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How to play the games? Nash versus Berge behavior rules

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Abstract: Social interactions regularly lead to mutually beneficial transactions that are sometimes puzzling. The prisoner's dilemma and the chicken and trust games prove to be less perplexing than Nash equilibrium predicts. Moral preferences seem to complement self-oriented motivations and their relative predominance in games is found to vary according to the individuals, their environment, and the game. This paper examines the appropriateness of Berge equilibrium to study several 2×2 game situations, notably cooperative games where mutual support yields socially better outcomes. We consider the Berge behavior rule complementarily to Nash: individuals play one behavior rule or another, depending on the game situation. We then define non-cooperative Berge equilibrium, discuss what it means to play in this fashion, and argue why individuals may choose to do so. Finally, we discuss the relationship between Nash and Berge notions and analyze the rationale of individuals playing in a situational perspective.

Keywords: Berge Equilibrium; Moral preferences; Mutual support; Social Dilemmas; Situations.

1. Introduction

Although experimental evidence supports the predictions of standard economic theory about the outcomes of social interactions in several competitive situations (Davis and Holt, 1993), it usually does not corroborate the theory in cases of cooperative situations. In two-player zero sum games, when there is a Nash equilibrium, subjects usually play according to that strategy (Lieberman, 1960) and even exploit the non-optimal responses of their partner in order to maximize their benefits (Kahan and Goehring, 2007).[1] Conversely, in mixed-motive game experiments, subjects often cooperate more than they should[2]. Despite the wide disparity in the experimental results and protocols on the prisoner's dilemma (PD), meta-analysis shows that, on average, about 50% of subjects cooperate (Colman, 1995; Ledyard, 1995; Sally, 1995). Similar anomalies related to Nash predictions have been documented in studies of the chicken game (CG), where cooperation is the dominant outcome observed (Rapoport and Chammah, 1965), and in trust or investment games, where trust and reciprocity are often more significant than predicted by subgame perfect equilibrium (see e.g. Berg *et al.*, 1995; Bolle, 1998).

Fischbacher *et al.* (2001) and Kurzban and House (2005) observe that in public good experiments, not all subjects play in the same fashion. In their experiments, more than 50% and up to 65% of subjects contribute on condition that others do the same, less than 30% are pure free riders, and the rest adopt a mix of these two behaviors. This illustrates the heterogeneity of behavior rules: individuals have types and are likely to adapt their behavior to their immediate environment (see also Boone *et al.*, 1999; Brandts and Schra, 2001; Keser and Winden, 2000; Fehr and Fischbacher, 2005). Experiments also show that individuals may change behavior according to the situation of their play. For example, Zan and Hildebrandt (2005) found in a school experiment that children adopt different behavior rules according to the type of game they are playing, with cooperative games involving more reciprocal interactions than competitive ones.[3] Players may also adopt different behavior rules according to their life situations and to the society in which they live. Henrich *et al.* (2004, 2010) for example, observe that fairness and mutually beneficial transactions are more frequent in

[1] Fehr and Fischbacher (2005) also review competition experiments where Nash prediction is not valid.
[2] Prisoner's dilemma, chicken games, public good and trust games are the best-documented examples of predictions of inefficient outcomes, which often are not confirmed by the empirical evidence. For surveys on the experimental evidence of other regarding preferences and the emergence of cooperation, see Camerer (2004), Fehr and Fishbacher (2005) or Fehr and Schmidt (2006).
[3] Note that there is plenty of experimental evidence of situationalism in the social psychology literature. For example, many examples are provided by Mischel and Shoda (1995).

integrated societies. Their interpretation is that subjects conform less to Nash predictions, as if they were being motivated by social norms reflecting moral preferences[4]. This conclusion is confirmed by other experimental studies such as Engelmann and Normann (2010). These authors have found that levels of contribution in a minimum-effort game vary across countries and, more interestingly, between natives, former immigrants, and new immigrants within the same country.

The formal literature often considers moral preferences in games as other-regarding payoff transformations, a concept first mooted by Edgeworth (1893). The key to this approach is the assumption that a player's utility is a twofold function, related to individual welfare and to the welfare of the other. Individuals are found to care about how payoffs are allocated, depending on the partner, the game situation, and how the allocation is made. To redefine the utility function in this way allows for rationalizing behaviors.[5] The Nash behavior rule is safe and players are supposed to choose the actions that maximize their individual redefined utility, given that others do the same.[6] However, to include moral preferences in the utility function leads us to assume that moral agents are concerned only with outcomes rather than with actions, which is a peculiar interpretation of moral preferences. As Vanberg (2008: 608) contends, "*moral principles, standards of fairness, justice,[...] are codes of conduct that require persons to act in fair, just, or ethical ways. They tell them not to steal, not to lie, to keep promises, etc. They are typically concerned not so much with what a person wants to achieve but with how she seeks to achieve what she wants".* In other words, moral preferences are also preferences for acting morally, following a moral rule of conduct.[7]

Our principal motivation in this paper is to examine whether complementary behavior rules and equilibrium may be intertwined with the Nash rule, leaving the payoff matrix unchanged. In line with Pruit and Kimmel (1977), we confer on individuals the capacity to adapt their behavior rules to the situation. In some games, such as zero-sum situations where self-oriented maximization is sufficient to drive action, the Nash rule would tend to be adopted. In others, such as games involving collective action, complementary rules embedding moral

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[4] We intentionally employ the term *moral preferences* instead of *other-regarding preferences*. As Vanberg (2008) claims, there is indeed a significant difference between, on the one hand, claiming that agents evaluate outcomes not only in terms of their own narrowly defined interests but also in terms of how they affect the wellbeing of other persons (other regarding preferences) and, on the other hand, claiming that agents are motivated to act in accordance with ethical rules or principles such as fairness (moral preferences).

[5] Falk and Fischbacher (2005) propose a review of the formal models of strong reciprocity.

[6] In particular, Fehr and Schmidt (1999), Fehr and Fischbacher (2000) and Fehr and Falk (2003) argue that the experimental evidence for deviations from the predictions of rational choice theory can be accounted for if other-regarding concerns are allowed to be included in individuals' utility functions, while maintaining the assumption that agents are fully rational maximizers given their utility functions.

[7] Note that those norms of conduct may well be the result of an evolutionary procedure and therefore find roots in an outcome-based approach. We further develop this point in Section 2.2 of the paper.

preferences would potentially drive the action. This situational perspective has analogies with the rule-following behavior approach proposed by Vanberg (2008), and is more generally inspired by the situational approach[8] in social psychology, according to which personality is construed not as a generalized or a contextual tendency but as a set of "*If ...then*" contingencies that spawn behaviour of the "*If situation X, then behavior Y*" type (Mischel and Shoda, 1995, 1999).

We focus on how to play usual game situations such as PD, CG or trust games and posit one possible complementary behavior rule to Nash and its associated equilibrium concept. Keeping the utilitarian perspective and building on the experimental observation that the majority of subjects are reciprocal in public good games, we focus on specific forms of reciprocity that may well illustrate collective decision-making.[9] Our behavioral hypothesis is that choice in many interactive situations requires that each player make the welfare of the other a key feature of his or her reasoning. Individuals would choose to play this way because this is a common rule-following behavior that improves social welfare in many situations. This is mutual support and leads us to posit that in some game situations, individuals care about the welfare of others *if* they believe that others reciprocate. Real life examples are numerous and are related to *savoir vivre, a* set of rules of conduct such as respect for others, politeness or courtesy.

To examine mutual support in social interactions, we exploit an old concept, the Berge equilibrium. We think this concept is appropriate for two main reasons. The first is that mutual support is a possible interpretation of Berge equilibrium. Playing under Berge rules, agents choose the strategy that maximizes the welfare of others. The second is that, theoretically, the Berge behavior rule and Berge equilibrium are good complements for Nash: Berge equilibrium is defined in a non-cooperative game theoretical setting but is not a refinement of Nash; it explains some cooperative situations while Nash explains many competitive ones; and it has some common theoretical properties with Nash, making it particularly appropriate and easy to handle in a type-based perspective.

The paper is organized as follows. Section 2 introduces non-cooperative Berge equilibrium. We discuss the concept from a historical perspective and propose a definition. We interpret the Berge behavior rule and focus on mutual support interpreted as utilitarian behavior. Section 3 discusses decision-making and examines the rationales of Nash-Berge

[8] A good literature review of the situational approach in social psychology is provided in Reis (2008).

[9] As noted previously, Fischbacher *et al.* (2001) observe in a public good experiment that the majority of subjects are reciprocal rather than individualistic. Similar observations are documented for example in Kurzban and Houser (2005), who found 63% of reciprocal-type agents in their public good experiment.

players. We analyze the relations between Berge and Nash equilibria. The existence conditions for Berge equilibrium are examined and a systematic and simple method to bridge the two equilibrium notions is proposed. Finally, we study the rationales of agents playing as Nash or Berge maximizers and examine when players adopt one behavior rule rather than the other. The last section offers some conclusions.

2. Non-cooperative Berge equilibrium

This is Harsanyi (1966) that made Nash equilibrium and its refinements the canonical concept in game theory**.** Nash equilibrium became the *"test"* against which all solutions for any game must be measured, and as stressed by Rasmussen (2007, p.27), *"Nash equilibrium is so widely accepted that the reader can assume that if a model does not specify which equilibrium concept is being used it is Nash equilibrium"***.** Reasons behind this success are manifold: it constitutes the minimal stability concept which can be defined in a non-cooperative game setting; it is particularly appropriate to study competition situations and admits a few competitors that are not refinements. However, one may argue that it is not sufficient as such to capture the logic of collective action resulting from non-purely self-oriented motivations. As a complementary notion we re-introduce and present in this section non cooperative Berge equilibrium.

2.1 The history of a little-known concept

Between the intuition at the origins of Berge equilibrium and conceptualization of its existence conditions, there was a gap of 50 years. The initial intuition came from the mathematician Claude Berge when defining coalitional equilibria[10] in the "*general theory on n-player games*" published in 1957.[11]

Berge's book made only a minor ripple in the academic pool, and is rarely cited.[12] However, it provides an impressive assessment of the state of the art in 1950s' game theory, as well as a diagnosis and interesting development of new results. From a contemporaneous perspective, two specificities of the book are particularly striking. First, the "*general theory of n-player games"* remains current, and any up-to-date textbook striving to provide a general theory of games would include similar content. Berge's book, in five chapters, covers the

[10] Refer to Laraki (2009) for the properties of the Berge coalitional equilibrium.
[11] The book was published in 1957 when Claude Berge was visiting professor at the Mathematics Department in Princeton University.
[12] Among the few citations to his work, most are to the generalization of the Zermelo-Morgenstern's theorem in the first chapter, e.g. Aumann (1960). Note also that most references are in the area of applied mathematics, not economics.

major themes that have been the motivation for game theoretic research in the last 50 years: games with complete information (ch. 1), topological games (ch. 2), games with incomplete information (ch. 3), convex games (ch. 4), and coalitional games (ch. 5). Second, the book is an impressive contribution to the literature in its provision of a compilation of theorems related to n-player games. Some were new, others were already known but Berge provided alternative demonstrations for them, for example, the theorem on unicity and existence of the Shapley value, and the Von-Neumann Morgenstern solution.

In our view, there are four major reasons for the small impact made by Berge's book. First, it is published in French, which limited its diffusion at the international level. Second, it is not aimed at economists: Berge was first and foremost a mathematician and wrote his book from this perspective. There are no examples or applications of his results, which probably disappointed the 1950s' social scientists who were not well acquainted with mathematical techniques. Third, Berge defines strategies and equilibria using graph theory and again, social scientists were probably not comfortable with this mix of mathematical techniques. And fourth, in 1957 Luce and Raiffa published their seminal work, which is a more pedagogical contribution which contains examples and applications.

Turning to recensions to Berge's work, we find two unique reviews. One is by the mathematician, John Peck in 1960, and one by the economist, Martin Shubik in 1961. The words of Peck are not eulogistic and criticize the false simplicity of Berge's work: *"In his preface, the author states that he has taken care to write for a reader who knows no more than the elements of algebra and set theory, and a little topology for chapters 2 and 4. He might have added that a mathematical maturity is also required, for this is not an easy book for a beginner. With a multiplicity of new notions, some defined on almost every page, and some (e.g. cooperative) perhaps not at all, an index of terminology is sorely missed"* (p. 348). Confirming this, Shubik states that *"the argument is presented in a highly abstract manner and no consideration is given to applications to economics"* (p. 821).

Berge's book was translated into Russian in 1961 and first reference to Berge equilibrium was in 1985 by Zhukovskii, a Russian mathematician who reformulated the Berge coalitional equilibrium from an individualistic perspective, naming it the Berge equilibrium. Zhukovskii's paper does not focus exclusively on Berge equilibrium: it is some 90 pages long and discusses the design of a research program on differential games. The author highlights 10 hot topics, the 10th being Berge equilibrium. According to Zhukovskii, this equilibrium notion should be introduced into differential games because it admits the nice properties of Nash equilibrium, excluding some of its disadvantages, in particular inexistence. This position is certainly not sufficient to justify the use of one equilibrium notion over another. But it was enough for Russian mathematicians to start working on the topic, and to study the conditions for existence, and the properties of Berge equilibrium in differential games.[13]

We need to wait up to 2004 for Abalo and Kostreva (2004, 2005) to propose an existence theorem of pure strategy Berge equilibrium in normal form games. They elaborate their theorem on the basis of the work of Radjef (1988), a former PhD student of Zukovskii, who defined an existence theorem of Berge equilibrium in differential games. Nessah *et al.* (2007) and Larbani and Nessah (2008) then proposed a new existence theorem providing analytical validity to Berge equilibrium, and demonstrating that the conditions in Abalo and Kostreva (2004, 2005) are not sufficient to prove the existence of a pure-strategy Berge equilibrium.

2.2 Definition and interpretation

Consider the game G = $(N, S_i, U_i)_{i \in N}$ where N denotes the set of players, S_i the nonempty strategy set of player *i*, and U_i his utility function. U_i is defined on $S = \prod_{i \in N} S_i$, where S is the set of all strategy profiles and denote by s_{-i} the strategy profile $(s_1, ..., s_{i-1}, s_{i+1}, ...) \in S_{-i} = \prod_{j \neq i} S_j$.[14] We start with the definition of Nash equilibrium and proceed to the definition of Berge equilibrium.

Definition 1. A feasible strategy profile $s^* \in S$ is said to be a Nash equilibrium if, for any player $i \in N$, and any $s_i \in S_i$, we have :

$$U_i(s_i, s^*_{-i}) \leq U_i(s^*)$$

The Nash equilibrium is immune to unilateral deviations: player *i* has no incentive to deviate from his Nash strategy given that other players also do not deviate from their Nash strategy.

Definition 2 (Zhukovskii, 1985). A feasible strategy profile $s^* \in S$ is said to be a Berge equilibrium if, for any player $i \in N$, and any $s_{-i} \in S_{-i}$, we have:

[13] A synthesis of those works is provided in Zukovskii and Tchikri (1994).
[14] In game theory, utility functions usually reflect overall preferences of agents and therefore encapsulate preferences over outcomes such as equity concerns about distribution of rewards. In the current paper, the reader may either consider this usual definition, preferences over actions not being accounted in the payoff valuation, or consider as in experimental gaming that it reflects simply a reward, a fixed amount of money associated with a choice that does not reflects any other-regarding preferences.

$$U_i(s_i^*, s_{-i}) \leq U_i(s^*) \qquad (1)$$

Playing Berge equilibrium strategy, *i* yields his highest utility when others also play according to Berge strategy. Unlike Nash equilibrium, Berge equilibrium is not immune to unilateral deviations. Player *i* is penalized if other players deviate from the Berge strategy but the equilibrium notion does not say anything about player *i* might improve his welfare by deviating. In this sense, Berge equilibrium is not a standard game solution as defined by non-cooperative game theory in that it is not meant to be immune to unilateral or collective deviations. In contrast to Nash equilibrium where each player maximizes his utility over his own strategy set, playing a Berge equilibrium strategy consists of maximizing over the set of strategies of the other players.

We think this equilibrium concept deserves a particular attention because of the reciprocal dimension it embeds. To shed light on its meaning we start with an illustration. Consider a simple PD. As usual, players may either cooperate (C) or defect (D), resulting in four possible outcomes: mutual cooperation (CC), unilateral exploitation (CD or DC), and mutual defection or DD. The game is illustrated by the following matrix:

		Player 2	
		C	D
Player 1	C	R,R	S,T
	D	T,S	P,P

with R the reward for mutual cooperation; P the punishment for mutual defection; T the temptation to cheat the opponent; and S the payoff for one being sucked. For a strict dilemma situation, we set T > R > P > S, strategy D is a dominant strategy and outcome (D,D) is the pure-strategy Nash equilibrium of the game.

Let us now look at the Berge equilibrium of this game. Observe that outcome (C,C) fulfils definition 2:

$$U_1(C,C) > U_1(C,D) \quad \text{and} \quad U_2(C,C) > U_2(D,C)$$

This is not true for (D,D):

$$U_1(D,D) < U_1(D,C) \quad \text{and} \quad U_2(D,D) < U_2(C,D)$$

We deduce that mutual cooperation (C,C) is a pure-strategy Berge equilibrium while (D,D) is not. The cooperative outcome in the PD is yielded when players follow a Berge behavior rule.

Define now α_i the maximum security level of player *i:*

$$\alpha_i = \sup_{s_i \in S_i} \inf_{s_{-i} \in S_{-i}} U_i(s_i, s_{-i}) \leq U_i(s^*) \ i \in N,\ s_{-i} \in S_{-i}. \quad (2)$$

If inequality 2 is true for any player $i \in N$, the Berge equilibrium yields a payoff that must be no less than the maxmin.

Considering the PD, we have:

$$\alpha_1 = \max\{\min_{s_2} U_1(C, s_2), \min_{s_2} U_1(D, s_2)\} = \max\{S,P\} = P < R \text{ and } \alpha_2 = P < R,$$

and we conclude that the strategy profile (C,C) is individually rational. Considering now a simple CG and using similar notations, the payoffs order is T > R > S > P. Beside the two pure-strategy Nash equilibrium, (C,C) is the only pure strategy Berge equilibrium and this outcome is individually rational.

In order to understand how paradoxes are disentangled, we scrutinize the logic underlying this equilibrium concept and the meanings of the associated behavior rule. The main question that arises is why would other players consent to playing Berge strategy when player *i* does so? Individual utility maximization predicts unilateral deviation and playing in a Berge fashion can be interpreted in two ways:

The first interpretation is related to altruism and finds analogies with solidarity as defined first by Ibn Khadun (1378), by Durkheim (1893) and many others.[15] Members of a same family, for example husband and wife, may put the utility of the other before his or her own[16]. Even in a winner-looser zero-sum game, this altruistic type of individual attempt to lose in order for the other to feel good. Maximization of the utility of the other translates in minimization of individual utility. In other game situations, such as PD or CG, altruistic individuals naturally cooperate. They do not compete and cooperation is the dominant strategy to maximize the utility of the other. Both players end up in a better situation. The principal limit of this perspective is its narrow domain of application. Pure altruism can exist only in a specific environment, such as the family circle, where the other is more valuable than oneself.

The second interpretation, mutual support, is related more to a form of reciprocity and find analogies with introspection. Consider a player *j* who can either play his Berge strategy or not, given that the N-1 other players play their Berge strategy. According to definition 2, we have**:**

$$U_i(s_i^*, s_{-i-j}^*, s_j^*) \geq U_i(s_i^*, s_{-i-j}^*, s_j) \ \forall i \in N,\ \forall s_j \in S_j$$

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[15] Ibn Khaldun conception of solidarity (*"asabiyah"*) is dynastic and occurs within small groups such as tribes. For Durkheim, solidarity is a sense of likeness that would favor a common consciousness maintained by social pressure and conformity.

[16] A treatment of solidarity related to our approach is performed in Arnsperger and Varoufakis (2003).

When playing his Berge strategy, player *j* maximizes the payoff of *i*. This is true for any $i \in N$ and, in fact, player *j* maximizes the utility of all other players. Reciprocally, in playing Berge strategies, the other players maximize the utility of *j* and of all their partners if they also play Berge strategies. In several game situations, everyone improves his utility: this is mutual support and is unrelated to solidarity or dynasties. Mutual support can be observed between strangers, and individuals play this way because it is a set of rules of conduct that serve common interest. For Sen (1987), when players face situations such as the PD, they may adopt reciprocal behavior because they understand that success in such situations is the result of mutual interdependance. Even if players do not encapsulate others players' goals, acknowledging interdependance may lead to adopt behavior rules that realise the goals of the members of the group. According to this logic, the Berge equilibrium should not be seen as a solution concept opposed to the Nash equilibrium, but rather as a complementary concept insofar as it applies to situations where agents think that the others can adopt the same type of reasoning as themselves.

To the question how can mutual support be sustainable against deviations over time, the natural response is then to borrow from the work of cognitive psychologists. According to Anderson (1991, p. 428), *"The mind has the structure it has because the world has the structure it has*". In other words, the mind has evolved certain structures because those structures permitted our early ancestors to solve critical problems effectively and efficiently. More specifically, the rules of conducts underlying mutual support are related to Kropotkin's mutual aid principle, which is the predisposition to help one another.[17] In "*Mutual Aid: A factor of evolution*"[18] published in 1902, Kropotkin gives a scientific foundation to mutual aid elaborating the work of Darwin (1859) and responding to social Darwinist, Thomas Huxley (1888). Kropotkin claims that codification and interpretation of social relationships under the prism of Darwin's "*struggle for life*" theory is a misunderstanding. His view is that mutual aid plays a significant role in the evolution of society, far more than is posited in the "*social struggle for life*" theory.[19] Considering historic events, Kropotkin observes that when faced by

[17] Note that Kropotkin in the *"Anarchist Moral"* published in 1891 employs the terms solidarity and mutual aid indiscriminately. He then abandons the term solidarity which he judges to be too focused to include mutual aid motivated only by the mutual interest in helping one another.

[18] Although mutual aid did not attract much attention from the biology and economics scientific literatures, authors such as Fong *et al.* (2006) and Foster and Xavier (2007) recommend further study of Kropotkin's work to better understand the foundations of cooperation.

[19] Dugger (1984, p. 973) notes that the book *"was written especially to show that a full theory of evolution must include the workings of cooperation for survival as well as the standard competition for survival".* This statement was defended notably by Gould (1988).

the scarcity of a resource, overpopulation does not lead necessarily to conflict but may lead to migration. In his view, life organized in society is the most adequate response to the struggle for life in an inhospitable world. Hence, he contrasts struggling for life against one another within a group with struggling for life by the group against the world. Life in a society is viewed as mutual protection enabling conservation and prosperity of the species.[20] Although accepting the importance of the individual in the community, Kropotkin claims that progress cannot be the result of individualistic competition. Instead it is the result of the capacity mutually to aid each other when problems involve collective action.[21] In this perspective, mutual support and egoism coexist, with individuals playing one behavior rule or the other according to the problem with which they are confronted. Singer (1993) supports this utilitarian perspective arguing that consideration of others' interests has for long been a necessary part of the human experience. By playing mutual support in some situations, total utility is maximized; individual utility maximization is a corollary.[22] Self-interest obviously can conflict with utilitarianism and lead to collective action paradoxes. However, as suggested by Singer (1993, p. 143), in a reference to the Golden rule: "*Given others have senses, and like us, feel suffering and pain […] our reason should tell us that if we would not like to be made to suffer, neither will they*". In other words, this is reminiscent of Axelrod's tit-for-tat strategy and in analogy to Binmore (2007)'s illustration of anonymous vampire bats strategy to survive, mutual support would be one of the social behavior used in the repeated game of life to ensure success in some situations, punishment being obviously not explicit here.

Back to Berge equilibrium, as mutual support translates into playing Berge strategy and egoistic competition into playing Nash strategy, we next examine how the game may be played, and in what particular situations.

3. Nash versus Berge behavior rule

3.1 Theoretically, two related equilibrium concepts

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[20]Focusing on Siberian tribes, on Polynesian islanders, on medieval corporations and on the nascent industrialized society; he illustrates mutual aid in the development of human society. He argues in particular that since Stone Age man, mutual aid has played a key role in survival and progress, leading humans to live first in clans, next in tribes. Through hunting, collective defense and common territorial property, human beings developed social institutions that were the foundations for progress. Society enlarged successively, with villages, cities, countries, ruled by stringent social institutions enabling collective action, and limiting individualism.

[21] Refer also to the analysis of Kropotkin's work in Glassman (2000) and Caparros *et al.* (2010).

[22] A large literature is devoted to the validity of this corollary with notably criticisms of utilitarianism based on ethical considerations around equity, average versus total utility paradoxes, and the repugnant conclusion (Parfit, 1984; Rachels, 2001).

In studying Nash and Berge equilibria in well known two player games, we observe that the relationship between the two equilibrium concepts is not straightforward. In some games, there is no Nash equilibrium but a unique Berge equilibrium (e.g. the taxation game), in others this is the reverse. There are games with a multiplicity of Nash equilibrium but a unique Berge equilibrium (e.g. the CG) and others with multiple Berge equilibrium but a single Nash equilibrium. There are games where Nash and Berge equilibria coincide, the case, for instance, with the battle of the sexes, and games where they do not (e.g. PD).

Larbani and Nessah (2008) study conditions for the two equilibria to coincide. Complementary, and in order to better understand how the two concepts are bridged, we study the existence condition of Berge equilibrium and propose a simple rule illustrating the relationship between the two.

We note first that the existence conditions for Nash equilibrium and Berge equilibrium are related. Focusing on two player games[23], N= $\{1,2\}$, and denoting by S_i the set of strategies of player *i*, we have:

Proposition 1. *A* 2×2 *game has at least one Berge equilibrium if:*

- *The strategy sets* S_1 *and* S_2 *are nonempty, convex and compact,*

- *the* utility *functions* U_1 *and* U_2 *are continuous on S,*

- *the function* U_1 *is quasiconcave on* S_2, $\forall\ s_1 \in S_1$, *and the function* U_2 *is quasiconcave on* S_1, $\forall\ s_2 \in S_2$.

Proof. *Let C:* $S \to S$ *be a multivalued mapping such that C(* s_1,s_2 *)=* $C_1\left(s_1,s_2\right) x\, C_2\left(s_1,s_2\right)$

where:

$$C_1\left(s_1,S_2\right) = \left\{s_1^* \in S_1 \,/\, U_2(s_1^*,s_2) = \mathrm{Max}_{s_1 \in S_1} U_1(s_1,s_2)\right\} \subset S_1$$

$$C_2\left(s_1,S_2\right) = \left\{s_2^* \in S_2 \,/\, U_2(s_1,s_2^*) = \mathrm{Max}_{s_2 \in S_2} U_1(s_1,S_2)\right\} \subset S_2 .$$

By compactness of S_i *and continuity of* U_i, *i = 1, 2, we can easily show that C has nonempty, compact values and a closed graph. Furthermore, it also has convex values whenever the* U_i, *i = 1, 2, is quasiconcave. Then, by Fan-Glicksberg's fixed point theorem, the multivalued mapping C has a fixed point and so the game has a pure Berge equilibrium #*

[23] In the case of n-player games, additional conditions are necessary to ensure the existence of Berge equilibrium. For more details, see Nessah *et al.* (2007).

The first two conditions are common to the Nash equilibrium existence conditions. The only difference between the two equilibria is that the function $U_i(s_1, s_2)$ must be quasi-concave in s_i for all given s_j in the Nash equilibrium, and quasi-concave in s_j for all given s_i in the Berge equilibrium. Fan-Glicksberg's fixed point theorem is sufficient to ensure the existence condition of Nash equilibrium when the objective functions are continuous in their domains and quasiconcave in their own strategy. It is respectively sufficient to ensure the existence condition of Berge equilibrium when the objective functions are continuous in their own domains but quasi-concave in the strategy of the other. It results that both equilibrium is a fixed point; Nash equilibrium being immune to deviation from individual action, Berge equilibrium being immune to deviation in the action of the other.

We deduce an explicit relation between the two equilibria. Let associate the game $\bar{G}$ = $(N = \{1,2\}, S_1, S_2, V_1, V_2)$ to the game $G = (N = \{1,2\}, S_1, S_2, U_1, U_2)$, with $V_1 = U_2$ and $V_2 = U_1$. The proposition follows:

Proposition 2. *$s^* \in S$ is a Nash equilibrium of the game G if and only if s* is a Berge equilibrium of the game* $\bar{G}$.

Proof. *Consider the game G and let s*=* (s_1^*, s_2^*) *be a Nash equilibrium of G. By definition, we have:*

$$\forall\ s_1 \in S_1 \quad U_1(s_1, s_2^*) \le U_1(s_1^*, s_2^*)$$

$$\forall\ s_2 \in S_2 \quad U_2(s_1^*, s_2) \le U_2(s_1^*, s_2^*).$$

Given $V_1 = U_2$ *and* $V_2 = U_1$,

$$\forall\ s_1 \in S_1 \quad V_2(s_1, s_2^*) \le V_2(s_1^*, s_2^*)$$

$$\forall\ s_2 \in S_2 \quad V_1(s_1^*, s_2) \le V_1(s_1^*, s_2^*).$$

Thus s is a Berge equilibrium, the reciprocal being proved in a similar way .* #

In other words, the set of Berge equilibrium in the 2x2 game coincides with the set of Nash equilibria of the homothetic game consisting of permutating the utility of the two players. To identify the Berge equilibrium of a game, it suffices to permute the utility of players - as if they were assuming their partner's joys and sorrows – and to identify the Nash equilibrium resulting from this new situation.

We illustrate this result in a simple taxation game (where there is no Nash equilibrium). Let player 1 be the state and player 2 be a firm. The state can either tax (denoted T) or not (denoted NT) while the firm can either invest (denoted I) or not (denoted NI). The matrix of the game is the following:

		Player 2	
		NI	I
Player 1	T	0,1	3,0
	NT	1,2	2,3

We have $U_1(NT, I) > U_1(NT, NI)$ and $U_2(NT, I) > U_2(T, I)$, and there is a unique Berge equilibrium given by (NT,I). Permutating utilities, we obtain the following modified game:

		Player 2	
		NI	I
Player 1	T	1,0	0,3
	NT	2,1	3,2

which admits a unique Nash equilibrium given by (NT,I). Proposition 2 tells that this is also the unique Berge equilibrium of the initial game, and this corresponds exactly to the previous result.

It follows that technically, analyzing the choices of agents that mutually support each other, coincides with analyzing the choices of agents acting egoistically in a modified game where utilities are permutated. We deduce that Berge equilibrium admits similar properties to Nash equilibrium in the sense that according to the payoff structure, it may exist or not, be unique or multiple. Three corollaries apply: (1) if in the modified game the set of Nash equilibrium is empty, there is no Berge equilibrium in the initial game; (2) if there are several Nash equilibrium in the modified game, there are also several Berge equilibrium in the initial game; (3) if the modified game coincides with the initial game, Nash and Berge equilibria also coincide.

3.2 Situational perspective and utilitarism

As soon as we assume that according to the situation, individual decision making may be ruled by distinct behavior rules, a crucial question is to ask when one behavior rule is likely to be employed rather than the other. This question is not new and fed the trait-situation debate in social psychology over the last decades.[24] In particular, many critcized the situational approach for lacking conceptualization and for failing to address an operational theory of the mind. For example, Kenny *et al.* (2001, p. 129) reproached that "*there is no universally accepted scheme for understanding what is meant by situation. It does not even appear that there are major competing schemes, and all too often the situation is undefined*". Reis (2008) admits the concept of situation is ill-defined but presents a taxonomy to characterize situations. Reviewing the various attempts that were accomplish to formulate a situation based theory of personality, he derives from Interdependance Theory a taxonomy in terms of six dimensions of outcome interdependence: (1) the extent to which an individual's outcomes depend on the actions of others; (2) whether individuals have mutual or asymmetric power over each other's outcomes; (3) whether one individual's outcomes correspond or conflict with the other's; (4) whether partners must coordinate their activities to produce satisfactory outcomes, or whether each one's actions are sufficient to determine the other's outcomes; (5) the situation's temporal structure: whether the situation involves interaction over the long term; and (6) information certainty: whether partners have the information needed to make good decisions, or whether uncertainty exists about the future.

Contrasting with most situational approaches in social psychology, the context we examine is relatively simple given we consider only two behavior rules and focus on simple 2×2 game situations. Using previous taxonomy, one may conjecture that Berge equilibrium is all the more pertinent when individuals have mutual power over each other outcomes, when outcomes do not correspond, when partners tend to need to coordinate to produce the outcome, when the situation is repeated and when as much information is available. Although that would be interesting to test those hypotheses experimentally, we follow an alternative avenue to explain which rule may be preferred when. We consider that individuals play in a Berge fashion when they expect that the other does the same and when they know that this rule of conduct is able to make their life go best for them.

In other words, we posit that whatever the behavior rule they choose, agents are motivated by utilitarianism motivations. They play either following a self-oriented or in a mutual supportive rule of conduct but always are motivated by success. This leads to define classes of games where mutual support is the most successful strategy and where it is not.

The Berge behavior rule and equilibrium gives peculiar results when studying zero sum game type situations. To see this, consider a two player zero sum game where U_1 is the utility

[24] For an overview of the long standing debate about personality and situation, refer to Van Mechelen and De Raad (1999).

function of player 1, and U_2 is the loss function of player 2, $U_2 = -U_1$. We know that $s^* \in S$ is a Berge equilibrium if:

$$\forall\ s_2 \in S_2,\ U_1(s_1^*, s_2) \leq U_1(s_1^*, s_2^*),$$

$$\forall\ s_1 \in S_1,\ U_2(s_1, s_2^*) \leq U_2(s_1^*, s_2^*).$$

As $U_2 = -U_1$, player 1 obtains the maximum payoff if 2 agrees to play a Berge strategy s_2^* which consists of maximizing his loss (*i.e.*, $\max_{s_2} U_1(s_1^*, s_2) = \max_{s_2}[-U_2(s_1^*, s_2)]$). Similarly, player 2 obtains the lowest loss if 1 agrees to play a Berge strategy s_1^* so as to minimize his utility (*i.e.*, $\min_{s_1} U_2(s_1, s_2^*) = \max_{s_1}[-U_1(s_1, s_2^*)]$). This is sacrificial behavior and it is not compatible with a utilitarian treatment. More generally, competition situations, such as competitive games, Bertrand or Cournot duopolies, do not fit with mutual support because it involves mutually exclusive goal attainment. In those cases one may assume that individuals play mostly in a Nash fashion. Conversely, Berge rule is often appropriate in cooperative type of situation where agents must coordinate their activities to produce satisfactory outcomes. But in all cases and as suggested by experimental evidence, there is no straight rule of thumb and as part of the situation approach, the environment within which players are interacting in affects significantly the behavior rule they follow. In particular, perceptions of the other's intent are a critical determinant of choices in most bargaining and social dilemma games (Messick & Brewer, 1983). Individuals in close relationships respond differently to conflicts of interest depending on whether they perceive their partners to be open minded and responsive or self serving and hostile (Murray *et al.*, 2006). Finally, individuals are much more likely to approach strangers who they expect will like them rather than not like them (Berscheid and Walster,1978). A key component when choosing how to act is related to the expectation of how partners will react.

3.3. Situations and dispositions: an operational approach

Gauthier (1986) is certainly the first to analyse games in a situational perspective. His approach is all the more relevant for us that applying it makes unecessary the association between behavior rules and situations. Using Gauthier's disposition approach tells us in utilitarist terms whether a given game is played using Nash or Berge rule.[25] Gauthier considers that individuals choose their disposition prior to interaction. Dispositions are defined as behaviour rules and may change according to the situations. Focusing on the PD, Gauthier assumes individuals may be in two dispositions: (i) *"straightforward maximization"* a behaviour rule according to they *seek to maximize their utility given the strategies of those with whom they interact*; and (ii) *"constrained maximization"* a behaviour rule according to they *"seek in some situations to maximize their utility, given not the strategies but the utilities of those with whom they interact"* (p. 167). Given those dispositions, Gauthier's result is that players should choose constrained maximization in the PD.

Complementing this work, Brennan and Hamlin (2000) further consider what may be available dispositions. They propose to substitute the hypothesis of egoism by the hypothesis of competing motivations, self-interest being one of them. They argue that: *« the disposition of rational egoism is not the disposition that will make your life go best for you. Your expected lifetime pay-off may be larger if you were to have different disposition. (The analysis of rational trustworthiness is a relevant example here). If this is true, the disposition of rational egoism (the strict homo economicus disposition) is self-defeating in Parfit's sense; and it would be in your own interest to choose a different disposition if only that is possible"* (Brennan and Hamlin 2008, p. 80). This is the perspective we consider in order to give support to Berge equilibrium and we apply Gauthier considering individuals have two available dispositions: adopt a Berge or a Nash behavior-rule. In order to show how we proceed we examine several examples.

Let us first consider a well known cooperation game situation, the trust game:

		Player 2	
		Honor	Exploit
Player 1	Trust	X,X	Y,Z
	Distrust	0,0	0,0

$Y < 0 < X < Z$. Observe that for player 2, Exploit is a weakly dominant strategy. The Nash equilibrium (Distrust, Exploit) is unique, the Berge equilibrium (Trust, Honor) as well.

Assume that players are paired randomly. They have the choice between two dispositions: the Nash behavior rule (NR) and the Berge behavior rule (BR). We call the NR player the first

[25] Note that the word disposition is usually employed in the psychology literature as synonymous to trait. A predisposition to have a given identity as something fixed. Instead in Gauthier, dispositions are inclinations that may change according to the situation faced, they are dynamic and may change.

type and the BR player the second type. Players follow BR when they expect their partner does the same and the choice to be of one type rather than the other depends on the relative expected utilities. Probability to play as a type 1 or as a type 2 is even. We denote by α the share of BR players in the population. Supposing first that before the game starts, players know their own type as well as the type of their partner, the expected utilities of NR and BR players is respectively EU(NR) = 0 and EU(BR) = αX. For any $\alpha > 0$, the expected utility of BR players is strictly higher than the expected utility of NR players; if $\alpha = 0$, the expected utilities of the two types of players are even. To be a BR player improves welfare as soon as there are other BR players in the population with whom to establish trust relations. Otherwise, if he is unique, BR player plays as if he were a NR player.

Relaxing the assumption that individuals identify the type of their partner, the result remains robust. To see this, assume that both BR and NR players fail to identify those they interact with. Let β be the probability that BR players identify each other and θ the probability that they fail to identify NR players. The expected utilities of BR and NR players are respectively:

$$\mathrm{EU(BR)} = \alpha\beta X + (1-\alpha)\frac{\theta Y}{2} \text{ ; } \mathrm{EU(NR)} = \frac{\alpha\theta Z}{2}.$$

and an individual chooses to be a BR player if : $\dfrac{\beta}{\theta} > \dfrac{\alpha Z - (1-\alpha)Y}{2\alpha X}$. (3)

If condition (3) is fulfilled, players adopt BR even though they may interact unknowingly with NR players. Two remarks follow. First, when the proportion of BR players increases, $\dfrac{\beta}{\theta}$ also increases, lowering the risk of mistaking NR players for BR players. Second, when the relative gain from cooperation increases, condition (3) becomes less constraining making BR more attractive. We deduce that individuals will be more likely to adopt BR when the magnitude of the social dilemma is important and when their social environment is not too egoistic. To illustrate it, let X = 2, Y = -1, Z = 4 and α = 1/2. Individuals choose to follow BR only if $\dfrac{\beta}{\theta}$ is to be at least equal to 5/4. That is when the probability of achieving mutual recognition is to be at least 1.25 times higher than the probability to fail recognizing a NR player.

Considering other game situations may lead us to the opposite result that NR should be preferred. This is the case for zero-sum games, in most competitive situations and even in cooperation games where interests are not conflicting. Consider for example the following game:

		Player 2	
		C	D
Player 1	C	3,3	4,1
	D	1,4	2,2

There is a unique Nash equilibrium at (C,C) and a unique Berge equilibrium at (D,D). Letting individuals choose their disposition before the game starts, we deduce that best for players is to play in a Nash fashion. To see it, let first individuals know the type of their partner. We have: EU(NR) = 3 and EU(BR) = $3 - \alpha$ and for any $\alpha > 0$, it pays to choose a NR disposition. Now let assume that individuals do not know the type of their partner. We have U(NR) = $\alpha\theta + 3$ and U(BR) = $\alpha(2\theta - \beta) + 3 - 2\theta$ and we deduce that U(NR) > U(BR) leads to inequality $\frac{\beta}{\theta} > \frac{(\alpha - 2)}{\alpha}$. This is always true and individuals always choose to play in a NR fashion.

Generally and taking for granted the revisionist rational view according to individuals follow the rules of conduct that makes your life go best for you, this diposition-based approach may tell us for any game situation when Berge equilibrium is to be applied to a game situation and when Nash equilibrium is to be applied. The answer in each case will rely on the utility structure of the game and on player subjective probabilistic appreciation of the type of partner they are interacting with.

4 Conclusion

This paper provides a step toward the treatment of moral preferences focusing on behavior rules. In contrast to the consequentialist approach which adds other-regarding expressions into the utility function of players, we question the canonical view that the Nash rule is appropriate to examine any game situation. We depict decision making within a situational perspective which assumes that individuals' behavior rules vary according to the situations faced. We focus on 2×2 game situations and argue that in cooperative situations, social norms, including reciprocity and kindness, suggest that individuals often play in a mutually supporting fashion.

Mutual support does not capture the many idiosyncratic moral preferences observed in the experimental literature and we do not aim here to provide an exhaustive treatment of situational decision-making. Rather, our objective as a first step to design a situational decision-making theory was to focus on a simple behavior rule that may complement Nash. The behavior rule is mutual support to model it, we revive non-cooperative Berge equilibrium. Studying the conditions of its existence, we show that Nash and Berge equilibrium are strongly related and we define a simple method to link one with the other.

Because playing in a Berge fashion is not immune to deviation, we examine the rationale for playing in a Berge fashion. Assuming individuals play according to one behavior rule or the other, depending on the situation, we show à la Gauthier that a player may be well-off playing a Berge behavior rule in some game situations even when no repetition or punishment mechanisms are made available. Per se, the disposition approach is an operational approach that tells us which behavior rule is played when.

In terms of further, related research there are three lines that we see as being particularly appealing. The first is an experimental paper which complements this conjectural paper, whose assumptions call for experiments. Along the lines of Henrich *et al.* (2004, 2010), we are interested in a better understanding of when individuals tend towards one behavior rule or another. Again, we can make multiple assumptions and exploit the situational taxonomy of Reis (2008), in particular. The second enquiry is theoretical and relates to one of our companion papers on the properties of n-players Berge equilibrium. We saw in the examples considered in the paper that for PD, CG, taxation and trust games, Berge equilibrium are Pareto-optimal. However, this is not always the case and an interesting line of research is to define classes of games for which Berge equilibrium is Pareto-optimal and always Pareto-dominated. Finally, to conclude, we have attempted to show that the Berge rule may be appropriate to apprehend human behaviors in some situations, and the Nash rule in others. This is inevitably a simplification and we think that many other rules complete these two. Better scrutinization of other behavior rules and their axiomatic and theoretical properties are the next step in defining a situational theory of decision making.

References

Abalo K., Kostreva M. (2004), Some Existence Theorems of Nash and Berge Equilibria, Applied Mathematics Letters, 17, 569-573.

——————————— (2005), Berge Equilibrium: Some Results from Fixed-Point Theorems, Applied Mathematics and Computation, 169, 624-638.

Anderson J. R. (1991), The Adaptive Nature of Human Categorization. Psychological Review, 98, 409-429.

Arnsperger C., Varoufakis Y. (2003), Toward a Theory of Solidarity, Erkenntnis, 59, 157-188.

Aumann R. (1960), Acceptable Points in Games of Perfect Information, Pacific Journal of Mathematics, 10, 381-417.

Berg J., Dickhaut J., McCabe K. (1995), Trust, Reciprocity, and Social History, Games and Economic Behavior, 10, 122-142.

Berge C. (1957), Théorie Générale des Jeux à N Personnes, Paris, Gauthier Villars.

Berscheid E., Walster E. H. (1978), Interpersonal attraction (2nd ed.). Reading, MA: Addison-Wesley.

Binmore K. (2007), The Origins of Fair Play, miméo.

Bolle F. (1998), Rewarding Trust: An Experimental Study, Theory and Decision, 45, 83-98.

Boone C., de Brabander B., van Wtiteloostuijn A. (1999), The Impacto f Personality on Behavior in five Prisoner’s Dilemma Games. Journal of Economic Psychology, 20, 343-377.

Brandts J., Schram A. (2001), Cooperation and Noise in Public Goods Experiments: Applying the Contribution Function Approach. Journal of Public Economics, 79, 399–427.

Brennan G., Hamlin A. (2000), Democratic Devices and Desires, Cambridge, Cambridge University Press.

Brennan G., Hamlin A. (2008), Revisionist Public Choice Theory, New Political Economy, 13, p. 77-88.

Camerer C. (2004), Behavioral Game Theory. Experiments in Strategic Interaction, Princeton, Princeton University Press.

Caparros A., Péreau J.-C., Tazdaït T. (2010), Mutual Aid: An Indirect Evolution Analysis, Rationality and Society, 22,103-128.

Colman A.M. (1995), Game Theory and its Applications in the Social and Biological Sciences, Oxford, Butterworth-Heinemann (Second Edition).

Davis D.D., Holt C.A. (1993), Experimental economics. Princeton, Princeton University Press.

Darwin C. (1859/1968), The Origin of the Species, Middlesex, Penguin Books, 1859/1968.

Dugger W.M. (1984), Veblen and Kropotkin on Human Evolution, Journal of Economic Issues, 18, 971-985.

Durkheim E. (1893/1997), The Division of Labor in Society, New York, The Free Press.

Edgeworth F.Y. (1893/1997), Mathematical Psychics: An Essay on the Application of Mathematics to the Moral Sciences, London, Kegan Paul.

Engelmann D., Normann H.T. (2010), Maximum Effort in the Minimum-Effort Game, miméo.

Falk A., Fishbacher U. (2005), Modeling Strong Reciprocity, in H.Gintis et al. (eds), Moral Sentiments and Material Interests, Cambridge MS, MIT Press, 193-213.

Fehr E., Fischbacher U. (2005), The Economics of Strong Reciprocity, in H.Gintis et al. (eds), Moral Sentiments and Material Interests, Cambridge MS, MIT Press, 151-191.

Fehr E., Schmidt K.M. (1999), A Theory of Fairness, Competition, and Coperation. Quaterly Journal of economics, 114, 817-868.

Fehr E., Schmidt K.M. (2006), The Economics of Fairness, Reciprocity and Altruism. Experimental Evidence and New Theories, in: S.C. Kolm and J.M. Ythier (eds.), The Handbook of the Economics of Giving, Altruism and Reciprocity, Volume 1, Amsterdam, Elsevier, 615-691.

Fischbacher U., Gächter S., Fehr E. (2001), Are People Conditionally Cooperative? Evidence from a Public Goods Experiment, Economics Letters, 71, 397-404.

Fong C. M., Bowles S., Gintis H. (2006), Strong Reciprocity and the Welfare State, in: S.-C. Kolm and J. M. Ythier (eds.) Handbook on the Economics of Giving, Altruism and Reciprocity, Volume 2, Amsterdam, Elsevier, 1440-1464.

Foster K.R., Xavier J.B. (2007), Cooperation: Bridging Ecology and Sociobiology, Current Biology, 17, 319-321.

Gauthier D.P. (1986), Morals by Agreement, Oxford, Oxford University Press.

Glassman M. (2000), Mutual Aid Theory and Human Development: Sociability as Primary, Journal for Theory of Social Behavior, 30, 391-412.

Gould S.J. (1988), Kropotkin Was no Crackpot, Natural History, 97, 12-21.

Harsanyi J.C. (1966), A General Theory of Rational Behavior in Game Situations, Econometrica, 34, 613-634.

Henrich J. *et al.* (2004), Foundations of Human Sociality: Economic Experiments and Ethnographic Evidence from Fifteen Small Scale Societies, Oxford, Oxford University Press.

Henrich J. *et al.* (2010), Markets, Religion, Community Size and the Evolution of Fairness and Punishment, Science, 327, 1480-1484.

Huxley T.H. (1888), The Struggle for Existence: A Programme, The Nineteenth Century, 23, 161-180.

Ibn Khaldun A. (1378/1967), Muqaddimah: An Introduction to History, vol. 1, London, Routledge.

Kahan J.P., Goehring D.J. (2007), Responsiveness in Two-person Zero-sum Games, Behavioral Science, 18, 27-33.

Kenny D. A., Mohr C. D., Levesque, M. J. (2001), A Social Relations Variance Partitioning of Dyadic Behavior. Psychological Bulletin, 127, 128-141.

Keser C., van Winden F. (2000), Conditional Cooperation and Voluntary Contributions to Public Goods. (2000). Scandinavian Journal of Economics, 102, 23–39.

Kropotkine A. (1891/1989), La Morale Anarchiste, Fresnes, éds Volonté Anarchiste.

————————. (1902/1955), Mutual Aid: A Factor in Evolution, Boston, Extending Horizon Books.

Kurzban R., Houser D. (2005), Experiments Investigating Cooperative Types in Humans: A Complement to Evolutionary Theory and Simulations, PNAS, 102(5), 1803-1807.

Laraki R. (2009), Coalitional Equilibria of Strategic Games, Working Paper 2009-42, Département d'Economie, Ecole Polytechnique.

Larbani M., Nessah R. (2008), A Note on the Existence of Berge and Berge-Nash Equilibria, Mathematical Social Sciences, 55, 258-271.

Ledyard J.O. (1995), Public Goods: A Survey of Experimental Research, In J.H. Kagel and A.E. Roth (Eds), The Handbook of Experimental Economics, Princeton, Princeton University Press, 111-194.

Lieberman B. (1960), Human Behavior in a Strictly Determined 3x3 Matrix Game, Behavioral Science, 5, 317-322.

Luce R.D., Raifa H. (1957), Games and Decisions, New York, Wiley.

Van Mechelen I., De Raad B. (1999), Editorial: Personality and Situations, European Journal of Personality, 13, 333-336.

Messick D. M., & Brewer M. B. (1983), Solving social dilemmas: A review. Review of Personality and Social Psychology, 4, 11-44.

Mischel W., Shoda Y., (1995), A Cognitive-Affective System Theory of Personality: Reconceptualizing Situations, Dispositions, Dynamics, and the Invariance in Personality Structure, Psychological Review, 102, 246-268.

Mischel W., Shoda Y. (1999), Integrating Dispositions and Processing Dynamics within a Unified Theory of Personality: The Cognitive-Affective Personality System. In L. A. Pervin & O. P. John (Eds.), Handbook of personality (2nd ed., pp. 197-218). New York.

Murray S. L., Holmes J. G., Collins, N. L. (2006), Optimizing Assurance: The Risk Regulation System in Relationships. Psychological Bulletin, 132, 641-666.

Nash J.F. (1950), Equilibrium Points in N-Person Games, Proceedings of the National Academy of Sciences U.S.A, 36, 48-49.

Nessah R., Larbani M., Tazdaït T. (2007), A Note on Berge Equilibrium, Applied Mathematics Letters, 20, 926-932.

Parfit D. (1984), Reasons and Persons, Oxford, Oxford University Press.

Peck J.E.L. (1960), Berge Claude: Théorie Générale à n Personnes, Zentralblatt Für Mathematik, 82, 347-348.

Pruit D.G, Kimmel M.J. (1977), Twenty Years of Experimental Gaming: Critiques, Synthesis and Suggestions for the Future, Annual Review of Psychology, 28, 363-392.

Rachels S. (2001), A Set of Solutions to Parfit's Problems, Noûs, 35, 214-238.

Radjef M.S. (1988), Sur l’Existence d’un Equilibre de Berge pour un Jeu Différentiel à n personnes, Cahiers Mathématiques de l’Université d’Oran, 1, 89-93.

Rapoport A., Chammah A.M. (1965), Prisoner's Dilemma: A Study in Conflict and Cooperation, Ann Arbor, University of Michigan Press.

Rasmussen E. (2007), Games and Information, Oxford, Basil Blackwell (Fourth Edition).

Reis T. (2008), Reinvigorating the Concept of Situation in Social Psychology, Personality and Social Psychology Review, 12 (4), 311-329.

Sally D. (1995), Conversation and Cooperation in Social Dilemmas: A Meta-Analysis of Experiments from 1958 to 1992, Rationality and Society, 7, 58-92.

Sen, A. (1987), On Ethics and Economics, Oxford, Basil Blackwell.

Shubik M. (1961), The General Theory of n-Person Games. By Claude Berge, Econometrica, 29, 82.

Singer P. (1981), The Expanding Circle: Ethics and Sociobiology, Oxford, Oxford University Press.

Singer P. (1993), How are we to live: Ethics in an Age of Self-interest, Melbourne, Text Publishing.

Vanberg V. (2008), On the Economics of Moral Preferences, American Journal of Economics and Sociology, 67(4), 605–628.

Zan B., Hildebrandt C. (2005), Cooperative and Competitive Games in Constructivist Classrooms, The Constructivist, 16, 1-13.

Zhukovskii V.I. (1985), Some Problems of Non-Antagonistic Differential Games, In P. Kenderov (Ed.), Matematiceskie Metody v Issledovanii Operacij [Mathematical Methods in Operations Research], Sofia, Bulgarian Academy of Sciences, 103-195.

Zhukovskii V.I., Tchikri A.A. (1994), Lineino-Kvadratichnye Differentsial’nye Igry [Linear Quadratic Differential Games], Kiev, Naoukova Doumka.

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