our approach does not require us to relax the assumptions of transitivity or completeness of the preference relations.

As a first development, we apply our definition of rationality to situations where consequences of actions depend on others' behavior (Game Theory). In a simple manner, the integration of procedural concerns in the notion of equilibrium enlightens a key issue of social coordination: the characterization of a salient

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<sup>1</sup>There is therefore no lexicographic ordering of these two dimensions.

<sup>2</sup>The construction of preferences as of two types reflects the approach of ideal-types of Max Weber : a rational action is in general oriented by consideration of the consequences and the action itself. A related work that considers rationality as a combination of different dimensions is Nozick (1993).

equilibrium (Schelling, [1960]1980). Such an equilibrium reflects the influence of a social norm which enables a collectivity of individuals to coordinate their actions in an efficient manner (Lewis, 1969).

Although we are not aware of any mathematical formulation of rationality as a composition of procedural rationality and consequential rationality, nor of the game-theoretic development that is proposed here, many of the ideas on which this work is built are present in the references provided in the core or at the end of the paper. In particular, Sen (1995, 1997) highlights the justification and benefits of combining both consequential and procedural dimensions of rational behavior and also provides an extensive discussion of the key literature. In a game-theoretic perspective, Binmore (1994) builds on the consideration that Consequentialism differs from Utilitarianism. He stresses that there is no a priori incompatibility between ethical concerns and maximization of utility. On rationality, Elster (1979, 1989) develops many considerations on which this work relies and in particular the notion of commitment, interpretable as leading to a procedural preference. Procedural rationality has also become a key element of Simon's approach of Bounded Rationality (1976, 1978, 1979) with the emphasis that the cognitive limitations in predicting consequences justify procedural rationality. In sociology, a seminal and condensed view of the basic concepts used to explain individual actions in a social context, and in particular the duality of rationality, remains chapter I of Weber's *Economy and Society* ([1956]1978). Our treatment of the issue of coordination relies on the seminal works of Schelling ([1960]1980) and Lewis (1969). In particular, we argue that our concept of Optimal Equilibrium captures the notion of convention due to Lewis (1969).

Finally, we have chosen not to consider in this paper the implications of procedural preferences when probabilities play a role. It prevents therefore a rigorous discussion of the relationship between our approach and Expected Utility, as well as Multi-attribute Expected Utility, two formalizations where probabilities play a foundational role. In short, primitive entities assumed in these approaches consist of combinations of probabilities and utilities (von Neumann and Morgenstern, [1944][1947]1953; Fishburn, 1982). In the model we propose, actions remain in the control of the individual. Therefore, actions do not combine with probabilities. As a result, we do not assume that utilities for actions combine with probabilities<sup>3</sup>. Although our approach remains close with Expected Utility, it also departs from it in a substantial manner. Indeed, the introduction of probabilities draws close links

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<sup>3</sup>In the discussion of their formal system, von Neumann and Morgenstern say "...We have assumed only one thing -and for this there is good empirical evidence- namely that imagined events can be combined with probabilities. And therefore the same must be assumed for the utilities attached to them, -whatever they may be." ([1944][1947]1953 : 20). Precisely, this assumption cannot be maintained for utilities attached to actions or processes, which does not combine with probabilities but induce them.

with the literature on state-dependent preferences (Drèze: 1987; Fishburn: 1973, Karni & Al: 1983), although it leads to a notion better called process-dependence. The treatment of these issues, as well as of the relationship between Consequentialism and Expected Utility Theory, could not take place in this introductory paper and are left for a later discussion of its axiomatic foundations.

The rest of the paper is organized as follows: section 2 proposes a conceptual and formal definition of rationality considering a single decision-maker (decision-theoretic formulation). Section 3 develops this definition in the case of several decision-makers who interact (game-theoretic formulation). Section 4 applies the proposed framework to the analysis of the Prisoners' Dilemma and section 5 provides conclusive comments.

## 2. Individual Rationality in a Social Context

### 2.1. Actions, Consequences, and Acts

Couples composed of an action and its consequence are considered the primitive entity of analysis. When an individual acts, he or she takes an action  $a$ , anticipating some consequence  $c$ . We give a particular name to the couple  $(a; c)$ , and we call it an act<sup>4</sup>. An action and its consequence are also related to each other by way of a consequence function. The consequence function reflects the anticipation of the specific consequence of an action by an individual when he or she takes the action. Calling  $A$  the set of actions and  $C$  the set of consequences, the consequence function  $g$  is a function with domain  $A$  and range  $C$ . An act can then be written  $(a; g(a))$ <sup>5</sup>. The set of acts  $F$  appears as a Cartesian product of  $A$  and  $C$ . We note  $F = A \times C$ , and  $f = (a; g(a)) \in F$ . The valuation of such acts is considered below.

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<sup>4</sup>We have to stress the fundamental difference between this definition of an act and the one of Savage (1954). It is however necessary to reflect in the primitive entity the simultaneous consideration of both the consequence and the action itself. We have chosen to use the terminology act as the formal terminology of this dual entity. In Sociology, it corresponds to the terminology social action (Weber, [1956]1978). In a qualitative manner, Simon has perfectly described this duality by speaking of means and ends of a social action but such wording appeared too far from the traditional wording of formalized approaches.

<sup>5</sup>If the action is a transformation of the world carried out by the individual, the consequence function reflects the process of anticipating it. The former is actually occurring in the reality while the latter remains a cognitive process. Hence, the two objects are actually of a different nature. It is precisely such confusion that appears in the formal system of Savage (1954).

## 2.2. Consequential and Procedural Preferences

As a primitive, we consider that rational behavior reveals a valuation for acts. When all acts are valued, and their valuation is transitive, a preference relation  $\&$  over the set of acts  $F$  results. Having emphasized the duality of acts in our definition, we assume that the preference relation over acts can be separated into two preference relations: one over consequences, and one over actions, as means or processes towards consequences. As we have said, this assumption corresponds to the idea that rational individuals are conscious of both actions and consequences, and hence are capable of evaluating each of them separately. We call the preference relation  $\&^P$  over actions a procedural preference relation. We call the preference relation  $\&^C$  over consequences a consequential preference relation. This consequential preference relation reflects the extent to which consequences are valued independently of the action implemented to reach them. The procedural preference relation reflects the extent to which an action is valued independently of its consequence. The action is valued as a process to reach some specific consequence.

## 2.3. An Integrated Definition of Rationality

A first characterization of individual rationality in a social context emerges naturally as the choice of the action that corresponds to the preferred act. Therefore, rationality combines procedural and consequential preferences. We propose properties that this combination of preferences must respect. It seems reasonable to assume that when all actions are valued identically, then only the consequences matter. Reciprocally, when all consequences are valued equivalently, only the actions matter. Finally, when an act is composed of the preferred action and of the preferred consequence, then such act should be preferred. As a result, it is possible to state a definition of individual rationality in terms of the three preference relations  $\&$ ,  $\&^C$ , and  $\&^P$ :

**Definition 2.1.** An individual is acting rationally if and only if he or she takes action  $a^a \in A$  such that  $(a^a; g(a^a)) \& (a; g(a)) \exists a \in A$ , while requiring:

P1. Consequential Rationality:

$\exists (a; g(a)) \in F$  such that  $a \succ^P a^a : g(a^a) \&^C g(a) \Leftrightarrow (a^a; g(a^a)) \& (a; g(a))$ ;

P2. Procedural Rationality:

$\exists (a; g(a)) \in F$  such that  $g(a) \succ^C g(a^a) : a^a \&^P a \Leftrightarrow (a^a; g(a^a)) \& (a; g(a))$ ;

P3. Optimality:

$\exists (a; g(a)) \in F : g(a^a) \&^C g(a) \text{ and } a^a \&^P a \Rightarrow (a^a; g(a^a)) \& (a; g(a))$ .

Rationality is thus characterizing the choice of the action that corresponds to the preferred act of the individual. However, this valuation is seen as dual:

it combines both a valuation of the consequence and a valuation of the action, as a process to reach a consequence. Rationality is thus a composition of consequential rationality and procedural rationality. Reduction of the valuation to the consequences only, or to actions only, are limit cases corresponding respectively to consequential rationality (the choice of the preferred consequence) and procedural rationality (the choice of the preferred action or process). Optimality corresponds to a particular case, when the preferred action combines with the preferred consequence. As such, optimal acts are a selection of all rational acts characterizing situations where there is no conflict nor dilemma between the evaluation of processes and the evaluation of consequences. When such an optimal act exists, it is sufficient that it is strictly preferred, either for its action or its consequence, to be unique. However, it is not always the case and in some situations, there is no optimal act. In these situations, individual rationality is not determined by simply considering the ordering among actions and the ordering among consequences. We propose that it remains an inherently empirical primitive<sup>6</sup>.

## 2.4. Utility Representation<sup>7</sup>

Technically, we have required a property of weak separability (Fishburn and Wakker, 1995: 1140) for the preference relation  $\&$  over acts. This preference relation being transitive, it entails monotonicity for  $\&$  with respect to  $\&^P$  and  $\&^C$ . In the language of multi-attribute utility functions, the set of actions  $A$  is utility independent of the set of consequences  $C$ , and conversely,  $C$  is utility independent of  $A$ <sup>8</sup>. If  $u(\cdot)$  is a real-valued function representing the preference relation  $\&$  on  $F = A \times C$ , then  $u(\cdot)$  can be separated in a multiplicative form as  $u(a; g(a)) = u^P(a) \times u^C(g(a))$ , where  $u^P(\cdot)$  represents the preference relation  $\&^P$  on  $A$  and  $u^C(\cdot)$  represents the preference relation  $\&^C$  on  $C$  (see for instance Fishburn, 1982: 75). We are interested in a particular form of this separation where  $u^C(\cdot)$  is strictly positive and  $u^P(\cdot)$  is strictly positive such that  $\int_A u^P(a) = 1$ . In this way, the representation respects the above definition of rationality, that is properties P1, P2, and P3. In order to specify that  $u^P(\cdot)$  meets these two conditions (scaling between 0 and 1 and additivity), we note  $u^P(\cdot) = \otimes(\cdot)$ . As a result, we will use the utility

<sup>6</sup>This "inherently empirical component" is precisely the one called for by Schelling ([1960]1980 : 285) to take account of the specificity of each individual (their "skills", their "values"...) and of the influence of the context.

<sup>7</sup>Although our theoretic development of the next section does not rely on it, we introduce a utility representation to ease the interpretation of the limit-cases which follow and for the purpose of the application of section 4. We do not pretend to give a complete and rigorous treatment of the issue.

<sup>8</sup>For logical reasons, it is meaningless to say that actions and consequences are independent. Only their evaluation is assumed to be.

representation:

$$u : F \rightarrow \mathbb{R}_+^n; f \mapsto u(f) = u(a; g(a)) = \sum_{a \in A} \omega(a) u^C(g(a)); \quad (2.1)$$

with (i)  $u^C(g(a)) > 0$ ; (ii)  $\omega(a) > 0 \forall a \in A$ ; and (iii)  $\sum_{a \in A} \omega(a) = 1$ :

We call  $u(f)$  the utility of act  $f$ , we call  $\omega(a)$  the procedural utility of action  $a$ , and we call  $u^C(g(a))$  the consequential utility of consequence  $g(a)$ . Intuitively, we have constructed a weighted utility function over consequences where each weight represents the procedural utility attached to the action independently of its consequences. The weights are positive, and sum to one. We say that the weights on each action account for a process-dependence or a path-dependence of the utility for acts since they represent the utility attached to actions as processes<sup>9</sup>.

## 2.5. Limit-cases

The limit-cases of this utility representation help to draw the link with other theoretical approaches of rationality. In particular, we want to stress the relationship between procedural rationality and the type of "value-rational" actions proposed by Weber ([1956]1978), as well as highlight the relationship between consequential rationality and the formalization proposed by von Neumann and Morgenstern ([1944][1947]1953).

First, we can realize that when an action is given a weight of 1, then it is chosen independently of its consequences. This is precisely the 'ideal-type' of the conceptualization of Max Weber where actions that are not oriented by consideration of their consequences are called value-rational (Weber [1956]1978: 24). If we want to consider situations where the individual has a choice among actions, we must not allow for weights of 0 or 1 for any action. Such weights of 0 or 1 induce a violation of the definition of procedural preferences and consequential preferences that has been proposed. As a result, we exclude value-rational actions of this approach of rational choice and we require that any available action belongs to the support of  $\omega(\cdot)$ .

Second, when all actions are given an equal weight, then the individual acts as if valuing only consequences. In other words, valuing acts becomes equivalent to valuing consequences only. Such actions are called neutral. In such a case, the formalization presented here is identical to the formalization of von Neumann and

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<sup>9</sup>As introduced in note 8, the multiplicative representation with additive weights necessitates further justification whose rigorous treatment would be beyond the present paper. The intuition behind it is that procedural valuations are a particular type of beliefs. On the relationship between value-rationality and beliefs, see Boudon (1996).

Morgenstern where procedural concerns are not integrated<sup>10</sup>. It corresponds to the other 'ideal-type' proposed by Max Weber that characterizes actions oriented solely by their consequences. In Weber's typology, they are called "instrumentally-rational". It is also the second limit-case of this formal approach of rational behavior.

## 2.6. Example

Imagine a situation where you could either receive \$x without having to lie, or receive \$y but having to lie. Which alternative would you prefer?... Of course, your behavior would depend on the social context. It might depend on your own personality or skills, on the relationship you have with the person to whom you would have to lie, on the nature of the lie itself, on the evaluation of the amount of money at stake, etc. For instance, you may prefer not to lie for a gain of \$100 against \$50, but this preference might reverse for other amounts, like \$1,000,000 against \$50. Preferences for amounts of money are consequential preferences. Preferences for not lying are procedural preferences. In general, a rational individual who values more money than less and does not like to lie is assumed not to lie whenever  $x > y$ . However, if  $y > x$ , we cannot conclude on the rationality or irrationality of the individual when lying is observed. Indeed, observing an individual lying only reveals the intensity of his or her procedural valuation for not lying in a given social context.

To the extent that we can control for the social context, it is theoretically possible to reveal amounts of money  $x$  and  $y$  such that the individual is indifferent between receiving  $x$  without lying and receiving  $y$  with lying. Such experimental revelations of procedural preferences, which are in this example part of the deepest subjective values of the individual, raise difficulties whose detailed analysis are beyond the scope of this paper. Moreover, the use of such revealed preferences for predicting behavior in other contexts would necessitate additional consistency assumptions that we have not discussed or proposed. In this paper, we first develop the approach by considering social interactions, where the qualitative structure of the approach leads to simple and powerful characterization of the equilibrium notion.

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<sup>10</sup>This point is discussed by von Neumann and Morgenstern when considering the impossibility of their approach to integrate utility or disutility for gambling, which is a procedural concern. See the last pages of their appendix : 1953 : 629 and 632.

### 3. Interactions of Rational Individuals in a Social Context

#### 3.1. Interactions, Interdependent Consequences, and Acts

The essential characteristic of situations where several decision-makers interact in a social context is that consequences are interdependent. In other words, consequences are not determined by one individual action but by profiles of actions, i.e. vectors composed of one action per individual. If we refer to individual  $i$  as a member of a set  $N$  of  $n$  individuals, we say that individual  $i$  takes an action  $a_i$  belonging to the set  $A_i$  of all available actions of individual  $i$ , and we denote  $a = (a_1; \dots; a_n)$  a profile of actions, or equivalently  $a = (a_i; a_{-i})$  when we want to specify the action  $a_i$  of individual  $i$  versus all other actions  $a_{-i}$  of all other individuals  $j \neq i$ , with  $j \in N$ . The consequence of profile of action  $a$  is noted  $g(a)$  where  $g$  is a consequence function whose domain is the set of profiles of actions and whose range is the set of interdependent consequences  $C$ . The set of profiles of actions is a Cartesian product of the sets of individuals' actions and is denoted  $A = \prod_{i \in N} A_i$ . The definition of acts remains as couples of actions and consequences as represented by the consequence function  $g$  and are denoted  $(a_i; g(a_i; a_{-i}))$ <sup>11</sup>. The set of acts for individual  $i$  is denoted  $F_i = A_i \times C$  and one of its members  $f_i = (a_i; g(a_i; a_{-i})); f_i \in F_i$ . This defines the basic concepts. We turn now to conceptual considerations on the type of interactions studied in this section.

#### 3.2. Strategic Games with Perfect Social Knowledge

In this paper, we shall restrict our attention to one-shot simultaneous games. Actions of such games are taken simultaneously and at the same single stage for all individuals. Individuals may have interacted in the past or may interact in the future, which may influence their valuation for acts. We consider situations where individuals know each other and have a common knowledge of the social norms they share (Lewis, 1969). The games we are studying are of "perfect information" with regard to the set of consequences  $C$ , to the rationality of individuals and to their preference relations. In order to stress the social nature of this information, the term of social knowledge is used preferentially (Arrow, 1994)<sup>12</sup>. In terms of preferences, and without modification from the single decision-maker case, a rational individual  $i$  is assumed to have a preference relation  $\succsim_i$  over his or her set of acts  $F_i$ . This preference relation can be separated into a procedural preference

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<sup>11</sup>Thus, one action alone does not univoquely determine one act, which is the essence of interdependent consequences.

<sup>12</sup>In particular it helps to differentiate information about others from information about nature.

relation  $\&_i^P$  over the set of actions  $A_i$ , and a consequential preference relation  $\&_i^C$  over the set of consequences  $C$ . These preference relations verify properties P1, P2 and P3 and are represented by the utility functions  $u_i(\cdot)$ ,  $\otimes_i(\cdot)$  and  $u_i^C(\cdot)$ <sup>13</sup>. We can then propose a definition of a strategic game with perfect social knowledge:

**Definition 3.1.** <sup>14</sup>A strategic game  $\langle N; (A_i); (u_i) \rangle$  with perfect social knowledge and preferences for acts is defined by:

- (i) A set of rational individuals  $N$ , of cardinality  $n$ .
- (ii) A set of actions  $A_i$  for each individual  $i \in N$ .
- (iii) A consequence function  $g$  from  $A = \prod_{i \in N} A_i$  to  $C$ , the set of consequences.
- (iv) Preference relations  $\&_i$ ,  $\&_i^C$ , and  $\&_i^P$  of individual  $i$  over  $F_i$ ,  $C$ , and  $A_i$  for each  $i \in N$ . These preference relations satisfy properties P1, P2, and P3 and are represented by utility functions  $u_i(\cdot)$ ,  $\otimes_i(\cdot)$  and  $u_i^C(\cdot)$  such that  $u_i(f_i) = u_i(a_i; g(a_i; a_{-i})) = \prod_{a_i \in A_i} u_i^C(g(a))$  with  $u_i^C(g(a)) > 0$  for all  $a \in A$ ;  $\otimes_i(a_i) > 0$  for all  $a_i \in A_i$ ; and  $\sum_{A_i} \otimes_i(a_i) = 1$ .

We now introduce a solution concept for these games.

### 3.3. Preferences, Choice and the Solution Concept of Nash Equilibrium

The distinction between a game theoretic approach and a decision theoretic one is that the domain of the consequence function is now profiles of actions. As a result, there is a discrepancy between what the individual effectively controls (which action to take) and what he or she values (couples of action and consequence). This is a fundamental characteristic of Game Theory: individuals value acts while they choose to take actions. As a result, Game Theory does not characterize directly the rationality of choice but proposes solution concepts characterizing the result of interactions. In particular, the solution concept of Nash Equilibrium characterizes a profile of actions to the extent it corresponds to a steady-state, whereby no individual would have preferred to choose another action given the actions of others. With these considerations in mind, understanding the following definition of a Nash Equilibrium should not raise any difficulty:

**Definition 3.2.** Nash Equilibrium with Preferences for Acts.

A profile of actions  $(a_i^a; a_{-i}^a)$  is a Nash Equilibrium if and only if, for all  $i \in N$  :  $\forall a_i \in A_i; (a_i^a; g(a_i^a; a_{-i}^a)) \&_i (a_i; g(a_i; a_{-i}^a))$ :

<sup>13</sup>We remind the reader that the notation  $\otimes(\cdot)$  reflects the two conditions (positiveness and additivity) on the representation of  $\&^P$ .

<sup>14</sup>Notation and style for definitions are inspired from Osborne and Rubinstein (1994).

We have therefore integrated procedural preferences in the solution concept of Nash Equilibrium in a simple manner. Before applying such solution concept (which is proposed in the next section), we use the separation of preferences into procedural preferences and consequential preferences to approach the issue of equilibrium selection.

### 3.4. Optimal Nash Equilibrium

Two types of consideration are relevant to the question of equilibrium selection and might help to introduce the specificity of the concept of Optimal Nash Equilibrium. The first consideration is related to the idea of Pareto-efficiency, and the second to the issue of coordination.

When applied to strategic games, the idea of Pareto-efficiency characterizes a profile of actions such that all individuals prefer the state corresponding to this profile rather than any other state. The difficulty is that such a state might not be an equilibrium at all. For instance, mutual cooperation in a one-shot Prisoners' Dilemma with pure consequential rationality might be considered as Pareto-efficient. However, it is not an equilibrium in non-cooperative Game Theory.

As a result, we might come to the idea of applying the notion of Pareto-efficiency to equilibria only. In particular, we can use Pareto-efficiency in order to select among equilibria. Applying the idea of collective efficiency to the set of Nash Equilibria when several coexist, the selected equilibrium should thus be the most preferred state among all steady-states. In this case, the difficulty lies in the justification for the attainment of this equilibrium rather than other equilibria: how do individuals coordinate to identify and reach such an equilibrium? In his work, Schelling has long recognized that efficiency considerations are not sufficient to justify coordination of interactions (Schelling, [1960]1980: 113):

“It is that the mathematical properties of a game, like the aesthetic properties, the historical properties, the legal and moral properties, the cultural properties, and all the other suggestive and connotative details, can serve to focus the expectations of certain participants on certain solutions.”

Schelling proposes the idea of 'focal point' or 'salience' to encompass these considerations. Drawing from his work, Lewis (1969) showed that the attainment of such a focal point might be justified by considering social norms as coordinating interactions. When such social norms are leading to a preferred state, they can be interpreted as conventions, thus bringing together the two notions of focal point and of Pareto-efficient states.

The following concept of Optimal Nash Equilibrium is a proposal to formalize these ideas and to relate the concept of convention to a precise and formal definition of rationality. It may complement formal approaches carried out to refine the concept of equilibrium (Harsanyi and Selten: 1988; Selten: 1995) although there exists no widely accepted criterion in the literature to distinguish among Nash Equilibria. Our proposal of Optimal Nash Equilibrium directly exploits the separation of preferences into consequential and procedural preferences and is a collective characterization since it must be the case for all individuals. When such equilibrium exists, the actions towards the equilibrium are the preferred ones for all individuals, and their consequence is also the preferred one at any equilibrium for all individuals. Denoting  $A^n$  the set of profiles of actions that are Nash Equilibria, we can define an Optimal Nash Equilibrium as follows:

**Definition 3.3.** Optimal Nash Equilibrium with Preferences for Acts.

A profile of actions  $a^n = (a_i^n; a_i^n)$  is an Optimal Nash Equilibrium if and only if,  $\forall i \in N : a_i^n \in A_i^n; g(a^n) \succeq_i^C g(a_i^n)$ ; and  $\forall a_i \in A_i; a_i \succeq_i^P a_i$ .

Technically, we note that this definition is not based on a fixed-point but rather on a selection among Nash Equilibria. It selects the consequentially preferred Nash Equilibrium when it is composed of the procedurally preferred actions. It is more restrictive than a Pareto-efficient Nash Equilibrium and indeed implies that: an Optimal Nash Equilibrium is always a Pareto-efficient equilibrium<sup>15</sup>.

As in many real life situations, and as recognized in the case of a single decision-maker, such optimality between procedural and consequential rationality may not exist. There are therefore strategic games without Optimal Nash Equilibrium. However, when an Optimal Nash Equilibrium does exist, it is sufficient for one of the preferences (procedural or consequential) to be strict for such an equilibrium to be unique<sup>16</sup>. As a result, the concept of Optimal Nash Equilibrium leads to unambiguous 'good reasons' to select a particular and well-defined solution: the procedurally preferred action lead to the consequentially preferred Nash Equilibrium. As claimed, the integration of procedural concerns in the solution concept of Nash Equilibrium leads to a simple characterization of the 'focal' or 'salient' equilibrium. Moreover, procedural preferences and the qualitative notion of optimality<sup>17</sup> help us to understand where 'salience' comes from, a pending issue of

<sup>15</sup>A profile  $(a_i^n; a_i^n)$  is a Pareto-efficient Equilibrium if and only if  $(a_i^n; a_i^n) \succeq_i (a_i^0; a_i^0)$  for all  $i \in N$  and  $(a_i^0; a_i^0) \in A^n$ . Such condition being satisfied by P3 for any Optimal Nash Equilibrium.

<sup>16</sup>There might be situations where a unique non-Optimal Nash Equilibrium exists (Cf. next section).

<sup>17</sup>It does not rely on the utility representation but is a property of the underlying qualitative structure.

alternative formalizations of conventions<sup>18</sup>.

We propose now to apply this approach of rationality for social interactions to the well-known game of the Prisoners' Dilemma.

## 4. A PRISONERS' DILEMMA WITH PROCEDURAL PREFERENCES

### 4.1. Dilemma

In the Prisoners' Dilemma, each individual can take two actions: Cooperation and Defection. By definition, utility for consequences is structured such that: (i) if both individuals cooperate, they reach a consequence that is preferred to the consequence resulting from mutual defection, (ii) if only one defects, he or she reaches a consequence that is preferred to the consequence resulting from mutual cooperation, and the other reaches a consequence that is not preferred to the consequence resulting from mutual defection. Analyzing such a game in terms of consequential preferences is straightforward. Cooperation is dominated and the only Nash Equilibrium is when both individuals Defect. The difficulty is that we might intuitively think of both individuals 'Cooperating' as the rational choice, since they would end up in a better state. However, this state is not a steady-state and thus, it is not recognized as an equilibrium. However, the occurrence of such a state (both individuals cooperating) is high in experiments attempting to reproduce the idealized situation of the Prisoners' Dilemma<sup>19</sup>.

The approach proposed here is based on a formalization of the consideration that the game perceived by the individuals is not the game of consequences. In other words, individuals may have procedural preferences to Cooperate that lead them to act rationally in a way that is not the one formalized with rationality of consequences. Moreover, since such preferences affect the process itself, it could not have been measured beforehand. Only the interaction reveals it. In this section, we do not solve a Prisoners' Dilemma but try to make explicit how a Prisoners' Dilemma can be perceived in a social context where individuals have procedural preferences. For weak procedural preferences, the perceived game indeed remains such that mutual defection is the only equilibrium. The interest is thus not to identify a unique rational solution but to show how the integration of procedural preferences helps to reveal the extent of the perceptual transformation when the game of consequences is embedded in a social context. Procedural pref-

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<sup>18</sup>See for instance Vanderschraaf (1995) where the solution concept of Correlated Equilibrium serves to characterize conventions.

<sup>19</sup>In a Meta-Analysis conducted over 1952 to 1992, the average rate of cooperation was found to be above 40% (Sally, 1996).

erences are thus an interesting opportunity to render Game Theory meaningful in a social context (Schelling [1960]1980: 285).

## 4.2. Set-up

A two-individual Prisoners' Dilemma with perfect social knowledge and preferences for acts can be defined by:

(i)  $N = \{1, 2\}$  the set of individuals.

(ii) Two available actions for each individual:  $A_i = \{Co, De\}$ ,  $i \in N$ . Profiles of actions are  $(Co, Co)$ ;  $(Co, De)$ ;  $(De, Co)$ , and  $(De, De)$  where the first action is attributed to individual  $i$ , the second to individual  $j \neq i$ .

(iii) A weak ordering  $\succsim_i$  of individual  $i$  over acts, represented by the utility function  $u_i(\cdot)$ ;  $i \in N$ . Acts of individual  $i$  are  $(Co; g(Co; Co))$ ,  $(Co; g(Co; De))$ ,  $(De; g(De; Co))$ , and  $(De; g(De; De))$ .

Individual  $i$ 's consequential utility representation is given by:

$$u_i^C(g(De; Co)) = w_i \text{ (i defects but } j \text{ cooperates);} \quad (4.1)$$

$$u_i^C(g(Co; Co)) = x_i \text{ (both cooperate);} \quad (4.2)$$

$$u_i^C(g(De; De)) = y_i \text{ (both defect);} \quad (4.3)$$

$$u_i^C(g(Co; De)) = z_i \text{ (i cooperates but } j \text{ defects);} \quad (4.4)$$

We have  $w_i, x_i, y_i$ , and  $z_i \in \mathbb{R}$ : For the separation to hold and for the game to be a Prisoners' Dilemma, we must have  $w_i > x_i > y_i > z_i > 0$ . The game of consequences can be represented in its normal form by the following matrix where actions of individual 1 are stated in rows and actions of individual 2 are stated in columns. In each box, utility of individual 1 is stated first:

Table 4.1: Representation of the Prisoners' Dilemma of consequences

	Cooperation (Co)	Defection (De)
Cooperation (Co)	$x_1; x_2$	$z_1; w_2$
Defection (De)	$w_1; z_2$	$y_1; y_2$

Individual  $i$ 's procedural utility representation is given by:

$$\begin{aligned} \succsim_i : \quad & \begin{aligned} & \frac{1}{2} \\ & \succsim_i(Co) = \alpha_i \\ & \succsim_i(De) = 1 - \alpha_i \end{aligned} \quad \text{with } \frac{1}{2} < \alpha_i < 1: \end{aligned} \quad (4.5)$$

We can now represent the game as it is perceived, i.e. integrating procedural concerns in the normal form:

Table 4.2: Representation of the Perceived Prisoners' Dilemma

	Cooperation (Co)	Defection (De)
Cooperation (Co)	$\otimes_1 \in x_1; \otimes_2 \in x_2$	$\otimes_1 \in z_1; (1 - \otimes_2) \in w_2$
Defection (De)	$(1 - \otimes_1) \in w_1; \otimes_2 \in z_2$	$(1 - \otimes_1) \in y_1; (1 - \otimes_2) \in y_2$

#### 4.3. Existence of Nash Equilibria:

The Nash Equilibria of this game depend on the values of the individuals for cooperation  $\otimes_1$  and  $\otimes_2$ . Applying definition 3.2. for the profile of actions (Co; Co), Cooperation of both individuals is a Nash Equilibrium with preferences for acts if and only if:

$$\forall i \in N; (Co; g(Co; Co)) \succ_i (De; g(De; Co)) \quad (4.6)$$

$$(\ ) \quad \forall i \in N; u_i(Co; g(Co; Co)) \succ u_i(De; g(De; Co)) \quad (4.7)$$

$$(\ ) \quad \forall i \in N; \otimes_i(Co) \in u_i^C(g(Co; Co)) \succ \otimes_i(De) \in u_i^C(g(De; Co)) \quad (4.8)$$

$$(\ ) \quad \otimes_1 x_1 \succ (1 - \otimes_1) w_1 \text{ and } \otimes_2 x_2 \succ (1 - \otimes_2) w_2 \quad (4.9)$$

$$(\ ) \quad \otimes_1 \succ \frac{w_1}{w_1 + x_1} \text{ and } \otimes_2 \succ \frac{w_2}{w_2 + x_2} \quad (4.10)$$

Similarly, (De; De) is a Nash Equilibrium with preferences for acts if and only if:

$$\frac{y_1}{y_1 + z_1} \succ \otimes_1 \text{ and } \frac{y_2}{y_2 + z_2} \succ \otimes_2 \quad (4.11)$$

This game may also include asymmetric equilibria. Individual  $i$  taking action Co and individual  $j$  taking action De, that is profile of actions (Co; De) is a Nash Equilibrium with preferences for acts if and only if:

$$\frac{w_{j i}}{w_{j i} + x_{j i}} \succ \otimes_{j i} \text{ and } \otimes_{i j} \succ \frac{y_i}{y_i + z_i} \quad (4.12)$$

Having determined the conditions of existence of Nash Equilibria, we characterize now situations where several of them coexist.

#### 4.4. Multiple Nash Equilibria:

Firstly, we can see that asymmetric equilibria cannot coexist with symmetric equilibria, conditions (4.12) being not compatible with either (4.10) or (4.11).

Secondly, symmetric equilibria can coexist. The conditions for such coexistence of symmetric Nash Equilibria are:

$$\frac{y_i}{y_i + z_i} \succ \otimes_{i i} \succ \frac{w_i}{w_i + x_i}; \forall i \in N \quad (4.13)$$

Thirdly, asymmetric equilibria can also coexist. The conditions for such coexistence of asymmetric Nash Equilibria, i.e. (Co; De) and (De; Co) are both Nash Equilibria are:

$$\frac{w_i}{w_i + y_i} > \alpha_i > \frac{y_i}{y_i + z_i}; \forall i \in N: \quad (4.14)$$

Finally, a special case arises where no Nash Equilibrium exists. The conditions for absence of Nash Equilibrium are (pairs of indices (i; j) being (1; 2) or (2; 1)):

$$\frac{y_i}{y_i + z_i} > \alpha_i > \frac{w_i}{w_i + x_i} \text{ and } \frac{w_{j-i}}{w_{j-i} + x_{j-i}} > \alpha_{j-i} > \frac{y_{j-i}}{y_{j-i} + z_{j-i}}: \quad (4.15)$$

#### 4.5. Optimal Nash Equilibria:

When it exists, equilibrium (Co; Co) is always the unique Optimal Nash Equilibrium. The equilibrium (Co; Co) can coexist only with (De; De) and in such a case, it is optimal while (De; De) is not. This is because of the construction  $\frac{w_i}{w_i + x_i} > \frac{1}{2}$ ,  $\forall i \in N$ . Therefore,  $\alpha_i > \frac{w_i}{w_i + x_i}; \forall i \in N \Rightarrow \alpha_i > \frac{1}{2}$  and as a result  $\alpha_i(\text{Co}) > \alpha_i(\text{De})$ . Since we have also  $g(\text{Co}; \text{Co}) > g(\text{De}; \text{De})$  by construction, it makes (Co; Co) an Optimal and Unique Nash Equilibrium.

Asymmetric Nash Equilibria of this game are never optimal. This is due to the fact that the procedural condition  $\alpha_i(\text{De}) > \alpha_i(\text{Co})$  is never satisfied in such cases.

Finally, equilibrium (De; De) is the unique Optimal Nash Equilibrium if and only if  $\alpha_i = \frac{1}{2}$ , which is the limit-case where individuals are procedurally neutral, or purely consequential.

#### 4.6. Graphical Summary of Solutions

As we have said, the interest of the approach is not to determine a unique rational solution for the Prisoners' Dilemma but to make full use of empirical observation of rational behavior to reveal procedural preferences. Once consequential preferences have been measured beforehand, we can express rational solutions of the perceived game depending on procedural preferences. To this purpose, we represent graphically the existence of the different Nash Equilibria and their optimality using the procedural values  $\alpha_1$  and  $\alpha_2$  of individuals 1 and 2 as coordinates. These values reflect a procedural preferences for Cooperation and thus have a range from 1=2 to 1 excluded. Values of 1=2 are interpreted as neutral values while values of 1 are interpreted as value-rational for the action of cooperation. These are the two limit-cases discussed in the first section. We distinguish three representations corresponding to three classes of Prisoners' Dilemma games:

4.6.1. Case 1:  $\frac{y_i}{y_i+z_i} > \frac{w_i}{w_i+x_i}$  for all individuals  $i$  :

As shown in Figure 4.1., a Nash Equilibrium always exists in this case. Symmetric equilibria of Cooperation and Defection can coexist but as we have shown, only the cooperation equilibrium is optimal. At each asymmetric corner, there exists an asymmetric equilibrium which is not optimal for both individuals. For low procedural values, only the Defection equilibrium remains, which is never optimal, except for the limit-case of procedural neutrality of all individuals.

Figure 4.1: Nash Equilibria in a Prisoners' Dilemma with procedural preferences for Cooperation - Case 1

4.6.2. Case 2:  $\frac{w_i}{w_i+x_i} > \frac{y_i}{y_i+z_i}$  for all individuals  $i$  :

As shown in Figure 4.2., a Nash Equilibrium also always exists in this case. The symmetric and optimal equilibrium of Cooperation is restricted to stronger procedural preferences than in case 1. The symmetric equilibrium of defection holds for symmetrical procedural values close to neutrality but it never coexists with the Cooperation equilibrium. At each asymmetric corner, the asymmetric equilibria exists similarly to case 1, but they also coexist for some values of the profile  $(\theta_1; \theta_2)$ .

Figure 4.2: Nash Equilibria in a Prisoners' Dilemma with procedural preferences for Cooperation - Case 2

4.7. Cases 3:  $\frac{y_i}{y_i+z_i} \geq \frac{w_i}{w_i+x_i}$  and  $\frac{w_{j-i}}{w_{j-i}+x_{j-i}} \geq \frac{y_{j-i}}{y_{j-i}+z_{j-i}}$  :

Figure 4.3 indeed represents two permutable third cases depending whether we take  $i = 1 (j = 2)$  or  $i = 2 (j = 1)$ . These third cases are characterized by their asymmetry, which entails the absence of equilibrium for some values of  $(\alpha_1; \alpha_2)$ . There is no coexistence of equilibria.

Figure 4.3: Nash Equilibria in a Prisoners' Dilemma with procedural preferences for Cooperation - Cases 3

## 5. CONCLUSION

This paper proposed a definition of rationality that combines consequential rationality and procedural rationality. This definition relies on a modification of the object of choice and therefore of the empirical primitives. Acts are a primitive concept and are defined as couples composed of an action and its consequence according to a consequence function. Preferences for acts are separated into preferences for consequences (consequential preferences) and preferences for actions, as processes towards consequences (procedural preferences). This separation is reflected in the representation of preferences with utility functions. Utility for acts is represented by a weighted consequential utility function, where the weights represent procedural preferences and the consequential utility function represents consequential preferences. Our definition integrates procedural concerns while still being represented as a maximization of utility: rational individuals act according to what they prefer. It allows for the interpretation of two limit-cases: one of pure consequential rationality, which is formulated in a way equivalent to Utility Theory (von Neumann and Morgenstern, [1944][1947]1953); and secondly one of pure procedural rationality, where consequences do not play a role in the evaluation of acts. The former limit-case corresponds to the 'ideal-type' of instrumental-rationality and the latter to the 'ideal-type' of value-rationality of Max Weber ([1956]1978). As such, the separation helps to draw links with sociological analysis. We consider thus that a development of this approach of rationality is proposed in the case of interactions of several decision-makers (Game Theory).

The approach enables us to state the solution concept of Nash Equilibrium with preferences for acts instead of preferences for consequences in a straightforward manner. We thus include procedural concerns in the notion of Equilibrium. The structure of the approach leads to considering a strong refinement of the Nash Equilibrium concept. Such selection is based on the concept of Optimal Nash Equilibrium that characterizes a state composed of procedurally preferred actions and preferred consequences. There are 'good reasons' to reach such equilibrium since all individuals prefer the action to attain it, and also prefer the consequences they will reach over all consequences reached at equilibrium. When such an optimal equilibrium exists, and either procedural or consequential preferences is strict, then such Optimal Nash Equilibrium is unique. By justifying the existence of 'salient equilibria', the integration of procedural preferences in the definition of rationality leads to a richer understanding of the general notion of equilibrium.

As an application, the approach is used to analyze a one-shot Prisoners' Dilemma in a social context. Depending on procedural preferences, many solutions of such a game do exist, even when utilities for consequences have been

'accurately measured' beforehand. Observation of a state other than the one where both individuals are defecting, does not reveal irrationality, but reveals the influence of a social norm on consequential behavior. Sufficiently strong procedural preferences, as interpreted relative to the preferences for consequences, lead to both individuals cooperating as the unique Optimal Nash Equilibrium of the game. In such situations, consequential behavior is influenced by a social norm that helps the collectivity of individuals to reach a more efficient state. Hence, the approach presented here does not rely on altruism to explain such social coordination phenomena, but on the internalization of social norms in the preferences of individuals. Social norms leading to an Optimal Nash Equilibrium act here as a convention (Lewis, 1969). On the contrary, mutual defection is an Optimal Nash Equilibrium in the particular case where individuals have neutral procedural preferences (the instrumentally-rational case). This situation of neutral procedural preferences can be interpreted as reflecting a 'state of nature' (Skyrms, 1990) or a market of 'pure competition' (Williamson, 1975).

Considering the importance of rationality, the present work should be seen as preliminary in nature. It presents a first and introductory development showing how procedural rationality might provide us with a better understanding of theoretical and empirical dimensions of rational behavior in a social context. Further work shall clarify the underlying nature of the structure proposed as well as explore its potential benefits. In particular, the approach might enlighten the relationship between rationality and communication, since many social norms are deemed to emerge from communication (Knight, [1947]1982: 280).

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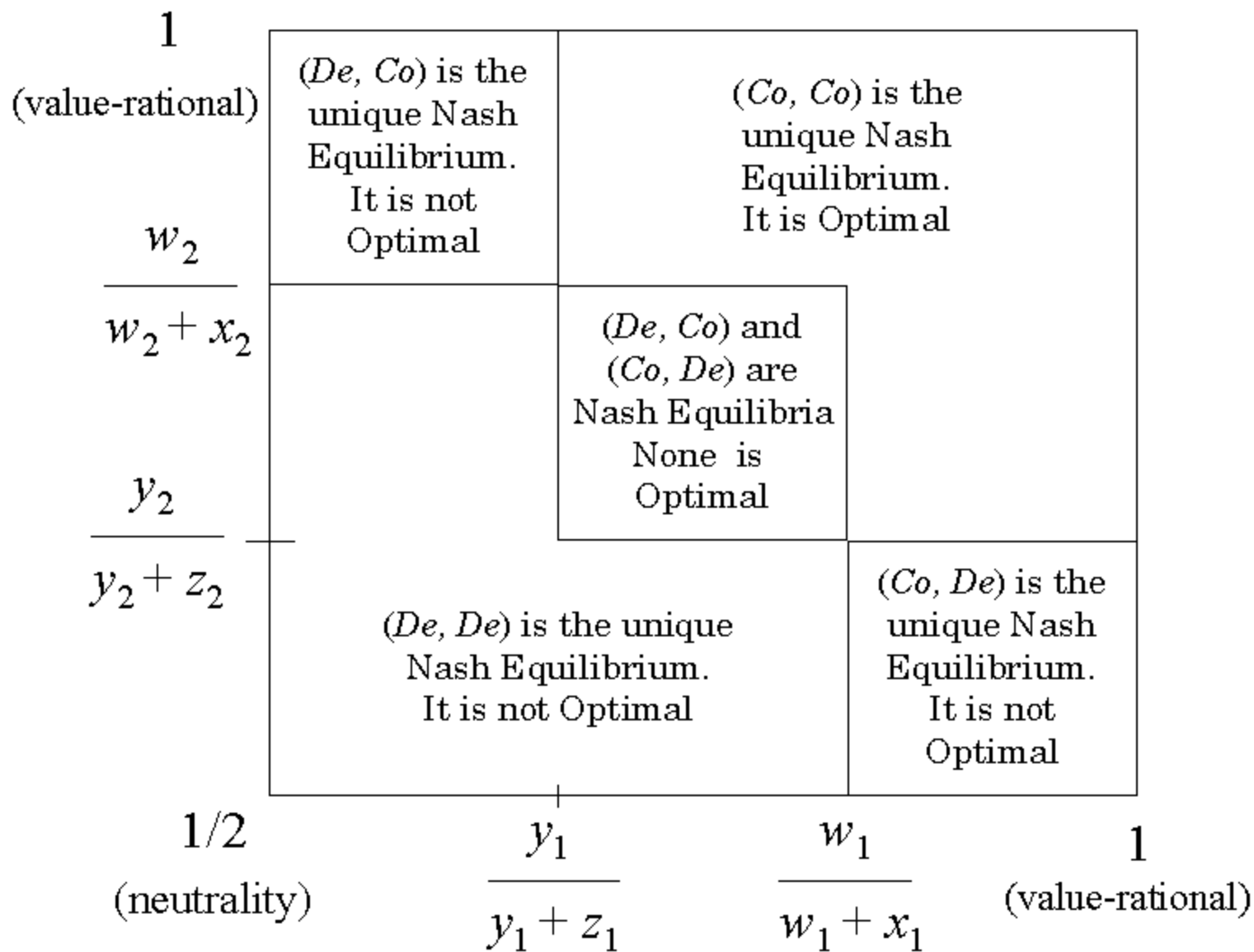
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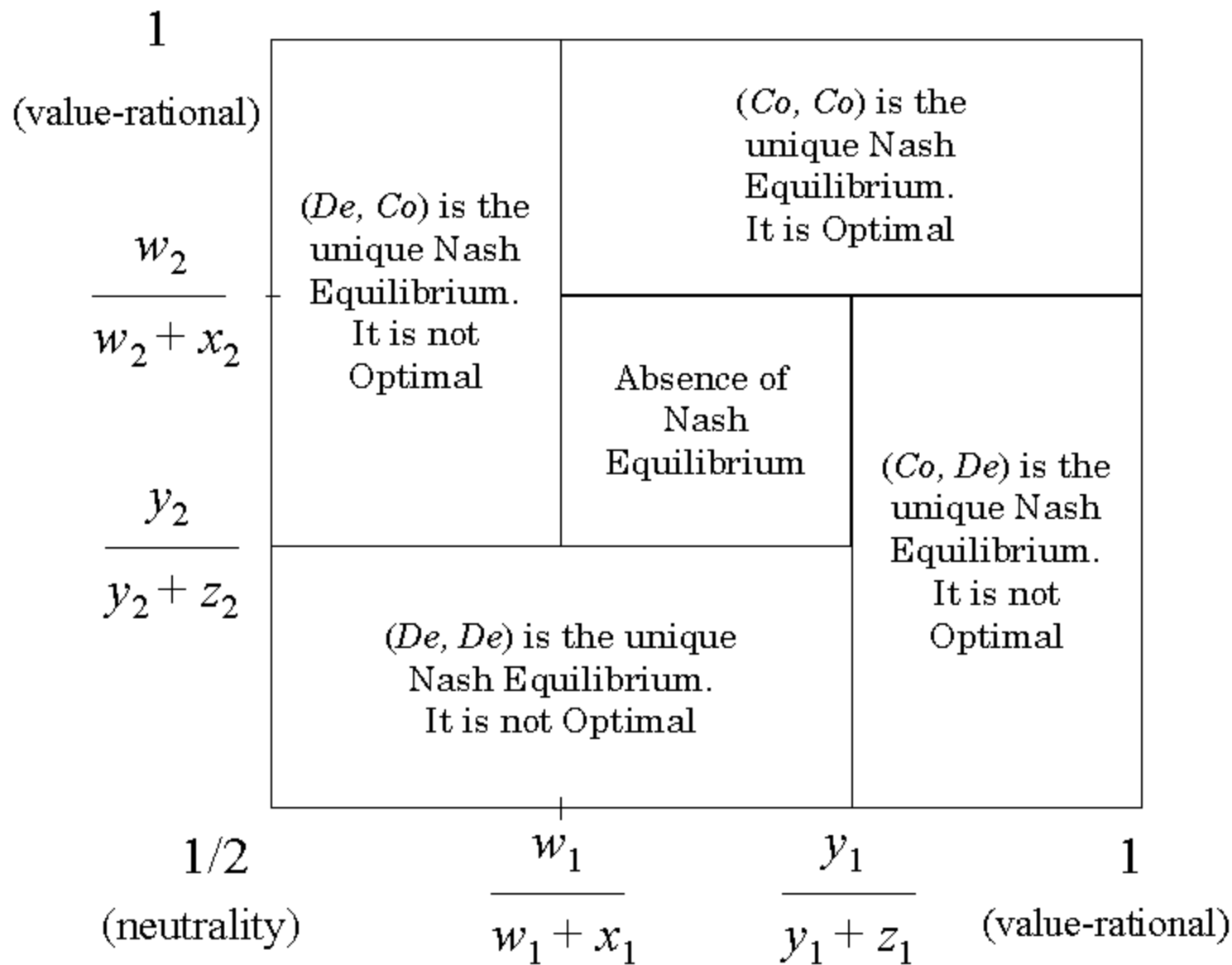
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<p>1 (value-rational)</p>	<p><math>y_2</math></p> <hr/> <p><math>y_2 + z_2</math></p> <hr/> <p><math>w_2</math></p> <hr/> <p><math>w_2 + x_2</math></p>	<p>(<i>De</i>, <i>Co</i>) is the unique Nash Equilibrium. It is not Optimal</p>	<p>(<i>Co</i>, <i>Co</i>) is the unique Nash Equilibrium. It is Optimal</p>
<p>1/2 (neutrality)</p>	<p><math>w_1</math></p> <hr/> <p><math>w_1 + x_1</math></p>	<p>(<i>Co</i>, <i>Co</i>) and (<i>De</i>, <i>De</i>) are Nash Equilibria Only (<i>Co</i>, <i>Co</i>) is Optimal</p>	<p>(<i>Co</i>, <i>De</i>) is the unique Nash Equilibrium. It is not Optimal</p>
<p>1 (value-rational)</p>	<p><math>y_1</math></p> <hr/> <p><math>y_1 + z_1</math></p>		

Procedural Utility of Individual 2 for cooperation ( $\alpha_2$ )



Procedural Utility of Individual 1 for cooperation ( $\alpha_1$ )



Procedural Utility of Individual 1 for cooperation ( $\alpha_1$ )