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Economic preferences 2.0: Connecting competition, cooperation and inter-temporal preferences

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ABSTRACT

This paper presents a "second generation" theory on the nature of social preferences. Incorporating an inter-temporal ingredient, we generate an outcome-based model which focuses on the conflict between cooperation towards social efficiency and competition for the individual relative standing. We build on the argument that cooperative (competitive) patterns are more likely to arise when the future is perceived as secure and predictable (unsecure and unpredictable). In order to accommodate this argument with recent experimental results showing a relationship between individuals' inter-temporal preferences and social behavior in *one-shot* games, social efficiency is assumed to trigger long-run satisfaction whereas relative standing is linked to short-run satisfaction. In so doing, we add a dynamic component to social preferences. This feature of the model implies that more patient individuals are more willing to get involved in cooperative affairs while more impatient individuals are more likely to display competitive patterns. Yet, an individual's inter-temporal preferences interact with contextual factors (cues of future (un)predictability) to determine her course of action. The theory is then tested to shed new light on individuals' decisions in different games used in experimental research where a relationship between game play and inter-temporal preferences has been found. We show that our new combination of social and inter-temporal preferences adds well to the explanatory power of economic theory on human decision making.

JEL Codes: C91, D63

Introduction

Over the last years, a bulk of empirical evidence has challenged the assumption of traditional economic models that individuals care only about their own self-interest. The predictions of the (narrow) self-interest model have proved unsatisfactory when it comes to describe individuals' observed behavior in a variety of social situations. For instance, people often donate money and/or organs, cooperate with others in absence of future returns, incur personal costs to punish norm violations and overbid in auctions. Social (other-regarding) preferences theorists have proposed a number of utility functions in order to account for such departures from the predictions of the self-interest model: thus, it has been suggested that people care not only about their own material payoff but also, for instance, about payoff equality (Fehr & Schmidt 1999, Bolton & Ockenfels 2000), others' kind or unkind intentions (Rabin 1993, Dufwenberg & Kirchsteiger 2004), social welfare/efficiency (Charness & Rabin 2002), norm-breaking (López-Pérez 2008) and relative standing (Kirchsteiger 1994, Charness & Rabin 2002).

Yet, recent experimental research on the psychological basis of social behavior (e.g., Curry et al. 2008, Espín et al. 2012, Rand et al. 2012) suggests that these behavioral theories of social preferences—which have been traditionally justified on empirical grounds—need to be enriched to incorporate factors that allow for more flexible and psychology-nuanced definitions. We here propose a model that provides an alternative rationale for some of the above behavioral regularities on the basis of a conflict between agents' pro-self (although other-regarding as well) and pro-social motivations, and involving different time scales in the decision-making process. Our model builds on two main assumptions: (i) people value positively both their relative standing within the group they belong to and the group's welfare; (ii) relative standing constitutes a short-run source of satisfaction while social welfare yields long-run satisfaction. Below we expand on each of these assumptions and in particular on the empirical observations sustaining them.

Evidence from research on subjective well-being indicates that people are concerned with their relative income (e.g., Luttmer 2005, Clark et al. 2008). That is, individuals compare their performance to that of others from a reference group (e.g., their co-workers or neighbors) and feel happier the better they are in relative, rather than absolute, terms. This can be modeled as if, *ceteris paribus*, the income of others in the reference group affect negatively individuals' utility.[1]

[1] Such concern for one's own relative standing has important implications for investment, labor and consumption decisions (Duesenberry 1949, Frank 1985). The literature on its effects on consumption has a longer tradition which

In experimental research, it has also been shown that people often reduce others' payoffs at personal cost when the cost imposed on others is larger than that incurred by the decision maker (e.g., Zizzo & Oswald 2001, Abbink et al. 2010, Abbink & Herrmann 2011, Brañas-Garza et al. 2014), which is consistent with individuals having a preference for increasing their relative standing. However, the opposite is often observed as well: people are willing to sacrifice their own payoffs in order to increase the welfare of others (e.g., Piliavin & Charng 1990, Forsythe et al. 1994, Ledyard 1995, Camerer 2003, Staffiero et al. 2013, Brethel-Haurwitz & Marsh 2014), which could be modeled as if others' payoffs enter positively into the individuals' utility functions.[2] Based on all this evidence, we shall assume that individuals aim at increasing their relative standing within the group they belong to (i.e., they are "competitive")[3] but also at enhancing the performance of the group, or social efficiency (i.e., they are "cooperative"; see McClintock 1972, Van Lange et al. 1997, Charness & Rabin 2002).[4]

Recent neural research indeed indicates that cooperation with conspecifics is in itself psychologically rewarding for humans (Rilling et al. 2002, 2004, Decety et al. 2004, Harbaugh et al. 2007; see Tabibnia & Lieberman 2007 for a review), but also that people's satisfaction, as measured by striatal activation, relates better to their payoff compared to that of others than to their absolute payoff when competition among individuals is experimentally promoted through social comparison tasks (Fliessbach et al. 2007, Dvash et al. 2010, Bault et al. 2011, Dohmen et al. 2011). Such findings corroborate that people are concerned with increasing both their relative payoff (which suggests a negative impact of others' payoffs on the utility function) and the collective payoff (which suggests a positive impact of others' payoffs on the utility function) and indicate that contextual factors, such as cues of competition or cooperation, may matter for the

can be dated back to at least Veblen (1899), who coined the term "conspicuous consumption" to refer to the consumption of goods that increase status within a society (i.e., "positional goods"). See, e.g., Leibenstein (1950), Galbraith (1958), Hirsch (1976) and Bagwell & Bernheim (1996). Note, however, that recent evidence suggests that the impact of relative income on well-being might be overestimated in happiness research (Espín et al. 2016).

[2] Moreover, sometimes it is even the same individuals who behave in such extremely different ways (e.g., Herrmann & Orzen 2008). These observations suggest that social preferences are not fixed but may be importantly dependent upon the context where social interactions take place (McClintock 1972, Fehr & Krajbich 2009).

[3] Note that, following the tradition in social psychology, we use the term competition/competitive to refer to individuals' concern about their relative payoff (e.g., Messick & McClintock 1968).

[4] A similar approach can be found in the literature on the so-called "co-opetition" (e.g., Brandenburger & Nalebuff 1996). However, the social preferences perspective is completely different from the one adopted in such theories which are based on *self-interested* agents and focus on market outcomes, industrial organization and the management of firms. It is said that two or more firms are in "co-opetition" when they cooperate to make the "pie" as big as possible and then compete (in the economics sense) to get the largest share of it. For an experimental approach, see Lacomba et al. (2011).

prevalence of one motive over the other (McClintock 1972, Loewenstein et al. 1989, Rose & Colman 2007, Basurto et al. 2016).[5]

However, there is also evidence of temporally-stable individual differences in social preferences, as some people tend to be in general more cooperative or competitive than others (Van Lange 1999, de Oliveira et al. 2012, Carlsson et al. 2014). The implications of our second assumption, which is discussed in detail below, will introduce the sources of stable individual heterogeneity in competitive and cooperative preferences.

The second ingredient and the main novelty of our theory is the assumption that individuals perceive the goal of increasing their relative standing as a short-run aspiration, while the improvement of group's performance is perceived as a long-run goal, even in one-shot interactions where no future personal gains are expected. This assumption is built on the observation that social behavior is importantly shaped by future (un)predictability cues. Secure and predictable environments elicit cooperative and forward-looking patterns whereas investing resources to outcompete others can be adaptive under harsh and unpredictable conditions where the future has little value (Wilson & Daly 1985, Nisbett & Cohen 1996, Kubrin & Weitzer 2003, Hill et al. 2008, McCullough et al. 2012). Indeed, recent empirical evidence has linked future orientation (i.e. patience) to cooperativeness in a non-repeated social dilemma game (Curry et al. 2008), and impatience to sporadic competitive behavior both in a social dilemma game with punishment (Espín et al. 2012) and in an ultimatum game (Espín et al. 2015).

In this sense, our model brings a new paradigm for the study of social preferences insofar as it introduces a dynamic component into the utility function of individuals, in contrast to the static approach typically featured in existing models. As this is amongst the main contributions of our paper, it is worth discussing further the rationale supporting it.

The social preferences approach can be understood as being based on the individuals' rational maximization of hedonic, non-monetary values associated to social outcomes (Fehr & Schmidt 2006, Fehr & Krajbich 2009). Following this view and assuming that such non-monetary incentives need not necessarily be static, some of these hedonic values could thus be anticipated to be more lasting or more delayed than others. To put it simply, when facing a one-shot interaction

[5] Moreover, it has been shown that separate areas in the cerebral cortex encode a trade-off between competition and cooperation. Cooperation differentially activates the medial orbitofrontal cortex while competition is related to activation in the inferior parietal and medial prefrontal cortices (Decety et al. 2004).

with a group of individuals, our representative individual will think “I know that if I earn more than others in the group I will feel good, but if the group’s welfare increases I will feel good *for a long time*.” This distinction between two temporally decoupled sources of satisfaction is in some sense analogous to that between “joy” and “pride” (Fredrickson 2001, Williams & DeSteno 2008, Eyal & Fishbach 2010) and to that between short-term and long-term well-being (Kahneman et al. 1999, Oishi et al. 2001, Kahneman & Krueger 2006), both featuring prominently in psychological and happiness research. Prosocial behaviors have been indeed found to correlate positively with long-term (eudaimonic) components of subjective well-being (Konow & Earley 2008, Koch 2016). Note that under the label “satisfaction” we consider not only positive but also negative emotions. For instance, uncooperative behavior may trigger lasting negative emotions such as guilt (for reducing the group’s welfare), whereas being cooperative may trigger immediate negative emotions such as envy (for getting less than uncooperative group members).

The areas within the striatum and the cerebral cortex that encode social preferences are known to be involved in crucial aspects of social and non-social behavior like “mentalizing” (Frith & Frith 2003), self-other identification (Farrer & Frith 2002) and goal-directed behavior (Tremblay & Schultz 1999) as well as in the evaluation of immediate and delayed rewards during inter-temporal choice tasks (McClure et al. 2004, Hariri et al. 2006, Roesch et al. 2006, Kable & Glimcher 2007, Ballard & Knutson 2009, Cai et al. 2011, Sellitto et al. 2011). Crucially for our model, the fact that the brain regions that encode the emotional satisfaction derived from cooperative and competitive outcomes are also involved in the evaluation of inter-temporal choices opens the door for the possibility that the utility associated with one motive is perceived as more delayed or more lasting than that associated with the other motive (Espín et al. 2015).

Our assumption, therefore, is that individuals derive short-run satisfaction from increasing their relative payoff within their group and long-run satisfaction from increasing the group’s payoff. However, when the future is uncertain, the long-run hedonic values associated with cooperation will likely be unaffordable. This means that whether it is worthwhile to wait for reaping such delayed satisfaction depends on the specific environmental conditions under which interactions take place and is thus context-dependent. As detailed in the next section, our model also provides an approximation to the context-dependence of social preferences based on this argument. In particular, individuals will be more willing to cooperate in secure environments where there is certainty about the future and thus long-run utility is sufficiently valued. In this vein, while benign environments favor cooperation toward social efficiency, harsh environments engender competition for the relative standing.

According to the above, it follows that impatient individuals who discount long-run incentives heavily will be more concerned with their relative standing, while patient individuals will be more concerned with the group's performance. Individuals' inter-temporal preferences (impatience or time discounting) have been demonstrated to be as temporally stable as personality traits (Kirby 2009) and genetically determined to some extent (Anokhin et al. 2011, Gianotti et al. 2012). However, great individual heterogeneity in discount rates is also commonly reported (Frederick et al. 2002). These observations allow us to model (im)patience as a fixed individual factor determining stable differences in social preferences.

Crucially, the relationship between time discounting and social behavior does not arise in our model due to the existence of repeated interactions between the same individuals but, instead, from the fact that the psychological benefits (or costs) associated with cooperation are considered to be more delayed or more lasting than those linked to competition. It is important to realize, therefore, that the motivational trade-off we want to move toward is not the traditional conflict of cooperation versus pure, narrowly-defined self-interest (e.g., Rapoport & Chammah 1965, Axelrod 1984), but versus competition, a different aspect of pro-self—although other-regarding—preferences which often contradicts pure self-interest (Van Lange 1999, Charness & Rabin 2002). In this regard, we want to emphasize that the interpretation that cooperation, or the collective interest, obeys to long-run incentives has been largely discussed across the biological, social and behavioral sciences (e.g., Frank 1992, Rachlin 2002, Stevens & Hauser 2004, Stevens et al. 2005). However, in contrast with the cooperation-competition conflict we posit in this paper, such long-term collective interest has been traditionally seen as opposed to short-term self-interest (e.g., Van Lange et al. 2013).[6] In other words, we model the long-term collective interest as opposed to the short-term "competitive interest".

[6] The trade-off between self-interest and collective interest has also been modeled as a self-control problem where the decision maker has to exert cognitive control in order to resist the "selfish temptation" (Loewenstein 1996, Moore & Loewenstein 2004, Loewenstein & O'Donoghue 2007, Kocher et al. 2016). In this sense, selfish choices are considered of an automatic nature while pursuing social goals requires a more thoughtful process. Note however that, although the conflict between automatic/impulsive and thoughtful/controlled processes is often treated as identical to the conflict between short-term and long-term incentives, recent neural evidence indicates that these two types of motivational conflicts have different psychological grounds (Kable & Glimcher 2007, Figner et al. 2010).

In what follows, we procure an agnostic point of view regarding how the distribution of social preferences in the population should be and focus only on what could be explained by the trade-off of competition versus cooperation, "sooner versus later". For this reason, we will provide the implications of the model for some canonical games used to study social preferences where players' relative payoffs and group's joint payoffs are, or may be, confronted to each other. Among those, we will focus on the games for which there is empirical evidence of a relationship between inter-temporal preferences and game play.

Since our intent is to provide a benchmark theoretical study of such relationship, we will assume equal weight for the competitive and cooperative psychological satisfaction on the individual's utility function, which need not necessarily be the case. In this way, other theories on social preferences can be adapted into our model by integrating the appropriate parameters. For instance, Deng and Chu (2011) employ a utility specification similar to the one presented here—not involving inter-temporal concerns though—and incorporate one parameter, *k*, ranging from -1 to +1, which represents the competitive or cooperative character of the individual.[7] It is not our intention therefore to test any of these models but to suggest that there are good reasons to think that the emotional satisfaction associated with different social outcomes might be spreading over different time horizons. Consequently, our view entails that temporal discounting could be a potent instrument for the study of social preferences. Another important implication of our approach is that an individual's negative and positive other-regarding concerns do not merely cancel out; inter-temporal trade-offs need to be considered.

Finally, we intend to stay within the boundaries of outcome-based social preferences and, consequently, we do not consider intentionality or reciprocity issues (e.g., Rabin 1993, Charness & Rabin 2002, Falk & Fischbacher 2006) in the analyses—although they could be adapted to the framework as well. Despite its simplicity, nonetheless, we believe that our model is able to capture an essential dynamic aspect of the trade-off between competition and cooperation, present in very many daily social interactions. Also, the model can rationally explain decisions made by subjects in economic experiments which have been often considered as irrational because they contradict the traditional assumption of self-interest. We elucidate the theoretical conditions under which individuals, for instance, reject "unfair" offers in an ultimatum game or cooperate in a one-shot

[7] In fact, while other social preferences models (e.g., Charness & Rabin 2002) incorporate parameters able to capture competitive and cooperative concerns, Deng & Chu (2011) is the only theoretical model we are aware of explicitly proposing these two factors as the individuals' unique motivations.

social dilemma game. While recent evidence on the relationship between individuals' game play and their inter-temporal preferences is assessed throughout the paper, a calibration of the model parameters is beyond the scope of this paper and is left for future (less abstract) developments.

The utility function: Two sources of satisfaction

In our model, the individual's horizon covers only two periods, capturing the short- and long-run satisfaction linked to competition and cooperation, respectively.[8] We think this simplification should not represent a major theoretical concern but it allows us to avoid entering the discussion between exponential and hyperbolic functional forms—and other developments—to capture individuals' temporal discounting if more periods were accounted for (McClure et al. 2004, Kable & Glimcher 2007, Andersen et al. 2008; see Frederick et al. 2002 and Green & Myerson 2004 for reviews).

In order to capture the long-run satisfaction linked to cooperation, we model individuals as being concerned with a lasting emotion (or set of emotions) associated to social welfare. An individual will derive long-run utility if the group welfare improves thanks to her (or of anybody else's) actions. To allow the existence of a context-dependent component of perceived cooperativeness/competitiveness (McClintock 1972, Rose & Colman 2007, Fehr & Krajbich 2009) we consider future (un)predictability. Following the aforementioned argument, the predictability of an environment is associated with the likelihood that an individual will feel any long-run (social) emotion. As a cue of future predictability, we use the growth rate of resources[9]: the future is perceived to be more certain in environments with more positive growth rates. One parameter, $\gamma_t \geq 0$, is introduced to capture the *perceived* variation of available resources from the present (t) to the future ($t+1$) and is equal to the ratio between future and present resources. Thus, γ_t can be expressed as $1+\sigma_t$, where σ_t is the growth rate of resources from t to $t+1$. We assume γ_t to be constant across individuals in each environment as it is considered an intrinsic feature of the specific social context. This parameter is exogenous to the individual and may change across environments.

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[8] It is important to note that, although we use the term "periods", short-run (present) and long-run (future) in our model are not referring, respectively, to the current period and the next one during a particular experiment or social interaction. Here, "present" and "future" are more abstract concepts. Moreover, an experiment (or a series of finitely repeated interactions) could be even considered as belonging just to the short-run.

[9] An alternative way of modeling this is to simply add the probability that the future will really take place (i.e., that the individual will be alive in the future). However, this would add the individual's risk preferences to the model, which would lead to more complex predictions relying on the interaction between intertemporal and risk preferences.

The total value of the (perceived) future emotional satisfaction is discounted with factor $\delta_i \in [0, 1]$, which captures the individual's patience, to obtain the present value of the cooperative source of satisfaction. According to both exponential and hyperbolic standard forms of discounting, the discount factor for a one-period delay can be characterized as $\frac{1}{1+r_i}$, with r_i being the individual's discount rate. The present value, in time *t*, of the emotional satisfaction derived by individual *i* from the welfare of the group (of size *n*) is thus given by:

(1) $$\delta_i E_i(\gamma_t) \sum_{j=1}^{n} x_{jt} \ ,$$

where x_{jt} denotes the individual *j*'s material payoff in period *t* and $E_i(\gamma_t)$ is a monotonically increasing function of γ_t that defines the subjective value of the future emotions linked to social efficiency. For simplicity, here we will consider $E_i(\gamma_t) = \gamma_t, \ \forall i$.

For the other ingredient of our model, i.e., the competitive component, the individual's satisfaction source, related to her linear relative payoff, is not delayed but "immediate". Note here that linear relative payoffs are used for the sake of simplicity but other, more complex specifications may be valid as well. Individuals derive a psychological benefit (cost) whenever their present payoff is higher (lower) than that of their counterparts.

Combining these two contributions, and denoting by X_t the payoff vector of the *n* group members in period *t*, the individual *i*'s utility function is defined as:

(2) $$U_{it}(X_t) = \sum_{j \neq i}^{n} (x_{it} - x_{jt}) + \delta_i \gamma_t \sum_{j=1}^{n} x_{jt}$$

Rearranging terms we obtain a new specification for the utility function:

(3) $$U_{it}(X_t) = x_{it}(n - 1 + \delta_i \gamma_t) + \bar{x}_{-it}(n-1)(\delta_i \gamma_t - 1) \ ,$$

with $\bar{x}_{-it} = \frac{1}{n-1} \sum_{j \neq i}^{n} x_{jt}$

It is worth noting this last transformation of the model because it captures two components largely discussed in existing theoretical approximations to social preferences (e.g., Bolton 1991, Kirchsteiger 1994, Ledyard 1995, Levine 1998). To simplify, we will refer to this specification (Equation 3) as the "transformed utility" throughout the paper. The first component of this transformed utility is entirely egoistic: the individual *i* wants her present resources to be as large as possible. The second component is purely other-regarding. Following the characterization of Fehr

& Schmidt (2006), the individual i would be (a) *altruistic* (i.e., others' average payoff affects positively her utility, $\frac{\partial U_i}{\partial \bar{x}_{-i}} > 0$) if $\delta_i\gamma_t > 1$ (thus, $\delta_i > 1/\gamma_t$); (b) *indifferent to others' payoffs*, and her utility would be given exclusively by nx_{it}, if $\delta_i\gamma_t = 1$; and (c) *spiteful* (i.e., others' average payoff affects negatively her utility) if $\delta_i\gamma_t < 1$. For any given γ_t, therefore, more patient individuals are more likely to be altruistic and consequently less likely to be spiteful.

Note however that, due to the simplification mentioned earlier (i.e., $E_i(\gamma_t) = \gamma_t$), altruism requires at least that $\gamma_t > 1$ since $\delta_i \in [0, 1]$. This implies that for individual i to be altruistic the total resources must be perceived as increasing with time, although this condition is not sufficient as it requires enough patience. Note also that the growth rate of resources, σ_t, should be greater (smaller) than the discount rate of the individual i, r_i, for her to be altruistic (spiteful). In case the individual's discount rate equals the growth rate of resources, she would be indifferent to others' payoffs, i.e., egoistic/self-regarding. Thus, altruism, egoism or spitefulness are not intrinsic characteristics of the individuals but, instead, they result from the interaction between individual (patience, δ_i) and contextual (variation of resources, γ_t) factors.[10] For instance, if resources are perceived to shrink with time in a specific context ($\gamma_t < 1$ or $\sigma_t < 0$) then all individuals, as in some sort of "no-future", survival situation, would be spiteful regardless of their patience, given that $\delta_i \in [0, 1]$.

Having defined our model and discussed the general implications of our assumptions, in what follows we focus on specific scenarios to explore the consequences of the inter-temporal cooperation-competition conflict we posit. As a first case study we will address social dilemma games, in which individual and collective interests are confronted, as a situation where our model should be most relevant. Then we study the ultimatum game and the stag-hunt game. Note that subjects' behavior in experiments using these games has been found to correlate with their time discounting. Extensions of the basic game designs can be found in the Appendix.

Case study 1: Social dilemmas[11]

[10] However, we use the terms "altruistic/egoistic/spiteful individuals" for simplicity throughout the paper.

[11] Let us note here that, from a strictly game-theoretic perspective, once the utilities of players are defined in a different manner the games to be played are no longer the original ones. Thus, we shall provide solutions to these "new games", even though we refer to them by their original names.

The games most commonly used to model social dilemmas are the two-player prisoner's dilemma and the *n*-player public goods game. We will begin by discussing the former in detail and then provide some results about the latter.

Two players: Prisoner's Dilemma

The prisoner's dilemma (PD) is a two-player game extensively employed to study cooperation between individuals (Rapoport & Chammah 1965, Axelrod 1984, Rilling et al. 2002, 2004, Gracia-Lázaro et al. 2012). In the PD, both players must decide simultaneously whether to cooperate or not (i.e., defect) in a joint enterprise. Cooperation means incurring a cost, c, in order to generate a benefit, $b > c$ (or, alternatively, $b/c > 1$, as the relation benefit-cost is often expressed as their ratio), for the pair which will be shared evenly between both players, regardless of their cooperative level.[12] Since $b > c$, cooperation means maximizing the total resources, as defined here, and defection is competitive insofar as it maximizes the defector's relative standing for whatever values of b and c and whatever cooperative level of her partner. However, for cooperation to be confronted with strict (narrow) self-interest we need $b < 2c$ (the definition of a two-person social dilemma, strictly speaking, requires indeed this condition). If $b = 2c$, selfish individuals would be indifferent between cooperation and defection. Since $b > 2c$ implies that cooperation increases both the group and the cooperator's payoffs, cooperation and self-interest would not be in conflict and selfish individuals must always cooperate. Even in this case, however, we still have an opposition between cooperative and competitive aspirations.

Therefore, the PD is an excellent candidate for the study of cooperative and competitive motivational forces. Table 1A displays the 2x2 matrix of the material payoffs associated to the different possible outcomes in the PD. Row player 1's payoffs appear on the left hand and column player 2's payoffs on the right. In Table 1B we show the utility associated to those payoffs for player 1 (for player 2 it is symmetric), according to our model.[13]

	Cooperate	Defect
Cooperate	b-c, b-c	b/2-c, b/2
Defect	b/2, b/2-c	0, 0

Table 1A. Material payoffs in the PD

	Cooperate	Defect
Cooperate	$2\delta_1\gamma(b-c)$	$-c+\delta_1\gamma(b-c)$
Defect	$c+\delta_1\gamma(b-c)$	0

Table 1B. Utility associated to outcomes (player 1)

[12] In the context of a social dilemma, "cooperation" refers to a behavioral strategy in the game, in contrast to our definition of cooperation as a preference for the group's joint payoff.

[13] Since we are considering only period t (and implicitly also $t+1$), the period subscripts become unnecessary for the case studies. Therefore, they are omitted from here on.

Thus, for the individual i to be willing to cooperate, cooperation must represent a non-dominated pure strategy:[14] whatever the other player's decision, the utility from cooperation must not be smaller than the utility from defection. That is, individual i's utility must satisfy:

(4) $$-c + \delta_i\gamma(b-c) \geq 0$$

if the other player defects and

(5) $$2\delta_i\gamma(b-c) \geq c + \delta_i\gamma(b-c)$$

if the other player cooperates. Both inequalities turn out to be equivalent, and hence we end up in a unique (necessary; as for sufficiency we require strict inequality) condition for player i to cooperate:

(6) $\delta_i\gamma \geq \frac{c}{b-c}$ (or, alternatively, $\delta_i\gamma \geq \frac{1}{\frac{b}{c}-1}$)

When $b < 2c$, the above expression implies that cooperation requires a high degree of altruism; players with $\delta_i\gamma = 1$ would not cooperate, and larger values of $\delta_i\gamma$ would be necessary for cooperation to be a non-dominated strategy. This means that only if resources grow very quickly or individuals are very patient, cooperation may arise in the PD. Only when $b \geq 2c$ all altruistic players (and some of the spiteful ones) would cooperate. In Figure 1, we present the relationship between patience (vertical axis), variation of resources (horizontal axis), benefits from cooperation (increasing across the curves from right to left) and cooperation decisions. In other words, the figure displays the minimum δ required for cooperation to be a non-dominated strategy, as a function of γ and b (with $c = 1$). We will come back to these points below when we discuss the public goods game.

[14] We introduce indifference inside the "positive" case as we deliberatively do not require cooperation to be the dominant strategy, but a non-dominated strategy. To get strict dominance one has only to replace ≥ by > in the inequalities below.

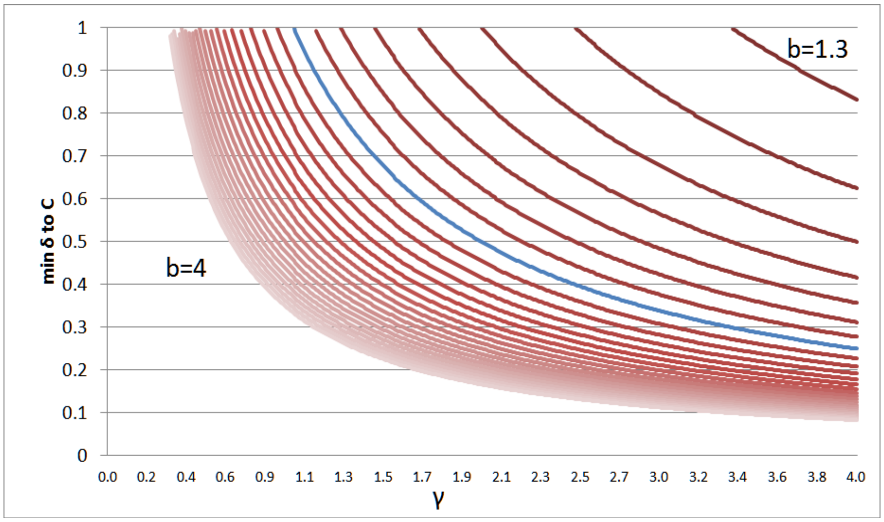

Figure 1. Relationship between individuals' patience and cooperation in the PD. In all cases $c = 1$ and b decreases from left to right by 0.1 in each curve. Above each curve players should cooperate, whereas below the curve they should defect. The blue line signals the $b = 2c$ threshold for cooperation to be confronted with self-interest (i.e., strictly-defined social dilemmas are captured on the right of the blue line).

N players: Public goods

The public goods game (PGG), as the *n*-person version of the PD, is used to study multilateral cooperation (see the reviews of Ledyard 1995 and Chaudhuri 2011). In the PGG the cooperation/defection decision is not dichotomous but continuous. The individual cooperation level is represented by $g \in [0, 1]$, capturing the continuum between full defection, $g = 0$, and full cooperation, $g = 1$. Any cooperation level implies a material cost for the cooperator, $gc > 0$, but generates a group benefit, $gb > gc$, which is shared among all the group members. The restriction for cooperation to be opposed to self-interest (and so making the PGG a social dilemma, strictly defined) is $b < nc$. The payoff for individual i who contributes g_i is given by the following equation:

(7) $$x_i = \frac{b(m_i(n-1)+g_i)}{n} - g_i c$$

with $m_i \in [0, 1]$ being the average cooperation level among the other, $n - 1$, group members different from individual i.

The average payoff of the other group members different from individual i is given by:

(8) $$\bar{x}_{-i} = \frac{b(m_i(n-1)+g_i)}{n} - m_i c$$

Individual i's utility is therefore defined by:

(9) $$U_i = \left(\frac{b(m_i(n-1)+g_i)}{n} - g_i c\right)(n-1+\delta_i\gamma) + \left(\frac{b(m_i(n-1)+g_i)}{n} - m_i c\right)(n-1)(\delta_i\gamma - 1)$$

Note that the transformed utility function (defined in Equation 3) is more useful here than the original specification (Eq. 2), since the other group members' individual payoffs are not known but their average payoff is easily computable. Simplifying, we obtain:

(10) $$U_i = \delta_i\gamma b(m_i(n-1)+g_i) - c((g_i - m_i)(n-1+\delta_i\gamma) + n\delta_i\gamma m_i)$$

For individual i to prefer cooperation, g must enter positively into her utility function. Therefore, cooperation requires $\frac{\partial U_i}{\partial g_i} \geq 0$, that is:

(11) $\delta_i\gamma \geq \frac{c(n-1)}{b-c}$ (or, alternatively, $\delta_i\gamma \geq \frac{n-1}{\frac{b}{c}-1}$)

Hence, in the PGG, as we have observed above for the PD, our theory entails the existence of two possible cases: (i) if b is smaller than nc, $\delta_i\gamma$ must be at least greater than 1 (i.e., individual i being altruistic) for cooperation to be a likely dominant strategy for the individual i; (ii) in the case b exceeds nc, $\delta_i\gamma$ can be lower than 1 (i.e., spiteful types) and still cooperation would be selected by some, sufficiently patient, individuals. Importantly, this implies that, in the framework of our model and in this type of social dilemmas, defection when $b > nc$ is an unequivocal symptom of spitefulness since egoists and altruists would always cooperate under these conditions.

Therefore, sufficient individual's patience is always required in social dilemmas as a necessary condition for cooperation. Of course, the higher the relative benefit of cooperation, b/c, and the higher γ, the lower the patience needed for preferring cooperation over defection and consequently more subjects would cooperate, as can be observed in Figure 1. It is also interesting to note a clear group size effect: *ceteris paribus,* less individuals would be willing to cooperate in bigger groups because the same benefit, b, has to be shared among more individuals, as is clear from Eq. (11).

Let us now discuss our results in the light of the available evidence. Although the classical assumption of selfishness predicts that no individual will cooperate when $b < nc$, both experimental and field evidence show that cooperation is observed even in non-repeated encounters (e.g., Ledyard 1995, Camerer 2003, Stevens & Hauser 2004). According to our model, patience would be essential for any cooperative act to exist. Indeed patient subjects have been proved more cooperative than impatient ones in both repeated and one-shot social dilemma experiments (Harris & Madden 2002, Yi et al. 2005, Curry et al. 2008).

On the other hand, when $b > nc$ both collective and personal interests would demand cooperation as it leads to maximal group and individual gains. However, experimental evidence has shown that not all subjects cooperate fully under these conditions; a fact that has been explained through spiteful preferences (this game is indeed also called "the spite dilemma") (Saijo & Nakamura 1995, Brandts et al. 2004, although see Brunton et al. 2001 and Kummerli et al. 2010 for other interpretations). Our model gives an explanation to defections within this setting and also associates their existence to spite, which is partially guided by impatience. To the best of our knowledge, no any study has tried to relate individuals' behavior in "the spite dilemma" with their inter-temporal preferences.

In the last years, it has been repeatedly shown that introducing the possibility to punish other group members at personal cost (i.e., "altruistic punishment"; see Fehr & Gächter 2002) in social dilemma games works as a mechanism able to enforce cooperation in situations where, otherwise, it would unravel. Although this paper aims at providing the basics of the relationship between patience and behavior in the most canonical games, we provide a further worked example including the possibility of punishment in Appendix 1 because recent findings suggest that players' inter-temporal preferences may also have an effect on their punishment behavior (Espín et al. 2012).

Finally, it must be highlighted that humans are often characterized as being conditionally cooperative to some extent (Brandts & Schram 2001, Fischbacher et al. 2001, Frey & Meier 2004, Kocher et al. 2008, Herrmann & Thöni 2009, Gracia-Lázaro et al. 2012). That is, people are more likely to cooperate with those who also cooperate. Our model, in its current form, cannot account for such conditional cooperation as individuals cooperate or not regardless of the other group members' cooperation. However, to reach conditional cooperation one can consider a higher synergy between cooperators by defining utility as having increasing returns in the total group's payoffs. For instance, γ can be defined as increasing with the proportion of cooperators in the group or we can introduce $(\sum_{j=1}^{n} x_{jt})^{k}$, with $k > 1$, to represent the satisfaction the individual obtains from the total group's resources. With this kind of relatively simple modifications one may attain the theoretical requirements for players to be conditionally cooperative. Under these specific conditions, up to three types of individuals might coexist: (i) patient individuals who always cooperate, (ii) intermediate-discounting individuals who cooperate in (increasing) function of their group partners' expected cooperative level (which in fact depends on their expected patience), and (iii) impatient individuals who never cooperate. As the main aim of this paper is to present the basic ideas about how inter-temporal preferences may affect the players' strategic choices, we will not dwell here into the details of these potential modifications of the model, which can capture more sophisticated behaviors such as conditional cooperation.

Case study 2: The ultimatum game

As the second scenario to test the predictions of our model, we have chosen the ultimatum game (UG) which, compared to the discussion in the previous section, brings in the asymmetry in the players' roles along with a vast corpus of experimental results. In the UG two players bargain on how to split a pie of fixed size. The proposer offers a fraction of the pie, $\alpha \in [0, 1]$, to the responder which she can accept or reject. If the responder accepts the proposer's offer, such a proposal is implemented. The payoffs would thus be $(x_p, x_r) = (1-\alpha, \alpha)$ in case of acceptance. However, if the responder rejects the offer, neither player gets anything. The UG has been widely used to study negotiations and reciprocal fairness across as well as within cultures (Güth et al. 1982, Camerer 2003, Henrich et al. 2005, 2006, Brañas-Garza et al. 2014).

Given that rejection leads to zero-payoff, the self-interest model predicts that the proposer offers the minimum share to the responder, which is accepted. According to our model, the utility associated by the proposer to any implemented (not rejected) split is:

(12) $$U_p = 1 - 2\alpha + \delta_p \gamma$$

Whereas the utility associated by the responder to any implemented (not rejected) split is:

(13) $$U_r = 2\alpha - 1 + \delta_r \gamma$$

Trivially, a rejection leads to zero-utility for both players according to both the cooperative and the competitive components. Therefore, in order the responder to accept an offer, the utility she associates to the proposed outcome should be positive. Also, the proposer must associate a positive utility to the outcome (in case of acceptance) in order to propose such a split. Thus, α must satisfy $U_i(\alpha) \geq 0,\ \forall i = p, r$.[15]

The upper bound for α comes from the proposer's utility. She is not willing to offer more than a specific fraction (above which she would prefer a rejection), which will be smaller the smaller is δ_p:

(14) $\alpha \leq \min\left\{\frac{1+\delta_p\gamma}{2}, 1\right\}$

The lower bound for α comes from the responder's utility. She is not willing to accept less than a specific fraction, called the minimum acceptable offer (MAO), which will be greater the smaller is δ_r:

(15) $\alpha \geq \max\left\{\frac{1-\delta_r\gamma}{2}, 0\right\}$

Therefore, impatient responders are more likely than patient ones to reject a given offer. Although the expected distribution of responders' inter-temporal preferences will determine the specific offer made by a proposer, the risk of non-agreement is perceived as more harmful by patient individuals because a rejection would destroy the total resources. Consequently, impatient proposers should offer a smaller fraction of the pie than patient ones, *ceteris paribus*. As the most extreme case, completely impatient individuals ($\delta_i = 0$) would never offer more than half of the pie as proposers and, as responders, would always reject any offer below that amount. This means that extremely impatient-spiteful subjects will never end with less resources than their partner. On the other hand, her partner getting the whole pie may be strictly more satisfying than a rejection for sufficiently patient-altruistic individuals. Therefore, patient individuals can greatly reduce their demands just to avoid upsetting their impatient, spiteful peers, meaning that the margin for agreement (i.e., the range of α where an agreement can take place) would increase along with patience. Figure 2 displays the relationship between individuals' patience and the lower/upper bounds for proposals in two different cases, namely $\gamma = 0.5$ and $\gamma = 2$.

[15] Notice that $U_i(\alpha) = 0$ would imply that the individual is indifferent between acceptance and rejection. However, indifference is deliberatively introduced inside the no-rejection case; when this fact has important theoretical implications these are pointed out in the text.

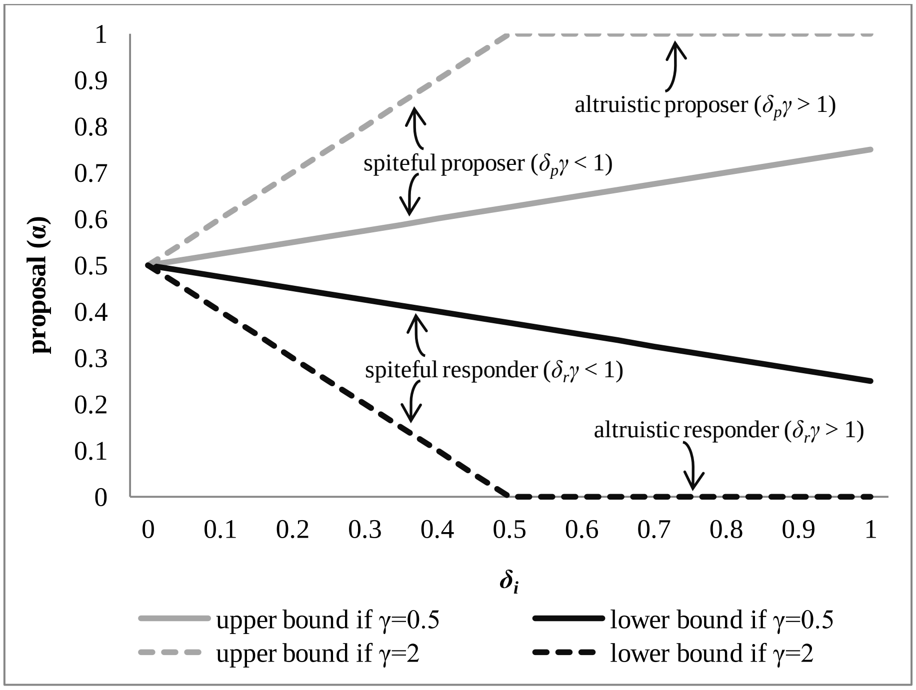

Figure 2. Relationship between individuals' patience and UG outcomes. In case γ = 0.5 (continuous lines) all individuals are spiteful: for its final implementation, the proposal should be exactly 50% if both players are extremely impatient and belong to [25%, 75%] if both players are extremely patient. In case γ = 2 (dashed lines) individuals with patience below, equal, and above 0.5 are spiteful, egoistic, and altruistic, respectively: for its final implementation, the proposal should be exactly 50% if both players are completely impatient and belong to [0%,100%] if both players' patience is greater or equal 0.5.

The predictions of our framework agree to a large extent with the available experimental observations. Indeed, both a negative relationship of patience with the willingness to reject low offers as responders (Crockett et al. 2010, LeVeck et al. 2014, Espín et al. 2015) and a positive relationship with the fraction offered as proposers (Espín et al. 2015) have been reported in UG experiments measuring participants' inter-temporal preferences. Interestingly, this implies that individuals' absolute payoffs in the UG, after playing in both roles, do not significantly relate to their patience but their relative payoffs (defined as the focal player's payoff minus the expected payoff of the rest of players when interacting with this focal player) do: patient (impatient) individuals get on average a smaller (greater) share of the pie than their partners (Espín et al. 2015).

Another important implication of our framework is that, based on the transformed utility specification (Eq. 3), only spite plays a role in establishing the upper and lower limits for α because $\delta_p\gamma \geq 1$ implies $\alpha \leq 1$ and $\delta_r\gamma \geq 1$ leads to $\alpha \geq 0$. Thus, altruism and indifference towards others' payoffs add nothing to the restrictions the game imposes for α by design. This does not mean that altruism has no implications on the individuals' disposition towards the possible outcomes of the game as altruist types would be better off when obtaining a zero-fraction than after a rejection.[16] However, the share obtained by the other player (if an agreement is reached) impacts always negatively on utility, as defined here, because the pie to split is fixed. This entails that any proposer's deviation from the zero-offer can be only motivated by the avoidance of rejection. Since the existence of rejections (i.e., MAOs > 0) is solely based on spiteful preferences with no role of altruism, the outcome of the game would be dramatically influenced by spite.

Vast evidence shows that the modal proposal in UG experiments is the "fair", equal split. Some other proposers offer "unfair" splits (e.g., 20% of the pie) that are quite often rejected and rarely, but sometimes, offers exceed the 50% (Camerer 2003, Oosterbeek et al. 2004, Henrich et al. 2005). These findings can also be explained using the present model. Following our theory, some impatient-spiteful responders are not willing to accept "unfair" splits and, therefore, proposers who try to avoid rejections must offer "fair" splits. Moreover, some extremely patient-altruistic proposers could be even willing to offer more than half of the pie in order to avoid rejections with certainty (note that completely impatient responders, $\delta_r = 0$, would be indifferent between accepting half of the pie and rejecting it).[17] "Fairness" would thus emerge uniquely driven by the avoidance of spiteful responders' rejections, and not as an intrinsic motivational force as proposed in previous models on social preferences (Rabin 1993, Fehr & Schmidt 1999, Bolton & Ockenfels 2000, Charness & Rabin 2002). Rejection of low offers would not therefore be used as a mechanism for punishing unfair behavior but instead as a way to increase the responders' relative standing and so satisfying their competitive or envious desires (Kirchsteiger 1994). Indeed, Carpenter (2003) found that individuals with a competitive social value orientation, rather than "fairmen", were responsible for most rejections. This is also compatible with the suggestion of de Oliveira & Eckel (2012) and Staffiero et al. (2013) that the acceptance of low offers could be a symptom of generosity or altruism, rather than selfishness.

An analysis of further extensions of the ultimatum game can be found in Appendix 2.

[16] If we require strict positive utility for the responder to accept the deal, individuals who are indifferent towards others' payoffs ($\delta_i\gamma = 1$) would demand $\alpha > 0$.

[17] This is consistent with the explanation that proposers within the Mapuche society gave to researchers in Henrich et al. (2005) to justify their offers above the equal split. Those proposers claimed that they feared rare spiteful responders willing to reject even 50/50 offers.

Case study 3: The stag-hunt game

Finally, to cover a different type of context where our model may have important implications while the cooperation-competition conflict is less evident, we shall now consider coordination games. To be specific, we study the stag-hunt game (SHG) as a pure coordination problem between two players. The SHG has been referred to as a context to study the puzzle of cooperation from a different, and sometimes more realistic, perspective than the one offered by social dilemma games (see, e.g., Van Huyck et al. 1990, Skyrms 2003). Players have to decide simultaneously between two possible strategies: they can choose either hunting stag (*S*) or hare (*H*). The symmetric payoff structure of the game, depicted in Table 2A, leads to the existence of a low-risk option (*H*) and a high-risk one (*S*). Hunting stag together (i.e., both choosing *S*) has attached a large gain, $a > 0$, for both hunters, and constitutes the socially-efficient outcome. However, hunting stag needs the cooperation of the other player to succeed and, therefore, it is risky. If the other player chooses *H*, the hunter trying to hunt stag alone gets the penalty payoff, which is normalized to zero. On the other hand, hunting individually (i.e., choosing *H*) leads always to at least a sure reward, catching hare, $c \in (0, a)$, more so, $b \in [c, a)$, if the other player chooses to hunt stag. Thus, the game imposes $a > b \geq c > 0$. Assuming players' strict self-interest would lead us to a pure strategy equilibrium in which both players coordinate on either *S* or *H*. Once coordinated on any of the two strategies no player has individual, selfish incentives to unilaterally deviate from it.

It can be seen from Table 2A that strategy *S* is not always cooperative in the terms of this paper. In fact, $b > 2c$ is required for *S* to maximize the joint payoff regardless of the other player's choice. In the case $b \leq 2c$ then the expected choice by the other player would determine which the joint-payoff-maximizing strategy is (in this case, *H* yields a higher joint payoff if the other player chooses *H*). On the other hand, choosing *H* is always competitive, as defined here. Given that $b > 0$, the strategy *H* maximizes the individual relative payoff, irrespective of what the other player chooses. Table 2B presents the utility player 1 associates to the different game outcomes (for player 2 it is symmetric), according to our model.

	Stag (*S*)	Hare (*H*)
Stag (*S*)	a, a	$0, b$
Hare (*H*)	$b, 0$	c, c

Table 2A. Material payoffs in the SHG

	Stag (*S*)	Hare (*H*)
Stag (*S*)	$2\delta_1\gamma a$	$b(\delta_1\gamma - 1)$
Hare (*H*)	$b(1 + \delta_1\gamma)$	$2\delta_1\gamma c$

Table 2B. Utility associated to outcomes (player 1)

Thus, for the individual i to choose *S*, as a (weakly) dominant pure strategy, the two following inequalities must hold:

(16) $2\delta_i\gamma a \geq b(1 + \delta_i\gamma)$, if her partner chooses *S*,

and

(17) $b(\delta_i\gamma - 1) \geq 2\delta_i\gamma c$, if her partner chooses *H*.

Thus, from Eq. (16), if her partner chooses *S*, the individual *i* would prefer choosing *S* if:

(18) $\delta_i\gamma \geq \frac{b}{2a-b}$

More patient individuals are therefore more likely to prefer *S* when the other player chooses *S*. Also, the greater *a* and the smaller *b*, the more individuals would prefer *S*. Furthermore, not only altruistic but even some spiteful individuals could prefer the "cooperative" strategy *S* in response to *S* because $\frac{b}{2a-b} < 1$.

Looking at the second inequality (Eq. 17) we can observe that spiteful and egoistic individuals ($\delta_i\gamma \leq 1$) would never prefer *S* when their partner chooses *H*, since for them the left-hand side of the inequality would be non-positive (and the right-hand side cannot be negative because $c > 0$). That is, for an individual to choose *S* when her partner chooses *H* she must be (sufficiently) altruistic. However, if $b \leq 2c$ nobody would prefer *S* in response to *H*, regardless of the values of δ_i and γ (i.e., regardless of the individual's level of altruism), because S does not maximize the joint payoff as stated above. Thus, if her partner chooses *H*, an altruistic individual *i* would prefer choosing *S* if:

(19) $\delta_i\gamma \geq \frac{b}{b-2c}$, and $b > 2c$.

Therefore, for the "cooperative" strategy *S* to be preferred always by the individual *i*, independently of the other player's choice, the three conditions obtained must be satisfied (which implies some level of altruism-patience). Under some circumstances, the individual's final decision in this game would thus depend on the expected distribution of patience in society, that is, it would depend on the counterpart's expected δ. A special form of "conditional cooperation" is so defined for this game.

In SHG experiments, an important share of playing pairs are normally able to coordinate in the cooperative outcome (*S*, *S*), thus maximizing both the total and the individual payoffs (see Devetag & Ortmann 2007 for a review). Our model requires individuals to be patient enough in order to achieve this coordinated outcome. The only experiment, to our knowledge, linking discounting to behavior in the SHG has been conducted by Al-Ubaydli et al. (2013). The authors found that more patient individuals were indeed more likely to choose *S*, though non-significantly. In their experiment, moreover, the patience of the pair (mean patience of the two players) was significantly and positively related to the likelihood of the pair to coordinate on the cooperative outcome across rounds. These two findings, taken together, give support to the notion of conditional cooperation introduced by our results (i.e., a patient player is more likely to choose *S* when paired with another patient player). Nevertheless, the repeated procedure used in such experiment invites us to consider the relationship between their findings and our theory with special care.

Conclusions

In this paper we have presented a novel theoretical framework that builds on relating the inter-temporal preferences of individuals to the social behaviors they are predisposed to, a hitherto unexplored research avenue to the best of our knowledge. The model is solely based on material outcomes with no involvement of intentionality or reciprocity concerns (Rabin 1993, Charness & Rabin 2002, Dufwenberg & Kirchsteiger 2004, Falk & Fischbacher 2006, Cox et al. 2007), although they have been proved crucial for the understanding of social behavior (Tomasello et al. 2005, Nowak 2006, Martinez-Vaquero et al. 2012). Our theory is nonetheless proposed as a first attempt to combine inter-temporal and social preferences of agents into a single framework able to explain strategic decisions in non-repeated interactions.

The utility an individual derives from a social outcome depends on the material payoffs of all involved, the individual's patience and contextual factors which influence how the future is perceived, that is, whether resources are perceived as increasing or decreasing with time. The relatively higher (lower) is the perceived amount of future vs. present resources available in one specific context—which proxies future (un)predictability—the more likely individuals will be to cooperate (compete) with each other in that context. How a situation is framed has been proved to crucially affect whether individuals' align to one or another specific social preference

(McClintock 1972, Rose & Colman 2007). In our model this "framing" is defined in terms of the dynamic pattern of resources.

Importantly, the general predictions of our framework align very well with experimental observations. As predicted, patient subjects are more cooperative than impatient ones in one-shot and repeated social dilemma experiments (Harris & Madden 2002, Yi et al. 2005, Curry et al. 2008). We have also been able to provide an alternative explanation, associated to spite-impatience, to the lack of cooperation when the payoffs are such that everybody should cooperate to maximize their gains—note that such an explanation in terms of inter-temporal preferences has never been considered before. In the ultimatum game, patience is negatively related to the willingness to reject low offers as responders (Crockett et al. 2010, LeVeck et al. 2014, Espín et al. 2015) and positively related to the fraction offered as proposers (Espín et al. 2015), as predicted by our theory. We have also provided hints as to why the majority of ultimatum offers are "fair". Finally, although there are not many experimental results for the stag-hunt game, the available evidence also supports the predicted relationship of patience with coordinating in the Pareto efficient equilibrium (Al-Ubaydli et al. 2013). As we have also shown in the Appendices, our theory can be extended to more elaborate situations, such as the possibility of punishment in social dilemmas and extensions of the ultimatum game, with very promising results. Therefore, we believe that the theory we are presenting here provides a fruitful way towards a rational solution for some of the most debated puzzles across the social, behavioral and biological sciences.

Since there are no studies (to the best of our knowledge) examining whether inter-temporal preferences predict behavior in other canonical set-ups such as the trust game or the rent-seeking game, we have not derived here the conditions explaining observed behavior in these games. It is not hard to see that for these or other games, solutions can be obtained very easily with our model. This is a particularly good feature of the model, its simplicity.

Regarding the reasons for the emergence of a link between inter-temporal preferences and social behavior in one-shot games, we can offer several insights. An influential strand of research suggests that non-selfish decisions in one-shot encounters arise because self-interested individuals "mistakenly" play non-repeated interactions applying previously-internalized heuristics from repeated encounters, which are more common in real life (Binmore 1998, Hagen & Hammerstein 2006, West et al. 2011, Rand et al. 2012, 2014). Indeed, if interactions are repeated and agents are sufficiently patient, cooperation in a social dilemma game can be modeled as a reputation-oriented selfish decision which relies on the expectation that future personal gains will emanate from others' direct or indirect reciprocity (Axelrod 1984, Fudenberg & Maskin 1986). The finding of Curry et al. (2008) that more patient individuals cooperate more in a one-shot public goods game could thus be interpreted as being in accordance with such a heuristics-based viewpoint (that does not consider social preferences), insofar as impatience must reduce the likelihood of internalizing a behavioral strategy that pays off only over the long-run. Also, since the fear of future rejection in an ultimatum game and the reputation gains from being prosocial should weigh more for patient individuals, the finding of Espín et al. (2015) that patient proposers are more generous also fits in reasonably well with that interpretation. However, in case rejections in the one-shot ultimatum game arise because responders mistakenly apply reputation-based heuristics leading them to reject low offers in order to encourage "future" generous offers by the proposer (Binmore 1998), one should expect a positive relationship between responders' patience and their willingness to reject low offers. But the empirical evidence is exactly the opposite: patient responders reject less (Crockett et al. 2010, LeVeck et al. 2014, Espín et al. 2015). Another observation that is hard to be aligned with this view is that impatient individuals mete out more competitive punishment (free-riders punishing other free-riders) than patient individuals in a one-shot public goods game with punishment (Espín et al. 2012).

Therefore, the argument that one-shot game behavior resembles that of repeated interactions cannot account for the whole range of empirical results on the relationship between inter-temporal preferences and game play. Our aim is to provide a framework that might encompass all that evidence. Nevertheless, our approach could in some sense reconcile the social preferences and social heuristics accounts by assuming that people do not only internalize behaviors but can also internalize the emotional satisfaction associated to the outcome of those behaviors. Under this interpretation, an outcome would be intrinsically valuable to the extent that it has typically been associated with *well-being* gains in the past. That is, during the individual lifetime, cooperation with others has likely been a profitable strategy in stable environments and long-run relationships, while competitive behaviors are proven to be more adaptive in unstable environments and short-run relationships (Wilson & Daly 1985, Van Lange et al. 1997, McCullough et al. 2012). Once the typical functioning of these processes is internalized, competition and cooperation can be automatically/intuitively associated with the "type" of well-being they most commonly produce—i.e., short-run and long-run satisfaction, respectively. These intuitive associations would thus be grounded on individuals' experience from past interactions, as suggested by a social heuristics approach (Rand et al. 2012, 2014), but internalization would occur at the level of emotional satisfaction instead of at a purely behavioral level. Further research is warranted to evaluate the validity of this argument.

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Appendix 1. Punishment in social dilemmas

An interesting and widely studied extension of the social dilemma games relates to the possibility of punishment, i.e., group members can incur a cost in order to punish their peers. In the last two decades, the capacity of sanctions between group members to enforce cooperation in social dilemmas has been consolidated as a major, unquestionable finding (Yamagishi 1986, Fehr & Gächter 2002, Ostrom et al. 1992, Herrmann et al. 2008, Gächter et al. 2008; see Gächter & Herrmann 2009 for a review). Since the use of punishment is costly, a strictly self-interested individual will never punish, at least if encounters are non-repeated. Moreover, punishment enforces cooperation in the group at a personal cost for the punisher which makes the decision to punish a second-order social dilemma (Yamagishi 1986, Fehr & Gächter 2002).

The possibility of peer-punishment is typically introduced following a social dilemma, cooperation stage (see, e.g., Dreber et al. 2008 for a different design). Players can incur in a cost, $q > 0$, in order to reduce the target player's earnings by $pq > q$ (we assume that the impact of punishment is higher than its cost as it is the common assumption and the typical experimental setting). Thus, the individual i's payoffs are given by:

(A1) $$x_i = \frac{b(m_i(n-1)+g_i)}{n} - g_i c - q_i - pQ_i$$

with Q_i being the sum of the expenditure by other group members different from the individual i in punishment targeted on her.

The average payoff of the other group members different from the individual i is calculated as:

(A2) $$\bar{x}_{-i} = \frac{b(m_i(n-1)+g_i)}{n} - m_i c - \frac{p(q_i+Q_j)}{n-1}$$

with Q_j being the sum of the expenditure by other group members in punishment targeted on players different from the individual i.

The individual i's utility would be given by:

(A3) $$U_i = \left(\frac{b(m_i(n-1)+g_i)}{n} - g_i c - q_i - pQ_i\right)(n-1+\delta_i\gamma) + \left(\frac{b(m_i(n-1)+g_i)}{n} - m_i c - \frac{p(q_i+Q_j)}{n-1}\right)(n-1)(\delta_i\gamma-1)$$

To keep the analytical development reasonably simple we will provide the implications of the model for a PD case in which only defectors can be punished but punishment can be implemented by both cooperators and defectors (for evolutionary models based on this payoff structure see, e.g., Eldakar et al. 2007, Eldakar & Wilson 2008, Helbing et al. 2010). Thus, for the sake of simplicity, we explicitly exclude the possibility that cooperators get punished, even though recent theoretical and empirical research has highlighted the important detrimental effects that such "anti-social" punishment of cooperators may have for the establishment of cooperation (Rand et al. 2010, Herrmann et al. 2008). Also for simplicity, we will show here the case in which only one player can punish. As explained below, although the theoretical conditions we obtain by reducing the strategy set in this way can be seen as incomplete, the behavioral implications remain qualitatively identical while avoiding to overload the analysis. This means that player 1 (the decision-maker) has four possible strategies whereas player 2 can only cooperate or defect. Player 1 has therefore to decide whether cooperate or defect and whether punish the defector (if it is the case that player 2 defects) or not. Player 1's strategies are characterized as *CN* (cooperation and no punishment), *DN* (defection and no punishment), *CP* (cooperation and punishment), *DP* (defection and punishment).

Simplifying the above equations for such specific case we obtain the 4x2 payoff matrix shown in Table A1A. The utilities associated by player 1 to those payoffs are presented in Table A1B.

	Cooperate	Defect
CN	b-c, b-c	b/2-c, b/2
DN	b/2, b/2-c	0, 0
CP	b-c, b-c	b/2-c-q, b/2-pq
DP	b/2, b/2-c	-q, -pq

Table A1A. Material payoffs

	Cooperate	Defect
CN	$2\delta_1\gamma(b-c)$	$-c+\delta_1\gamma(b-c)$
DN	$c+\delta_1\gamma(b-c)$	0
CP	$2\delta_1\gamma(b-c)$	$q(p-1)-c+\delta_1\gamma[b-c-q(p+1)]$
DP	$c+\delta_1\gamma(b-c)$	$q[p-1-\delta_1\gamma(p+1)]$

Table A1B. Utility associated to outcomes (player 1)

According to our model, the conditions that $\delta_i\gamma$ must satisfy for each strategy to be (weakly) dominant for the individual *i* are:

- For *CN*:
  - $\delta_i\gamma \geq \frac{c}{b-c}$, if $b \leq 2c\frac{p}{p-1}$

- $\delta_i\gamma \geq \frac{p-1}{p+1}$, if $b \geq 2c\frac{p}{p-1}$

- For *DN*:
  - $\frac{p-1}{p+1} \leq \delta_i\gamma \leq \frac{c}{b-c}$, if $b \leq 2c\frac{p}{p-1}$
  - $\emptyset$, if $b > 2c\frac{p}{p-1}$
- For *CP*:
  - $\emptyset$, if $b < 2c\frac{p}{p-1}$
  - $\frac{c}{b-c} \leq \delta_i\gamma \leq \frac{p-1}{p+1}$, if $b \geq 2c\frac{p}{p-1}$
- For *DP*:
  - $\delta_i\gamma \leq \frac{p-1}{p+1}$, if $b \leq 2c\frac{p}{p-1}$
  - $\delta_i\gamma \leq \frac{c}{b-c}$, if $b \geq 2c\frac{p}{p-1}$

Thus, we find that the most altruistic-patient individuals (i.e., those with highest $\delta_i\gamma$) adopt the strategy *CN*; therefore, they cooperate and refuse punishing defectors. On the contrary, we find that the most spiteful-impatient (lowest $\delta_i\gamma$) individuals adopt *DP*; hence, they defect and punish other defectors. Individuals with an intermediate $\delta_i\gamma$ (between $\frac{p-1}{p+1}$ and $\frac{c}{b-c}$) would select *DN*, thus defecting and not punishing, if the multiplier of cooperation, *b*, is relatively low but would cooperate and punish defectors (*CP*) if *b* is relatively high.

If we allowed player 2 to punish as well, which was excluded for simplicity, the number of cases obtained for each condition would be larger but the basic implications would not change: we would end up with *CN* and *DP* requiring the highest and lowest $\delta_i\gamma$, respectively; while intermediate $\delta_i\gamma$ would lead to choose *DN* (*CP*) when *b* is relatively low (high).

From those results, we find that the most altruistic-patient individuals (i.e., those with highest $\delta_i\gamma$) adopt the strategy *CN*; therefore, they cooperate and refuse punishing defectors. On the contrary, we find that the most spiteful-impatient (lowest $\delta_i\gamma$) individuals adopt *DP*; hence, they defect and punish other defectors. Individuals with an intermediate $\delta_i\gamma$ (between $\frac{p-1}{p+1}$ and $\frac{c}{b-c}$) would select *DN*, thus defecting and not punishing, if the multiplier of cooperation, *b*, is relatively low but would cooperate and punish defectors (*CP*) if *b* is relatively high.

The conditions we obtain indicate that no individual would select the strategy *CP* if $b < 2c$, which means that nobody would cooperate and punish defectors if the cooperation stage is a strict social dilemma. This constitutes an important limitation of the model since vast experimental evidence has shown that this is a very common behavior (e.g., Fehr & Gächter 2002, Gächter & Herrmann 2009). For the appearance of cooperators who punish defectors we need however b to be, at least, higher than $2c$, which turns the game into a "spite dilemma", and *CP* individuals turn out to be spiteful (since $p > 1$, $\delta_i\gamma \leq \frac{p-1}{p+1}$ implies $\delta_i\gamma < 1$), although not extremely.

To our best knowledge, no study has introduced the possibility of punishment in a "spite dilemma"; thus, we cannot affirm that subjects would select *CP* strategies also in that setting. Nonetheless, our model provides an analytical rationale for individuals who defect and punish other defectors in (strict) social dilemmas; a behavioral pattern which is quite commonly observed as well (Espín et al. 2012, Falk et al. 2005, Shinada et al. 2004) and cannot be explained by self-interest. We find that only extremely spiteful individuals would behave in this manner. Thus, impatience is characteristic of defectors who punish other defectors. We are aware of only one experiment relating subjects' inter-temporal preferences with their punishment behavior in a social dilemma game. Espín et al. (2012) found that more impatient non-cooperators were more likely to punish other non-cooperators in a one-shot public goods game, which is congruent with our predictions. In fact, this kind of punishment is associated in the literature with competitive or spiteful motives (Falk et al. 2005, Shinada et al. 2004). However, that paper also found that more patient cooperators were more willing to punish non-cooperators, which contradicts our predictions. To reconcile our theory with the latter finding, individuals should perceive the punishment of defectors by cooperators as a second-order cooperative behavior which increases the long-run collective payoff (as found by Gächter et al. 2008). If this is the case, according to our theory, cooperate and punish defectors would be linked to long-run psychological satisfaction and patient individuals would show a predisposition towards this kind of "moralistic" punishment in social dilemmas. We leave this possibility for future developments of the model.

Appendix 2. Extensions of the ultimatum game

One proposer, several responders

In the following we allow for more than one responder to play the game while still one single proposer has to make an offer. The proposer's offer is to be shared evenly among all the, $n - 1$, responders. Once the proposer makes her offer, a single responder rejecting it means zero-payoff for all players. Only if all the responders accept the deal, the proposal would be implemented. The standard UG with one responder represents a particular case of the multiple-responder UG. Let's see the implications our model has on the individuals' behavior in this extended UG.

The utility for the proposer of any implemented (not rejected) split is defined by:

(A4) $$U_p = n(1-\alpha) + \delta_p\gamma - 1$$

The utility for the responder *i* of any implemented (not rejected) split is defined by:

(A5) $$U_{ri} = \frac{n(\delta_{ri}\gamma + \alpha - 1) + 1 - \delta_{ri}\gamma}{n-1}$$

Therefore, the upper bound for α to be implemented is extracted from the proposers' utility ($U_p \geq 0$):

(A6) $$\alpha \leq \min\left\{\frac{n-1+\delta_p\gamma}{n}, 1\right\}$$

From the responders' utility we obtain the lower bound for α to be implemented ($U_{ri} \geq 0$). For the responder *i* we need:

(A7) $$\alpha \geq \max\left\{\frac{(1-\delta_{ri}\gamma)(n-1)}{n}, 0\right\}$$

Again, the upper bound of α would be higher for more patient proposers while the lower bound imposed by more patient responders would be smaller (thus, accepting lower offers than impatient responders). However, the addition of more responders (i.e., increasing n) leads the proposer to increase the maximum α she is willing to offer in order to avoid rejection. Also, the higher the number of responders the higher must be α to be accepted. However the minimum individual share each responder is willing to accept (strictly-defined MAO, i.e., $\frac{\alpha}{n-1} \geq \max\left\{\frac{1-\delta_{ri}\gamma}{n}, 0\right\}$) is reduced as we increase the number of responders. As a result, completely present-oriented, spiteful individuals (δ_i = 0) would be happier with the implementation of a proposed split than with the (0, 0) outcome attached to a rejection only if they get at least a "fair" fraction of the pie, that is, $\frac{1}{n}$. As in the two-player case shown in the main text, non-spiteful preferences ($\delta_i\gamma \geq 1$) do not alter the lower and upper bounds the game imposes for α by design.

The power to take

An interesting variant of the UG is the so-called power-to-take game (PTG). The PTG was invented by Bosman & van Winden (2002) and has been used to study rejection behavior from a different point of view (see also, e.g., Bosman et al. 2005). Both the proposer and the responder can be endowed with some income in this game. For simplification and ease of comparison with the UG we will assume that the responder is initially endowed with the whole pie, of size 1, and the proposer starts the game with nothing (it would be straightforward however developing the results for different initial endowments). The proposer must state a fraction $t \in [0, 1]$ she wants to take from the responder's endowment. The responder can then decide to destroy a fraction $d \in [0, 1]$ of the pie. Therefore, after both players' decisions, the proposer's payoff will be $t(1 - d)$ and the responder's payoff will be $(1 - t)(1 - d)$. This means that if the responder destroys her entire endowment, both players would end empty-handed, like after a rejection in the UG.

Thus, the utility associated by the proposer and the responder to the game outcome are defined, respectively, by:

(A8) $U_p = (1 - d)(2t - 1 + \delta_p\gamma)$

(A9) $U_r = (1 - d)(1 - 2t + \delta_r\gamma)$

For the responder to be willing to use the destruction mechanism, she must feel happier with the outcome of the game after destroying part of her endowment than leaving the proposer to take what she demands. That is, the destruction rate must enter positively in her utility, which requires $\frac{\partial U_r}{\partial d} \geq 0$. This leads to the condition $\delta_r\gamma \leq 2t - 1$.

Therefore, our model predicts that no responder would employ the destruction mechanism when the proposer wants to take less than half of the pie. However, if the proposer tries to take more than the 50% then most spiteful-impatient (i.e., lowest $\delta_i\gamma$) individuals would destroy the whole pie, just for not being in a relatively disadvantageous position. As in the case of the UG, non-spiteful individuals would never reject the other player's proposal (i.e., they would never destroy the pie). Given that the responder's share, $1 - t$, is always affecting negatively the proposer's utility, deviations from the "take-everything" proposal can only be based on the avoidance of pie-destruction by spiteful responders. In fact, the "fair", equal split given by $t = ½$ is the only one that will not be rejected for sure by some type of responder. As a result, "fairness" emerges again leaded by the proposers' willingness to avoid spiteful pie-destruction by impatient responders, and not as an intrinsic characteristic of the individuals' preferences. We are not aware of the existence of any empirical study analyzing the possible relationship between time discounting and behavior in the PTG so far.