Illustrations on Cooperative, Competitive and Temporal Choices

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RESUMEN DE LA TESIS EN ESPAÑOL

En esta Tesis se presentan cinco trabajos de investigación, precedidos de un capítulo introductorio. El corazón de la investigación se centra en los comportamientos cooperativos y competitivos, entendiéndose los primeros como aquéllos dirigidos a maximizar el bienestar social y los segundos como aquéllos encaminados a maximizar la posición relativa del individuo.

Desde la óptica de la Economía del Comportamiento, este trabajo pretende ofrecer respuestas a algunas de las preguntas más sugestivas en cuanto a la conducta social de los seres humanos. Primero, ¿cuáles son las bases psicológicas de las decisiones cooperativas y competitivas? Segundo, ¿hay individuos más cooperativos o competitivos que otros y, si es así, por qué? Tercero, si todos somos cooperativos y competitivos en alguna medida, ¿qué contextos son los que despiertan cada uno de estos tipos de motivación social? Cuarto, ¿puede el comportamiento de castigo social entre individuos emanar de motivaciones diferentes y, si es así, cómo se pueden distinguir tales motivaciones? Por supuesto, esta lista no pretende de ninguna manera ser completa (ni tan siquiera comprehensiva). Además, como sucede con cualquier esfuerzo investigador, probablemente sean más preguntas las que se susciten con este trabajo que las que con él se pueda, o incluso se pretenda, responder. En las líneas siguientes se resume el contenido de cada uno de los capítulos haciendo una especial mención al proceso dinámico seguido en la maduración de las investigaciones y su posterior desarrollo.

El **Capítulo 2** ("*Patient and impatient punishers of free-riders*") presenta los resultados de un experimento incentivado en el cual mis coautores y yo analizamos la relación entre las preferencias temporales (o impaciencia) de los sujetos y su comportamiento de castigo social en un entorno multilateral de cooperación económica esporádica (juego no repetido). Algunas investigaciones previas sobre las bases psicológicas del comportamiento de castigo arrojaban resultados aparentemente contradictorios y nuestra investigación pretendía esclarecer el porqué. Por un lado, un grupo de autores argumentan que el castigo sobre los que transgreden las normas sociales está ligado a factores psicológicos orientados hacia el largo plazo, relacionados con el comportamiento moral o normativo. Por contra, otros interpretan que el castigo es resultado de una reacción impulsiva, orientada hacia el presente, contra la propia violación de la norma. Aunque empleando diferentes metodologías para analizar dichos factores psicológicos, toda la investigación previa se ha realizado mediante el uso de juegos de negociación bilateral en los que es difícil distinguir entre las diferentes motivaciones que pueden conducir a castigar a otros, en particular, entre las motivaciones normativas y las competitivas. La visión más difundida es la que entiende el castigo como un comportamiento eminentemente normativo. Sin embargo, cuando examinamos la correlación existente entre la impaciencia de quien castiga y su comportamiento de cooperación, encontramos que existían dos tipos de castigadores: individuos cooperativos pacientes que castigaban a los no cooperativos e individuos impacientes no cooperativos que castigaban a otros individuos no cooperativos. Estos resultados indican que ambas interpretaciones sugeridas hasta el momento en la literatura pueden de hecho ser apropiadas si se aplican a la subpoblación correcta de individuos; o bien a los castigadores moralistas con orientación futura o bien a los castigadores competitivos con orientación presente.

Dado que investigaciones previas han revelado que los sujetos impacientes son más propensos a castigar la injusticia (esto es, a destruir todo el dinero mediante el rechazo de ofertas injustas) como jugador 2 en un juego del ultimátum, nuestros resultados planteaban una nueva e interesante pregunta: ¿esos castigadores impacientes del juego del ultimátum se mueven por un sentimiento de justicia o, como nuestro trabajo sugiere, por un impulso competitivo malicioso? Para responder a esta pregunta desarrollamos una investigación, cuyos resultados se exponen en el **Capítulo 3** (“*Delay discounting and spite in bargaining: Beyond strategic self-interest and fairness*”). Específicamente, lo que hicimos fue analizar los datos de una encuesta-experimento en la que se medía la impaciencia de los participantes y su comportamiento en un juego del ultimátum de doble rol. Este diseño nos permite observar si aquellos sujetos que castigan el comportamiento injusto de sus parejas de juego son ellos mismos justos o injustos cuando cambian de rol. Los análisis estadísticos revelan que los sujetos impacientes eran i) más proclives a castigar la injusticia como jugador 2 (replicando así los resultados hallados previamente por otros autores) y ii) más injustos ellos mismos como jugador 1. En consecuencia, aquéllos que interaccionaron con los sujetos más impacientes ganaron, en promedio, menos dinero. Estos nuevos resultados sugieren que las bases psicológicas del castigo ejercido durante una negociación bilateral podrían asemejarse hasta cierto punto al castigo competitivo que llevan a cabo los individuos no cooperativos en entornos de cooperación multilateral. Sobre la posible coexistencia de diferentes tipos de castigadores en el juego del ultimátum se profundiza en el Capítulo 5.

Los resultados de la investigación presentada en los capítulos anteriores unidos a evidencia previa sobre la relación existente entre la impaciencia de los individuos y su conducta social motivó la construcción de un modelo teórico, que se expone en el **Capítulo 4** (“*Competition or cooperation? Now or later?*”). Aunque todavía en versión preliminar, este modelo trata de abrir una nueva línea en el campo de las preferencias sociales. Dado que a los comportamientos competitivos y cooperativos se les asocia con motivaciones proximales de corto y largo plazo, respectivamente, la teoría propone que los individuos obtienen recompensas psicológicas diferidas por las ganancias conjuntas y recompensas psicológicas inmediatas por las ganancias relativas. Con esta base, la función de utilidad del individuo representativo está formada por dos componentes: una fuente inmediata de satisfacción derivada de su pago relativo y una fuente diferida de satisfacción derivada del pago grupal conjunto. Como resultado, los individuos pacientes (impacientes) que descuentan a una tasa menor (mayor) las recompensas psicológicas diferidas estarán más dispuestos a cooperar (competir). Los ingredientes de la función de utilidad se completan con factores contextuales: los individuos se tornan más cooperativos cuando las cosas marchan bien y más competitivos cuando las cosas marchan mal. El modelo se usa para explicar algunas regularidades conductuales observadas en experimentos económicos que son difícilmente reconciliables con el modelo tradicional basado en el interés individual. En particular, los resultados teóricos preliminares se muestran muy satisfactorios a la hora de explicar nuestros propios hallazgos empíricos.

Los estudios que se presentan en los Capítulos 5 y 6 siguen una metodología similar. En ambos casos, investigamos el comportamiento de los sujetos como jugador 2 en el juego del ultimátum usando el juego del dictador como herramienta auxiliar. Como se comenta con anterioridad, el **Capítulo 5** (“*Don’t mix it up: Fairness versus spite in the Ultimatum Game*”) se dedica a analizar la coexistencia de distintos tipos de castigadores en el juego del ultimátum. Los resultados son ciertamente provocadores. Usando dos muestras diferentes, encontramos clara evidencia de que el rechazo de ofertas injustas en el juego del ultimátum está determinado por dos subpoblaciones de sujetos: aquéllos que se comportan de forma totalmente justa en el juego del dictador (cediendo exactamente la mitad del dinero a otro participante) y aquéllos que se comportan de forma totalmente injusta (quedándoselo todo para ellos). En consecuencia, podemos concluir que el rechazo de ofertas injustas en el juego del ultimátum es llevado a cabo tanto por individuos preocupados por la justicia como por individuos competitivos-maliciosos. Así, la mera observación del comportamiento de rechazo no es suficiente para desenmascarar el peso relativo de cada una de estas subpoblaciones. Estos resultados tienen un interés particular a la luz de evidencia reciente que demuestra que la cooperación pública se puede destruir, en vez de reforzar, en presencia de estos "castigadores maliciosos".

Finalmente, el **Capítulo 6** ("*Accepting zero in the Ultimatum Game: Selfish Nash response?*") pone el foco en los sujetos que aceptan ofertas extremadamente injustas (es decir, que aceptan incluso que la otra persona se quede todo el dinero) como jugador 2 en el juego del ultimátum. Para un individuo egoísta, aceptar cualquier oferta, por mala que sea, es una estrategia dominante porque le lleva a maximizar su ganancia personal. Dado que a aquellos individuos que rechazan ofertas injustas se les puede considerar o bien como pro-sociales (dispuestos a incurrir en un coste para castigar la injusticia) o como competitivos (que intentan incrementar su estatus relativo), debe esperarse que los que no rechazan ninguna oferta sean individuos egoístas a los que sólo les importa su propia ganancia. Sin embargo, cuando analizamos el comportamiento de estos últimos en el juego del dictador encontramos que son claramente los más generosos dentro las dos muestras examinadas. Sugerimos por tanto que aceptar ofertas extremadamente injustas podría ser un comportamiento cooperativo o altruista. Este hallazgo aparentemente simple tiene no obstante unas implicaciones críticas, particularmente cuando se combina con los resultados del capítulo anterior: si tanto los sujetos que rechazan ofertas injustas como aquéllos que las aceptan pueden ser pro-sociales (Capítulo 6) y, por otro lado, los que rechazan estas ofertas injustas pueden ser o bien pro-sociales o competitivos-maliciosos, entonces ¿cómo se debe interpretar exactamente el juego del ultimátum? Es posible que la respuesta sea que el diseño del juego del ultimátum sea excesivamente simple como para extraer conclusión alguna acerca de las motivaciones de los sujetos, lo que permite a los investigadores demasiados "grados de libertad".

En definitiva, los resultados presentes en esta Tesis apuntan que la investigación sobre el comportamiento social humano podría beneficiarse de una perspectiva más amplia que tenga en cuenta tanto nuestra cara más "amable" como nuestro lado más "oscuro". Futuros avances pueden emanar de la confrontación de diferentes preferencias sociales, distanciándose así del enfoque que sitúa el egoísmo como el punto de referencia perpetuo de cualquier análisis.

Chapter 1

Introduction

> *In the race for wealth, and honours, and preferments he may run as hard as he can, and strain every nerve and muscle, in order to outstrip all his competitors. But if he should jostle or throw down any of them, the indulgence of the spectators is entirely at an end. It is a violation of fair play, which they cannot admit of.* [...] *They readily, therefore, sympathize with the natural resentment of the injured, and the offender becomes the object of their hatred and indignation. He is sensible that that he becomes so, and feels that those sentiments are ready to burst out from all sides against him.*
>
> —Adam Smith, *The Theory of Moral Sentiments* (1759)

Both cooperation and competition with conspecifics are essential to human social behavior. Organization in complex social systems, from teams to states, greatly depends on the interrelation between these two complementary elements of sociality. Cooperative behavior, in the broader sense of the term, is associated with social welfare gains while competitive behavior has to do with the individuals' relative standing within the group.

While the importance of the interaction between cooperative and competitive behaviors has featured prominently in the literature across the biological and the social sciences for a long time, economists have until recently remained largely oblivious to its impact on socio-economic outcomes. From my perspective, the reasons behind the ostracism of such concepts in the mainstream economics literature are basically two[1]. On

[1] Actually, one might argue that these are simply two different levels of one single reason.

the one hand, the neoclassical general equilibrium paradigm has focused on autonomous, self-regarding individuals who consistently maximize their material payoffs; thus abandoning the psychological and moral nuances present in the writings of classical economists such as A. Smith, J. Bentham or J.S. Mill. On the other hand, what was also abandoned with the advent of the so-called marginalist revolution of the 1870's was the dynamic conception of the economic system (North 1990). Static optimization developed by marginalist economists, which leads the social optimum to coincide with the market equilibrium, by definition rules out any need to consider cooperative or competitive behaviors as defined here. To put it briefly, when resources are scarce but constant because dynamics are disregarded, the game of economic life turns into a zero-sum game where relative- and absolute-payoff maximization become synonymous with each other and social welfare is automatically optimal through competition at the margin; thus making cooperation an unnecessary concept.

Cooperative norms are indispensable to maintain social harmony by keeping competition within the bounds of what Smith called the "*fair play*". In this sense, norms are able to restrict the destructive component of competition: spiteful behavior. When individuals are willing to even destroy available resources for the sake of increasing their own relative standing, competition may indeed become detrimental for society. Therefore, the negative-, zero- or positive-sum character of the game of social life will crucially depend on a delicate balance between cooperation and competition.

Individuals living in groups are thus not only required to cooperate with each other to improve group performance but also to compete for within-group status and hierarchies. Therefore, an evolutionary approach predicts the selection of proximate cognitive mechanisms for both affiliative and agonistic behaviors in social species like humans (Adolphs 1999, Dunbar 2003). Mentalizing is one of those mechanisms: in order to successfully cooperate or compete, it is very useful to be able to read others' minds and intentions during social encounters (Decety et al. 2004). Another mechanism is to derive psychological benefits (or costs) from cooperative and competitive achievements. For instance, deriving pleasure from the fortunes or misfortunes of others, depending on the context of the interaction, might help to overcome social problems that require cooperation or competition, respectively. In addition, the mechanisms that allow building inter-temporal representations can also crucially influence the way individuals solve cooperative and competitive situations. In this vein, the ability to delay personal gratification for the sake of future rewards associated with better group performance or the ability to weigh the future consequences of one's actions play a key role in social behavior.

These two last mechanisms are in the focus of my work: the importance of social psychological incentives as proximate forces behind social behavior and how these relate to inter-temporal mental processes. Adopting a motivational perspective, the terms competition and cooperation will therefore often be used throughout this dissertation to refer to actively pursuing one's own relative standing and social efficiency, respectively (McClintock 1972, Van Lange 1999, Charness & Rabin 2002). Specifically, the analysis of how these motivations may interact with the individuals' delay discounting (or impatience) will be addressed in the next three chapters.

It is interesting to note, however, that several mechanisms, which can be conceived as selected for competition are used by people to enforce cooperation. In particular, individuals' willingness to punish norm violations by paying a personal cost in order to impose a cost on social offenders (Fehr & Gächter 2002) might involve some of these mechanisms. Coming back to Smith's quotation, violations of fair play usually trigger observers' "*hatred and indignation*" against the offender. Feelings like these are arguably among the mechanisms evolved for competition rather than for cooperation with others. Nevertheless, they can be very powerful when it comes to enforce public cooperation. Given the double-edge character of punishment behavior, it is therefore crucial to know whether costs are imposed with pro-social or anti-social purposes (Herrmann et al. 2008, Rand & Nowak 2011). A relatively simple way to disentangle the two is to explore the behavior of those making use of peer punishment: does the punisher comply with the cooperative norm? I shall address this question especially in Chapters 2, 3 and 5; though this topic is in the core of the whole dissertation.

A behavioral economics approach

During the last decades, behavioral economists have extensively used controlled experimentation with human subjects to investigate social behavior. Indeed, data from experiments has revealed that the traditional economic model of self-interested actors lacks predictive power in a great variety of social situations (e.g., Andreoni 1995, Fehr & Schmidt 1999, Camerer 2003, Gächter & Herrmann 2009, Fehr & Gächter 2002, Henrich et al. 2005, Herrmann et al. 2008). Contrary to theoretical predictions, people, for instance, cooperate with each other in economic experiments without any possibility of future reciprocation (Ledyard 1995) or even invest their resources to punish those who do not cooperate in one-shot encounters (Fehr & Gächter 2002). These results have generated theories of altruism, inequality aversion and strong reciprocity, among others (Fehr & Schmidt 2006). Humans have therefore moved from being considered sheer payoff maximizers to be frequently labeled as pro-social, altruistic or cooperative in this literature. However, more often than not, the competitive, 'dark' side of human social behavior is being neglected. Exceptions of course exist (e.g., Kirchsteiger 1994, Zizzo & Oswald 2001, Abbink et al. 2010, Abbink & Herrmann 2011), but human hyper-competitiveness (Jensen 2010) is without a doubt far less explored than pro-sociality. The research presented in the following chapters provide several insights into both dimensions of social behavior.

In sum, the reader of this dissertation will find behavioral economics research that attempts to answer some of the most puzzling questions regarding human social interactions. First, which are the psychological underpinnings of cooperative and competitive choices? Second, are some individuals more cooperative or competitive than others and, if so, why? Third, if everyone is both cooperative and competitive to some extent, which are the contexts that more likely evoke each type of motivation? Fourth, could different motivations trigger peer punishment and, if so, how can they be disentangled? Of course, this list is by no means meant to be complete (or even totally comprehensive). Like any research effort, this work probably raises more questions than those it attempts to answer. In what follows, I shall briefly outline the content of each chapter, also explaining the dynamic process through which this research has matured and has been subsequently accomplished.

Chapter 2 ("*Patient and impatient punishers of free-riders*") presents the results of an incentivized experiment in which my coauthors and I analyzed the relationship between subjects' delay discounting and their punishment behavior in a one-shot multilateral cooperation game. Previous findings regarding the psychological basis of punishment behavior have been contradictory, and we thought of a possible reason. On the one hand, some authors have argued that the punishment of norm violations results from future-oriented psychological factors linked to far-sighted normative, moral behavior. On the other hand, others have interpreted that punishment is a result of an impulsive, present-oriented reaction against norm violations. Although employing different techniques to analyze such psychological factors, all previous research has been conducted using bilateral bargaining games at which normative and competitive motivations of punishment cannot be easily disentangled. Yet, the prevailing view was (and still is) that punishment is an eminently normative behavior. In examining the correlation between the punishers' delay discounting and their cooperative behavior previous to punishment, however, we found two types of punishers: patient cooperators who punish free-riders and impatient free-riders who punish other free-riders. Thus, our findings indicate that both interpretations suggested so far in the literature can actually be accurate if applied to the right subpopulation of individuals; either the moralistic, future-oriented punishers or the competitive, present-oriented ones.

Given that previous research reveals that impatient subjects are more likely to punish unfair behavior (i.e., to destroy the whole endowment through the rejection of unfair offers) as second movers in an ultimatum bargaining game, these results raised an interesting new question: are impatient punishers in the ultimatum game driven by fairness considerations or instead, as our findings suggested, by spiteful competition? To answer this question we performed a research, the results of which I report in Chapter 3 ("*Delay discounting and spite in bargaining: Beyond strategic self-interest and fairness*"). Specifically, we analyzed data from a large-scale survey-experiment measuring participants' impatience and their behavior in a dual-role ultimatum game. This design allowed us to observe whether those subjects who punish their counterparts' unfair behavior are themselves fair or in contrast are unfair when playing in the other role. The statistical analyses reveal that impatient subjects were i) more likely to punish unfair behavior as second movers (thus replicating previous results) and ii) more unfair themselves as first movers. As a consequence, those interacting with impatient subjects earned on average less money. These new results suggest that the psychological basis of punishment in bilateral bargaining might resemble to some extent the competitive, spiteful punishment by free-riders in multilateral cooperation. The possible coexistence of different types of punishers in the ultimatum game will be dealt with in more detail in Chapter 5.

The findings of the research reported in Chapters 2 and 3 taken together with previous evidence on the relationship between individuals' impatience and their social behavior in one-shot encounters encouraged the building of a theoretical model, which I present in Chapter 4 ("*Competition or cooperation? Now or later?*"). Although still in an early stage, this model is an attempt to open a new avenue in the field of other-regarding preferences. Since cooperative and competitive behaviors have been respectively associated with long-run and short-run proximate motivations, the theory proposes that individuals derive delayed psychological rewards from social gains and immediate psychological rewards from relative gains. Based upon this, the representative individual's utility function has two components: an immediate source of satisfaction derived from her own relative payoff and a delayed source of satisfaction derived from the group´s joint payoff. As a result, patient (impatient) individuals who discount delayed psychological rewards to a lesser (greater) extent will be more willing to cooperate (compete). Contextual factors complete the ingredients of this utility function: individuals are more cooperative when things go right and more competitive when things go wrong. The model is then used to explain several behavioral regularities observed in economic experiments that can be hardly reconciled with narrow self-interest. In particular, the preliminary theoretical results are very satisfactory in explaining our own previous findings.

The studies presented in Chapters 5 and 6 employ a similar methodology. In both cases, we investigated subjects' behavior as second movers in the ultimatum game using the dictator game as an auxiliary tool. As stated earlier, Chapter 5 ("*Don't mix it up: Fairness versus spite in the Ultimatum Game*") is devoted to analyze the coexistence of different types of punishers in the ultimatum game. The results are salient. Across two different large samples, we found clear evidence that rejection of unfair offers in the ultimatum game is mainly driven by two subpopulations of subjects: those who behave themselves entirely fair in the dictator game (by passing exactly half of the endowment to another participant) and those who behave entirely unfair (by keeping it all for themselves). As a result we can conclude that rejection of unfair offers in the ultimatum game is caused by both fairness-oriented and spiteful, competitive individuals. Thus, the mere observation of rejection behavior is not sufficient to unravel the relative importance of each subpopulation. These findings are of particular interest in the light of recent evidence showing that public cooperation can be even discouraged, rather than enforced, in the presence of such spiteful punishers.

Finally, Chapter 6 ("*Accepting zero in the Ultimatum Game: Selfish Nash response?*") puts the focus on those subjects who accept extremely unfair (zero) offers as second movers in the ultimatum game. For a selfish individual, accepting anything is a dominant strategy insofar as it leads to maximize his/her own payoff. Since those individuals who reject unfair offers can be considered as either pro-social (willing to incur a cost in order to punish unfairness) or spiteful (trying to increase their relative standing) one might expect that those who do not reject at all are self-regarding payoff maximizers who simply do not care about others' payoffs. However, in analyzing their behavior in the dictator game we found that those 'non-rejectors' were clearly the most generous individuals within the two samples under scrutiny. We suggest therefore that accepting extremely unfair offers might be a cooperative or altruistic behavior. This seemingly simple finding has however critical implications, in particular when combined with the results of the previous chapter: if both the subjects who reject unfair offers and those who accept them can be pro-social (Chapter 6) and, moreover, the subjects who reject unfair offers can either be pro-social or spiteful (Chapter 5), what is the ultimatum game about? I suggest that the design of the game is too simplified to be used in order to draw conclusions regarding motivations, thus allowing the researchers too many "degrees of freedom".

To sum up, the findings presented in the present dissertation point out that research on human social behavior might benefit from a broader perspective accounting for its 'bright' as well as for its 'dark' sides. Further advances may come from the confrontation between different social preferences, thus pulling back from the view of selfishness as the reference point.

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Chapter 2

Patient and impatient punishers of free-riders[1]

ABSTRACT

Costly punishment of cheaters who contribute little or nothing to a cooperating group has been extensively studied as an effective means to enforce cooperation. The prevailing view is that individuals use punishment to retaliate against transgressions of moral standards like fairness or equity. However, there is much debate regarding the psychological underpinnings of costly punishment. Some authors suggest that costly punishment must be a product of humans' capacity for reasoning, self-control, and long-term planning, while others argue that it is the result of an impulsive, present oriented, emotional drive. Here we explore the inter-temporal preferences of punishers in a multilateral cooperation game and show that both interpretations might be right as we can identify two different types of punishment: punishment of free-riders by cooperators, which is predicted by patience (future orientation) and free-riders' punishment of other free-riders, which is predicted by impatience (present orientation). Therefore, the picture is more complex as punishment by free-riders probably comes not from a reaction against a moral transgression, but instead from a competitive, spiteful drive. Thus, punishment grounded on morals may be related to lasting or delayed psychological incentives, while punishment triggered by competitive desires may be linked to short-run aspirations. These results indicate that the individual's time horizon is relevant for the type of social behavior she opts for. Integrating such differences in inter-temporal preferences and the social behavior of agents might help to achieve a better understanding of how human cooperation and punishment behavior has evolved.

[1] This paper has been published as Espín, A.M., Brañas-Garza, P., Herrmann, B., Gamella, J.F. (2012) Patient and impatient punishers of free-riders. *Proceedings of the Royal Society of London B* 279: 4923-4928.

Introduction

Altruistic (costly) punishment refers to the readiness of humans to punish cheating group members at their own cost, even in one-shot interactions when no clear future returns are available. Such costly sanctions are a powerful instrument for protecting cooperation against exploitation by cheaters and therefore help to sustain high cooperation levels (Yamagishi 1986, Fehr & Gächter 2002, Dawes et al 2007, Herrmann et al. 2008, Henrich et al. 2006, Gächter et al. 2008, Falk et al. 2005, Gächter & Herrmann 2009); a fact which puzzles scientists across the behavioral and biological sciences.

Despite increasing research interest, the mechanisms involved in costly punishment are poorly understood. Costly punishment of free-riders is supposed to be spurred by a moralistic drive to impose norms of fairness (Fehr & Gächter 2002, Dawes et al 2007, Henrich et al. 2006, Falk et al. 2005, Knoch et al. 2006, 2010, Crockett et al. 2008, 2010, Pillutla & Murningham 1996, van't Wout et al. 2006, Sanfey et al. 2003). But, what if the punishing individual is also a free-rider? Free-riders' punishment is unlikely driven by the same moral sentiments. More likely, the punishment by a free-rider could serve a competitive desire to achieve a higher payoff than the other group members even at own absolute cost (Falk et al. 2005, Eldakar et al. 2007, Shinada et al. 2004, Charness & Rabin 2002, Van Lange 1999). Falk et al. (2005) described the different nature of punishment by free-riders versus the punishment by cooperators. Punishment by free-riders is very sensitive to the relative cost of punishment: when no improvement of relative standing is possible, free-riders no longer punish. In contrast, punishment by cooperators is barely influenced by the cost of punishment; as if cooperators were ready to teach cheaters a lesson at any cost, even if this means losing relative standing within the group.

This potentially fundamental difference in motivation must be kept in mind when investigating the possible drivers of punishment decisions. Moralistic punishment of norm-violations is currently interpreted as either a product of humans' capacity for reasoning, self-control, and long-term planning (Knoch et al. 2006, 2010) or, at the opposite extreme, as a result of an impulsive, present-oriented emotional drive (Crockett et al. 2008, 2010, Pillutla & Murningham 1996, van't Wout et al. 2006, Sanfey et al. 2003). However, within the debate on the psychological roots of punishment, the possibility that some punishers (i.e., free-riders or norm-violators) may be guided by non-moralistic motives has not been deeply explored. This paper focuses on the link between the punisher's inter-temporal preferences and the type of costly punishment she opts for and explores whether the two antagonistic forces behind punishment may be partially predicted by this individual characteristic.

The relationship between inter-temporal preferences and punishment behavior has so far only been investigated with the Ultimatum Game (UG). The UG is based on a stake which has to be shared between two individuals according to the proposal of one of them (proposer), which the second player (responder) can accept or reject. If the responder rejects, both players get nothing. Rejection of unfair offers is considered an act of costly fairness-enforcement. In this game, impatient (present-oriented) individuals are more prone to reject low offers (Crockett et al. 2010). This result seems to back other researchers' interpretation that costly punishment is driven by impulsive emotions (Crockett et al. 2008, Pillutla & Murningham 1996, van't Wout et al. 2006, Sanfey et al. 2003). According to this view, an 'irrational' impulse would lead the punisher to disregard the future consequences of punishing norm violations. However, the standard UG does not allow disentangling whether observed behavior is driven by competition on relative outcome—envy in psychological terms—or by moralistic reactions against unfairness since both natures of punishment would result in the rejection of low offers, that is, the same observable behavior (Kirchsteiger 1994). In fact, some challenging neural evidence points to the involvement of self-control and long-term planning in rejection decisions (Knoch et al. 2006, 2010).

We analysed the connection between inter-temporal preferences and the nature of punishment by cooperators and free-riders using a one-shot public good game with punishment (PGP). The PGP makes it easier to disentangle different types of punishers by analyzing their behavior in the cooperation stage previous to punishment. Therefore, it allows determining whether the punishing individuals are in compliance with the norm or not; a dichotomy which has been found to have critical implications for cooperation and its evolution (Herrmann et al. 2008, Gächter & Herrmann 2009, Eldakar et al. 2007, Eldakar & Wilson 2008, Helbing et al. 2010, Rand et al. 2010).

We used a one-shot procedure in order to elicit individuals' behavioral norms when punishing (Henrich et al. 2006). In our PGP, four anonymous players endowed with €10 first decided how much money to contribute to a common group pot. The sum of contributions in the pot was then multiplied by two and shared evenly among the four group members, which incentivized free-riding on others' cooperation. Therefore, although the socially efficient outcome in this game is full cooperation, the Nash equilibrium based on narrowly-defined selfish rationality predicts full defection. The results of the contribution stage were then made public and participants were allowed to reduce other group members' earnings at their own cost (punishment stage). Participants were allowed to spend up to three euros to reduce other group members' earnings, with each euro spent reducing the target player's earnings by three euros. This 1:3 ratio allows punishment to be implemented with competitive as well as moralistic goals. However, a selfish individual would never make use of punishment in our one-shot anonymous setting. We also asked participants how much punishment they expected to receive from the other group members (see Methods).

Individuals' manner of discounting delayed outcomes (i.e., their inter-temporal preferences or impatience) is a stable personal attribute (Kirby 2009) that unambiguously influences many fields of human behavior (Chabris et al. 2008). High delay discounting (DD) measuring the willingness to prefer smaller rewards to larger but more delayed rewards has been related to different scales of impulsivity and to lessened self-control (Kirby & Finch 2010) (however, see Figner et al. 2010) for neural evidence suggesting that self-control and the evaluation of delayed rewards might respond to different psychological processes). As DD can predict inter-temporal decisions (Chabris et al. 2008), it constitutes a helpful method for disentangling whether individuals perceive a given behavioral strategy as linked to early or delayed psychological incentives (see below for a discussion on an alternative interpretation).

We obtained DD functions for each participant through a standard task (Harrison et al. 2002) computing their discounting parameter k from the hyperbolic characterization (Mazur 1987). The parameter k represents the steepness of the discount function. The higher an individual's k, the more she discounts delays and therefore the higher her impatience.

We ran field experiments with 160 participants (mean age 46.8; 64% females) from all walks of life in southern Spain. By means of out-of-lab experiments we expected to attain higher heterogeneity among individuals' discount rates (Andersen et al. 2010). We indeed found important differences in DD among participants (see Supplementary Information (SI) Figure S4). The average k in our sample was 0.759 (±0.034, SEM) in annual terms and related negatively to different income variables as in other field studies (Tanaka et al. 2010), but it was unrelated to individuals' contributions to the public good (SI Table S1). This no-relationship between DD and contributions might result from the incentives to strategically cooperate introduced by punishment (i.e., potential free-riders cooperate in order not to be punished) since others have found that DD and contributions are negatively correlated in one-shot public good games without punishment (Curry et al. 2008) (see SI).

Results

Sixty participants (37.5%) used the sanctioning mechanism at least once. The total amount of money reduced through punishment was €496 (from €2,585 earned by cooperation), with 124 instances of punishment in total (€124 paid by punishers caused a reduction of €372 to the punished group members). In Figure 1 (panel A) we show how the individual's DD and her deviation from other group members' mean contribution (deviation henceforth) impact on her willingness to punish. Individuals contributing more than €1 below the others' mean (i.e., deviation<-1) are included within the "below average" category, those around the others' mean contribution (deviation between -1 and 1) within "average", and high contributors (deviation>+1) within "above average" (same classification as in Gächter & Herrmann 2009). To facilitate visual interpretation, DD is depicted in colors, with k increasing from blue to red. Three categories of DD are constructed, each with 1/3 of the sample. The probability of punishing, $P(p)$, in the vertical axis represents the fraction of individuals using punishment. That is, $P(p)$ captures the proportion of punishers within each category of Figure 1A. Evident differences exist between the punishment patterns of the three DD categories. However, since DD and deviation are continuous variables, the proper method to estimate the existing link is through regression analysis, which also allows controlling for other personal characteristics given the field origin of data. That is, the probability of punishing—whether an individual implements punishment or not—is regressed as a function of the punisher's deviation and *k* (probit regression with robust standard errors clustered at the group level).

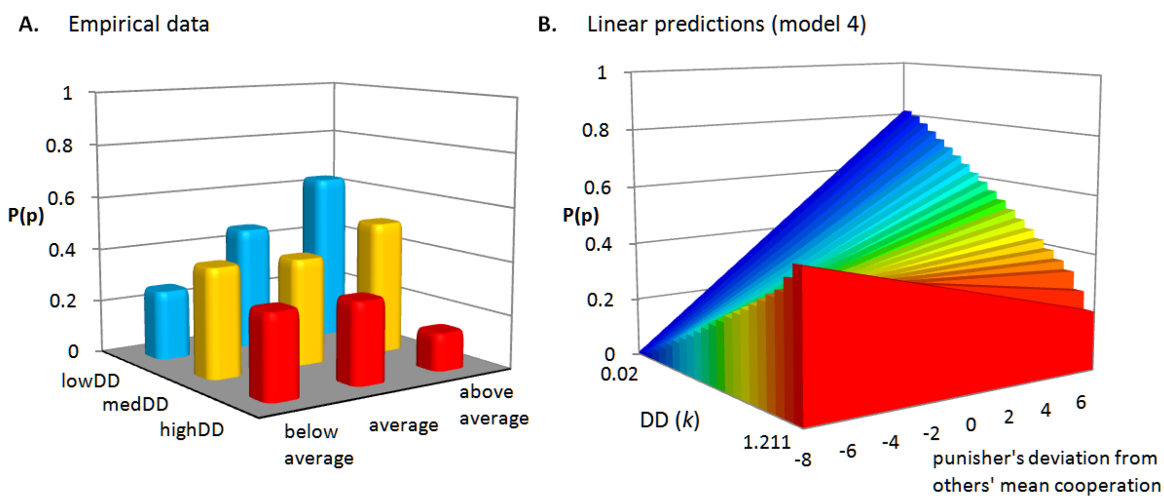

Figure 1. DD, deviation & willingness to punish. This figure shows the willingness to punish (*P(p)*) as a function of the punisher's DD and relative contribution to the public good. Patient punishers are denoted in blue with impatience increasing towards red. **Panel A.** DD is divided into 3 quantiles, each with 1/3 of the sample (low, medium, and high DD), while the punisher's deviation from other group members' mean cooperation is split into three theoretical categories: below average, average, and above average. The number of observations in each category (lowDD, medDD, highDD) are: below average (23, 22, 19), average (13, 10, 13), and above average (19, 20, 21). **Panel B**. The punisher's DD and deviation are plotted as continuous variables impacting on *P(p)* from the specification of model 4 of SI Table S2 (including controls and keeping them at the mean), but using OLS coefficients (SI Table S3). When comparing both panels, it can be observed that the disparities increase as more extreme cases are reached. Although the punisher's deviation theoretically belongs to the interval [-10, +10], in our sample it is reduced to the interval [-8, +6.667]. The 4 extreme values (corners) are (*k*¸ deviation, *P(p)*): (0.02, -8, 0.007), (0.02, +6.667, 0.814), (1.211, -8, 0.489) & (1.211, +6.667, 0.204).

Neither the positive effect of the punisher's deviation (*P*>0.5) nor the negative effect of *k* (*P*>0.1) on *P(p)* reach significance (SI Table S2, model 2), but their interaction does (*P*<0.01) (model 4). The predictions of the model are shown in Figure 1 (panel B). It is notable that the strong positive relationship between deviation and *P(p)* capturing the behavior of low DD subjects reverses its slope as DD moves closer to its highest value. Wald tests reveal that DD is negatively related to *P(p)* for extreme positive deviations (most cooperative individuals) (P<0.01), while for extreme negative deviations (strongly free-riding individuals) the sign of this relationship is positive (P<0.05). In sum, punishment from the cooperative side is carried out by patient individuals, but impatient ones implement punishment when their own contributions are relatively low.

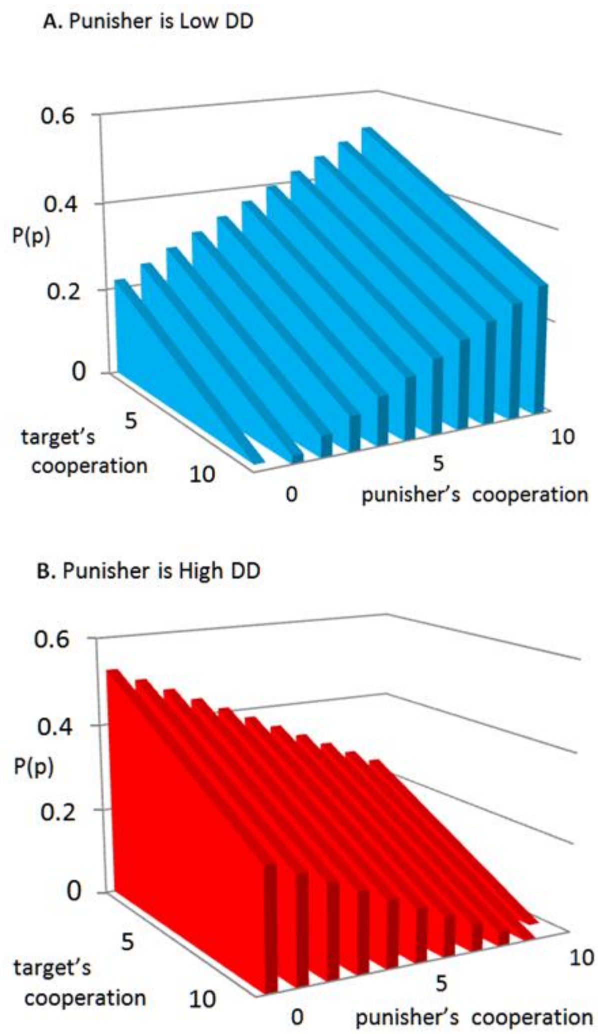

Figure 2. DD, punisher's & target's cooperation. The figure shows linear predictions from model 4 of SI Table S6 (including controls and keeping them at the mean) for the two extreme DD categories of Figure1A. **Panel A** represents the predicted likelihood of low DD (patient) individuals punishing another group member as a function of the contribution level of both the punisher and the target. **Panel B** shows the same predictions for high DD (impatient) individuals. For these plots we use the mean k value within the DD category: 0.2284 and 1.211 for low and high DD, respectively.

The next analysis is to explore who receives the punishment by patient cooperators and impatient free-riders. Figure 2 shows the predicted likelihood of punishing another group member depending on the punisher's and target's absolute cooperative levels (i.e., their raw contributions, from 0 to 10). Two different panels for the low and high categories of DD characterized in Figure 1A are presented. For this model (SI Table S6) we use three observations per subject (one for each partner) with the likelihood of punishing each partner as the dependent variable (robust standard errors are clustered to account for correlation at the individual and group dimensions). The estimate of the interaction effect between the punisher's DD and cooperation is negative and significant ($P<0.01$, model 4), thus supporting the previous result using the deviation variable. The axis in Figure 2 representing the punisher's cooperation shows that low DD, future-oriented individuals (panel A) are more likely to punish the more cooperative they are, whereas high DD, present-oriented individuals (panel B) punish less the more cooperative they are. On the other side, the target's cooperation always impacts negatively on the likelihood of her being punished ($P<0.01$), meaning that lower contributions are more likely to get punished. However, the interaction between the punisher's DD and the target's cooperation is largely insignificant in our model ($P>0.6$). Hence, although free-riding behavior is most likely to receive punishment, looking at the behavior of punishers, it is patient cooperators and impatient free-riders who head the retaliation.

Analyses based on the punishment expected by the subjects reveal that patient and impatient individuals do not have different expectations on what levels of contribution are more likely to get punished (SI Table S5). Also, the scrutiny of the subjects' expectations on punishment suggests that, in the eyes of impatient free-riders, punishing other free-riders seemed to be adequate when it came to fighting for the relative position, to beating the rival. This insight is extracted from the fact that impatient free-riders did not expect to receive a sufficient level of punishment to put at risk the payoff advantage they had over cooperators (see SI).

Discussion

These results indicate that both previous interpretations of costly punishment might be correct if applied to the right sub-population of punishers. Patience is characteristic of cooperators who decide to punish free-riders. Impatience, however, links to the punishment of free-riders by other free-riders. It has been shown that moralistic punishment benefits the society only in the long-run (Gächter et al. 2008). Therefore, given its link with future orientation, it is possible that this kind of punishment is grounded in far-sighted collective motivations. On the other side, the punishment implemented with non-moralistic goals by impatient free-riders seems to be characteristic of aggressive, ultracompetitive behavior, which has been previously found to be related to present orientation (Nelson & Trainor 2007).

In the light of recent research on the role of intuition versus reflection in social decision making (Rand et al. 2012, Schulz et al. in press), one might wonder whether the decisions on punishment are also shaped by intuition. Indeed, impatient responses in DD tasks have also been related to individuals' predisposition to follow their intuitions (Frederick 2005). There might therefore exist an underlying common cognitive process leading individuals to choose sooner-smaller rewards (i.e., being impatient in DD tasks) and to behave intuitively without further deliberation. It would be interesting for future research to analyze response times of free-riders and cooperators when punishing in order to unravel whether our results are only due to individuals' inter-temporal preferences or instead driven by a more basic cognitive process (see Rubinstein 2007, Haidt 2001).

From the results we cannot reject the hypothesis that negative emotions spur moralistic punishment in the PGP but, if any, these must be founded in more far-sighted, pro-social sentiments than mere, self-centered revenge or spite. Given that previous research has found that more impatient responders in the UG are more likely to reject low offers (Crockett et al. 2010), this new evidence also suggests a potential difference between cooperators' punishment in the PGP and responders' rejections in the UG. This possibility should be explored in deeper detail in further research analyzing, for instance, whether impatient responders who reject unfair offers are themselves fair or instead unfair. Indeed, Carpenter (2003) found that subjects with a competitive social value orientation (Van Lange 1999) rather than "fairmen" were responsible for most rejections in his experiments.

Our findings indicate that inter-temporal preferences and social behavior are interrelated with each other in a much more complex fashion than discussed so far. Future research has to elicit the exact role of impulse, habits and reasoning for cooperation and defection (Rand et al. 2012), as well as for punishment and reward decisions. A better understanding of the role of inter-temporal preferences (and their possible context dependence) for shaping social and anti-social behavior of agents might be important to refine our understanding of how human cooperation and punishment behavior has evolved.

Methods

160 inhabitants of small, semi-rural populations (1000-7000 inhabitants) in northern Granada (Andalusia, Spain) were invited to take part in experiments designed to elicit their DD and behavior in a one-shot public good game with punishment. The participants, 103 of whom were female, were aged between 16 and 82 (mean 46.8, ±18.5 SD). The experiments were conducted in five sessions (32 subjects per session) at five different locations. Adapted standard instructions were read aloud and several examples were illustrated on a whiteboard to ensure that the participants understood them. An experienced, Spanish-speaking experimenter conducted all the sessions with an identical protocol (available in Supplementary Information). The show-up fee was €5 and a drink and "tapa" after the experiment.

In the PGP, four anonymous players cooperated by contributing amounts of money from their endowment (€10) to a common pot. The sum of contributions in the pot was multiplied by 2 and evenly shared among the 4 group members. Hence, the individual returns of each monetary unit inside the pot, whatever their cooperative level, were $\alpha=2/4$, meaning that contributing one unit had a cost of $1-\alpha>0$. Thus, every euro invested in cooperation increased the group's earnings by €2, but cost the investor 50 cents.

The participants cooperated simultaneously and were informed ex ante about the possibility of reducing the other group members' payoffs at a personal cost after the results of the first contribution stage had been revealed. The price of punishment was one third of the total reduction in income imposed on the punished subject. Reduction through punishment was limited to a maximum of €9 (i.e., 3 punishment opportunities, without restrictions on their distribution among partners) to rule out negative payoffs. The subjects also had to report their expectations regarding the punishment they would receive from their partners.

For the statistical analyses we used the likelihood of punishing and not the intensity of punishment because the decision to punish and the decision of which amount are intrinsically different (Carpenter & Matthews 2009) and it was our interest to explore what is behind the decision of incurring *any* cost to punish others. Also, the existing limit for the amount of punishment implemented (max. €9) generates dramatically different decisions depending on the distribution of other group members' behaviors and not only on their mean behavior. However, the main results remain similar if we use the intensity of punishment as the dependent variable in the regressions (available upon request from the authors).

The discounting task for measuring participants' inter-temporal preferences was a simplified version of Harrison et al. (2002) involving real monetary incentives with a front-end delay procedure (both the sooner and the later reward are delayed). The task consisted of making 20 decisions on whether to receive €150 one month following the experiment or a higher amount (increasing from €151.50 to €225) after six extra months. The decision card contained a table with two columns (options A and B) and 20 rows. In each row, option A offered €150 to be received one month after the experiment, while option B offered a higher amount to be received seven months later. Thus, option B in the first row offered €151.50 and option B in the twentieth row €225. The participants had to decide between option A and B in each of the 20 rows. The lower amount at which an individual was willing to wait half a year was considered her indifference point (between options A and B). We employed the discounting parameter ($k \in [0.02, 1.211]$) from the hyperbolic characterization (Mazur 1987), calculated at the individual's indifference point, since it is the most commonly accepted functional form among behavioral scientists (see SI Table S7 for analyses based on other discounting functional forms). Data available at http://dx.doi.org/10.5061/dryad.r7c7p.

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Chapter 3

Delay discounting and spite in bargaining: Beyond strategic self-interest and fairness

ABSTRACT

Contrary to the predictions of standard economic models, responders in the ultimatum game (UG) often reject 'unfair', low offers at a cost to themselves, which is considered as a form of costly fairness-enforcement. If the likelihood of a low offer to be turned down is sufficiently high, offering a 'fair', equal split is on the self-interest of proposers. A proposer who, anticipating future punishment, increases her offer might therefore appear as fair when her behavior is just strategically selfish. For responders, self-interest would lead to accept any positive offer, albeit 'unfair'. However, there exist other motives than strategic self-interest and fairness which could lead a proposer to offer a particular split and a responder to accept or reject it. Here we explore the relationship between subjects' delay discounting, a measure of individuals' concern about future events, and their behavior in a large-scale dual-role UG experiment. We find that high discounting (present orientation) predicts low offers as proposer and high rejection rates as responder, which narrows the margin for agreeing with others. This is consistent with high discounting predicting less strategic self-interested behavior. However, high discounters do not have significantly lower expected payoffs but their partners do. Our data suggest that high discounting may relate to spiteful behavior, not to less strategic behavior and that the psychological basis of rejections may resemble the competitive punishment by free-riders in social dilemma games which has been previously found to be implemented by high discounters.

Introduction

The ultimatum game (UG) is an economic experimental set-up widely used to study the nature of human bargaining and the enforcement of fairness norms (Güth et al. 1982, Sanfey et al. 2003, Henrich et al. 2005, 2006). In this game, the first player (the proposer) proposes how to split a sum of money with the second player (the responder). The responder can either accept or reject the proposal. If the proposal is accepted, the pie is divided accordingly; if rejected, neither player is paid. Economic models based on narrow self-interest predict that the responder should accept any positive offer, at least in non-repeated interactions. By backward induction, the proposer should offer the smallest positive amount to the responder, who will accept the deal. However, empirical evidence has consistently contradicted these predictions as responders very often reject 'unfair', albeit positive offers—thus punishing stingy proposers—and most proposers offer 'fair', equal splits (Camerer 2003).

Explaining proposers' generous offers is straightforward from an strategic viewpoint: since a low offer will be likely rejected, it is on the proposer's self-interest to make a high offer to avoid ending empty-handed. Strategic reasoning does not apply, however, to responders' observed behavior if future encounters with the same proposer are unlikely (otherwise, rejections might be used to encourage higher future offers). Most scholars have invoked fairness-based rationales for the appearance of rejections in one-shot interactions: people dislike unfairness—either complex forms like intentional unfairness ("unkindness") (Rabin 1993, Charness & Rabin 2002) or simpler like mere payoff inequality (Fehr & Schmidt 1999, Bolton & Ockenfels 2000). Therefore, the mainstream view is that the UG poses a trade-off between (strategic) self-interest and fairness considerations.

Less attention has been paid however to other motivations like spite, the "ugly twin" of altruism, as a crucial force underlying observed behavior *in both roles* of the UG. For a spiteful individual, others are competitors whose payoffs affect negatively her utility (e.g., Kirschteiger 1994, Levine 1998, see Fehr & Schmidt 2006 for a review).

Anticipation is on the basis of strategic behavior. Anticipation of what others' will do or the future consequences of own decisions are critical elements of choice. Therefore, one might hypothesize that subjects' inter-temporal preferences should correlate to their decisions in the UG if strategic thinking prevails. Delay discounting (DD) is a behavioral measure of individuals' concern about future events (see the reviews by Frederick et al. 2002, Green & Myerson 2004, and Luhmann 2009) with strong predictive power when it comes to explain decisions involving inter-temporal trade-offs (e.g., Kirby et al. 1999, Chabris et al. 2008, Meier & Sprenger 2012). If subjects with a high rate of DD, who are supposed to care less about the future consequences of their decisions, are found to be more stingy proposers and more intolerant responders (i.e., they are more willing to reject low offers) it might imply that DD predicts subjects' ability to make strategic self-interested choices. If this is the case, DD should also relate negatively to the subjects' final payoffs, meaning that high discounters accomplish less adaptive strategies. The finding of Crockett et al. (2010) that responders' DD is positively related to higher rejection rates seems to partially support this hypothesis.

Alternatively, also compatible with the finding of Crockett et al. (2010) it might be that fairness is associated to immediate psychological rewards. Fair outcomes have been shown to activate different areas within the neural circuitry of reward (Tabibnia et al. 2008, de Quervain et al. 2004; see Tabibnia & Lieberman 2007 for a review). It can be the case that the psychological satisfaction triggered by fairness is less delayed or lasting than the satisfaction associated to other outcomes (such as earning some money through the acceptance of a low offer or coercing the other player by means of offering her a low amount). According to this hypothesis, we should expect high DD individuals to be more concerned about fairness in both roles of the game, offering equal, fair splits as proposers and rejecting unequal splits as responders in order to restore fairness.

Finally, Espín et al. (2012) found that high DD is characteristic of free-riders who pay a cost to punish other free-riders in a one-shot public goods game. Punishment by free-riders is considered as motivated by competitive spite (Shinada et al. 2004, Falk et al. 2005, Eldakar et al. 2007, Espín et al. 2012) because it is hardly reconcilable with the moralistic motives that are assumed when it is cooperator who punishes. This finding suggests that competitive, spiteful behavior aimed at increasing the individual's relative standing even at a personal cost might respond to immediate psychological rewards. In fact, it is known that the individuals' payoffs relative to others, rather than in absolute terms, correlate with the activation of reward areas in the cerebral striatum when social interactions take place in competitive frameworks (Fliessbach et al. 2007, Dvash et al. 2010, Bault et al. 2011). In the context of the UG, these hedonic feelings being immediate could lead high DD individuals to behave spitefully in both roles, rejecting unequal splits as responders but also offering unequal splits as proposers. As the reader may notice, the behavioral implications of this hypothesis basically coincide with those of the hypothesis claiming that high DD is related to less adaptive strategic behavior. However, spiteful behavior is not aimed to achieve a particular payoff for the self but instead to reduce others' payoffs, possibly, as a form of coercion or social dominance. Thus, if spite is what triggers decisions of high DD individuals we should observe that subjects' DD relates negatively to the payoff of their interacting partners, not to their own payoff.

Procedures

To test these hypotheses we analyze data from a citywide survey-experiment (see Exadaktylos et al. 2012 for a detailed description) containing a dual-role UG and measuring participants' inter-temporal preferences with standard methods. All participants (N=713 final observations, 386 females) were inhabitants of Granada (Spain)—a representative sample of the city's adult population—and made their experimental decisions anonymously from their own households. Participants' (mathematical) cognitive abilities, risk preferences and extensive socio-economic information were also gauged (see Supporting Information (SI)).

In the discounting task, participants had to state their willingness to wait in order to receive a hypothetical monetary payoff. Decisions in this task were not incentivized with money for technical and logistical reasons. Nevertheless, previous studies have shown that real incentives do not change the distribution of individual responses in DD tasks, neither within nor between subjects (Johnson & Bickel 2002, Lagorio & Madden 2005, Madden et al. 2004). Typically, participants had to choose between sooner-smaller rewards and larger, but more delayed rewards in a series of binary decisions. The larger the delayed amount needed for ‘convincing’ an individual to wait, the higher her DD score—which turns to be a measure of people’s impatience.

Participants completed two complementary DD subtasks with six decisions each: the first involved a one-day wait whereas the second implied a six-month delay. The inter-temporal preferences elicited over these delays will be hereafter referred to as short-run and long-run DD, respectively. This will serve us to check whether DD elicited over different time horizons may result in different associations with behavior. So, the short-run DD was measured by making participants to choose between €5 available “today” and €5+X (X belonging to [€0, €5]) to be received “tomorrow”. For the long-run DD, the six choices were between €150 delayed by one month and €150+X (X belonging to [€0, €100]) delayed by seven months (see SI).

The average number of impatient responses (out of six) was 2.75±0.127 (robust SEM clustered by interviewer to account for dependency between the observations gathered by the same interviewers, leaving a total of 108 independent groups) in the short-run subtask and 3.16±0.087 in the long-run one. Looking at this information, short-run DD data seem to be noisier as, for a 15% smaller average, the standard error is 46% greater than that of the long-run DD measure (see Figure S1 for the distribution of choices in the DD subtasks). The Spearman’s rank order correlation between the number of impatient responses in short-run and long-run subtasks was 0.302 (P=0.000). This far-from-perfect correlation opens a door for the two measures to be actually capturing different psychological constructs and, consequently, having distinct associated behaviors (see SI).

In the UG, participants made decisions as both proposer and responder in random order. The pie to split was €20 (≈$27) and decisions in the responder role were elicited through the strategy method (Mitzkewitz & Nagel 1993). As proposers, they must state which share of the €20 (in 10% increments) they wanted to offer to an anonymous partner. As responders, participants had to choose whether to accept or reject each of the following proposals (proposer’s payoff, responder’s payoff): (€20, €0), (€18, €2), (€16, €4), (€14, €6), (€12, €8), (€10, €10). This allowed the elicitation of each participant’s minimum acceptable offer (MAO). By making the responders to decide in a rather ‘cold’ state we reduce the scope for rejections to be guided by emotional reactivity against the proposer’s actual behavior. Hence, we obtained the strategy profile for each subject consisting of an offer as proposer and a MAO as responder. After making their decisions, participants would be randomly paired in order to calculate the real payoffs according to their chosen strategies and those of their counterpart. Thus, subjects were playing a one-shot, dual-role, simultaneous UG (see Figure S2 for the distribution of choices in the game). One out of every ten participants was randomly selected for real payment (see SI).

Results

Delay discounting and behavior in the ultimatum game

Table 1 presents the estimates for the impact of DD over UG behavioral strategies in columns (1)-(3). Each cell contains estimates from one separate regression with the variable on the top of the column as the dependent variable. In all regressions we control for socio-demographic variables (age, gender, marital status, household income, and educational level), cognitive abilities, risk preferences, and order effects as possible confounding factors. OLS estimates are shown for comparability of coefficients (other regression methods like Tobit or ordered models yield similar main results and are available upon request from the authors). Darker cells identify significant predictors (*p*-values in brackets). Complete regressions can be found in Tables S1-S4.

Different characterizations of DD are presented in rows. The first and second rows are devoted to the effect of short-run and long-run DD, respectively, on the dependent variables. To capture short- and long-run DD we use the number of impatient responses the individual made for each delay (from 0 to 6). In the third row "combined DD" refers to the average of the above DD measures. These three categorizations of DD are normalized to the interval [0, 1] for their use as explanatory variables. Finally, "highDD vs. lowDD", in the fourth row, is a binary variable taking the value 1 if the individual belongs to the top 33% and 0 if belongs to the bottom 33% of the distribution of "combined DD". Observations falling in the central 33% are missing in the analyses using this variable.

Columns (1), (2), and (3) refer respectively to regressions with the individual's offer, MAO, and their difference as dependent variables. This last variable (offer-MAO) will serve us as a measure of the margin of agreement each individual allows: the larger one's offer with respect to one's MAO the more likely to agree with others. All these variables are expressed as fraction of the pie.

dependent vars.:	**offer** (1)	**MAO** (2)	**offer-MAO** (3)	***own payoff*** (4)	***other's payoff*** (5)
short-run DD	-0.0294 (0.157)	0.0428 (0.052)	-0.0722 (0.024)	-0.0115 (0.131)	-0.0252 (0.053)
long-run DD	-0.0324 (0.041)	0.0393 (0.051)	-0.0717 (0.004)	0.0018 (0.785)	-0.0269 (0.009)
combined DD	-0.0437 (0.038)	0.0581 (0.017)	-0.1018 (0.002)	-0.0070 (0.404)	-0.0369 (0.006)
highDD vs. lowDD	-0.0281 (0.052)	0.0431 (0.005)	-0.0711 (0.001)	-0.0069 (0.215)	-0.0231 (0.013)

Table 1. Impact of DD over UG strategies and expected payoffs. Estimated coefficients for different DD characterizations as explanatory variables in rows. Dependent variables are expressed as fraction of the pie. Each estimate refers to a different OLS regression with robust standard errors clustered by interviewer (108 groups) and controlling for age, gender, married, household income, educational level, mathematical cognitive abilities, risk preferences, and order effects. N=713, except for the last row where n=488. P-values are shown in brackets. Darker cells display significant estimates (all $Ps \leq 0.053$). Complete regressions are presented in Tables S1-S4.

As it can be observed, the impact of both short-run and long-run DD on offers (column (1)) is negative, and quantitatively similar, but it only reaches significance in the case of long-run DD. A seemingly additive effect (when including both variables in a single regression their coefficients are still negative but lose significance; not reported) suggests that we will possibly obtain a better picture by combining both measures. In fact, the variable "combined DD" reports a slightly stronger effect on offers. The binary specification of DD yields a similar result. Thus, the effect of DD on offers is negative, though rather small (between 2.8% and 4.4% of the pie). On the other hand, all the estimates of DD are positive and significant when the dependent variable is the individual's MAO (column (2)). Hence, we replicate the finding by Crockett et al. (2010) insofar as more impatient responders are more likely to reject low offers. The effect of DD on MAOs is larger than that on offers but still quite small (between 3.9% and 5.8% of the pie).

Column (3) shows that the above relationships traduce into a relatively strong effect of DD on “offer-MAO”. This means that the margin for agreement shrinks as DD increases. It will therefore be easier to shake hands with a patient individual. Specifically, these effects lie between 7.1% and 10.2% of the pie. In the three previous analyses short-run and long-run DD are associated to the same patterns, and combining the two measures improves the model’s power of fit.

In Figure 1 we show the mean (± robust SEM clustered by interviewer) offer (panel A), MAO (panel B), and offer-MAO (panel C) as a function of DD measures. For visual clarity we categorized individuals in three groups according to their DD and plot offers and MAOs in terms of their deviation from the mean offer (0.462±0.007) and MAO (0.350±0.009). Positive deviations indicate above-average offers or MAOs in each case.

From left to right, separated by dashed lines, the short-run, long-run, and combined DDs appear split in terciles (“low”, “med”, and “high” for the bottom, middle, and top tercile, respectively). While the estimated effects and their significance are obtained through the regression analyses summarized in Table 1, it is clear from Figure 1 that the graphical method leads to an identical conclusion: patient individuals better pave the way for agreement. Specifically, the margin for agreement with lowest discounters virtually doubles that with highest discounters.

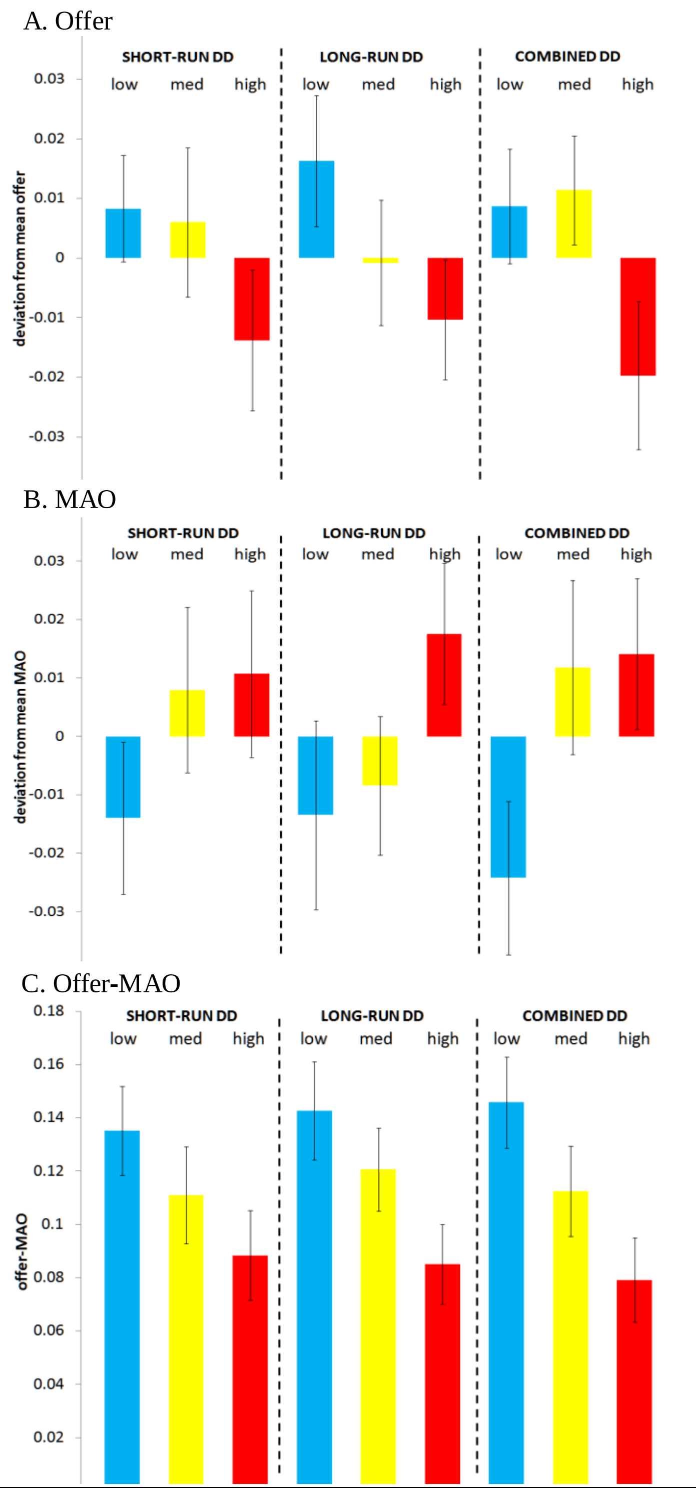

Figure 1. Offer, MAO, and Offer-MAO by DD groups. Mean (±robust SEM clustered by interviewer) offer (panel A), MAO (panel B), and offer-MAO (panel C) by groups of DD. Both offers and MAOs are plotted in terms of their deviation from the mean behavior. From left to right, separated by dashed lines, the short-run, long-run, and combined DD appear split in terciles ("low", "med", and "high" for the 1st, 2nd, and 3rd tercile, respectively).

How does the final outcome relate to individuals' delay discounting?

In the light of the above findings we must reject the hypothesis that high DD is a predictor of individuals' concern for fairness in both roles since the offers made by high DD proposers are more unfair on average. We still have therefore two competing hypotheses which are congruent with the results presented thus far. It can be that high DD predicts either less strategic or more spiteful behavior. To disentangle between these two hypotheses we focus now on the participants' payoffs.

We simulated a perfect random matching between participants—i.e., like a round-robin where everybody plays once against everybody in each role, resulting in 1,424 (712 interacting partners * 2 roles) simulated interactions per subject—and computed their expected (mean) payoffs as a proxy for reproductive fitness. This method will actually give us an appropriate measure for the adaptiveness of the strategies adopted since the probability of matching with each of the other participants across the city was identical. We obtained the expected payoff per interaction of each individual (*own payoff*) and that of her counterparts (*other's payoff*), calculated from the actual distribution of individual strategies in the sample (see SI).

In column (4) of Table 1 we display the estimates for regressions with the expected *own payoff* as the dependent variable, expressed as fraction of the pie. None of the DD specifications result in significant estimates. Thus, according to the simulation analysis we cannot accept the argument that high DD is a predictor of individuals' less adaptive strategic behavior as participants' payoffs were not significantly related to their DD. However, those who interact with high DD individuals do earn less. That is, DD impacts negative and significantly on *other's payoffs* according to all DD specifications (column (5)). The total effect of DD on *other's payoff* range between 2.3% and 3.7% of the pie. Therefore, it appears that high DD predicts spiteful, rather than less strategic, behavior.

If we consider these expected payoffs as a measure for reproductive fitness, the impact of DD on *other's payoff* is non-negligible. The 50th and 99th percentiles of the distribution of *own payoff* are 0.451 and 0.482, hence, a seemingly small 3.1% increase in payoff is sufficient for an individual to promote from the median to the top fitness.

Therefore, the strategies adopted by patient and impatient individuals are equally adaptive but individuals who interact with patient partners will more likely survive than those dealing with impatient ones, even when encounters were sporadic.

In Figure 2, *own payoff* (panel A) and *other's payoff* (panel B) are plotted in terms of their deviation from the mean payoff (0.430±0.003). The same categorizations of DD of Figure 1 are employed. It can be observed that the previous analytic results largely hold when using a visual procedure: the struggle will be more fierce with impatient interacting partners.

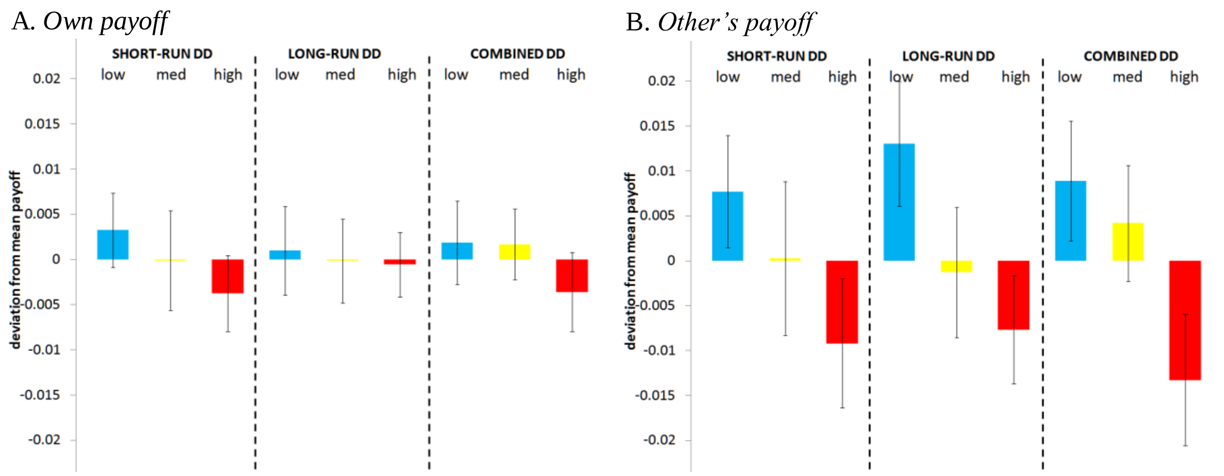

Figure 2. Own and other's payoff by DD groups. Mean (±robust SEM clustered by interviewer) *own payoff* (panel A) and *other's payoff* (panel B) by groups of DD (same groups as in Figure 1). Both own and other's mean payoffs are plotted in terms of their deviation from the mean payoff.

Lastly, we want to highlight an interesting finding that can shed some light on how behavior and payoffs interrelate to each other. Higher cognitive abilities of subjects consistently predict higher *own payoffs* (P=0.009 in the regression using "combined DD"; Table S3, column (4)) even though they also predict higher MAOs (P=0.029; column (2)) and are unrelated to offers (P>0.7; column (1)) and *other's payoff* (P>0.6; column (5)) (see Tables S1-S4). This observation is important insofar as subjects with high cognitive abilities manage to be treated not very 'unfairly' as responders but still achieve high payoffs. Thus, the relationship between behavioral predictors and expected payoffs is not as clear cut as could be presumed since it is the combination of both roles' behavior and the exact distribution of choices in the population which would finally determine the subjects' payoffs.

Discussion

Recently, delay discounting has been proposed as a useful tool to uncover the motivations underlying humans' social behavior. Note that only if an inter-temporal trade-off exists during a specific social interaction, DD can be predictive of its final behavioral outcome. Furthermore, when there is no possibility of future encounters, the existence of an inter-temporal deliberation might entail that the psychological incentives behind one choice or another differ in the moment they are perceived to take place.

In this vein, Espín et al. (2012) showed that high DD predicts the punishment by free-riders in a one-shot public goods game. Since interactions were non-repeated, the authors interpreted that competitive, spiteful behavior (free-riders who punish other free-riders, to outperform them) might respond to immediate feelings. Along the same lines, Crockett et al. (2010) found that high-DD, impatient responders were more likely to reject low offers in a standard UG, where the only information about a responder's strategy is her acceptance or rejection of a number of proposals. Their interpretation was however that promoting long-run material self-interest requires overriding the emotional impulse to punish violations of fairness norms.

Low offers clearly violate fairness norms but, at the same time, they provide the perfect reason for envious or spiteful desires to arise (Kirschteiger 1994, Jensen 2010). Our design, in which subjects play both roles of the UG, allows to disentangle if impatient responders are truly concerned with fairness when rejecting low offers. In our experiment, high DD predicts spiteful strategies in both roles. These spiteful strategies involve the rejection of disadvantageous, 'unfair' splits, but also the proposal of advantageous, 'unfair' splits. As a result, decisions by high discounters do not lead them to earn less—i.e., their strategies are equally adaptive—but condemn those who interact with them to a significantly lower fitness. This is consistent with the view of Marlowe et al. (2011) that hunter-gatherers of smaller societies, supposed to strongly discount the future (Woodburn

1980), show more spiteful behavior in the UG. Present orientation has indeed been related to both aggressive (Nelson & Trainor 2007) and uncooperative (Curry et al. 2008) patterns.

Based upon previous research (Espín et al. 2012), our findings suggest that rejection behavior in the UG might better resemble the spiteful punishment by free-riders, in terms of its psychological foundations, than the 'moralistic' punishment by cooperators (which was found to be implemented by low-DD individuals). In effect, the bargaining, intrinsically conflictive nature of the UG could generate a competitive environment where outperforming the other player is a primary goal (Fliessbach et al 2007, Bault et al. 2011, Dvash et al. 2010). In ultimatum bargaining, both players can make use of their own forces to prevent the other player from achieving her goals, thus offering a natural context for the expression of dominance-seeking behavior, which is deeply rooted in early human cognitive development (Mascaro & Csibra 2012, Thomsen et al. 2011). This would explain why high testosterone levels, usually linked to male-male competition (Mazur & Booth 1998), predict men's spiteful behavior in the UG but not in other, less conflict-like experimental frameworks (Zak et al. 2009).

At least, we can confirm that not all punishers in the UG are in compliance with the cooperative norm of fairness, as it had been shown before in social dilemma games (Herrmann et al. 2008, Gächter & Herrmann 2009, Falk et al. 2005, Shinada et al. 2004, Rand & Nowak 2011). Thus, our results pose important doubts on the interpretation of rejections in the UG as being merely guided by fairness considerations (a pro-social sentiment) and support the presence of competitive spite (a pro-self sentiment) as a key psychological ingredient (Kirschteiger 1994, Carpenter 2003, Jensen 2010).

In social dilemmas, the punishment of free-riders by cooperators is considered a second-order cooperative behavior as it is beneficial for the group (Fehr & Gächter 2002, Gächter et al. 2008), though not for the punisher (Dreber et al. 2008), in the long term. However, both empirical (Herrmann et al. 2008) and theoretical (Rand et al. 2010, Helbing et al. 2010, Rand & Nowak 2011) evidence suggests that, under specific circumstances, spiteful punishment by free-riders may dramatically challenge the norm of cooperation and the long-run social efficiency. Special care has therefore to be taken when using the standard UG as a device to study peer punishment and, on top of that, when building theories on how individuals, institutions or groups enforce the relevant social norms based on results from rejection behavior in this game. Researchers must account that hyper-competitiveness (Jensen 2010) might be as fundamental to the complexity of human social behavior as ultra-sociality (Richerson & Boyd 1998).

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Chapter 4

Competition or cooperation? Now or later?

ABSTRACT

Economic models assuming individuals' narrow self-interest have been proved to poorly predict humans' decisions in many social contexts. Social preferences theorists have proposed several forms of non-selfish motivational forces in order to give explanation, at the proximate level, to individual behaviors observed in both the field and the lab which contradict the canonical axiom of selfish rationality. Behaviors which pure self-interest falls short of explaining include, among others, cooperation, altruistic giving, costly punishment of norm-violations and (spiteful) competition. Here we present an outcome-based theoretical model which focuses on the conflict between cooperation towards social efficiency and competition for the individual relative standing. We propose the trade-off between these two social motivations as being decided through an exclusively inter-temporal deliberation: cooperation is considered to be related to delayed or lasting psychological rewards whereas competition is linked to immediate ones. This implies that patient, future-oriented individuals are more willing to get involved in cooperative affairs while impatient, present-oriented individuals are more likely to succumb to the short-run incentives of competition when joint and relative payoffs are confronted. The theory is then applied to shed light on individuals' decisions in different games used in experimental research with humans and, when available, existing evidence on the relationship between game play and inter-temporal preferences is addressed. Our model also brings a novel approach to egoistic, altruistic and spiteful preferences, by making their interaction to rely on the individuals' inter-temporal preferences and contextual factors.

Introduction

The mechanisms involved in social cognition develop conditioned by the confrontation between competitive and cooperative aspirations. Cooperation with other group members favors the long-run stability of resources (Rachlin 2002). Competition between group members can, however, put such future stability at risk (Hamilton 1970). Such a risk would emerge when competitors are even willing to destroy potential resources if this leads to increasing their own relative standing (i.e., spiteful competition). On the other hand, cooperators sometimes have to sacrifice their own relative standing for benefitting the group and the long-run stability of its resources.

Belonging to a powerful group means that the likelihood of outperforming other groups increases. This would spur a conflict between cooperative and competitive aspirations to arise. In few words, if you put effort in making your group to be powerful, then, other groups would not outperform it but maybe your group partners outperform you. However, if you try to outperform your group partners maybe other, more powerful groups will outperform your group. Social interactions like team works or sports are plenty of decisions involving such a trade-off.

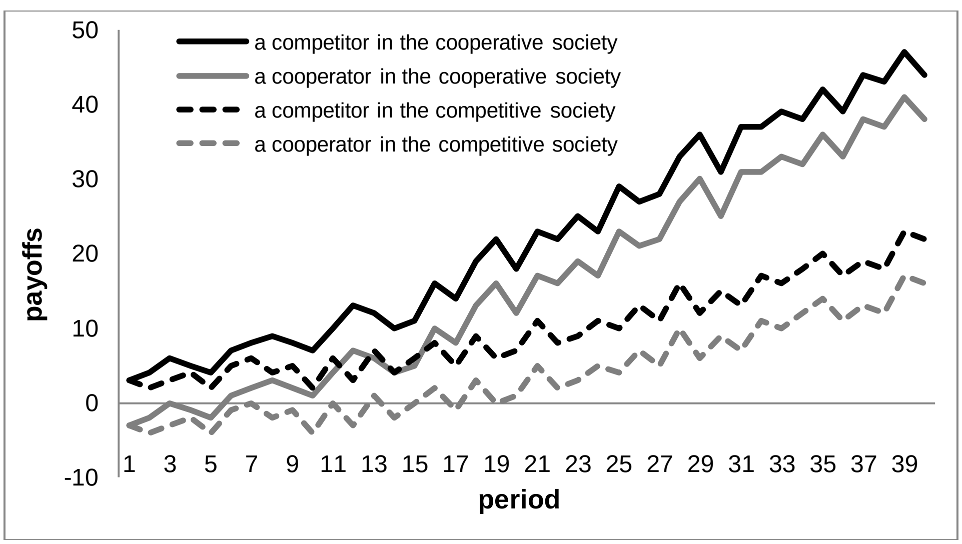

Figure 1. Illustration of the dynamic trade-off between competition and cooperation. Competitive individuals' payoffs overcome cooperative individuals' payoffs in the short-run both within and across societies. However, in the long-run the payoffs of cooperators from a cooperative society overcome those of the competitors from a competitive society.

How this dynamic trade-off works is illustrated in Figure 1. A given society (or group), called the *cooperative society* (continuous lines), is mainly composed of cooperative individuals who aim to increase the societal payoffs even sacrificing their own relative standing. In the *competitive society* (dashed lines), however, the majority of individuals are competitors aimed at increasing their relative standing within their own society even if this requires spiteful acts like the destruction of others' resources. Nonetheless, there are cooperative (light lines) and competitive (dark lines) individuals living in both societies. If both societies start with identical resources, in the first periods being competitive is more profitable than being cooperative, regardless of the society where an individual lives. The ranks are clear as competitive individuals' payoffs are above those of cooperative individuals across as well as within societies in the short-run. However, while acting competitively leads to increases of relative standing within the own society, the existence of too many competitors can destroy the potential social achievements in the long-run. As a result, after some periods the payoffs of cooperative individuals who live in the *cooperative society* might overcome those of competitive individuals from the *competitive society*. This would trigger an inter-temporal conflict between competition and cooperation.

Neural evidence suggests that cooperation with conspecifics is in itself psychologically rewarding for humans (Rilling et al. 2002, 2004, Decety et al. 2004; see Tabibnia & Lieberman 2007 for a review), but also that people's satisfaction, as measured by striatal activation, relates better to individuals' payoffs compared to 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). Moreover, it has been shown that separate areas in the cerebral cortex encode the trade-off of competition versus 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). These areas within the striatum and the cerebral cortex 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 (McClure et al. 2004, 2007, Hariri et al. 2006, Roesch et al. 2006, Kable & Glimcher 2007, Ballard & Knutson 2009, Cai et al. 2011, Sellitto et al. 2011).

Although other-regarding (social) preferences have been recently introduced into the toolkit of economists and behavioral scientists (see Fehr & Schmidt 2006 and Cooper & Kagel 2012 for reviews), from the point of view of economic theory, few attempts have been made towards the explicit understanding of cooperation and competition as, very often opposed, motivational forces.[1] Among the utility functions proposed by social preferences theorists to explain observed behaviors that contradict narrow self-interest, some are indeed capable to capture individuals' concerns for both social efficiency and relative standing (see, e.g, Charness & Rabin 2002). However, these two motives are typically not featured as unique driving forces. Here, we aim to contribute to fill this gap. Social value orientation theories by social psychologists (see e.g., McClintock 1972, Van Lange et al. 1997, Van Lange 1999, Rose and Colman 2007) are conceptually closer to our view insofar as they ground on people's pure distributional preferences and confront social efficiency with relative standing, that is, cooperation (often referred to as "prosociality") with competition.

The main statement of this paper is that humans identify competition with short-run psychological incentives and cooperation with more delayed aspirations, and behave accordingly. We argue that, for any given distribution of other-regarding preferences in society, individuals discounting future events in a steeper manner ('impatient' individuals) would put more weight on competition when it is confronted with cooperation. Impatient individuals would not be able to sufficiently value the potential benefits from cooperation (Axelrod 1984, Stevens & Hauser 2004, Stevens 2009), hence would be less likely to commit themselves towards cooperative, pro-social behavior (Rachlin 2002, Frank 1992), and as a result they would prefer competing for their relative standing within the group, which relates to short-run satisfaction.

Individuals' inter-temporal preferences, or time discounting, have been demonstrated as temporarily stable as personality traits (Kirby 2009) and genetically determined to some

[1] A possible exception can be found in the economic 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 almost exclusively focus on market outcomes, industrial organization and the management of firms.

extent (Anokhin et al. 2011, Gianotti et al. 2012). Supporting our viewpoint, there is indeed evidence linking patience (sometimes termed as future orientation or self-control; although we shall not use the latter term since neural differences between self-control and inter-temporal preferences have been recently suggested (Figner et al. 2010)) to cooperativeness in non-repeated encounters (Curry et al. 2008), and also linking impatience (present orientation) to sporadic aggressive, ultracompetitive behavior (Nelson & Trainor 2007).

As explained above, the motivational trade-off we want to move toward is not the traditional conflict of cooperation versus pure, narrowly-defined egoism (e.g., Rapoport & Chammah 1965, Axelrod 1984, Rachlin 2002, Frank 1992), but versus competition, a different aspect of pro-self—although other-regarding—preferences which sometimes contradicts pure egoism (Charness & Rabin 2002, Van Lange 1999). In fact, some degree of egoism is implicitly entailed by both long-run, cooperative and short-run, competitive aspirations as defined here.

The individual therefore wants to maximize both the short-term satisfaction associated with her own relative payoff and the long-term satisfaction associated with the group's joint payoff. The willingness to maximize joint payoffs has also been proposed as a basic principle of collective preferences (i.e., the maximization of group's utility, not of an individual utility taking into account group's payoffs as we propose here; see Colman et al. 2008 for a game-theoretic discussion on the differences between these two approaches) which are crucial in team reasoning (Sudgen 1993, Gilbert 1994, Dawes et al. 1990, Bacharach 2006, Rose & Colman 2007). Thus, roughly speaking, the individual wishes to be the best player within the best possible team. This is not to say that the behavioral motivations are considered as self-interested at the proximate level, but actually competitive and cooperative. Nevertheless, self-interest could be still considered a likely ultimate cause, for instance, at the gene level (Dawkins 1976)—i.e., humans, as ultra-social animals, have developed mechanisms, like ability for communication, patience, capacity of "mentalizing" or empathy, which were selected because of making them better competitors or cooperators, depending on the needs of the social context (Jensen 2010, Herrmann et al. 2007, Decety et al. 2004, Adolphs 1999). Thus, our theory tries to give an explanation at the proximate level, that is, what is perceived by the decision-maker.

Assuming the above statements we develop a two-component model where the psychological rewards linked to cooperation are perceived by the individuals as delayed (i.e., they are anticipated). For the other component, we assume that individuals perceive the satisfaction associated to competition as immediate (or, at least, less delayed than that associated to cooperation). Thus, while both kinds of rewards could be desirable for everyone to some extent, patient individuals who weigh distant rewards more heavily would be also more likely to behave cooperatively even if encounters are sporadic. Impatient individuals, instead, would more likely compete when both motivations are confronted. These intrinsic motivations and the behaviors they trigger are therefore considered rational insofar as individuals respond to the maximization of their psychological satisfaction (Fehr & Schmidt 2006).

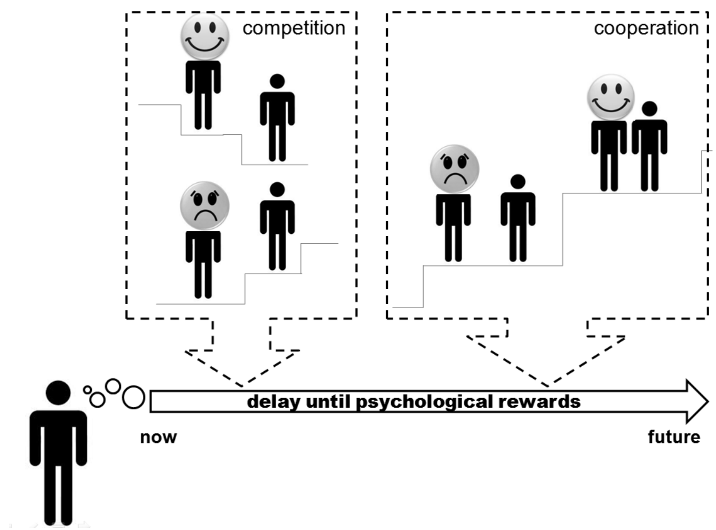

Figure 2. Deciding between competition and cooperation. Our model states that the psychological rewards which individuals associate to cooperation are more delayed than those associated to competition. Short-run satisfaction relates to the individual's relative payoff (competition) while long-run satisfaction relates to the joint payoff (cooperation).

Figure 2 illustrates how we model the psychological rewards associated to competition and cooperation during social encounters. The decision-maker evaluates whether to act competitively or cooperatively towards his partner. For his evaluation, he attaches different subjective values to the relative and joint payoffs. The relative payoff (the competitive outcome on the left-hand side) yields a psychological incentive which takes place in the short-term. Instead, the joint payoff (the cooperative outcome on the right-hand side) impacts on his long-term utility. Note that the long-term character of the cooperative incentives does not necessarily entail that these rewards are emerging later. Instead, their effects might be simply more lasting and spread over a longer period.

In the way we present them, social preferences may be interpreted similarly to the behavioral habits (a view partially supported by Cornelissen et al. 2011, Schulz et al. 2012, and Rand et al. 2012), which are automatic and less flexible than the goal-directed behavior guided by conscious processes (Bargh 1989, 1990, Aarts & Dijksterhuis 2000). Past experience becomes the crucial parameter for the development of stable habits and reasonably also of social preferences (Van Lange et al. 1997). The way of acquiring such predispositions involves previous learning in similar situations that generates automatic associations between contexts and behaviors (Ouellette & Wood 1998). In terms of the focus of this paper, past experience would develop mental schemas linking competition and cooperation to present and future psychological rewards, respectively. Thus, the most likely intuitive response for future-oriented people when faced with a conflict like that suggested here would be to cooperate whereas for present-oriented people it would be to compete.

We procure an agnostic point of view regarding how the distribution of social preferences among the population should be and focus only in what can be explained by the trade-off of competition versus cooperation, now versus later. We even assume equal weight for these two components on the individual's satisfaction, which does not need to be necessarily the case. In this way, other theories on social preferences (e.g., Kirschteiger 1994, Levine 1998, Fehr & Schmidt 1999, Bolton & Ockenfels 2000, Charness & Rabin 2002) can be adapted into our model by integrating the appropriate parameters. For instance, Deng and Chu (2011) employ a similar utility specification to the one presented here—not involving discounting though—and incorporate one parameter, *k*, ranging from -1 to +1, which represents the competitive or cooperative[2] character of the individual (i.e., her social value orientation). It is not our intention therefore to validate or invalidate any of

[2] In fact, Deng and Chu (2011) is the only theoretical model we know which has explicitly proposed the cooperative and competitive concerns of individuals as their main motivations.

these models but to suggest that there is no reason to think that the psychological rewards associated to different social outcomes necessarily spread over identical periods. Consequently, our view entails that temporal discounting could be a potent instrument for the study of social preferences.

The intent of our theory is 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) in the analyses—although could be adapted to the framework as well. Despite of 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 tons of 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 canonical axiom of selfish rationality. We elucidate the theoretical conditions under which individuals, for instance, reject 'unfair' offers in an ultimatum game or cooperate in a one-shot social dilemma game. Recent evidence on the relationship between individuals' game play and their inter-temporal preferences is also assessed throughout the paper. However, a calibration of the model parameters is beyond the scope of this paper—which purely aims to bring a theory of inter-temporal conflicts between psychological rewards into the lively debate on human social preferences—and is left for future developments.

The utility function: Two sources of satisfaction

In our model the individual satisfaction covers two periods capturing the short- and long-run psychological incentives linked to competition and cooperation, respectively. 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 (Kable & Glimcher 2007, McClure et al. 2004, Figner et al. 2010, Harrison et al. 2002, Andersen et al. 2008, Ainslie 1992, Ainslie 2012; see Frederick et al. 2002 and Green & Myerson 2004 for reviews).

In abstract terms, individuals perceive that cooperation means something similar to accumulating group's resources for the future (i.e., keeping the team working), which would be higher the higher the total group's resources available in the present.[3] One parameter, $\gamma \geq 0$, is introduced to capture the perceived variation of available resources from the present to the future. γ can be expressed as $1+g$, where g is the growth rate of resources. We assume γ to be constant across individuals in each environment as it is considered an intrinsic feature of the specific social context. So, this parameter is exogenous to the individual and may change across environments. This allows the existence of a context-dependent component of perceived cooperativeness (McClintock 1972, Rose & Colman 2007). The total value of these perceived future joint resources is discounted with factor $\delta \in [0, 1]$, which captures patience and can vary among individuals, to obtain the present value of the cooperative source of psychological satisfaction. According to both exponential and hyperbolic standard forms of discounting the discount factor for a one-period delay can be characterized as $\frac{1}{1+r}$, with r being the discount rate.

For the competitive component, the individual's satisfaction source, related to her linear relative payoff, is not delayed but immediate. Individuals derive a psychological benefit (cost) whenever their present payoff is higher (lower) than that of their counterparts.

Being x_{it} the individual i's material payoff in period t and X_t the payoff matrix of the n group members in period t, the individual i's utility function is defined as:

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

We assume $x_{jt+1} = \gamma x_{jt}$, $\forall j = 1, \dots n$, with $\gamma \geq 0$. Thus, in period t the individual i will choose an strategy so as to maximize:

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

[3] Note that we do not try to say that encounters with the same group partners are repeated or that individuals mistakenly behave as if this were the case (as suggested for instance by Binmore 1998), but instead that the satisfaction extracted from cooperation is related to delayed or lasting psychological rewards which individuals can anticipate. However, the likelihood of a new encounter can be added to our model, which would of course alter the differential weight that the decision-maker gives to cooperative and competitive achievements.

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

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

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

This last transformation of the model is worthy of note because it captures two components largely discussed in existing theoretical approximations to social preferences (e.g., Ledyard 1995, Levine 1998, Kirschteiger 1994, Bolton 1991). To simplify, we will refer to this specification as the "transformed utility" throughout the paper. The first component is entirely egoistic (individualistic in terms of social value orientation): the individual i wants her present and (perceived) future resources to be as large as possible. The second component is purely other-regarding. It implies that the individual i would be altruistic (i.e., others' average payoff affects positively her utility, $\frac{\partial U_i}{\partial \bar{x}_j} > 0$) if $\delta_i\gamma > 1$ (thus, $\delta_i > 1/\gamma$). The individual i would be indifferent to others' payoffs, and her utility would be given exclusively by nx_{it}, if $\delta_i\gamma = 1$. Lastly, the individual i would be spiteful (i.e., others' average payoff affects negatively her utility) if $\delta_i\gamma < 1$. For any given γ, therefore, more patient individuals are more likely to be altruistic and consequently less likely to be spiteful. Note however that altruism requires at least that $\gamma > 1$ since $\delta_i \in [0, 1]$ and this implies $\sum_{j=1}^{n} x_{jt+1} > \sum_{j=1}^{n} x_{jt}$. That is, for the individual i to be altruistic the total group's 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, g, should be greater (smaller) than the discount rate of the individual i, r_i, for her to be altruistic (spiteful). In the case the individual's discount rate equals the growth rate of resources, she would be indifferent to others' payoffs; i.e., egoistic. Thus, altruism or spitefulness are not intrinsic characteristic of the individuals but, instead, a result of the interaction between individual (patience, δ_i) and contextual (γ) factors. For instance, if resources are perceived to shrink with time in a specific context ($\gamma < 1$ or $g < 0$) then all individuals, as in some sort of "no-future", survival situation, would be spiteful regardless of their patience.

It is appealing pointing out the implications of the model for the individuals' preferred group size. The utility attached to competitive and cooperative aspirations is purposely not normalized to the size of the reference group for letting group size have an impact on utility because the amplitude the own social network has been proved to affect people's satisfaction (Fowler et al. 2008). In this vein, individuals will prefer larger groups if $\frac{\partial U_i}{\partial n} \geq 0$, that is, $x_{it} + \bar{x}_{jt}(\delta_i\gamma - 1) \geq 0$. This implies that non-spiteful individuals[4] (i.e., $\delta_i\gamma \geq 1$) will be always happier in bigger groups except in cases where they, their partners or both face sufficiently large loses. For the case in which payoffs are positive this last inequality does not necessarily hold for spiteful types. In fact, they should not be in a very low relative position within the reference group in order to enjoy others being around. A completely impatient individual (δ_i = 0), as extreme case, would like belonging to large groups only if her payoff overcomes the others' average payoff (i.e., the individual is in an advantageous relative position) but would prefer being alone, if possible, just to avoid falling below others.

Applying the theory to games[5]

The ultimatum game

In the ultimatum game (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 be thus (x_p, x_r) = (1-α, α) in case of acceptance. However, if the responder rejects the offer, both players would end empty-handed. The UG has been widely used to study negotiations and reciprocal fairness across as well as within cultures (Güth et al. 1982, Henrich et al. 2005, 2006, Camerer 2003).

The utility associated by the proposer to any implemented (not rejected) split is:

[4] Remember that being altruist/spiteful is not a stable characteristic of the individual, but it depends on the context. However, we use the term "altruist/spiteful individuals" for simplicity.

[5] It is important to note 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.

$U_p = 1 - 2\alpha + \delta_p \gamma$

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

$U_r = 2\alpha - 1 + \delta_r \gamma$

Since a rejection shrinks both players' resources to zero, it leads to zero-utility 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 $U_i(\alpha) \geq 0,\ \forall i = p, r$.[6]

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:

$\alpha \leq \min\left\{1 - \frac{1-\delta_p\gamma}{2}, 1\right\}$

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:

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

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. Therefore, impatient proposers should offer a smaller fraction of the pie than patient ones, *ceteris paribus*. As the most extreme case again, 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

[6] 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 and, when this fact has important theoretical implications these are pointed out in the text.

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 spiteful peers, meaning that the margin for agreement (i.e., the space where an agreement can take place) would increase along with patience. Figure 3 displays the relationship between individuals' patience and the lower/upper bounds for proposals in two different cases, namely γ = 0.5 and γ = 2.

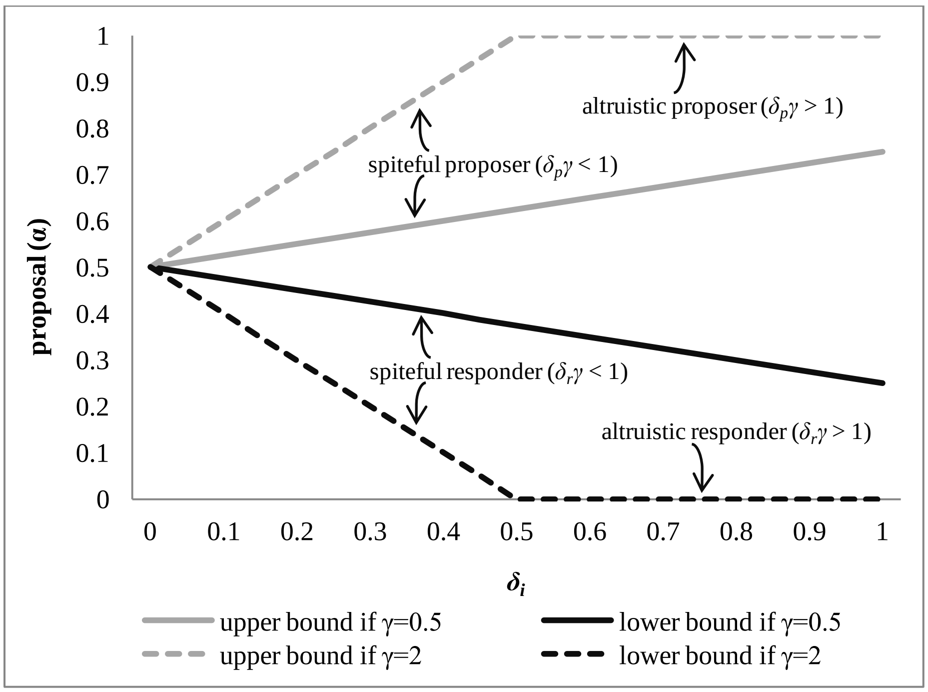

Figure 3. Relationship between individuals' patience and UG outcomes. In case γ = 0.5 (continuous lines) all individuals are spiteful: for its final implementation, the proposal should be exactly 50% if both players are extremely impatient and belong to [25%, 75%] if both players are extremely patient. 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.

Both a negative relationship of patience with the willingness to reject low offers as responders (Crockett et al. 2010, Espín et al. 2012b) and a positive relationship with the fraction offered as proposers (Espín et al. 2012b) have been indeed reported in UG experiments measuring participants' inter-temporal preferences. As a result, individuals' absolute payoffs in the UG, after playing in both roles, do not significantly relate to their patience but their relative payoffs do: patient (impatient) individuals get on average a smaller (greater) share of the pie than their partners (Espín et al. 2012b).

It is interesting that, based on the transformed utility specification, 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.[7] However the share of 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 (and egoism).

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% (Henrich et al. 2005, Camerer 2003, Oosterbeek et al. 2004). These findings can 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).[8] 'Fairness' would thus emerge uniquely driven by the avoidance of spiteful responders' rejections, and not as an intrinsic motivational force as proposed in previous

[7] Nonetheless, 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 $\alpha > 0$.

[8] 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.

models on social preferences (Bolton & Ockenfels 2000, Fehr & Schmidt 1999, Charness & Rabin 2002, Rabin 1993). Rejections 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 (Kirschteiger 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 observation by de Oliveira and Eckel (2012) who, in light of recent empirical evidence, suggest that the acceptance zero-offers could be a symptom of generous, altruistic behavior.

Further developments of the ultimatum game can be found in Extensions, section E1.

The dictator game

The dictator game (DG) is an adaptation of the UG in which responders have no possibility to reject the proposed split (Forsythe et al. 1994). For this reason the first player is called dictator, instead of proposer, and the second player is often called recipient (or receiver), instead of responder. This game is mainly used as a measure of individuals' altruism[9] or generosity (e.g., Henrich et al. 2005, 2006; see the meta-analysis of Engel 2011).

According to our model, the utility of the dictator and the recipient in the DG are identical to the proposer's and the responder's ones, respectively, when a proposal is implemented in the UG. However, since there is no possibility of shrinking the pie through rejection, the total resources are constant and therefore competitive and cooperative aspirations, as defined here, are not confronted in this game. As, moreover, the recipient's payoff impacts negatively on the dictator's utility, our model predicts zero-offers in the DG. Thus, patience cannot predict the behavior of dictators (and recipients are passive). However, the same upper and lower bounds obtained in the UG, for α to be implemented, hold in the DG as well, but now for the individual to be better-off with the outcome of the

[9] Although an straightforward association of dictator's positive offers to altruism has some theoretical caveats: a simple linear model of altruism—e.g., $U_i(X) = x_i + \sigma_i x_j$, with σ_i measuring the individual i's altruism (spitefulness if $\sigma_i < 0$)—would require the improbable condition of individuals being more concerned with the others' payoffs than with their own payoff (i.e., $\sigma_i > 1$) in order to support the existence of positive offers in the DG (furthermore, for $\sigma_i > 1$ the dictator would offer the whole pie to the recipient). The existence of generous offers would require concavity of the altruistic utility function. This is triggered by the zero-sum character of the DG.

game than not participating in it. Completely impatient individuals would be willing to participate only if they are going to get at least 50% of the pie. Therefore, if a completely impatient individual's payoff falls short of that of her partner, she would feel a disutility even when receiving a positive amount. Patient (actually, altruistic) individuals would however participate in the DG even to get nothing. To the best of our knowledge, no study has analyzed the link between discounting and behavior in the DG. Nevertheless, our model predicts that, *ceteris paribus*, offers in the DG must be smaller than in the UG, which is supported by experimental results in most subject pools scrutinized (Camerer 2003).

Further developments of the dictator game can be found in Extensions, section E2.

The social dilemma games

Social dilemmas are defined as those situations in which individual and collective interests are confronted. The most commonly used games are the two-player, prisoner's dilemma and the n-player, public goods game.

The prisoner's dilemma game

The prisoner's dilemma (PD) is a two-player game extensively employed to study cooperation between individuals (Axelrod 1984, Rapoport & Chammah 1965, 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) for a joint enterprise. Cooperation means incurring a cost, c, in order to generate a benefit, $b > c$, for the pair which will be shared evenly between both players, regardless of their cooperative level.[10] Since $b > c$, cooperation means maximizing the total resources, as defined here, and defection is competitive as far 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 $b = 2c$, narrowly-defined 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

[10] Some authors define the benefits from cooperation as being received only by the cooperator's counterpart and not by both players (e.g., Deng and Chu 2011). Such a definition is also compatible with our model and its main implications.

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 seems to be an excellent candidate for the study of cooperative and competitive motivational forces. The 2x2 payoff matrix with the material payoffs associated to the different possible outcomes in the PD is displayed in Table 1A. 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.

	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)

Thus, for the individual *i* to be willing to cooperate, cooperation must represent a non-dominated strategy.[11] For whatever the other player's decision, the utility from cooperation must not be smaller than the utility from defection. That is, the individual *i*'s utility must satisfy:

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

if the other player defects and

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

if the other player cooperates.

Since both inequalities are equivalent, we end up in a unique (necessary; as for sufficiency we require strict inequality) condition for player *i* to cooperate which is:

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

[11] Again, 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 the strict dominance case one has only to replace ≥ by > in next inequalities.

The public goods game

The public goods game (PGG) is the *n*-person version of the PD and 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 PGG can be therefore considered as the generalized case of the social dilemma games. 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. As in the PD, we need $b > c$ for cooperation to be confronted with competition. The restriction for cooperation to be opposed to strict self-interest (and so making the PGG a social dilemma, strictly defined) is $b < nc$. The individual *i*'s payoffs are given by the following equation:

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

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

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

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

The individual *i*'s utility is therefore defined by:

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

Note that the transformed utility function is more useful for simplicity here than the original specification since the other group members' individual payoffs are not known but their average payoff is easily computable. Simplifying, we obtain:

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

Table 2A shows the payoff matrix of the PGG. Player 1's payoffs are on the left hand, while the average payoffs of the other group members, different from player 1, are on the right hand. Table 2B shows the utility associated to the game outcomes for player 1.

	$m_1 = 1$	…	…	..	$m_1 = 0$
$g_1 = 1$	b-c, b-c	…	$\frac{b(m_1(n-1)+1)}{n} - c,\ \frac{b(m_1(n-1)+1)}{n} - m_1 c$	…	$\frac{b}{n} - c,\ \frac{b}{n}$
…	…	…	…	…	…
…	$\frac{b(n-1+g_1)}{n} - g_1 c,\ \frac{b(n-1+g_1)}{n} - c$	…	$\frac{b(m_1(n-1)+g_1)}{n} - g_1 c,\ \frac{b(m_1(n-1)+g_1)}{n} - m_1 c$	…	$\frac{bg_1}{n} - g_1 c,\ \frac{bg_1}{n}$
…	…	…	…	…	…
$g_1 = 0$	$\frac{b(n-1)}{n},\ \frac{b(n-1)}{n} - c$	…	$\frac{bm_1(n-1)}{n},\ \frac{bm_1(n-1)}{n} - m_1 c$	…	0, 0

Table 2A. Material payoffs in the PGG

	$m_1 = 1$	…	…	…	$m_1 = 0$
$g_1 = 1$	$n\delta_1\gamma$(b-c)	…	$\delta_1\gamma b(m_1(n-1)+1) - c((1-m_1)(n-1+\delta_1\gamma) + n\delta_1\gamma m_1)$	…	$\delta_1\gamma b - c(n-1+\delta_1\gamma)$
…	…	…	…	…	…
…	$\delta_1\gamma b(n-1+g_1) - c((g_1-1)(n-1+\delta_1\gamma) + n\delta_1\gamma)$	…	$\delta_1\gamma b(m_1(n-1)+g_1) - c((g_1-m_1)(n-1+\delta_1\gamma) + n\delta_1\gamma m_1)$	…	$g_1(\delta_1\gamma b - c(n-1+\delta_1\gamma))$
…	…	…	…	…	…
$g_1 = 0$	$\delta_1\gamma b(n-1) - c(1-n+\delta_1\gamma(n-1))$	…	$\delta_1\gamma b m_1(n-1) - cm_1(1-n+\delta_1\gamma(n-1))$	…	0

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

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

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

Hence, in social dilemma games, 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., the 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. This means that defection when $b > nc$ is an unequivocal symptom of spitefulness since egoists and altruists would always cooperate under these conditions.

Therefore, individual's enough patience is always required as a necessary condition for cooperation. Of course, the higher is the relative benefit of cooperation, b/c, and the higher is γ, then, the lower is the patience needed for preferring cooperation over defection and consequently more subjects would cooperate. Also, *ceteris paribus*, less individuals would be willing to cooperate in bigger groups because the same benefit, b, has to be shared among more individuals.

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 (Stevens & Hauser 2004, Ledyard 1995, Camerer 2003). 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.

It must be highlighted that humans are often characterized as being conditionally cooperative to some extent (Fischbacher et al. 2001, Brandts & Schram 2001, Kocher et al. 2008, Frey & Meier 2004, Herrmann & Thöni 2009). That is, people more likely 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 the total group's payoffs as having increasing returns to scale on utility. For instance, γ can be defined as increasing with the proportion of cooperators in the group or we can introduce $(\sum_{j=1}^{n} x_{jt})^{r}$, with $r > 1$ (with special care, of course, on the treatment of negative payoffs if using non-integer or even values for r), 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 the 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. However, it is not the aim of this paper dwell into potential modifications of the model which can capture more sophisticated behaviors such as conditional cooperation.

When peer-punishment is possible

What if 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 & Gachter 2002, Ostrom et al. 1992, Herrmann et al. 2008, Gachter et al. 2008). 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 & Gachter 2002). Among the mechanisms proposed to enforce cooperation, costly punishment has concentrated an important share of the scientists' attention (see Gachter & Herrmann 2009 for a review).

The possibility of peer-punishment is typically introduced following a social dilemma, cooperation stage (see e.g., Dreber et al. 2008 for another frequently used 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 a common assumption and the typical experimental setting). Thus, the individual i's payoffs are given by:

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

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:

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

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:

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

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 suggest 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). For simplicity too, we will show here the case in which the counterpart of the decision-maker cannot 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 3A. The utilities associated by player 1 to those payoffs are presented in Table 3B.

	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 3A. 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 3B. Utility associated to outcomes (player 1)

According to our model, the conditions that $\delta_1\gamma$ must satisfy for each strategy to be (weakly) dominant for player 1 are:

- For *CN*:
  - $\delta_1\gamma \geq \frac{c}{b-c}$, if $b \leq 2c\frac{p}{p-1}$
  - $\delta_1\gamma \geq \frac{p-1}{p+1}$, if $b \geq 2c\frac{p}{p-1}$
- For *DN*:
  - $\frac{p-1}{p+1} \leq \delta_1\gamma \leq \frac{c}{b-c}$, if $b \leq 2c\frac{p}{p-1}$
  - $\emptyset$, if $b > 2c\frac{p}{p-1}$
- For *CP*:
  - $\emptyset$, if $b < 2c\frac{p}{p-1}$
  - $\frac{c}{b-c} \leq \delta_1\gamma \leq \frac{p-1}{p+1}$, if $b \geq 2c\frac{p}{p-1}$
- For *DP*:
  - $\delta_1\gamma \leq \frac{p-1}{p+1}$, if $b \leq 2c\frac{p}{p-1}$
  - $\delta_1\gamma \leq \frac{c}{b-c}$, 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).

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 those individuals 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 such 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. 2012a, 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. (2012a) 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 delayed psychological rewards and patient individuals might develop a predisposition towards this kind of "moralistic" punishment in social dilemmas. We leave this possibility for future developments of the model.

The stag-hunt game

The stag-hunt game (SHG) posits a 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 interesting, perspective than the one offered by social dilemma games (see, e.g., Skyrms 2003, Van Huyck et al. 1990). Players have to decide simultaneously between two possible strategies: they can either choose hunting a stag (S) together or hunting a hare (H) individually. The symmetric payoff structure of the game, depicted in Table 4A, leads to the existence of a low-risk option (H) and a high-risk one (S). Hunting the stag together (i.e., both choosing S) has attached a large gain, $a > 0$, for both hunters. However, hunting the 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 the 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, the hare, $c \in (0, a)$, and probably something more, $b \in [c, a)$, if the other player chooses to hunt the stag. Thus, the game imposes $a > b \geq c > 0$. Assuming players' strict self-interest would lead us to an 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.

Although any convex combination between $2a$ and b will be always strictly greater than any other between $2c$ and b, 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 that $b \leq 2c$ 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 4B 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 4A. 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 4B. 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:

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

and

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

Thus, if her partner chooses S, the individual i would prefer choosing S if:

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

More patient individuals are more likely to prefer S when the other player chooses S. Also, the greater is a and the smaller is 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 we can observe how spiteful and egoist individuals ($\delta_i\gamma \leq 1$) would never prefer S when their partner chooses H, since for them the left part of the inequality would be non-positive (and the right part cannot be negative since $c > 0$). 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:

$\delta_i\gamma \geq \frac{b}{b-2c}$, 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, 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 strategy (S, S), thus maximizing both the total and the individual payoffs (see Devetag & Ortmann 2007 for a review). Our model requires individuals to be enough patient 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. (2011). The authors found that indeed patient individuals were 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. Nevertheless, the repeated procedure used in such experiment invites us to consider the relationship between their findings and our theory with special care.

Conclusions

To the best of our knowledge, no any theoretical research has tried before to relate the inter-temporal preferences of individuals to the social behaviors they are predisposed to in the way we propose. The reason why we consider that such individual characteristic can influence the willingness to cooperate or to compete in non-repeated interactions has a four-fold basis: (i) humans are both more cooperative and more patient than most other species (Stevens & Hauser 2004, Stevens et al. 2005); (ii) if, ultimately, competition destroys resources and cooperation is costly in terms of relative standing, then they are the perfect candidates to represent the two opposite extremes of a social preference continuum (Van Lange et al. 1997, Deng & Chu 2011); (iii) this continuum might be defined in terms of its association to an expectation of delayed or immediate psychological rewards—neural evidence points to the presence of psychological satisfaction associated with both cooperation and competition, but it also suggests that separate brain areas may encode a conflicting pattern similar to the one found for the trade-off between immediate and future rewards (Rilling 2002, Fliessbach 2007, Decety et al. 2004, Winstanley et al. 2004, Hariri et al. 2006, McClure et al. 2004, 2007, Kable & Glimcher 2007)—; (iv) patient (impatient) humans are more likely to cooperate (aggressively compete) in sporadic encounters (Curry et al. 2008, Nelson & Trainor 2007).

The model we present is solely based on material outcomes with no involvement of intentionality or reciprocity concerns (Rabin 1993, Dufwenberg & Kirchsteiger 2004, Charness & Rabin 2002, Cox et al. 2007), although they have been proved crucial for the understanding of social behavior (Nowak 2006, Tomasello et al. 2005, Martinez-Vaquero et al. 2012). Our theory is nonetheless proposed as a first attempt to include social learning from past experience as the mechanism through which stable social preferences develop. Concretely, preferences are linked to the intuitive associations made by individuals between decisions and psychological rewards. Individuals who value more future rewards also value more those behaviors which are automatically associated with them. We suggest that cooperation is associated with long-run, stable rewards and competition with short-run, (and perhaps more unstable) rewards. As a result, the individuals' response when faced with situations where competitive and cooperative achievements are present is to intuitively associate such aspirations with immediate and delayed psychological satisfaction, respectively. That said, the behavioral outcome is already given: for the exact same one-shot encounter (equal payoff structure and context) patient individuals are more likely to cooperate favoring social efficiency and less likely to compete for the sake of increasing their relative standing.

For the development of a simple model based on the above assumptions, we further define a utility function which relates to the own material payoff but also to that of the other members of a reference group. The individual maximizes the sum of the immediate and the delayed satisfaction sources, that is, the sum of the relative and the (discounted) joint payoffs. A rearrangement of terms in the utility function leads us to a definition of the decision problem as grounded on the maximization of the present and future own payoff (purely egoistic component), on the one hand, and the maximization or minimization of others' present and future average payoffs (other-regarding component, either altruistic or spiteful), on the other.

The utility an individual attaches to different outcomes depends on the material payoffs, the individual's patience and contextual factors. Such contextual factors define the perception of all individuals involved about the dynamic pattern followed by the available resources, that is, whether resources are perceived as increasing or decreasing with time. The relatively higher (lower) is the perceived amount of future resources available in one specific context the more likely individuals will 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.

Using the model we show the conditions under which people cooperate and/or punish defectors in a social dilemma game, and reject 'unfair' and/or propose 'fair' offers in the ultimatum game, among other behaviors that contradict the canonical assumption of selfish rationality. Hence, this paper proposes a rational solution for some of the most debated puzzles across the social, behavioral and biological sciences.

Extensions

E1. Developments 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:

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

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

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

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

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

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

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

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 ($\delta_i = 0$) 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 before, 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:

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

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

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.

E2. Third-party punishment in the dictator game

The third-party punishment game (TPG) modifies the DG and introduces the possibility for an observer, third-party of punishing the dictator's behavior (Fehr & Fischbacher 2004). In the basic design of the game, the third-party is endowed with ½ of the total amount given to the dictator for its division with the recipient. As in the DG, the dictator has to propose a fraction, $\alpha \in [0, 1]$, to be transferred to the recipient while the latter is totally passive. The third-party can incur a cost, $c \in [0, ½]$, which is deducted from her endowment, in order to reduce the dictator's payoff by pc.

The payoffs of the three players are therefore given by:

$$x_D = 1 - \alpha - pc$$

$$x_R = \alpha$$

$$x_T = \frac{1}{2} - c$$

where x_D, x_R, and x_T are the payoffs of the dictator, the recipient, and the third-party, respectively.

The utility players associate to the game outcomes is given by:

$$U_D = 3(\frac{1}{2} - \alpha) + c(1 - 2p) + \delta_D \gamma \left(\frac{3}{2} - c(p + 1)\right)$$

$$U_R = 3(\alpha - \frac{1}{2}) + c(p + 1) + \delta_R \gamma \left(\frac{3}{2} - c(p + 1)\right)$$

$$U_T = c(p - 2) + \delta_T \gamma \left(\frac{3}{2} - c(p + 1)\right)$$

The third-party would punish the dictator if her expenditure in punishment, c, affects positively her utility (given, of course, the effects of punishment on the dictator's payoff). Thus, $\frac{\partial U_T}{\partial c} \geq 0$ is required for the third-party to punish, that is:

$$\delta_T \gamma \leq \frac{p-2}{p+1}$$

The implications of the condition obtained above are: (i) non-spiteful individuals ($\delta_T \gamma \geq 1$) would never punish (in fact, the willingness to punish is linked to spitefulness-impatience), (ii) punishment is more likely to happen (i.e., more individuals would punish) the greater is the relative reduction of the dictator's payoff because of punishment, that is, p (which has to be at least 2 for leading the most spiteful-impatient individuals to punish), and (iii) punishment is independent of the dictator's offer, α. The last implication is interesting but it suggests nevertheless an important limitation of our theory to explain third-party punishment. The empirical findings clearly evidence that punishment is indeed more likely to happen the lower is the dictator's offer (Fehr & Fischbacher 2004). Hence, our model proposes spiteful preferences and impatience as important determinants of punishment by third-parties but it cannot account for the existing relationship of punishment with the dictator's behavior. Therefore, dictators' behavior will not be influenced by the observer's preferences (impatience) which would lead the dictator decision to be identically characterized as in the standard DG. This should be addressed in further research.[12] Again, we do not know any research trying to find a link between time discounting and behavior in the TPG.

[12] This limitation can be solved through the introduction of other factors in the model—like, for instance, norm-compliance (López-Pérez 2008) or inequity aversion (Fehr & Schmidt 1999, Bolton & Ockenfels 2000)—or, for example, by changing the composition of the reference group of the third-party by excluding the recipient (see McDonald et al. 2009).

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Chapter 5

Don't mix it up: Fairness versus spite in the Ultimatum Game

ABSTRACT

In the Ultimatum Game, a proposer and a responder have to agree on how to split a sum of money. If the responder rejects the proposer's offer, both players get nothing. Rejection of positive but unequal offers is considered a form of costly punishment of unfair behavior able to enforce the social norm of fairness. However, research using other experimental frameworks has shown that punishment can be also driven by competitive and spiteful motivations and furthermore that, in the presence of such punishers, sanctioning institutions may finally be detrimental for the social norm. By analyzing responders' behavior in a different social situation (as dictators in the Dictator Game) we show the existence of both 'spiteful' and 'fair' punishers also in the Ultimatum Game.

Introduction

The Ultimatum Game (UG) has been one of the most prolific set-ups for unraveling the nature of human fairness over the last years. In this game, one player (the proposer) proposes a way to split a sum of money with another player (the responder). If the responder accepts the offer, both players are paid accordingly; if she rejects, neither player is paid. Rejection of positive, albeit low offers is considered to be an expression of costly punishment of unfair behavior able to enforce the social norm of fairness (Sanfey et al. 2003, Knoch et al. 2006, Crockett et al. 2008, Henrich et al. 2006).

However, such an interpretation need not necessarily be the case. Other, less pro-social motivations can be behind UG rejections. Recent research on social dilemma games reveals that costly punishment is also used by non-cooperators, who punish either other non-cooperators (Espín et al. 2012) or even cooperators (Herrmann et al. 2008, Rand & Nowak 2011). These punishment patterns have been traced back to competitive, spiteful individuals aimed at increasing their own relative payoff. Such findings are particularly important insofar as theoretical and empirical evidence demonstrates that commons can be destroyed by the presence of 'spiteful punishers', which ultimately turns a sanctioning institution into a detrimental force for public cooperation (Herrmann et al. 2008, Rand et al. 2010).

Here, we investigate experimentally whether punishment in the UG can also be the result of competitive spite rather than fairness. UG rejections are indeed equally compatible with competitive, spiteful motives (Kirchsteiger 1994). A spiteful responder prefers a zero-zero outcome over one that leaves her below the proposer. Thus she will reject any offer below the equal split; just like an individual concerned with the fairness norm. This implies that the mere observation of UG behavior is not sufficient to determine the motivation of rejections.

To disentangle the two, this paper employs the Dictator Game (DG) as an auxiliary tool. The DG is identical to the UG except that the second player is now passive, i.e. she cannot reject the offer. As a result, generous offers of dictators are genuinely pro-social. A pro-social individual concerned about fairness will split the pie equally in the DG *and* reject unequal offers in the UG. A spite-driven individual on the other hand will still reject unequal offers but transfer nothing in the DG in order to achieve the highest payoff differential (hence being totally unfair). Note that pure selfishness also predicts a zero-transfer in the DG but never the rejection of any positive offers in the UG. Therefore, the rejection of unequal but positive offers combined with zero-transfers in the DG is an unequivocal symptom of competitive spite.

We report data from two studies. Study 1 (n=754) employed a representative sample of a city's adult population and was carried out at participants' households. Study 2 (n=623) recruited a sample of university students (freshmen) playing in the lab. Both studies consisted of an identical survey-experiment and were conducted in Granada (Spain). The pie to be split was €20 in each game. For UG responses we used the strategy method where the responder states whether she accepts/rejects any possible offer beforehand (see Supplementary Materials).

Results and discussion

Figure 1 splits the sample into three groups according to participants' decisions in the DG: "unfair" are those who offer zero in the DG; "fair" are those who make an equal split; and those who make an offer in between are labeled "remaining". For each group, we display the percentage of responders who reject offers below the equal split in the UG. Study 1 [2] is captured by the left [right] panel. We find that not only the "fair" but also the "unfair" dictators reject unequal offers significantly more often than the "remaining" group (Probit model controlling for order effects in decisions; fair vs. remaining: P=0.000 in Study 1 and 2; unfair vs. remaining: P=0.005 in Study 1, P=0.000 in Study2). What is more, both groups are similarly likely to reject an unequal offer (P=0.123 in Study1, P=0.356 in Study 2) (see Supplementary Materials). Thus, rejections in the UG are indistinguishably fairness- and spite-motivated.

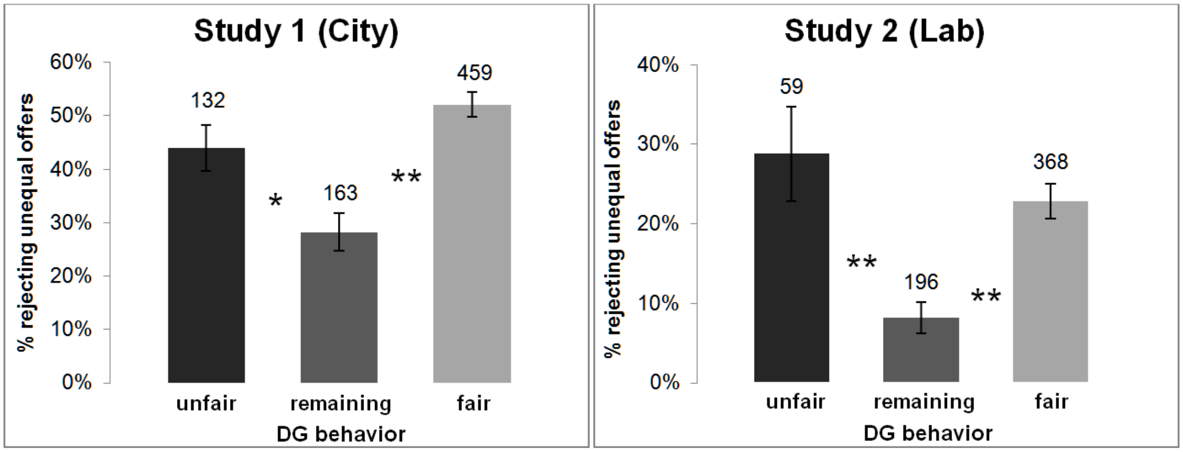

Figure 1. Willingness to reject unequal offers by DG groups. Left [right] panel for Study 1 [2]. The horizontal axis depicts behavior in the DG: unfair (offer 0%), remaining (offer between 0 and 50%), fair (offer 50%). The numbers on top of the bars denote the total number of observations in each group. The vertical axis represents the percentage of individuals (± SE) who reject offers below 50% in the UG, i.e. whose minimum acceptable offer is the equal split. * P=0.005, ** P=0.000.

These results are of great importance especially given that studies addressing the psychological or neural basis of costly punishment using data from the UG are usually conducted with small samples. Studies mixing the two subpopulations of punishers can misevaluate the role and consequences of fairness-oriented punishment. Apparently contradictory observations, as in the case of the impact of self-control on punishment behavior (Sanfey et al. 2003, Knoch et al. 2006), might be a result of such a mix-up. Future studies should account for the different natures of punishment behavior in the UG.

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Chapter 6

Accepting zero in the Ultimatum Game: Selfish Nash response?

ABSTRACT

The rejection of unfair proposals in ultimatum games is often quoted as evidence of other-regarding preferences. In this paper we focus on those responders who accept any proposals, setting the minimum acceptable offer (MAO) at zero. While this behavior could result from the randomization between the two payoff-maximizing strategies (i.e. setting MAO at zero or at the smallest positive amount), it also implies that the opponent's payoff is maximized and the "pie" remains intact. We match subjects' behavior as ultimatum responders with their choices in the dictator game, in two large-scale experiments. We find that those who set MAO at zero are the most generous dictators. Moreover, they differ substantially from responders whose MAO is the smallest positive offer, who are the greediest dictators. Thus, an interpretation of zero MAOs in terms of selfish, payoff-maximizing behavior could be misleading. Our evidence indicates that the restraint from punishing others can be driven by altruism and by the desire to maximize social welfare.

Introduction

In the ultimatum game (UG) (Güth et al. 1982), a proposer issues an offer on how to divide a sum of money to a responder who may either accept and thus implement the proposer's split or reject at the cost of destroying the whole endowment. This design has been widely used to show how human behavior deviates from standard Nash equilibrium predictions.

Based on the canonical assumption of selfish rationality, standard economic theory predicts that a responder should accept any positive amount since a rejection would leave her (as well as the proposer) with no earnings at all. In case the proposal leaves her exactly a zero-payoff, a selfish responder should be indifferent between accepting and rejecting it. Technically speaking, her weakly dominant strategies consist in setting her minimum acceptable offer (MAO) either to zero or to the smallest positive amount (ε). If both options are available, the responder choice should result from randomization between the two. By applying simple backward induction, a payoff-maximizing proposer fully exploits his first-mover advantage offering to the responder, at best, the smallest possible amount.

Subjects' behavior in UG experiments, however, does not comply with theoretical predictions. Lots of players propose fair divisions of the pie, while unequal offers are very often rejected by responders even in one-shot games (see Camerer 2003). Several theoretical approaches have been recently proposed in order to account for these deviations by relaxing one of the standard assumptions, that is, either the selfishness or the rationality assumption. As regards to rationality, it has been suggested that subjects *erroneously* interpret one-shot situations as repeated (Binmore 1998), where rejecting a low, positive offer might encourage the proposer to increase her offers in subsequent rounds.

Economists have dropped the selfishness assumption more often and suggested that people have other-regarding preferences. A plethora of such models have been developed each of which trying to explain as many of the observed behavioral "irregularities" as possible (see the reviews of Fehr & Schmidt 2006, Meier 2007, and Cooper & Kagel 2012). The same behavioral pattern is often compatible with more than one set of assumptions. UG rejections for example have been rationalized on the basis of responders' inequity aversion (Fehr & Schmidt 1999, Bolton & Ockenfels 2000), spiteful preferences (Kirchsteiger 1994), negative reciprocity (Rabin 1993) or norm-compliance (López-Pérez 2008).

Relatively less attention has been devoted to the motives behind those strategies that *do* follow standard predictions since they were automatically considered to be confirming the theory and its main assumptions.[1] However, just like in the cases where observations clearly deviate from theory, individuals choosing these strategies do not need to necessarily follow the rational-selfish agent pattern.

In this paper we focus on one particular strategy, which is compatible with both rationality and selfishness and is actually the Nash prediction under these assumptions: the willingness to accept any offer, i.e. setting MAO at zero.

We will refer to players choosing this strategy as "MAO-zero players". Those who choose to accept the smallest positive offer but to reject zero will be referred to as "MAO-ε players". MAO-zero and MAO-ε players are usually supposed to be "Nash responders", i.e. sheer payoff maximizers unwilling to make any sacrifice in order to punish a stingy proposer.

The acceptance of a low, unfair offer also implies that the pie will not be destroyed. Such a behavior is thus compatible with motivations other than selfishness. These can be altruism, the desire to keep overall welfare high or simply the unwillingness to hurt the other player despite his greed. We argue that an agent driven by such motives will *neither* set her MAO to the smallest positive amount, *nor* will she randomize at the risk of destroying the whole endowment. She will choose to accept *any* offer, including zero.

Reciprocity and inequity aversion, highlighted in influential models of other-regarding preferences, are incompatible with the acceptance of zero offers. On the other hand, models of altruism (Becker 1974) or social welfare maximization (Charness & Rabin

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[1] Indeed a non-negligible portion of the subjects in experiments (between 20% and 50% depending on the studies) behave according to the predictions of a fully-rational, fully-selfish agent (see e.g. Fehr & Schmidt 2006).

2002) can incorporate such behavior. The acceptance of low offers has also been linked to cultural and religious values, such as gypsies' solidarity (Brañas-Garza et al. 2006) and Tibetans' Buddhism (Chen & Tang 2009).

A way to disentangle selfish and other possible motivations consists in observing choices by the same subjects in other games. An obvious option in the case of the UG is the Dictator Game (DG), where the possibility of rejection is removed, so that first movers ("dictators") simply decide the distribution of the pie. Forsythe et al. (1994) combine the two games in a between-subjects design in order to interpret generous non-Nash proposals in the UG. As dictators' average offers are positive but lower than UG proposals, the latter appear to stem from the interplay of fairness and fear of rejection.

Here we follow a similar route, but we use the DG in a within-subjects design, combining MAO responses and DG offers selected by each participant. We argue that if a MAO-zero player keeps the whole pie for himself when playing as a dictator, she is likely to be a payoff maximizer whose MAO in the UG was possibly determined by a random choice between 0 and ε. If, on the other hand, she concedes a significant amount to the person she is matched with in the DG, her motives must incorporate factors beyond her own payoff such as altruism or social welfare maximization. If this is the case we could even expect DG offers made by MAO-zero players to be on average significantly higher than those made by MAO-ε players. Such evidence would undermine the interpretation of zero MAO responses coming from selfish individuals.

We test these hypotheses using data from both a controlled laboratory experiment with university students and a controlled field experiment recruiting a representative sample of a city's adult population. Both types of ways to collect evidence entail advantages and drawbacks. Lab data are "cleaner" in terms of smoothness of experimental procedures but the sample is entirely comprised by university students. The city-experiment on the other hand offers a more representative sample but this comes with the necessary noise of a field study. We believe that the consistency of our results in both experimental environments strengthens the validity of our findings.

Experimental procedures

The city-experiment took place between November and December 2010 in the city of Granada, in the southern Spanish region of Andalusia, with a sample of 835 citizens between 16 and 91 years old who, after having previously agreed to participate in a survey, were interviewed in their own apartments by university students.

The lab experiment was conducted in the Granada Lab of Experimental Economics EGEO at the University of Granada during October 2011. During 27 sessions data were collected from a sample of 659 university students.

In both cases, subjects completed the exact same survey-experiment comprising a dictator and a ultimatum game[2]. All subjects (i) decided how to split the pie in the DG, (ii) made an offer on how to split the pie in the UG (in both cases multiples of 2, between 0 and 20 euros, were used) and, (iii) employing the strategy method, whether they accept or reject any possible UG proposal (limiting this option to offers between 0 and 10). The order in which decisions were presented was randomized across participants.

Subjects were also informed that after the experiment a random selection would determine who among them (one out of ten subjects) would receive a payment and which game would determine the amount. The benefits of the strategy method introduced by Selten (1967) and applied in the UG by Mitzkewitz and Nagel (1993) are obvious in terms of data collection; in particular since low offers – necessary for our analysis – tend to be rare[3]. In addition, given that we are analyzing behavior in two games, these procedures permit to isolate the choices in a game from the possible effects of the outcomes achieved in another game previously played.

[2] They also played a Trust game. The exact design of the survey-experiment has been previously reported and described in detail in Exadaktylos et al. (2012).

[3] The possible behavioral bias due to this method has been extensively analyzed. A recent review by Brandts & Charness (2011) shows that results with direct responses are similar to the ones observed with the use of the strategy method. In the specific question regarding UG responders' behavior, Oxoby & McLeish (2004) find that rejection is more frequent when players are faced with real, rather than hypothetical unfair proposals. On the other hand, Armantier (2006) finds that very few responders, who submit their strategy before knowing actual proposals, revise their strategy when given the opportunity to do so. Those who do in most cases decide to accept proposals just below their previously stated MAO.

Hypotheses

The focus is on the behavior of MAO-zero players who accept any offer. This strategy is weakly dominant if the responder only cares about her payoff. The following hypotheses have been designed in order to test whether the standard assumption of selfish rationality actually applies to the behavior of MAO-zero players.

Hypothesis 1: MAO-zero players give nothing in the DG.

If this hypothesis is confirmed, then accepting zero should indeed be interpreted as rational profit maximizing, Nash behavior. However, a potential rejection of the *hypothesis 1* could be due to other factors pushing DG offers upwards in our experiment. We therefore construct *hypothesis* 2, in which we relax *hypothesis 1* and test whether the behavior of MAO-zero subjects is consistently closer to payoff-maximization with respect to other players' even if, strictly speaking, does not comply with the Nash prediction, i.e. zero-DG offers.

Hypothesis 2: MAO-zero responders offer less than the average when they play the DG.

Even if both hypotheses are rejected, it could still be argued that behavior in the UG and in the DG might not necessarily be associated in the way we have assumed. Perhaps subjects are driven by different motivations in a strategic environment like the UG than in the non-strategic environment of the DG. A responder can be self-regarding in the UG and other-regarding in the DG. Thus, it can actually be the case that selfish responders in the UG are indeed randomizing between 0 and ε but this is independent of DG behavior, meaning that an ex-ante prediction about dictator decisions made by selfish responders cannot be drawn. As a consequence, behavior of MAO-zero and MAO-ε players in the DG should still be indistinguishable.

Hypothesis 3: There is no significant difference in DG behavior between MAO-zero and MAO-ε responders.

Failing to reject the three hypotheses above would provide evidence that the motives behind the acceptance of zero offers is in line with the *homo oeconomicus* principles – rationality and self-regarding payoff maximization – along which this strategy is predicted in standard economic theory. The rejection on the other hand of any of these hypotheses would cast doubts. Data leading to the rejection of *all* these hypotheses would seriously undermine the whole idea that MAO-zero strategy is the expression of self-interest.

Results

54 out 645 subjects (8.37%) in the lab and 102 out of 796 (12.81%) in the city chose MAO=0 as their UG strategy.[4] In Figure 1 we show the pattern of DG giving in the lab according to the MAO chosen as responder in the UG, separated in the three groups related to our hypotheses, i.e. MAO=0 (MAO-zero players), MAO=2 (MAO-ε players) and MAO>2.

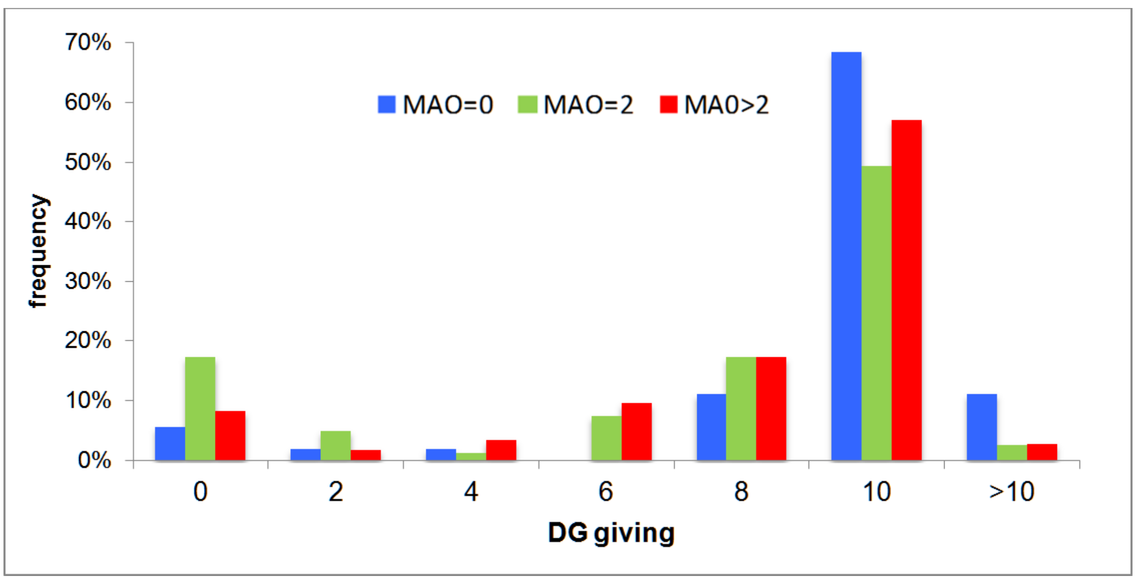

Figure 1. Dictator giving according to MAO groups in the lab

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[4] Data from 14 subjects in the lab and from 39 subjects in the city were removed due to inconsistency problems (e.g. accepting a UG proposal and rejecting a higher one) or to missing values in any of the decisions.

We observe that only around 5% of MAO-zero players choose to give zero as dictators. The percentages of zero-giving are higher among subjects who have not chosen zero as MAO, in particular among MAO-ε players (almost 20%). Conversely, the percentages are visibly higher among MAO-zero players when we move to dictators giving half or more than half of the pie (i.e. giving 10 or >10).

Although results in the city-experiment are less clear-cut, we can still observe a similar pattern (Figure 2): frequencies among MAO-zero players are higher with respect to giving half or more of the pie as dictators, and lower in correspondence to giving zero.

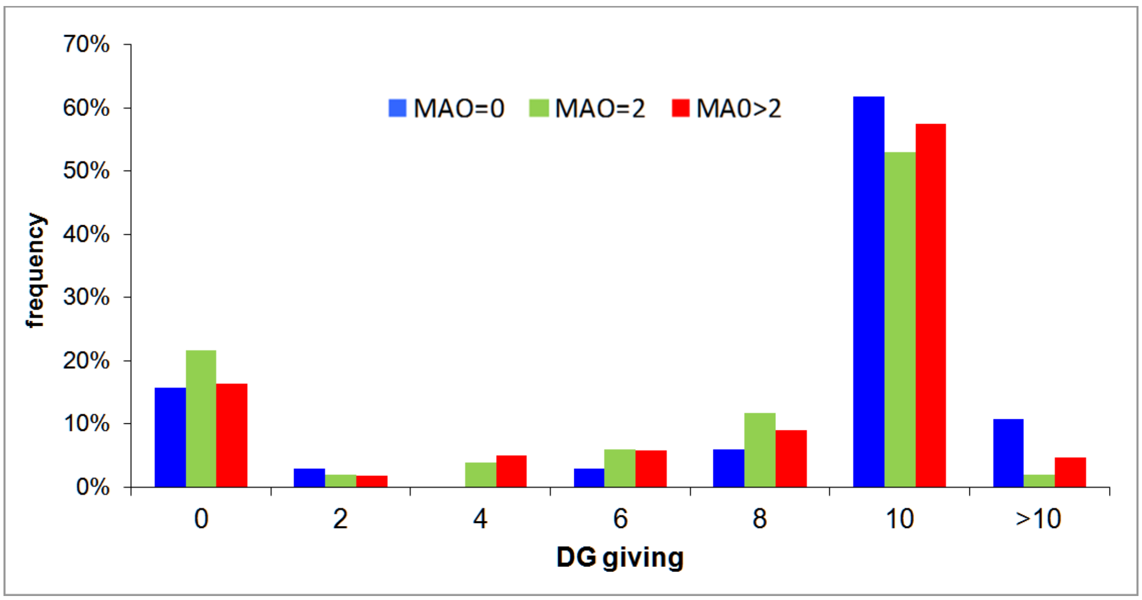

Figure 2. DG giving according to MAO groups in the city

In the lab, MAO-zero players give an average 9.70 out of their endowment of 20 in the DG. Only 3 out of 54 chose to maximize their payoff by giving zero. In the city, MAO-zero players gave 8.82 on average in the DG, and 16 out of 102 chose to give zero. While students in the lab were on average more generous,[5] in both cases giving by MAO-zero

[5] This is in contrast to previous evidence showing that students are a bit less generous than others, more representative samples (see e.g. Exadaktylos et al. 2012 and Carpenter et al. 2008). However, students in our

players was significantly positive according to any standard measure. From this data we can safely conclude the following.

Result 1: the hypothesis 1 is rejected.

On the basis of this evidence, it already appears unreasonable to imagine that those same players aim at maximizing their payoffs in the UG. The simplicity of the UG and, *a fortiori*, of the DG suggests that deviations on the latter cannot be based on confusion.

We now move on to the second hypothesis, related to the comparison between MAO-zero and the rest of players. We have seen that in the lab MAO-zero players give 9.70 on average, while the average DG giving among subjects with a positive MAO (2 or more) decreases to 8.09. In the city, the difference in average DG giving between the two groups is smaller: the values are 8.82 and 7.72, respectively. Nevertheless, MAO-zero players give significantly more according to a two-tailed Mann-Whitney test both in the lab (p=0.0005) and in the city (p=0.0161).

Looking in more detail on lab behavior, we notice that while 79.63% of MAO-zero players give at least half of their endowment, the percentage decreases to 58.71% in the rest of the sample (the difference in proportions is significant according to a two-tailed Fisher's exact test, p=0.002). In the city, the percentages of subjects giving at least half of the endowment are 72.55% among those with MAO zero and 61.53% in the rest of the sample (the difference is also significant, p=0.037).

The evidence that, overall, behavior in the DG has been remarkably generous in our experiments could have raised suspicions that although MAO-zero players are not selfish in absolute terms, they could still be *more* selfish than the rest of our experimental pool. Our data show the opposite: MAO-zero responders are unquestionably more generous when playing as dictators.

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sample were "pseudo-volunteers" since participation was semi-obligatory during a class. Pseudo-volunteer students have been found to be more generous than the students who volunteer in experiments (the standard subject pool) (Eckel & Grossman 2000). Thus, our result might have been affected by this particular recruitment system. We do not see any reason however to think that this can influence our main analyses.

Result 2: the hypothesis 2 is rejected.

As explained above, if MAO-zero is a symptom of selfishness it should be resulting from a randomization with MAO-ε. Accordingly, we should expect the giving behavior of MAO-zero and MAO-ε players to be indistinguishable. In the next lines we shall analyze this; i.e. we test the hypothesis 3.

In the lab, MAO-zero players give significantly more than MAO-ε players (i.e. those who set MAO at 2) (Mann-Whitney test, p=0.0003. Average giving were 9.70 and 7.41, respectively. Furthermore, the percentage of dictators giving at least half of the endowment significantly decreases, from 79.63% of MAO-zero to 51.85% of MAO-ε players (Fisher's exact test, p=0.001).

DG giving was significantly higher among MAO-zero players in the city as well (Mann-Whitney test, p=0.0171). The two averages were 8.82 among MAO-zero and 7.02 among MAO-ε players. The percentage of dictators giving at least half of the endowment also significantly differ between these groups; they were 72.55% and 54.90%, respectively (Fisher's exact test, p=0.045).

All in all, the behavior of MAO-zero and that of MAO-ε players could not be more different across the sample: both in the lab and in the city, they are the most and the least generous groups in the DG (see also Tables 1 and 2), respectively.

Result 3: the hypothesis 3 is rejected.

From the results 1-3 we can safely conclude that accepting zero in the UG is not a selfish Nash response. But does this also imply that individuals with higher MAOs are not, in general, less selfish? In other words, given that the UG poses a trade-off between self-regarding and other-regarding goals such that responders have to sacrifice one goal to satisfy the other, one should expect MAOs to be positively correlated with giving in the DG. Mean offers by MAO groups are presented in Tables 1 (lab) and 2 (city).

Table 1: Average DG giving according to MAO in the lab

MAO	Observations	Mean DG offer	St. error	95% Confidence Interval	
0	54	9.70	0.50	8.72	10.69
2	81	7.41	0.48	6.46	8.35
4	66	7.61	0.39	6.84	8.37
6	160	8.39	0.21	7.97	8.80
8	165	8.29	0.25	7.81	8.78
10	119	8.15	0.34	7.48	8.83

Table 2: Average DG giving according to MAO in the city

MAO	Observations	Mean DG offer	St. error	95% Confidence Interval	
0	102	8.82	0.50	7.85	9.80
2	51	7.02	0.58	5.88	8.16
4	48	8.08	0.67	6.77	9.40
6	97	7.28	0.45	6.40	8.16
8	141	7.26	0.34	6.59	7.93
10	357	8.07	0.22	7.64	8.51

We do not observe significant correlation neither in the lab nor in the city (non-parametric trend test, $p>0.7$ and $p>0.9$, respectively). As Tables 1 and 2 show, there is no clear pattern in that relationship. In both samples, the average giving of the remaining MAO groups (2, 4, 6, 8) fall in between those of the generous MAO-zero players and the greedy MAO-ε players. However, a closer inspection of the data reveals that the absence of relationship is due to the "unexpected" generosity of MAO-zero players. Indeed, DG offers significantly increase along with MAOs when we restrict the analysis to positive MAOs ($p=0.002$ in the lab, $p=0.007$ in the city).

Discussion

We have found that people who accept any offer including the one that leaves them with zero payoff in the UG are far from selfish. This contradicts the idea that the responders whose behavior does not deviate from standard Nash predictions belong to this part of the population composed of payoff-maximizing individuals. An immediate corollary is that those who do deviate, sacrificing their payoffs in order to punish, are not necessarily "less selfish".

The fact that many people do not follow payoff-maximization behavior is already well-known among social scientists. The UG, as a matter of fact, has been one of the most used examples showing deviations by a number of agents in a variety of social and cultural settings (Henrich et al. 2005, Camerer 2003).

Of course, this does not mean that "anything goes". Precisely the consistency of patterns of deviation has lead economists to look for ways to adapt theories to richer versions of human motivations, along with the predictable heterogeneity of preferences among different people.

UG rejections can be explained in terms of negative reciprocity and inequality aversion. The latter can also explain why some dictators give away half of the pie. [6]

Generous dictators' giving in combination with not punishing in the UG can be explained in terms of altruism, whereby the opponent's payoff enters positively in the utility function. Concavity of the perfect altruist's utility functions in the two payoffs also explains choosing exactly 50% as the chunk of the pie to be given.[7] The choice of leaving intact the pie in the UG, no matter the choice of the proposer, is trivially the optimal one for

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[6] In Fehr & Schmidt (1999) it is argued that some players are simple payoff maximizers, while others are averse to unfavorable inequality (hence they reject unfair UG proposals) and to favorable equality (hence they act as generous dictators). A restriction is imposed so that one cannot be more averse to favorable than to unfavorable inequality, so someone who is generous in the DG should also punish unfair UG proposers.

[7] For a pie worth 10, a perfect altruist with the two payoffs entering its utility function uses the following program: Max $U(x, 10-x)$, which entails a first order condition $U'(x)-U'(10-x)=0$, hence (assuming strict concavity of U), $x=10-x=5$. Concavity also implies that the second order condition for a maximum holds.

altruists (here even a small degree of altruism suffices). The same follows if a player also considers efficiency, that immediately implies setting MAO=0. Overall, MAO-zero players maximize social welfare, both in the UG (destroying the pie obviously reduces welfare) and in the DG, where they tend to give half of the pie (if the marginal increase in welfare decreases with wealth, a fifty-fifty distribution is socially optimal).

The welfare-enhancing effect of the willingness to accept any proposals holds true in the static context of a one-shot game. Our setting does not include repetition, so we do not know whether MAO-zero players would use rejection in order to teach proposers to be "fair".[8] What we do find here is that altruism is related to restraining from punishment unlike, for instance, in Fehr & Gächter (2002).

Conclusions

Rejection in the UG reduces responders' monetary payoffs. It has been explained in terms of negative reciprocity and inequity aversion. On the other hand, the strategy choice of never rejecting is weakly dominant if a responder's goal is to maximize her own payoff.

While the experimental and behavioral economics literature acknowledges that some players are indeed selfish own-payoff maximizers, our evidence shows that the unwillingness to punish in one-shot UG is by no means related to selfishness. On the contrary, those who never punish are *more* generous than those who do, as shown by choices in the DG.

Although costly punishment has been related to "altruism", as it entails a sacrifice in order to teach a lesson to the greedy, here on the contrary we find that this motive, along

[8] Notice that if punishment is infrequent, so that selfish proposers have incentives to leave nothing, the few who do punish destroy welfare without any long-term positive effect. Only once the proportion of punishers reaches a critical mass, then all players (the selfish and the socially oriented alike) will propose fair divisions of the pie (Camerer & Fehr 2006). In public good settings, it is found that punishment occur with similar frequencies independently of whether the game is going to be repeated (Walker & Halloran 2004).

with the desire to maximize social welfare, lies behind the choice to allow proposers to get away with their preferred division of the pie instead of destroying it.

This behavior maximizes social welfare in our context, where DG and UG are combined in a one-shot game. In order to reach further conclusions concerning the general extent to which generous players may improve social welfare, future research is warranted. In particular, it would be interesting to analyze whether generous dictators become willing to punish in repeated games and/or in different types of strategic interactions where sanctions have been proved to be effective as cooperation-enhancing devices.

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Appendix of Chapter 2

Supplementary Information for

Patient and impatient punishers of free-riders

S1. Experimental design & procedures

S1.1. Subject pool & logistics

The experimental sessions were conducted between November 2008 and July 2009. Subjects were recruited in each of the five towns with the aid of staff at the city halls and a few private contacts (volunteers) who live in the towns. Each experimental session involved 32 individuals and lasted around two hours. Subjects were paid a €5 show-up fee (as had been announced during the recruitment stage) and told that they would receive a snack and a drink and possibly extra money depending on how the study progressed. Concretely, the experiments were run in the towns of Pedro Martínez, Deifontes, Benalúa de Guadix, Darro and Iznalloz. Their geographical location is shown on the map in Fig. S1.

Fig. S1. Geographical location of towns

Participants were 46.8 years of age on average (SD 18.5) and 64% were women. In terms of self-reported income status, 38% of the participants were earning a regular wage – chiefly from permanent contracts or retirement pensions – at the time of the study. The average overall monthly personal income of all participants was €498[1] (SD 491). Of these, roughly 25% had no income at the time of the experiment because they were unemployed or full-time students, while the average income of those who reported earning a regular wage was €867.5 (SD 492). About 26% of the participants had no formal educational training, while 10% had completed or were undergoing university studies at the moment of the experiment.

The same procedure was followed in each of the experimental sessions. On arrival, each participant was assigned to one of four color groups, and received a colored scarf corresponding to the group they had been assigned (yellow, orange, green or blue).

Once in the experimental room, the participants picked a number within their color group from four opaque bags. These numbers determined their place in the room. From then on, no communication was allowed among participants. The experimental room had 32 desks that were arranged by rows (colors) and columns (numbers) (see Fig. S2). The desks were placed within cubicles to prevent participants from seeing each other, but allowed them to see the whiteboard placed at the front of the room.

Fig. S2. Distribution of rooms. Subjects' color & number

Whiteboard & Instructor							
Yellow 8	Yellow 7	Yellow 6	Yellow 5	Yellow 4	Yellow 3	Yellow 2	Yellow 1
Orange 8	Orange 7	Orange 6	Orange 5	Orange 4	Orange 3	Orange 2	Orange 1
Green 8	Green 7	Green 6	Green 5	Green 4	Green 3	Green 2	Green 1
Blue 8	Blue 7	Blue 6	Blue 5	Blue 4	Blue 3	Blue 2	Blue 1

Each session comprised a standard one-shot public good game followed by a punishment stage. All participants then engaged in a discounting task to elicit their time

[1] Income was elicited in five intervals. To construct the averages we used the values at the central point of the intervals (see variables description in Text S2).

preferences. Finally, in the payment session outside the experimental room, participants were briefly interviewed on some of their personal and professional characteristics[2].

S1.2. The Public goods-punishment game

Once the participants were seated, and before the experiments began, the instructions were read aloud and always explained in the same manner and by the same instructor. Most participants had little formal education, and a significant portion was functionally illiterate (only being able to read and write numbers was required). Thus, we decided not to use written instructions for any of the experiment stages. A crucial issue in the study was to ensure that the participants understood the instructions correctly.

The participants were then randomly assigned to eight anonymous groups with four people each, who were in turn assigned a color. The four-people groups played the PGP as follows:

Each participant was endowed with €10, which were symbolically represented by a transparent box containing 10 real euro-coins that was placed on every desk. The participants had to decide, individually and anonymously, how many of the coins to keep for themselves – the private good – and how many to put in a "common fund" – the public good – by marking a cross on a previously prepared sheet (sheet 1)[3]. The total amount of money invested in the common fund was doubled and distributed evenly among the four group members, regardless of their specific contribution. Hence, each of the group members earned 50 cents for each euro invested in the fund. Consequently, player *i*'s earnings are given by the expression:

$$\Pi_i = 10 - C_i + \frac{1}{2}\sum_{j=1}^{4} C_j \quad \text{with } C_j \text{ being the contribution of player } j \qquad (1)$$

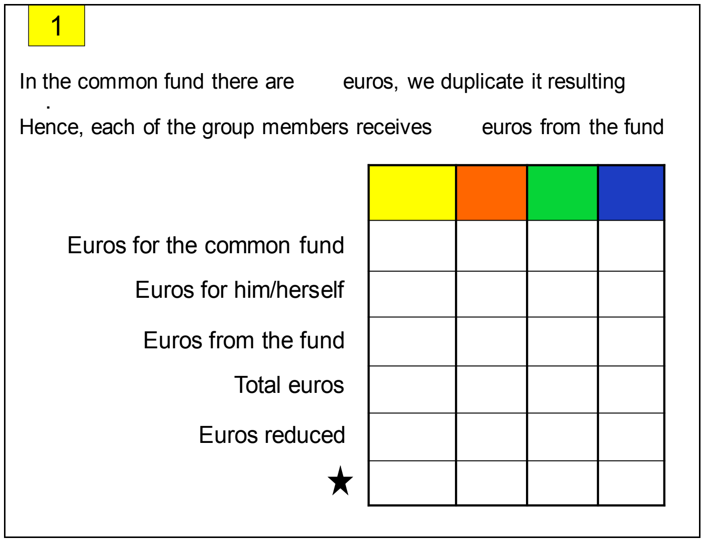
Hence, in our game the incentives for free-riding were clear, considering that every euro invested in the public good incurred a cost of 50 cents, while, *ceteris paribus*, the money for the private good incurred zero cost. The Nash equilibrium of the game predicts,

[2] An English translation of the general instructions can be found in Text S3.

[3] A translation of the three different sheets used for the experiments can be found in Text S3.

as a consequence, that none of the players will contribute anything to the public good. The social dilemma emerges as the size of the group (n) is larger than the factor that multiplies the total contributions (m) and the latter higher than one (in our case, n = 4, m = 2).

Fig. S3. Sheet 2 (yellow #1 participant example)


1

In the common fund there are euros, we duplicate it resulting

Hence, each of the group members receives euros from the fund

Euros for the common fund				
Euros for him/herself				
Euros from the fund				
Total euros				
Euros reduced				
★				

When explaining the procedure, the instructor played four different examples of the games using a whiteboard on which we projected the same tables that were given to the participants (see Fig. S3). The first example concerned a case in which none of the players contributed to the common fund. In consequence, every member of the group ended up with €10. In the second case every group member contributed her whole endowment to the fund, and the members therefore earned €20 each. In the third example, the instructor explained the free-rider case, in which player i contributes nothing and every player $j \neq i$ contributes the whole endowment, and, as a result, player i ends up with €25 and each player j with €15. And finally, the fourth example considered an intermediate case in which the contributions of the four players were €4, €5, €6 and €8, respectively.

It took about 30 minutes to explain the game. Before the participants decided about their contributions, we announced that a punishment stage would come afterwards when the participants would be shown the contributions and earnings of each member of their group. Every participant would be able to anonymously reduce the final earnings of the other players in the group by €3 by paying €1 – a standard punishment mechanism similar to those used by Fehr & Gächter [S1] and Herrmann et al. [S2]. Given that the maximum expenditure for reducing others' earnings was €3, the participants could reduce the earning of others by up to €9. We wanted to ensure that every participant decided on how much to contribute knowing there was a chance of being punished by the other group members in the next stage.

When the participants had filled out the first sheet with their contributions, they placed the sheets in individual envelops that were then collected by the experimental team. To add some realism to the contribution stage, we also collected the ten-coin boxes, although everybody knew that those coins were not going to be used for payments. Calculations were made in a separate room by four experimenters, noted by hand on the result sheets (sheet 2), and taken back in their envelopes to the experimental room where the 32 participants were waiting. The process took about 10 minutes, during which the instructor explained some examples of feasible situations concerning punishment using the table on the whiteboard.

Sheet 2 provided information to the participants on: total amount of money in the joint pot; their own contribution and earnings in the first column (own color) and the contribution and earnings of the other group members in the following three columns (other colors). Using this information, the participants had to decide how much to reduce others' earnings by writing the number (0, 3, 6 or 9) in a cell below each column. Following the same procedure used for sheet 1, sheet 2 was placed inside individual envelopes and collected by the experimenters. After the punishment stage, individual *i*'s earnings were defined by the equation:

$$\Pi_i = 10 - C_i + \frac{1}{2}\sum_{j=1}^{4} C_j - \sum_{j \neq i}^{4} p_{j\,i} - \frac{1}{3}\sum_{j \neq i}^{4} p_{i\,j} \qquad (2)$$

With C_j being the contribution of player *j* and p_{ij} the reduction applied by player *i* on player *j*'s payoff through punishment.

Furthermore, they had to state their expectations regarding the punishment they would receive from each of the other group members in the last row. This stage took place without monetary incentives, but it helped us to distinguish the participants' feelings concerning punishment. In order not to affect the punishment stage with the subjects' beliefs, the last row had no name (only a star symbol). However, the instructor announced that the decision which must be taken in the "star row" would not influence/change the results of previous stages.

In addition to the show-up fee, the average earnings after the contribution stage (equation 1) were €16.16 (SD 2.76), meaning an average contribution of €6.16, which was reduced by €3.1 on average during the punishment stage. The final average payment after the public goods game with punishment (equation 2) was therefore €13.06 (SD 3.94).

S1.3. The delay discounting task

For the last experimental stage we used an adaptation of the discounting task employed by Harrison et al. [S3] (see [S4] for a review of methods). We decided to use a front-end delay procedure in order to capture long-run discounting behavior and to minimize the effect of distrust (in terms of experimenters not returning to the town to make the payments) over the individuals' choices. To do so, we employed a task that consisted of 20 categories ranging from 2% to 100% annual simple interest rate (r). The procedure was as follows.

As the last sheets of the previous game were collected, we delivered the time preferences sheet (sheet 3) to the participants. Sheet 3 contained a table with two columns (options A and B) and 20 rows. In each row, option A offered €150 to be received one month after the experiment, while option B offered a higher amount to be received seven months later and also indicated the r to be gained following the six-month wait – which increases across rows. Thus, option B in the first row offered €151.50 (i.e. r = 0.02) and option B in the twentieth row €225 (r = 1). The participants had to decide between option A and B in each of the 20 rows by marking it with a cross. In order to avoid misunderstanding and, more precisely, inconsistent choices – a frequent problem with this type of task– the instructor conducted the task row by row. Subjects were asked, scenario by scenario, to choose between A and B. Moreover, they were advised that once option B was reached they should stay at that point, given that once B has been already chosen it makes no sense to again choose option A. The lower amount at which an individual is willing to wait half a year is considered her indifference point. Following the Mazur [S5] characterization for hyperbolic discounting, at the indifference point the discounted values of both options are equaled:

$$\text{sooner option} \quad \frac{V_1}{1+kd_1} = \frac{V_2}{1+kd_2} \quad \text{later option} \qquad (3)$$

Where V_1 = €150, d_1=1/12 years, d_2=7/12 years, V_2 is the higher (later) amount at the indifference point and k represents the individual's discounting parameter (expressed in years). Subjects who were not willing to wait for the highest stake (€225, which rounds the mean weekly per capita income in the area[4]) are included in an extra category[5]. The k elicited through equation 3 (21 different categories), belonging to the interval [0.02, 1.211], will be our measure for the individual's DD.

The subjects were told that because of financial constraints only one, randomly selected individual would be paid per session for this part. Once sheet 3 was collected, the "winner" and the "prize" (row) were randomly selected by picking numbered balls from an opaque bag in front of the participants. The average earnings of the five selected participants was €166.50. One of the experimenters phoned each of them in order to arrange a meeting to pay them after one or seven months depending on the prize. Since both task options were delayed (front-end delay), our design avoids the problem of different transaction costs between options – including different levels of trust in actually getting paid.

Lastly, while the participants were having a drink and a snack, they came in one by one to receive the money earned during the public goods-punishment game. At that moment they were asked personally – aloud, no anonymity toward experimenters – some questions regarding job status, income level and religiosity (information on educational levels and ages was provided by the city halls and private contacts).

[4] The average yearly per capita income of the five towns rounded out to €11,500 in 2008 according to income tax statements. Official statistics were obtained from [S6].

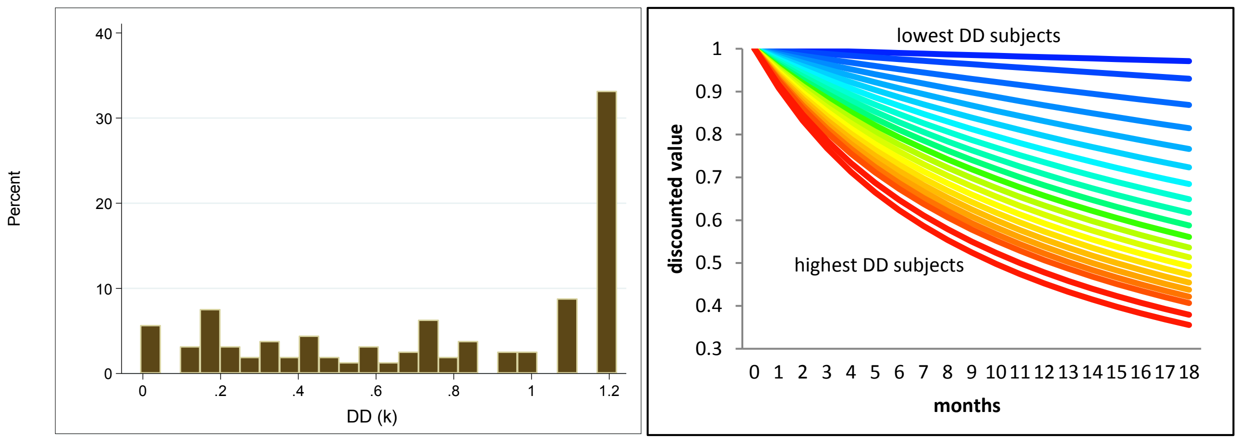
[5] This category is set above the last one at the same distance (in €) existing between option B of line 20 (€225) and the amount provided in option B of line 19.

S2. Data analysis

As can be observed in Fig. S4 (panel A), the choices in the discounting task are quite well distributed except for the fact that a high percentage of the participants (33%) are characterized in the highest category (k = 1.211). In panel B of the same figure we represent the hyperbolic discount functions linked to the elicited values of k.

Fig. S4.

A. Choices (*k*s) in the discounting task **B.** Individuals' discount functions



Description of variables:

- "Contribution" captures the number of €1 coins contributed to the public good (from 0 to 10).
- "Male" takes the value of 1 for males and 0 for females.
- "($C_i - C_o$)" refers to the punishers' deviation from the mean cooperation level of the other three group members.
- "DD (k)" captures the delay discounting parameter k.
- " ($C_i - C_o$) x k" is the interaction term between the above two variables.
- "Regular income dummy" captures subjects who self-reported earning a regular monthly income source. The source is considered regular when it is not going to disappear for one year following the experiment.

- "Personal monthly income" is the subject's self-reported average monthly income during the last year. The variable takes the value of 0 if no personal income was earned in the last year; 1 if average monthly income is between €0 and €499; 2 if it is between €500 and €999; 3 if it is between €1000 and €1999 and 4 between €2000 and €2999.

- "Household monthly income" refers to the subject's self-reported mean monthly income within the household, subtracting own income. Household monthly income has been assigned the same values and intervals as personal monthly income, with the exception of an extra category: 5 if average household monthly income is greater than or equal to €3000.

- "Educational level" captures the highest educational level achieved by the subject at the moment of the experiment. The variable takes the value of 0 if no formal education; 1 if elementary education (value 0.5 is given to those individuals who were preparing the exam to obtain the elementary education diploma at the moment of the experiment); 2 if secondary education; 3 if university diploma or technical degree; 4 if bachelor or postgraduate degree (not self-reported, information provided by city halls).

- "Evangelist dummy" takes the value of one if the subject self-reported being evangelist and zero otherwise.

- "Pool dummies" capture the five different locations of our experiments. There are ethnic differences between locations which are entirely controlled for by means of the pool dummies.

After including all the personal characteristics we obtained as controls (missing values in controls were adjusted to the sample mean), the individual's DD is negatively and significantly related to personal monthly income and to the remaining household's monthly income only, albeit weakly (Table S1 model 1). Also, we find no significant impact of DD on subjects' contributions to the public good, which are only influenced by the age and the educational level of the subjects, positively and weakly in both cases (Table S1 model 2).

Table S1. Tobit models: determinants of individuals' DD & contributions to the public good

Dependent variable:	**DD (*k*)** (1)	**Contribution** (2)
DD (*k*)		-0.0996 (0.811)
Age	0.0006 (0.004)	0.0404 * (0.024)
Male	-0.0495 (0.115)	0.1517 (0.717)
Regular income dummy	0.1904 (0.153)	0.4043 (0.843)
Personal monthly income	-0.1549 ** (0.068)	-0.1424 (0.417)
Household monthly income	-0.0758 * (0.043)	-0.2456 (0.301)
Educational level	0.0518 (0.08)	0.8828 * (0.52)
Evangelist dummy	-0.1823 (0.15)	-0.4892 (0.801)
Pool dummies	YES	YES
Constant	0.7136 ** (0.305)	4.5457 ** (1.967)
Log likelihood	-139.974	-355.556
LR (chi^2)	3.51 ***	1.31
Observations	160	160

Robust standard errors clustered by individuals are presented in brackets. *, **, *** indicate significance at the 0.10, 0.05 and 0.01 levels, respectively.

Existing evidence suggests that a high DD is related to a lower willingness to cooperate in public good games without punishment even when individuals interact only once [S7]. In non-repeated interactions without punishment opportunities, strategic considerations to contribute do not play a role. Hence, such evidence suggests a predisposition of future-oriented individuals to behave more pro-socially even when this does not mean getting future rewards linked to others' reciprocal altruism. However, the possibility of getting punished can blur such a relationship since it introduces short-run strategic reasons to cooperate. Indeed, in our experiment DD was not significantly related to contributions (P>0.9). The introduction of punishment may have therefore lifted the social dilemma to the second floor: the enforcement of cooperation.

Table S2. Probit model: Impact of DD & deviation over the willingness to punish

	No interaction term		With interaction term	
	(1)	(2)	(3)	(4)
$(C_i - C_o)$	0.0134 (0.03)	0.0184 (0.034)	0.1569 ** (0.063)	0.163 ** (0.068)
DD (k)	-0.467 * (0.247)	-0.292 (0.274)	-0.4457 * (0.264)	-0.2714 (0.293)
$(C_i - C_o)$ x k			-0.1883 *** (0.065)	-0.1884 *** (0.072)
Age		-0.0069 (0.009)		-0.0052 (0.009)
Male		-0.2648 (0.23)		-0.2565 (0.24)
Regular income dummy		0.5774 * (0.334)		0.55 * (0.333)
Personal monthly income		-0.1623 (0.17)		-0.1683 (0.168)
Household monthly income		0.064 (0.122)		0.0927 (0.121)
Educational level		-0.2905 * (0.173)		-0.3664 ** (0.168)
Evangelist dummy		0.2718 (0.372)		0.4303 (0.39)
Pool dummies	NO	YES	NO	YES
Intercept	0.0298 (0.218)	0.3834 (0.714)	0.0105 (0.229)	0.3128 (0.706)
Pseudo R^2	0.0194	0.1795	0.0509	0.2050
Log likelihood	-311.388	-260.555	-301.381	-252.463
LR (chi^2)	3.61	45.48 ***	11.10 **	67.27 ***
Correctly predicted (punishers)	51.67%	75%	53.33%	73.33%
Correctly predicted (non-punishers)	63%	63%	69%	69%
Correctly predicted (full sample)	58.75%	67.5%	63.13%	70.63%
Observations	160	160	160	160

Robust standard errors clustered by independent PGP groups are presented in brackets. *, **, *** indicate significance at the 0.10, 0.05 and 0.01 levels, respectively. Prediction statistics are calculated by cutting-off at the observed mean of the dependent variable (0.375).

We use the hyperbolic shape because it has been shown to fit individuals' inter-temporal decisions better than other specifications, although there exists controversy across and within disciplines [S4, S8, S9]. In Table S7 it can be found a reproduction of Table S2 models but using other, non-hyperboloid discounting characterizations. Although the main results are robust to these changes, the goodness of fit of models with the hyperbolic parameter *k* is slightly better than that of models with other discounting forms. For these reasons, all the analyses are conducted using the hyperbolic *k*.

Table S2.1. Marginal effects after probit model

	No interaction term		**With interaction term**	
	(1)	(2)	(3)	(4)
$(C_i - C_o)$	0.0051 (0.011)	0.0068 (0.013)	0.0592 *** (0.024)	0.0599 *** (0.025)
DD (*k*)	-0.1767 ** (0.093)	-0.1074 (0.101)	-0.1682 * (0.1)	-0.0996 (0.107)
$(C_i - C_o) \times k$			-0.0615 *** (0.025)	-0.0519 ** (0.028)

Robust standard errors clustered by independent PGP groups are presented in brackets. *, **, *** indicate significance at the 0.10, 0.07 and 0.02 levels, respectively. Marginal effects for the interaction terms and their significance are the observed mean values obtained as in Ai & Norton (2003).

Marginal effects of interaction terms in nonlinear models are not constant for the whole sample. In fact, the interaction effect in a nonlinear model, such as a probit model, is different for each observation. Moreover, the sign can vary for different observations [S10]. Because of this analysis becomes quite complicated. By default, statistical packages calculate the derivative of the expected value of the dependent variable (y) only with respect to the interaction term $(x_1 x_2)$, while the correct marginal effect is given by the cross-partial derivative of the expected value of *y* with respect to the two interacted independent variables (x_1, x_2). Incorrect and correct characterizations of the interaction marginal effect are given by equations 5 and 6, respectively. Here we show scatter plots of interaction marginal effects and significance levels (z-statistics) for every observation (Fig. S5), obtained through the *inteff* command for STATA [S11] as well as the incorrect interaction effect as calculated through equation 5. What is reported in Table S2.1 for the interaction term is the observed mean of the marginal effects (and mean significance levels).

Expected value of *y* (conditional mean):

$$E[y|x_1, x_2, X] = \Phi(\beta_1 x_1 + \beta_2 x_2 + \beta_{12} x_1 x_2 + X\beta) = \Phi(\text{u}) \qquad (4)$$

With X being the matrix of control variables.

Incorrect marginal effect for the interaction term:

$$\frac{\partial\Phi(u)}{\partial(x_1x_2)} = \beta_{12}\Phi'(u) \qquad (5)$$

Correct marginal effect for the interaction term[6]:

$$\frac{\partial^2\Phi(u)}{\partial x_1\partial x_2} = \beta_{12}\Phi^{'}(u) + (\beta_1 + \beta_{12}x_2)(\beta_2 + \beta_{12}x_1)\Phi^{''}(u) \qquad (6)$$

Fig. S5A. Interaction effects and z-statistics. Model 3 (Tables S2 & S2.1)

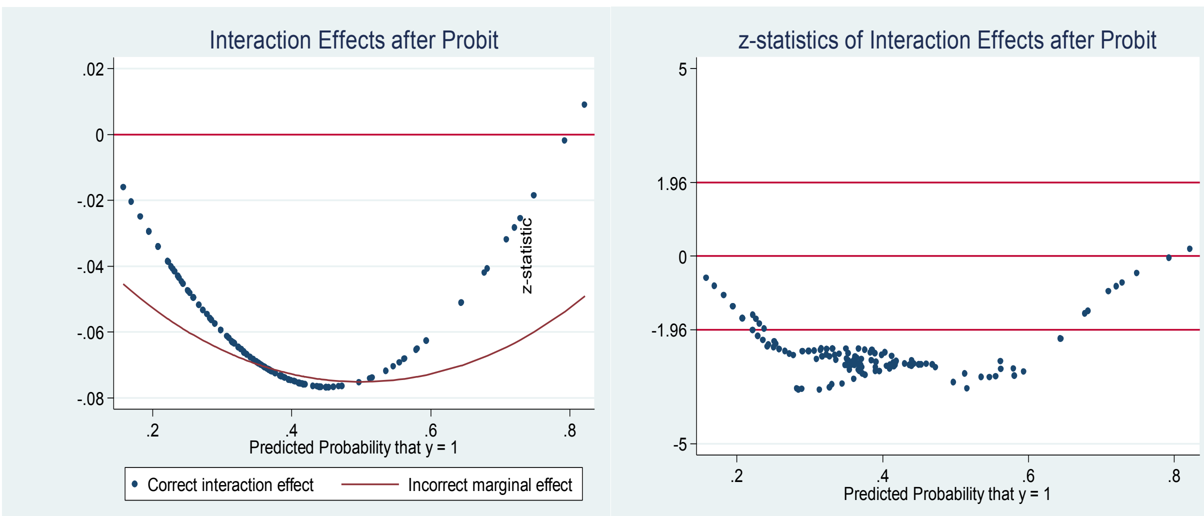
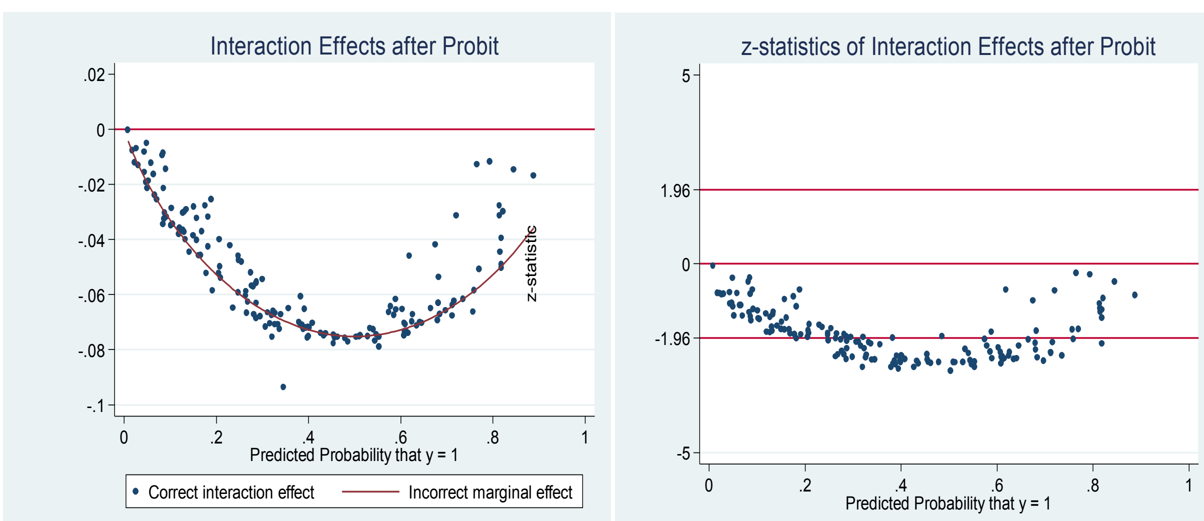


Fig. S5B. Interaction effects and z-statistics. Model 4 (Tables S2 & S2.1):



[6] In linear models the marginal effect of the interaction term is correctly characterized through equation 5.

As can be observed in Fig. S5, the marginal effects of the interaction reach their highest (absolute) value for subjects for whom the predicted likelihood of punishing is around the value 0.45. As regards Fig. 1B of the main text, the analysis of nonlinear marginal effects suggests that the slopes are higher than those actually reported in the figure (which is based on linear models from Table S3) when the predicted likelihood is closer to this value. However, the nonlinear slope is lower than that shown in such figure at the combinations of deviation and DD for which our models predict both the lowest and the highest likelihood of punishing. The same holds for Fig. S6 & S7.

Table S3. OLS model: Impact of DD & deviation over the willingness to punish

	No interaction term		**With interaction term**	
	(1)	(2)	(3)	(4)
$(C_i - C_o)$	0.0056 (0.011)	0.0072 (0.12)	0.0589 ** (0.022)	0.0563 ** (0.022)
DD (k)	-0.1767 * (0.092)	-0.0951 (0.09)	-0.1667 * (0.094)	-0.0956 (0.091)
$(C_i - C_o) \times k$			-0.069 *** (0.022)	-0.0625 ** (0.023)
Age		-0.0022 (0.003)		-0.0017 (0.003)
Male		-0.0789 (0.072)		-0.064 (0.072)
Regular income dummy		0.161 (0.105)		0.1549 (0.102)
Personal monthly income		-0.0535 (0.055)		-0.0574 (0.053)
Household monthly income		0.0187 (0.041)		0.0251 (0.039)
Educational level		-0.1026 * (0.058)		-0.1253 ** (0.053)
Evangelist dummy		0.0641 (0.086)		0.1078 (0.089)
Pool dummies	NO	YES	NO	YES
Constant	0.5091 *** (0.086)	0.6353 ** (0.24)	0.5034 *** (0.084)	0.6234 *** (0.23)
R^2	0.0258	0.2154	0.0669	0.2450
LR (F)	1.84	5.71 ***	4.45 ***	9.05 ***
Observations	160	160	160	160

Robust standard errors clustered by independent PGP groups are presented in brackets. *, **, *** indicate significance at the 0.10, 0.03 and 0.01 levels, respectively.

In Fig. S6 (and S7) we plot linear predictions of the models with interactions. The left and right plots are simply two different perspectives of the same prediction which allow us to better observe the values reached at the largest possible number of DD and deviation combinations.

Fig. S6. Linear predictions of models from Table S3

Fig. S6A. Model 4 (Fig. 1B of the main text):

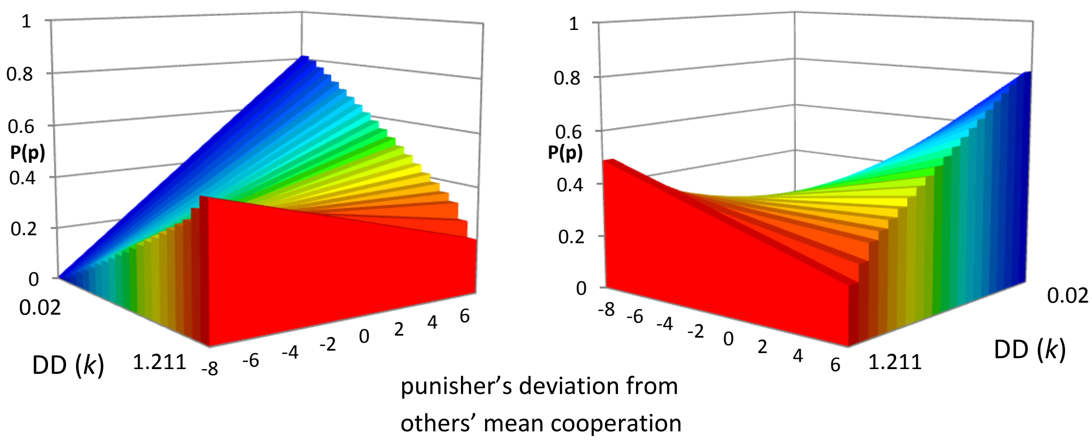
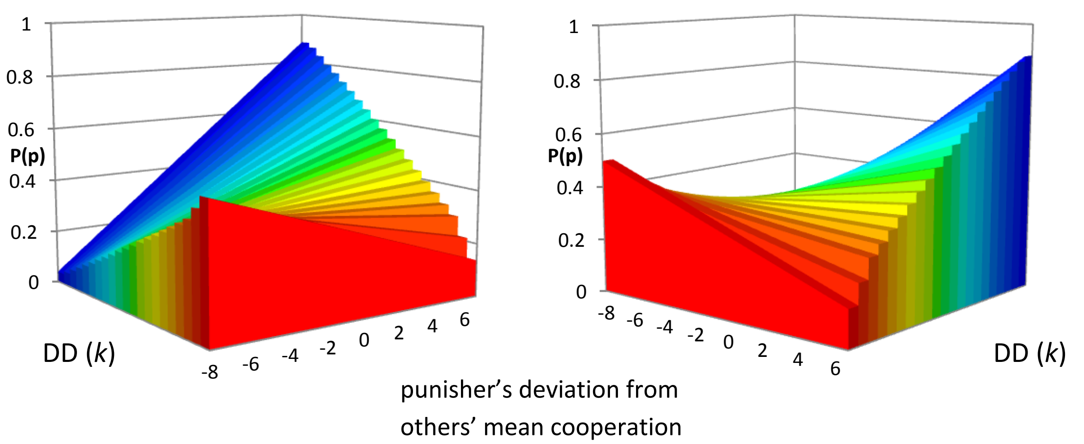


Fig. S6B. Model 3 (no controls):



In Table S4 "expects punishment" takes the value of 1 for participants who expected to get punished with any amount. As "controls" we include all the personal characteristics and pool dummies. Model 1 is the same specification as model 4 (whole sample) in Table S3, but adding the expectations of the punisher as a control. Models 2 & 3 take the subsample of individuals who self-reported earning a stable monthly income. For models 4 & 5 we construct a subsample which does not include participants who are characterized within the lowest and the highest DD categories. Finally, individuals aged above 69 years old are dropped for models 6 & 7. We present OLS estimations due to the comparability of coefficients and because we plot OLS predictions in subsequent figures. The probit models yield similar results (available from the authors upon request).

Table S4. OLS model: Impact of DD & deviation over the willingness to punish (robustness checks)

	Adding expectations	**Only regular income**		**No extreme DD**		**Age < 70**	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$(C_i - C_o)$	0.073 *** (0.022)	0.0736 *** (0.024)	0.1188 *** (0.028)	0.0772 *** (0.028)	0.086 *** (0.024)	0.0583 ** (0.024)	0.0525 ** (0.026)
DD (k)	-0.0673 (0.088)	-0.0565 (0.13)	-0.0647 (0.113)	-0.0273 (0.156)	0.1094 (0.168)	-0.147 (0.099)	-0.0841 (0.102)
$(C_i - C_o) \times k$	-0.0739 *** (0.023)	-0.115 *** (0.034)	-0.19 *** (0.039)	-0.0791 * (0.044)	-0.078 * (0.04)	-0.0711 *** (0.023)	-0.0573 ** (0.026)
Expects punishment	0.332 *** (0.074)						
Controls	YES	NO	YES	NO	YES	NO	YES
Constant	0.365 (0.221)	0.4597 *** (0.112)	-0.1004 (0.563)	0.4563 *** (0.111)	0.3812 (0.307)	0.4613 *** (0.089)	0.6045 ** (0.238)
R^2	0.3395	0.1464	0.3583	0.0608	0.3191	0.0614	0.2557
LR (F)	21.14 ***	4.69 ***	8.38 ***	2.79 *	18.16 ***	4.14 **	8.03 ***
Observations	160	61	61	98	98	139	139

Robust standard errors clustered by independent PGP groups are presented in brackets. *, **, *** indicate significance at the 0.08, 0.05 and 0.01 levels, respectively.

In this series of robustness checks we find that: (i) the interaction effect becomes stronger if we restrict the sample to subjects who had a regular source of monthly income at the time of the experiment (P<0.01, N=61) (Fig. S7B), while this effect remains similar if we (ii) control for the expectation of getting punished (P<0.01) (Fig. S7A), (iii) drop subjects in the 2 extreme categories of DD (i.e., censored observations) (P<0.07, N=98) (Fig. S7C), and (iv) take only subjects aged below 70 as in other studies on DD [S12] (P<0.05, N=139) (Fig. S7D). The estimate of the deviation variable is always positive and significant as its interaction with DD is enabled (Table S4). For space and technical reasons (different subsamples report different mean values for controls) in Fig. S7 we only plot linear predictions for the models which do not include control variables, with the exception of the model with expectations which does include them (model 1).

Fig. S7. Linear predictions of models from Table S4

Fig. S7A. Model 1 (with expectations)

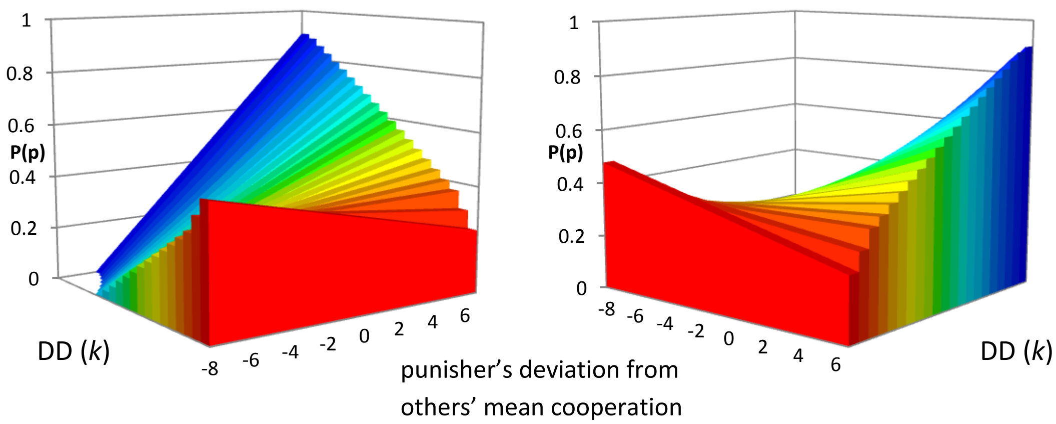


Fig. S7B. Model 2 (only regular income subjects)

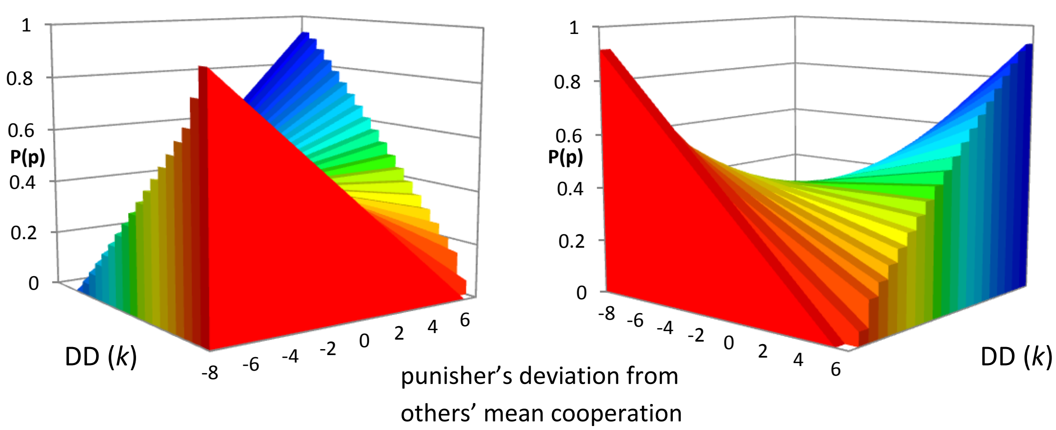


Fig. S7 (cont.). Linear predictions of models from Table S4

Fig. S7C. Model 4 (no extreme DD subjects)

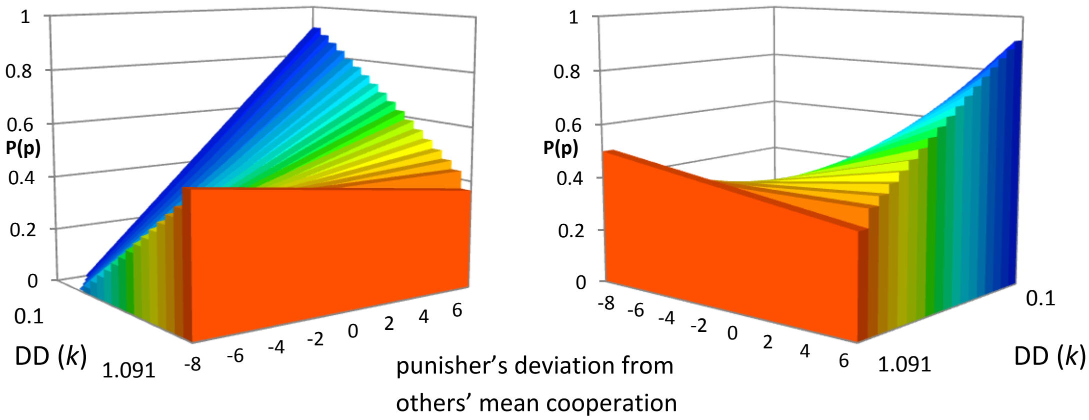
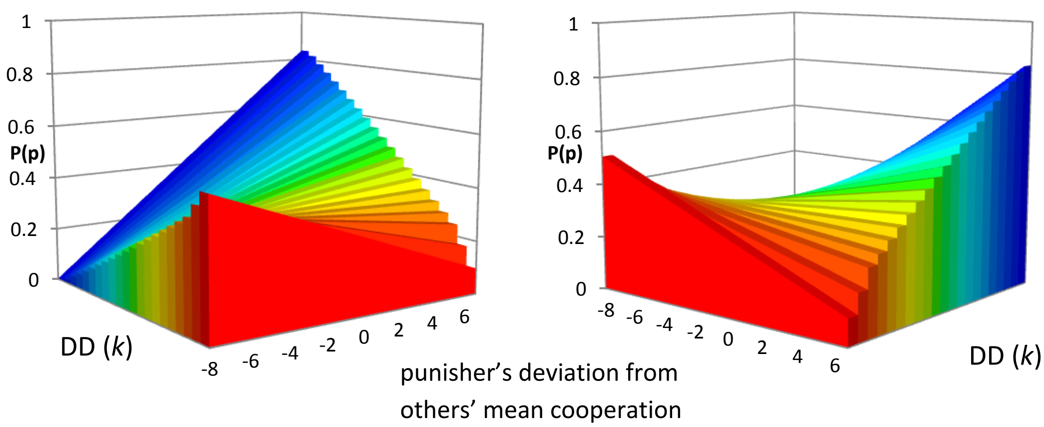


Fig. S7D. Model 6 (subjects aged < 70)



When comparing the coefficients of deviation between models 1 & 4 in Table S5 we observe that both the expectations about the likelihood of getting punished and the actual likelihood are negatively correlated with deviation from the mean cooperation level of the other three group members. Hence, negative deviations are expected to have a higher likelihood of being punished, as actually happens. We implement model 4 only controlling by pool dummies since the likelihood of getting punished has nothing to do with the personal characteristics of the punished individual with the exception of cooperative level. Indeed, although model 1 reports a coefficient for deviation from mean cooperation which is slightly lower than that of model 4, as we control for personal characteristics in the model of expectations (model 2) the coefficient for deviation from mean cooperation is closer to that of model 4 for actual punishment received and its statistical significance increases (from P=0.076 to P=0.052). We present OLS estimations due to the comparability of coefficients. The probit models yield similar results (available from the authors upon request).

Table S5. OLS model: DD, deviation, expectations & punishment received

Dependent variable (dummy):	Expected punishment (1)	(2)	(3)	Punishment received (4)
$(C_i - C_o)$	-0.0207 * (0.011)	-0.0237 ** (0.012)	-0.0505 ** (0.023)	-0.0256 *** (0.009)
DD (k)		-0.0855 (0.104)	-0.0852 (0.102)	
$(C_i - C_o) \times k$			0.0342 (0.026)	
Age		-0.0003 (0.003)	-0.0006 (0.003)	
Male		-0.0554 (0.088)	-0.0636 (0.086)	
Regular income dummy		0.2017 ** (0.104)	0.205 ** (0.104)	
Personal monthly income		-0.083 (0.052)	-0.0809 (0.051)	
Household monthly income		-0.0417 (0.04)	-0.0452 (0.04)	
Educational level		0.0006 (0.053)	0.0131 (0.055)	
Evangelist dummy		0.055 (0.105)	0.0311 (0.104)	
Pool dummies	YES	YES	YES	YES
Constant	0.6563 *** (0.089)	0.7718 *** (0.215)	0.7784 *** (0.215)	0.5938 *** (0.11)
R^2	0.15	0.1863	0.1947	0.2547
LR (F)	6.10 ***	5.30 ***	4.78 ***	12.69 ***
Observations	160	160	160	160

Robust standard errors clustered by independent PGP groups are presented in brackets. *, **, *** indicate significance at the 0.10, 0.06 and 0.01 levels, respectively.

By analyzing individuals' expectations on others' punishment, we can eliminate possible confounding factors that could explain our findings. In models 2 & 3 (Table S5) we observe that DD has no influence on the expected likelihood of getting punished, neither by itself nor through its interaction with cooperativeness (Ps>0.2). This means that impatient and patient individuals do not have different expectations on what levels of cooperation are more likely to get punished. Moreover, the percentages of successful predictions regarding getting punished are identical across DD categories (63%, 63.5% & 64.2% for low, medium & high DD, respectively; same categories as Fig.1A of the main text). It is therefore unlikely that the misunderstanding of rules by impatient subjects explains the observed cooperation and punishment behavior.

Table S6. OLS model: DD, own cooperation, target's cooperation & punishment

	No controls		**With controls**	
	(1)	(2)	(3)	(4)
Cooperation level (C_i)	0.0432 *** (0.016)	0.0433 *** (0.016)	0.0482 *** (0.016)	0.0484 *** (0.016)
DD (k)	0.2605 ** (0.107)	0.2774 * (0.147)	0.3147 *** (0.113)	0.3559 ** (0.154)
$C_i \times k$	-0.0598 *** (0.014)	-0.0599 *** (0.014)	-0.0592 *** (0.017)	-0.0595 *** (0.017)
Target's cooperation (C_t)	-0.0263 *** (0.008)	-0.0243 * (0.014)	-0.0225 *** (0.008)	-0.0174 (0.014)
$C_t \times k$		-0.0026 (0.015)		-0.0064 (0.015)
Age			-0.0004 (0.002)	-0.0004 (0.002)
Male			-0.0358 (0.045)	-0.0363 (0.045)
Regular income dummy			0.1058 (0.067)	0.1072 (0.068)
Personal monthly income			-0.0409 (0.031)	-0.0415 (0.031)
Household monthly income			0.0273 (0.026)	0.0269 (0.026)
Educational level			-0.0755 ** (0.033)	-0.0753 ** (0.033)
Evangelist dummy			0.0607 (0.059)	0.0591 (0.059)
Pool dummies	NO	NO	YES	YES
Constant	0.1966 * (0.1)	0.1832 (0.111)	0.192 (0.187)	0.1602 (0.198)
R^2	0.0726	0.0726	0.1722	0.1725
LR (F)	7.47 ***	6.20 ***	4.70 ***	4.45 ***
Observations	480	480	480	480

Robust standard errors clustered by independent PGP groups and individuals (two dimensions) are presented in brackets. *, **, *** indicate significance at the 0.10, 0.05 and 0.01 levels, respectively.

Table S6 shows the likelihood of punishing each of the other three group members as a function of the punisher's absolute cooperative level, C_i (from 0 to 10), and DD and the target's cooperation level, C_t. Here we use the cooperative level itself since using the deviation variable would complicate the analysis[7]. The interaction between punisher's cooperation and DD is always a significant predictor, whereas punisher's DD interacted with target's cooperation is largely insignificant (Ps>0.6) (models 2 and 4) although the latter is negative and significant by itself (models 1 and 3). We present OLS estimations due to the comparability of coefficients and because we plot OLS predictions in Fig. 2 of the main text. The probit models yield similar results (available from the authors upon request).

At this point, one might wonder whether the punishment of other low, but not high, contributors is the appropriate strategy to increase the relative standing of impatient low-contributors. To address this question we again focus on the participants' expectations about the punishment received. If the level of punishment expected to be received by an impatient free-rider is low enough, her relative standing will not be threatened by cooperators but only by other free-riders, whose payoffs are closer. However, in the event that the punishment one expects to receive could overcome the existing payoff advantage with respect to cooperators, a competitive punisher should be willing to reduce cooperators' payoffs through punishment as well. According to our data, we are not in the second case because the most impatient free-riders (that is, k=1.211 and deviation<-1) expected to lose €2.21 (±0.98, SEM) on average because of punishment, while the average difference in payoffs separating them from the above-average contributors in their groups was €5.68 (±0.41, SEM).

[7] The deviation from the mean cooperation of the other three group members would lead to different comparison points for the punisher and the target. If we avoid this problem by using the group's mean, which is constant across members, we instead encounter a new problem. In fact there are situations that, by definition, cannot happen given the features of the game. For instance, neither the punisher nor the target can deviate either negatively nor positively at the same time more than €5 from the group's mean cooperation. Moreover, at each deviation level and at each group's mean there exists a different theoretical deviation threshold which none of the other partners can overcome.

Table S7. Probit model: Main result (Table S2) with other discounting specifications

	No interaction term		**With interaction term**		**No interaction term**		**With interaction term**	
	(1a)	(2a)	(3a)	(4a)	(1b)	(2b)	(3b)	(4b)
$(C_i - C_o)$	0.0131 (0.03)	0.0182 (0.034)	0.1646** (0.068)	0.1695** (0.073)	0.0129 (0.03)	0.0182 (0.034)	0.1738** (0.07)	0.1767** (0.076)
DD	-0.6411* (0.353)	-0.4064 (0.391)	-0.6078 (0.384)	-0.3722 (0.423)	-0.0265* (0.015)	-0.0165 (0.017)	-0.0251 (0.016)	-0.015 (0.018)
$(C_i - C_o)$ x DD			-0.2614*** (0.095)	-0.2598** (0.106)			-0.0112*** (0.004)	-0.011** (0.005)
Controls	NO	YES	NO	YES	NO	YES	NO	YES
R^2	0.0178	0.1792	0.0478	0.2031	0.0169	0.1789	0.0479	0.2030
LR (Chi^2)	3.32	45.49***	9.80**	65.24***	3.15	45.53***	9.78**	64.31***

Robust standard errors clustered by independent PGP groups are presented in brackets. *, **, *** indicate significance at the 0.10, 0.05 and 0.01 levels, respectively.

Models in columns 1a-4a (Table S7) use the exponential form of the discount rate, $V_d = Ve^{-kd}$, (ranging from 0.02 to 0.877, in annual terms) to characterize DD. For columns 1b-4b we use the number of the switching row (between 1 and 21) as measure of DD. The R^2 values decrease with the use of these two alternative functional forms for discounting in relation to the use of the hyperbolic shape. However, our main results remain intact.

S3. General instructions

[As the participants are arriving they receive the show up fee (€5) and a colored scarf; subsequently they pick their number from the bag and are helped to find their specific cubicle]

Welcome to this study financed by the University of Granada, and thank you to all for taking part. This study deals with economic decisions, that is to say, decisions involving money. The first thing you must do is to make sure you have on each table: an envelope with own color, a piece of card with own color and number, one box containing 10 euro coins, a pen, and a blank sheet of paper. From this point onwards, no-one is allowed to talk, and, if you have a question, please raise your hand and we will personally attend you.

For the first part of the study everyone will be in a group of four. Within these groups of four there will be one participant of each color: yellow, orange, green and blue. Everyone will be in a group of four; not even we (the experimenters) know the composition of the groups. It is important that you realize that colors are not forming teams and that the number designated to you has nothing to do with who is in which group, that is to say, that number ones do not form a group, nor twos, etc. rather the groups' composition is going to be determined randomly by a computer. It is possible that Yellow 1 is in Orange 5´s group or Blue 3 is in Green 2´s group. You only know for sure that your group is composed by one person of each color; however you do not know their numbers. Is that clear? Anyone who is in doubt please raise your hand.

Another thing that should remain clear is that all decisions that you make later, when we explain what you must do, are completely anonymous. No-one here will know what decisions you will make, not even us. Also, all the information we collect is going to be used only for research questions and it will be not related to the name of the decision maker.

Now, each person has to decide what to do with the 10 euros you are endowed with (box). Concretely, the idea is to divide the €10 between the communal fund and themselves. And so what is the communal fund? Well, it is a fund for each group of four (remember: there is a person of each color in each group). This communal fund works in the following manner: all money raised in each fund will be doubled by ourselves, and shared out equally between individuals of each group. For example, if the communal fund holds 20 euros, we will double it, (so it now has 40) and share it equally between individuals. They will therefore get 10 euros each. But, what happens with the money you keep for yourself? That money is neither doubled nor shared and goes directly for you. Now with the examples given on the whiteboard you will understand the process more clearly.

Example 1:

Imagine I'm the yellow component of the group; I decide to put nothing into the common fund and keep €10 for myself; so I mark an X by "0 for communal fund" and another by "10 for myself" just below [S1E on the whiteboard with corresponding Xs]. And we all do the same, with no-one in my group putting any money in the common fund. [E1 on the whiteboard, emphasizing that the first column is always showing own situation]. As there is nothing in the communal fund, nothing is doubled or shared out and everyone simply keeps the €10 they have.

Example 2:

Imagine that I now decide to put €10 (all) into the communal fund and keep €0 for myself; so I mark an X over the 10 cell in the first row and another X over the 0 cell just below [S1E on the whiteboard with corresponding Xs]. Orange, green and blue do the same. Hence, every group member allocates the €10 to the common fund [E2 on the whiteboard]. As we have put all €10 in the communal fund, we have nothing left for ourselves. Therefore we have €40 in the common fund, which we double to €80 (remember that we only double money in the common fund). That means that each individual of the group receives €20. As no-one kept anything back for themselves, they now have a total of €20.

S1E.

Euros for the common fund	0	1	2	3	4	5	6	7	8	9	10
Euros for myself	10	9	8	7	6	5	4	3	2	1	0

E1.

Euros for the common fund	0	0	0	0
Euros for him/herself	10	10	10	10
Euros from the fund	0	0	0	0
Total euros	10	10	10	10

E2.

Euros for the common fund	10	10	10	10
Euros for him/herself	0	0	0	0
Euros from the fund	20	20	20	20
Total euros	20	20	20	20

E3.

Euros for the common fund	0	10	10	10
Euros for him/herself	10	0	0	0
Euros from the fund	15	15	15	15
Total euros	25	15	15	15

E4.

Euros for the common fund	4	5	6	8
Euros for him/herself	6	5	4	2
Euros from the fund	11.5	11.5	11.5	11.5
Total euros	17.5	16.5	15.5	13.5

Example 3:

Imagine now that the yellow member allocates €0 to the common fund while the rest of group members allocate the whole endowment (€10) to it [E3 on the whiteboard]. Since there are €30 in the common fund, it's doubled (€60) and evenly shared €15 for each one. Thus, the yellow member ends with €25, the €15 from the fund plus the €10 he/she kept, while the other group members end with €15, because they kept nothing.

Example 4:

For the last example we are going to complicate the situation a little bit. Take note that, in the next one, you will have to decide for yourselves. Imagine that the yellow member decides to put €4 in the common fund and keep €6 for him/herself [S1E on the whiteboard with corresponding Xs]. Now, the orange component allocates €5 to the joint pot and keeps €5. The green member puts €6 and keeps €4. And, lastly, the blue one allocates €8, keeping €2 [E4 on the whiteboard]. In this case, the total amount allocated in the common fund is €23. It's doubled (€46) and evenly shared €11.50 each. In this case, the yellow member ends with €17.50, the amount received from the pot plus the €6 he/she kept. The orange one ends with €16.50 while green and blue end with €15.50 and €13.50, respectively.

The next step is for you to decide how to divide your €10, so if you have any doubt please raise your hand now. As you know, the only thing you have to decide is how much to put into the communal fund of your group (first row) and, underneath, how much you wish to keep for yourselves. But before making your decision you have to know one last thing:

Now we will calculate each person´s winnings. You will receive a new sheet with the same structure we have used for the examples. Hence, you will see the information, regarding what each person has done, on your card. This way you will know, for each member, what he/she allocated in the common fund, what she/he kept and, finally, what he/she earned. It is possible that, for whatever reason, you therefore decide that you would like to reduce what some of your colleagues have won. We have foreseen this, and have invented a mechanism which will allow you to do so. The functioning of such mechanism is the following:

- You can use the mechanism to reduce someone's earnings up to 3 times.
- The mechanism reduces by €3 at a time.
- Therefore the most by which you can reduce is three times €3 (€9).
- The mechanism can be used against the same person three times, against each person once, or however you want.

- To use the mechanism is optional; you have not to use it if you don't want.
- However, the use of this mechanism is not free... Each time you use this mechanism you must pay €1. Hence, for you to reduce one of your partners' earnings by €3 your own earnings will be reduced by €1.

Remember that the use of this mechanism comes in the next stage. Now, you must decide how to divide your €10 between the common fund (first row) and the "private account" (second row). If you have to make any calculations you can use the blank paper which is on your table.

Once you make your decision, by marking with Xs over the cells you prefer in your sheet, please introduce it inside the envelope on your table. Please close the envelopes and the experimenters will collect them and the coins boxes.

[We collect the envelopes -using the opaque bags- and the coins boxes and bring them to the "calculate-earn" room]

Now, while the experimenters make the calculations of your earnings (5-10 minutes) in the adjoining room, we are going to illustrate on the whiteboard some examples regarding the functioning of the reduction mechanism.

Example 5:

Imagine that the yellow member see these results in his/her sheet. Then, he/she decide not to reduce other group members' earnings. In this case what he/she has to do is to write a zero in the prepared cell below each member earnings [E4.1 on the whiteboard]. Since he/she has not reduced others he/she has not to pay anything [**0→0** on the whiteboard]. Thus, everything remains equal.

As you can see, we have added two new rows at the lower part. The first one is for you to reduce others' earnings while the second, the one with the star, will be used afterwards. Only you have to know that the star row's decision will not influence/change the results of previous stages.

Example 6:

Imagine now that the yellow member of this group decides to reduce orange's earnings by €3 and nothing to the other members [E4.2 on the whiteboard]. Since he/she has used the mechanism only once he/she will pay €1 [**3→1** on the whiteboard].

E4.1.

Euros for the common fund	4	5	6	8
Euros for him/herself	6	5	4	2
Euros from the fund	11.5	11.5	11.5	11.5
Total euros	17.5	16.5	15.5	13.5
Euros reduced		0	0	0
★				
	17.5	16.5	15.5	13.5

E4.2.

Euros for the common fund	4	5	6	8
Euros for him/herself	6	5	4	2
Euros from the fund	11.5	11.5	11.5	11.5
Total euros	17.5	16.5	15.5	13.5
Euros reduced		3	0	0
★				
	17.5	16.5	15.5	13.5

E4.3.

Euros for the common fund	4	5	6	8
Euros for him/herself	6	5	4	2
Euros from the fund	11.5	11.5	11.5	11.5
Total euros	17.5	16.5	15.5	13.5
Euros reduced		3	3	0
★				
	17.5	16.5	15.5	13.5

E4.4.

Euros for the common fund	4	5	6	8
Euros for him/herself	6	5	4	2
Euros from the fund	11.5	11.5	11.5	11.5
Total euros	17.5	16.5	15.5	13.5
Euros reduced		3	0	6
★				
	17.5	16.5	15.5	13.5

Example 7:

Now, the yellow member of this group decides to reduce orange's earnings by €3, green's by €3 and nothing to the blue member [E4.3 on the whiteboard]. Since he/she has used the mechanism two times, reducing €6 in total, he/she will pay €2 [**6→2** on the whiteboard].

Example 8:

For the last example the yellow member of this group decides to reduce orange's earnings by €3, blue's by €6 and nothing to the green's earnings [E4.4 on the whiteboard].

Since he/she has used the mechanism three times, reducing €9 in total, he/she will pay €3 [**9→3** on the whiteboard]. You must understand that €9 is the maximum you can take away, and you can take it away in multiples of €3 in any way you choose, including €9 from the same person… and €3 is the maximum it will cost you to reduce others' earnings.

[The results sheets, once filled, are distributed among participants]

We have checked everything and now we will hand out some envelopes containing a card with your group´s results set out in a table, as you saw earlier on the whiteboard. Now please open your envelope and take out your group´s card. Please first check that the card has your number and color, and that it shows what you put into the common fund and what you kept for yourselves, in the first column. Everything ok? Anyone with doubts, please raise your hand and we will come to you.

You can now see the results. Remember: the first row is what each participant has put into the communal fund, the second is what he/she kept, the third is what corresponds to each participant from the group's fund, and the fourth is the total amount, adding what each person kept for themselves with their amount from the common pot.

Now you have to decide how much -if any- to reduce others' earnings by using the mechanism in the way you saw during the examples. Bear in mind that others from the same group can also take money away from you, but, as always, it is kept anonymous.

At this stage no-one can lose more than they have earned in the first part, no-one will have to put own money in if they have too much taken away. Even the €5 you received in the beginning do not "come into play" in any case. Any doubts?

Now, it's your time to fill the reduction row in the way you saw before. Once you finish with that you are going to fill the last row, the one with the star. Only I make you note that the decision of the star row will not influence/change the results of previous stages.

[Once they fill reduction row]

For the star row you simply have to write down what you think the other three participants of your group have taken away from you. That is, you must write inside the corresponding cell what you think the player from each color is reducing your earnings. For instance, if I think that the orange member has reduced my earnings by €3 then I write a 3 inside the cell of orange column. Also, imagine I believe that the green member has reduced my earnings in €9, then I write a 9 inside the corresponding cell. Finally, if I think for instance that the blue member has not implemented any reduction over my earnings then I write a 0 inside the matching cell [B1E on the whiteboard]. Is it clear? Now it's your turn.

Once you finish, put the card in the envelope, close it, and we will come around and collect it.

[Envelopes are collected -using the opaque bags- and sheet 3 is delivered]

B1E.

Euros for the common fund	4	5	6	8
Euros for him/herself	6	5	4	2
Euros from the fund	11.5	11.5	11.5	11.5
Total euros	17.5	16.5	15.5	13.5
Euros reduced		3	0	6
★		3	9	0
	17.5	16.5	15.5	13.5

Now we arrive at the last stage. After finishing you will be allowed to go outside for refreshments and, subsequently, be individually paid. While the experimenters calculate the payments, you must fill out the sheet just handed out to you. For this part, as it involves a lot of money and we have not enough for all of you, only one randomly selected participant will be paid. Lots will be drawn to decide the winner and the prize.

As you can see, two columns (options) are enabled in this sheet with different amounts of money. The amount in the first column, option A, is the quantity of money we will award in exactly a month time to the winner of the draw. The quantity of money in the second column, option B, is the amount we will give to you in seven months time. In each of the 20 rows what you have to decide is whether you prefer option A or B by marking an X in the corresponding cell. For instance, the first row is for you to decide between €150 in one month time and €151.50 in seven months time. If you prefer not to wait six months in order to receive €1.50 more then you must mark the option A. However, if you prefer to wait for this additional payment then you must mark with an X the option B's cell. This is the reasoning you should apply for every row. Also, the interest column provides you with the interest rate implied by the six-month wait. Since the amount of money implied by option B is increasing across rows, once you mark this option for one row, coming back to option A in subsequent rows makes no sense.

You must know that we are going to determine randomly the prize by picking one out of 20 balls representing the 20 rows from the bag. As a consequence, your decision in each row establishes the money you will receive and the moment of receiving it if you are the winner and such row is selected. Then, the prize depends on your decisions. Since the payment is not for today, the participant who wins will give us his/her phone number in order to arrange an appointment for paying him/her at the corresponding moment.

If you have no doubts, you can start on filling the sheet [It is conducted row by row]. Once you fill it please cut the upper left corner which contains your color and number. The experimenters will collect your pieces of paper using an opaque bag. Afterwards, one of you will introduce his/her "innocent" hand in the bag and he/she will pick one of the pieces of paper in order to select the winner. Also, he/she will pick one of the 20 balls which determine the prize from another opaque bag.

[We collect the pieces of paper -using an opaque bag- and the filled sheets]

[Lots are drawn]

The study has now finished. You are now free to go to the canteen, whilst we do the calculations, and we will call you one by one to pay you your earnings. Please do not lose your scarf and number otherwise we won't know how much to pay you.

THANK YOU FOR YOUR PARTICIPATION.

DECISION SHEETS

SHEET 1 (yellow #1 participant example)

1

You have 10 euros

(Mark with a X in the cell you prefer)

Euros for the common fund	0	1	2	3	4	5	6	7	8	9	10
Euros for myself	10	9	8	7	6	5	4	3	2	1	0

Remember: What you allocate for the common fund is doubled and evenly shared among the four members of your group.

SHEET 2 (yellow #1 participant example)

1

In the common fund there are euros, we duplicate it resulting .

Hence, each of the group members receives euros from the fund

Euros for the common fund				
Euros for him/herself				
Euros from the fund				
Total euros				
Euros reduced				
★				

SHEET 3 (yellow #1 participant example)

1

Mark with an X the chosen option

	1 MONTH OPTION A	7 MONTHS OPTION B	interest	A	B
1	150,00€	151,50€	2%		
2	150,00€	154,00€	5%		
3	150,00€	157,50€	10%		
4	150,00€	161,00€	15%		
5	150,00€	165,00€	20%		
6	150,00€	169,00€	25%		
7	150,00€	172,50€	30%		
8	150,00€	176,00€	35%		
9	150,00€	180,00€	40%		
10	150,00€	184,00€	45%		
11	150,00€	187,50€	50%		
12	150,00€	191,00€	55%		
13	150,00€	195,00€	60%		
14	150,00€	199,00€	65%		
15	150,00€	202,50€	70%		
16	150,00€	206,00€	75%		
17	150,00€	210,00€	80%		
18	150,00€	214,00€	85%		
19	150,00€	217,50€	90%		
20	150,00€	225,00€	100%		

1

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Appendix of Chapter 3

Supplementary Information for

Delay discounting and spite in bargaining: Beyond strategic self-interest and fairness

S1. Materials and Methods

The survey-experiment was conducted during Nov.-Dec. 2010, recruiting a representative sample of the adult population of the city of Granada, Spain. As shown in Exadaktylos et al. [S1], the sample was representative in terms of the geographical location of households within the city and also in terms of the age and gender of the participants. A total of 835 individuals were interviewed by 108 pairs of interviewers. The interviewers were last-course university students from the University of Granada who were enrolled in a course on "field experiments" in which they were instructed on the methodology and conduction of survey-experiments. Interviewers' performance was carefully monitored by the main researchers through a web-based system and follow-up phone calls to a number of randomly selected interviewees. To incentivize the fidelity of the data provided by the interviewers, their performance was finally determining whether they would pass or fail the course. All participants were ex-ante informed that the data would be used for scientific purposes only, that responses would never be linked to the identity of the respondent and that the procedures followed for the study and data acquisition were in accordance to the Spanish law on data protection guarantying full anonymity.[1]

For the current research, we selected only those participants whose responses in the delay discounting task and decisions in both roles of the ultimatum game were complete

[1] Detailed information about sampling methods and data acquisition can be found at https://sites.google.com/site/experimentalcity/home.

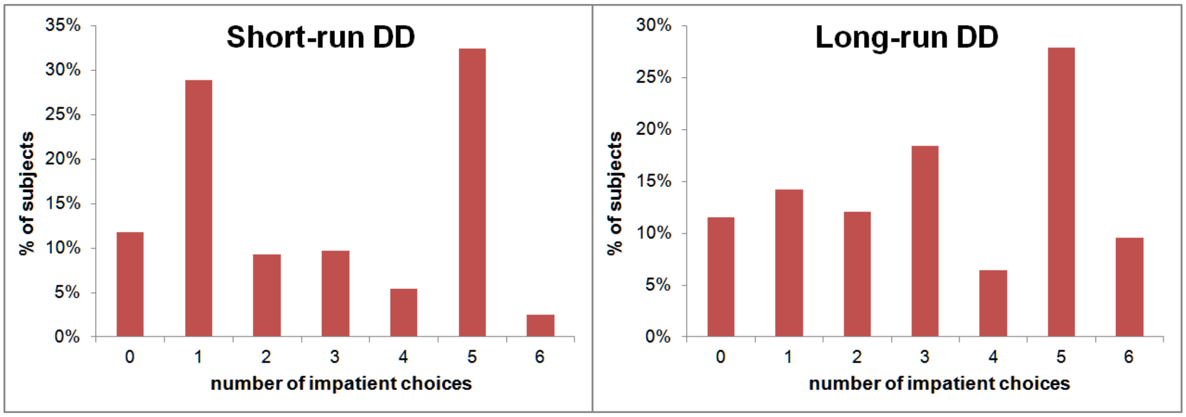
and fully reliable. This involved excluding from the sample those observations making multiple switching, following non-monotonic patterns, or never switching from the sooner to the later reward in any of the two DD subtasks (see Text S1.1) as we cannot ensure that the respondent understood correctly the task. Monotonicity was also assumed for decisions in the responder role of the UG (see Text S1.2). Therefore, participants making non-monotonic decisions were excluded from the sample. Given the field origin of data, controlling for potential confounding factors and socio-demographic variables was necessary. Thus, we also excluded from the sample those observations with missing values in any of the control variables. The final sample consists of 713 complete observations (average age 36.7±16.6 (SD), 54.14% female).

S1.1. The delay discounting task

Two series of inter-temporal decisions involving hypothetical monetary rewards were presented. One of the interviewers read the decisions aloud, one at a time, and the interviewee gave his or her choices also by word of mouth. Participants faced a total of six decisions in each subtask. In the first decision of the short-run DD subtask, participants had to choose between €5 to be received "today" (sooner option) and €5 to be received "tomorrow" (later option). The remaining five decisions kept the sooner reward constant while increasing the later reward, in this order: €6, €7, €8, €9, €10. In the first decision of the long-run DD subtask, participants had to choose between €150 to be received in one month time (sooner option) and €150 to be received in seven months time (later option). The remaining five decisions kept the sooner reward constant while increasing the later reward, in this order: €170, €190, €210, €230, €250.

This task was specifically created for this particular survey-experiment and was maximally simplified in order to be in accordance to the length and amplitude of the interviews. The two discounting measures captured with it were not conceived for parameterization (i.e., to be characterized in a particular functional form, either exponential or hyperbolic) but to be characterized in a non-parametric form such as the number of impatient responses in each subtask. The distribution of subjects' choices in the task are shown in Figure S1. In the case of the short-run DD, two categories concentrate more than 60% of subjects. However, choices in the long-run DD were better distributed.

Figure S1. Distribution of subjects' choices in the DD tasks



According to dual-valuation theories of DD [S2, S3], decisions involving immediate and delayed rewards are evaluated in the brain differently than those involving only delayed rewards. Concretely, the so-called "beta" and "delta" systems would be at work for valuating delayed rewards [S4]. The impatient beta system is supposed to steeply discount all non-immediate rewards (i.e., there is an immediacy premium or a present bias). The more patient delta system would discount delays in a less-steep, exponential shape. Thus, the subjective value of a delayed reward would result from subtracting the non-immediacy penalization (beta system) from the discounted value of the reward (delta system). It could be therefore that the two DD measures we obtained are in association with different behavioral patterns in the UG since only the short-run subtask involved immediate payoffs—meaning that the beta system would not determine choices in the long-run DD. On the contrary, single-valuation theories [S5, S6] argue in favor of a single psychological process evaluating both immediate and delayed rewards. This process would discount the value of all rewards in function of the delay to their delivery, following an hyperbolic form. According to this view, no behavioral differences should be found for the two DD measures we gathered.

S1.2. The ultimatum game

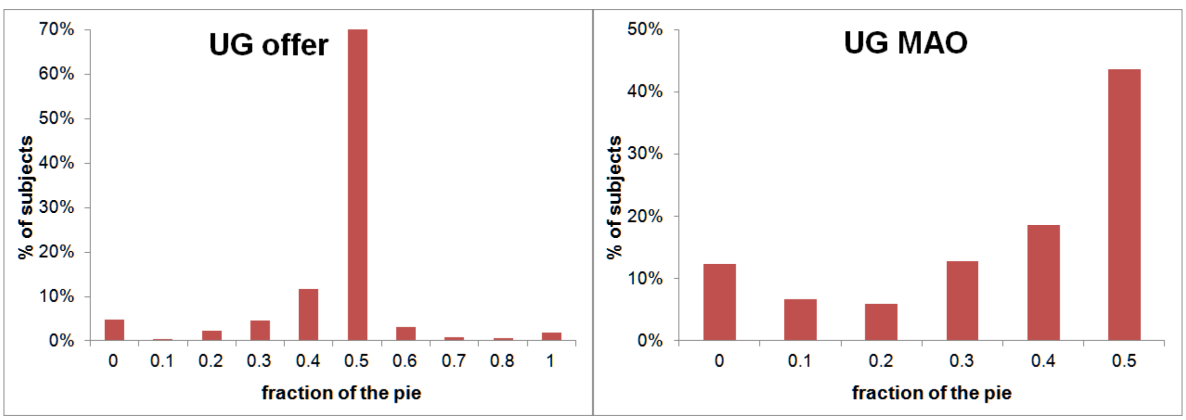
All participants made decisions in both roles of the game.[2] As proposers, subjects had to split a pie of €20 (in €2 increments) with another randomly matched participant. The

[2] An English translation of the experimental instructions and extensive information of the experimental procedures are also available at https://sites.google.com/site/experimentalcity/home.

average offer was 46.2% (±0.7; robust SEM clustered by interviewers) of the pie. In the role of responders, subjects had to state their willingness to accept or reject each of the following proposals (proposer's payoff (€), responder's payoff (€)): (20, 0); (18, 2); (16, 4); (14, 6); (12, 8); (10, 10). With this method we obtained the minimum acceptable offer (MAO) of each subject. The average MAO was 35.0% (±0.9) of the pie. These averages are within the range found in previous ultimatum field experiments [S7]. Figure S2 displays the distribution of offers and MAOs (expressed as fraction of the pie) in the sample.

The instructions the game were read aloud by one of the interviewers. Subsequently, participants were required to privately write down their choices on a decision sheet, which was subsequently introduced in an envelope to ensure a double-blind procedure. The order in which decisions were made was randomized across participants. Matching and payment took place within the next two weeks and the average earnings among winners were €9.60.

Figure S2. Distribution of subjects' choices in the UG



S1.3. Calculation of expected payoffs

To calculate the expected payoffs of participants we simulated a perfect random matching. After interacting with all the other subjects in both roles of the game, each subject's *own payoff* will be simply given by her mean payoff across the 712 encounters. The *other's payoff* will be given by the mean payoff of those who interact with her (i.e., how much one expects to earn when interacting with her), which should not be confounded however with the mean *own payoff* of the other subjects. Perhaps the easiest way to explain this is through an example.

Let's use a simple case with three subjects whose strategies are (offer, MAO): (8, 4), (2, 6), (8, 10). Imagine the case of the first subject. Her offer is 8 and her MAO is 4. The MAOs of the other two players are 6 and 10, which means that half of them will accept her offer. Thus, her expected payoff as proposer is (20-8)*50%=6. Others' expected payoff as responders when she is the proposer is 8*50%=4. As responder, her expected payoff will depend on others' offers, which are 2 and 8. So half of others' offers fall below her MAO (4) and half exceed it. Her expected payoff as responder is therefore 8*50%=4. Others' expected payoff as proposers when she is the responder is (20-8)*50%=6. Finally, o*wn payoff* and *other's payoff* would be equal to the mean expected payoff across roles since every encounter involves playing once in each role. In this case, *own payoff* is (6+4)/2=5 and *other's payoff* is (4+6)/2=5. For the second subject *own payoff* is (0+8)/2=4 and *other's payoff* is (0+12)/2=6. For the third subject *own payoff* is (12+0)/2=6 and *other's payoff* is (8+0)/2=4. Note that *other's payoff* does not coincide with the mean *own payoff* of others. For instance, the value of *other's payoff* for the third subject is 4 while the mean *own payoff* of others is 4.5.

S2. Supporting analyses

S2.1. Variables description

In the next subsection, we will provide the estimates of the regressions summarized in Table 1 of the main text. "Short-run DD" and "long-run DD" refer to the number of impatient responses the individual made for each delay; "combined DD" is the average of the two (these three categorizations of DD are normalized to the interval [0, 1]); "highDD vs. lowDD" takes the value 1 if the individual belongs to the top 33% and 0 if belongs to the bottom 33% of the distribution of "combined DD" (observations falling in the central 33% are missing in the analyses using this variable).

The control variables employed in the regressions are:

- *Age* ϵ [16, 89].

- *Male*: 1 if male, 0 if female.

- *Married*: 1 if married, 0 otherwise.

- *House inc* ϵ [0, 4500]: average household monthly income in the last year (in €500 increments).

- *Educ level* ϵ [0, 8]: no studies (0), incomplete primary school (1), complete primary school (2), incomplete secondary school (3), complete secondary school (4), incomplete university diploma or technical degree (5), complete university diploma or technical degree (6), incomplete bachelor or postgraduate degree (7), complete bachelor or postgraduate degree (8).

- *Cognit ab* ϵ [0, 5]: number of correct answers to five mathematical questions (see in [S1]).

- *Risk 1*: 1 if option b, 0 if option a in the question:

> *We flip a coin. Choose one of the following options:*
>
> *a. Take 1.000 Euros no matter if it is heads or tails.*
>
> *b. Take 2.000 Euros if it is heads and nothing if it is tails.*

- *Risk 2*: 1 if option a, 0 if option b in the question:

> *Choose one of the following options:*
>
> *a. Take a lottery ticket with 80% chance of winning 45 Euros and 20% chance of winning nothing.*
>
> *b. Take 30 Euros.*

- *Risk 3*: 1 if 'Yes', 0 if 'No' in the question:

> *Would you accept the following deal? We flip a coin. If it is heads you win 1,500 Euros and if it is tails you lose 1,000 Euros: Yes (Y), No (N)*

S2.2. Regression analyses

Tables S1 to S4, present the OLS regressions using "short-run DD", "long-run DD", "combined DD", and "highDD vs. lowDD", respectively, to characterize delay discounting as explanatory variables. The dependent variables (expressed as a fraction of the pie) in columns (1) to (5) are, respectively: offer, MAO, offer-MAO, *own payoff*, and *other's* *payoff*. In all regressions we control also for order effects. Robust standard errors clustered by interviewers are presented in brackets.

Table S1. UG behavior and expected payoffs as a function of *short-run DD*

	offer	**MAO**	**offer-MAO**	***own payoff***	***other's payoff***
	(1)	**(2)**	**(3)**	**(4)**	**(5)**
short-run DD	-0.0294	0.0428*	-0.0722**	-0.0115	-0.0252*
	(0.021)	(0.022)	(0.032)	(0.007)	(0.013)
age	0.0003	0.0008	-0.0005	0.0000	0.0003
	(0.000)	(0.001)	(0.001)	(0.000)	(0.000)
male	-0.0025	-0.013	0.0104	-0.0043	0.0005
	(0.010)	(0.013)	(0.015)	(0.004)	(0.006)
married	-0.0070	-0.0325*	0.0255	0.0053	-0.0038
	(0.014)	(0.017)	(0.024)	(0.005)	(0.008)
house inc	-0.0000	0.0000	-0.0000	-0.0000	-0.0000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
educ level	0.0021	-0.0041	0.0062	0.0011	0.0027
	(0.004)	(0.003)	(0.005)	(0.001)	(0.002)
cognit ab	0.0014	0.0117**	-0.0102	0.0052***	-0.0014
	(0.005)	(0.005)	(0.007)	(0.002)	(0.003)
risk 1	-0.0110	0.0560***	-0.0670**	-0.0044	-0.0133
	(0.016)	(0.0189)	(0.026)	(0.006)	(0.010)
risk 2	-0.0070	-0.0153	0.0083	-0.0021	-0.0008
	(0.013)	(0.017)	(0.023)	(0.005)	(0.009)
risk 3	0.0422**	-0.0381	0.0803*	0.0001	0.0266*
	(0.020)	(0.031)	(.041)	(0.009)	(0.014)
R^2	0.0415	0.0655	0.0511	0.0635	0.0523
F	2.42***	2.15***	1.72**	3.78***	1.47*
obs.	713	713	713	713	713

Notes: OLS estimates. Robust standard errors clustered by interviewers in brackets.*, **, *** indicate significance at the 0.10, 0.05 and 0.01 levels, respectively. All regressions control for order effects.

Table S2. UG behavior and expected payoffs as a function of *long-run DD*

	offer (1)	**MAO** (2)	**offer-MAO** (3)	***own payoff*** (4)	***other's payoff*** (5)
long-run DD	-0.0324**	0.0393*	-0.0717***	0.0018	-0.0269***
	(0.016)	(0.020)	(0.024)	(0.006)	(0.010)
age	0.0002	0.0008	-0.0006	0.0000	0.0003
	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)
male	-0.0018	-0.0138	0.0120	-0.0041	0.0011
	(0.010)	(0.012)	(0.015)	(0.004)	(0.006)
married	-0.0059	-0.0334*	0.0274	0.0046	-0.0030
	(0.014)	(0.018)	(0.025)	(0.005)	(0.009)
house inc	-0.0000	0.0000	-0.0000	-0.0000	-0.0000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
educ level	0.0023	-0.0044	0.0067	0.0012	0.0029
	(0.004)	(0.003)	(0.005)	(0.001)	(0.002)
cognit ab	0.0012	0.0120**	-0.0108	0.0051***	-0.0016
	(0.005)	(0.005)	(0.007)	(0.002)	(0.003)
risk 1	-0.0120	0.0569***	-0.0688***	-0.0036	-0.0141
	(0.016)	(0.019)	(0.025)	(0.006)	(0.010)
risk 2	-0.0049	-0.0182	0.0133	-0.0015	0.0010
	(0.013)	(0.017)	(0.023)	(0.005)	(0.008)
risk 3	0.0407**	-0.0364	0.0770*	0.0004	0.0254*
	(0.020)	(0.031)	(0.040)	(0.009)	(0.014)
R^2	0.0423	0.0646	0.0509	0.0601	0.0532
F	2.17***	2.14***	1.92**	4.37***	1.57*
obs.	713	713	713	713	713

Notes: OLS estimates. Robust standard errors clustered by interviewers in brackets.*, **, *** indicate significance at the 0.10, 0.05 and 0.01 levels, respectively. All regressions control for order effects.

Table S3. UG behavior and expected payoffs as a function of *combined DD*

	offer (1)	**MAO** (2)	**offer-MAO** (3)	***own payoff*** (4)	***other's payoff*** (5)
combined DD	-0.0437**	0.0581**	-0.1018***	-0.0070	-0.0369***
	(0.021)	(0.024)	(0.032)	(0.008)	(0.013)
age	0.0002	0.0008	-0.0006	0.0000	0.0003
	(0.000)	(0.001)	(0.001)	(0.000)	(0.000)
male	-0.0021	-0.0133	0.0112	-0.0041	0.0008
	(0.010)	(0.012)	(0.015)	(0.004)	(0.006)
married	-0.0054	-0.0343*	0.0289	0.0052	-0.0026
	(0.014)	(0.017)	(0.024)	(0.005)	(0.009)
house inc	-0.0000	0.0000	-0.0000	-0.0000	-0.0000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
educ level	0.0022	-0.0042	0.0064	0.0012	0.0027
	(0.004)	(0.003)	(0.005)	(0.001)	(0.002)
cognit ab	0.0014	0.0117**	-0.0103	0.0051***	-0.0014
	(0.005)	(0.005)	(0.007)	(0.002)	(0.003)
risk 1	-0.0126	0.0580***	-0.0707***	-0.0043	-0.0147
	(0.016)	(0.019)	(0.026)	(0.006)	(0.010)
risk 2	-0.0063	-0.0164	0.0101	-0.0016	-0.0002
	(0.013)	(0.017)	(0.023)	(0.005)	(0.008)
risk 3	0.0408**	-0.0363	0.0771*	0.0000	0.0255*
	(0.020)	(0.031)	(0.040)	(0.009)	(0.014)
R^2	0.0443	0.0680	0.0560	0.0610	0.0567
F	2.39***	2.24***	1.97***	4.30***	1.59*
obs.	713	713	713	713	713

Notes: OLS estimates. Robust standard errors clustered by interviewers in brackets.*, **, *** indicate significance at the 0.10, 0.05 and 0.01 levels, respectively. All regressions control for order effects.

Table S4. UG behavior and expected payoffs as a function of *highDD vs. lowDD*

	offer (1)	**MAO** (2)	**offer-MAO** (3)	***own payoff*** (4)	***other's payoff*** (5)
hDD vs. lDD	-0.0281* (0.014)	0.0431*** (0.015)	-0.0711*** (0.021)	-0.0069 (0.005)	-0.0231** (0.009)
age	-0.0003 (0.001)	0.0007 (0.001)	-0.0011 (0.001)	-0.0002 (0.000)	0.0000 (0.000)
male	-0.0016 (0.016)	-0.0118 (0.014)	0.0102 (0.022)	-0.0062 (0.005)	0.0017 (0.010)
married	0.0022 (0.017)	-0.0401* (0.021)	0.0423 (0.029)	0.0088 (0.007)	0.0011 (0.011)
house inc	-0.0000 (0.000)	0.0000 (0.000)	-0.0000 (0.000)	-0.0000 (0.000)	-0.0000 (0.000)
educ level	0.0056 (0.005)	-0.0086** (0.004)	0.0143* (0.007)	0.0009 (0.002)	0.0048 (0.003)
cognit ab	0.0022 (0.007)	0.0167** (0.006)	-0.0145 (0.010)	0.0063** (0.003)	-0.0014 (0.004)
risk 1	-0.0147 (0.020)	0.0613** (0.026)	-0.0761** (0.035)	0.0001 (0.008)	-0.0163 (0.014)
risk 2	-0.0096 (0.017)	-0.0078 (0.018)	-0.0018 (0.026)	-0.0093 (0.006)	-0.0036 (0.010)
risk 3	0.0399 (0.026)	-0.0434 (0.041)	0.0833 (0.056)	0.0012 (0.013)	0.0278 (0.019)
R^2	0.0611	0.0899	0.0774	0.0790	0.0711
F	2.47***	4.06***	2.09***	3.58***	1.71**
obs.	488	488	488	488	488

Notes: OLS estimates. Robust standard errors clustered by interviewers in brackets.*, **, *** indicate significance at the 0.10, 0.05 and 0.01 levels, respectively. All regressions control for order effects.

From the regression analyses it appears that the effect of DD on behavior and payoffs does not crucially depend on which period-length is used to measure it, though it is more prominent in the case of the longer delay. It might be that the beta component of DD (see Text S1.1) has no influence on behavior and it is the delta component which drives the results. This would explain why the long-run DD yields better estimates. However, this result can also be due to the higher noise of observations in the short-run DD subtask (see

Figure S1). Thus, our results do not provide unequivocal support for single- or dual-valuation theories.

Among the control variables, only the subjects' cognitive abilities, marital status and risk preferences yield significant coefficients across models. Cognitive abilities relate positively to MAO and *own payoff*, as reported in the main text. Different risk-taking measures report different relationships with behavior, thus making an interpretation difficult (also, a high level of collinearity between the measures could influence the estimation). Finally, married subjects are found to be less willing to reject low offers (i.e., they have a lower MAO), although weakly.

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Appendix of Chapter 5

Supplementary Materials for

Don't mix it up: Fairness versus spite in the Ultimatum Game

S1. Experimental procedures

After completing a questionnaire (identical across studies) on socio-economic and psychological information, subjects made decisions on a Dictator Game, an Ultimatum Game (both roles) and a Trust Game (both roles).[1] Since every subject made all five experimental decisions, the order both between and within games was randomized across subjects, resulting in 24 different orders (the two decisions of the same game were always set aside). In each study, one out of ten subjects was randomly selected to be paid for one randomly chosen game and role. Matching and payment took place within the next two weeks and the average earnings among winners were €9.60 in Study 1 and €10.43 in Study 2. In both cases the max. payoff was €40.

Study 1 (City) took place from November 23rd to December 15th 2010 in Granada, Spain. A total of 835 individuals, between 16 and 91 years old participated (average age 38.5±17.5 (SD), 53.9% female, 22% college students). The experiment was carried out in the subjects' houses and data were collected by 108 pairs of last-course university students who had first undergone a 10-hour training on the methodology of field experiments. The sample was obtained via a stratified random method, which ensured its representativeness. Extended information on the sampling procedures and the resulted sample has been previously reported [S1] and is also available at https://sites.google.com/site/experimentalcity/home.

[1] An English translation of the questionnaire and the complete experimental instructions (Study 1) is available at https://sites.google.com/site/experimentalcity/home.

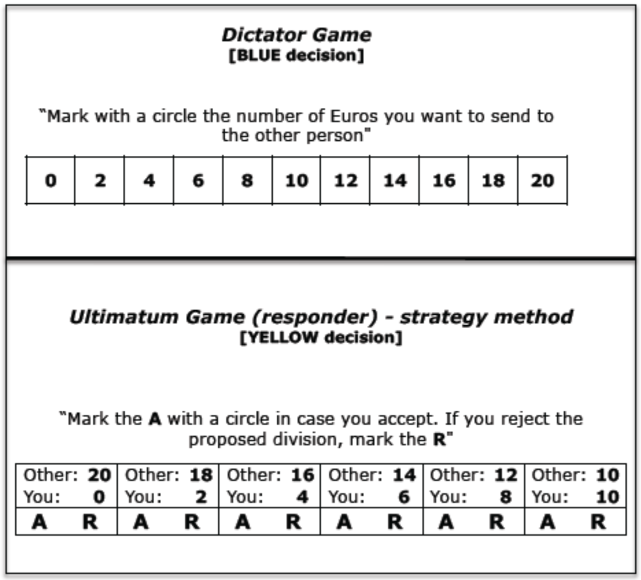
The experiment in Study 2 (Lab) took place during October 2011 in the Granada Lab of Experimental Economics EGEO at the University of Granada. In this study, all first-year students of the School of Economics were invited—class by class—to the lab to take part during the first week of practical classes. In a total of 27 sessions, a sample of 659 students participated (average age 19.1±2.3 (SD), 58.1% female).

In the Dictator Game (DG), subjects had to split a pie of €20 between themselves and another anonymous participant [S2]. Subjects decided which share of the €20 (in €2 increments) they wanted to transfer to the other subject. For the role of responder in the Ultimatum Game (UG) we used the strategy method [S3]. That is, subjects had to state their willingness to accept or reject each of the following proposals (proposer's payoff (€), responder's payoff (€)): (20, 0); (18, 2); (16, 4); (14, 6); (12, 8); (10, 10).

With this method we obtained the minimum acceptable offer (MAO) of each subject. For the analyses in this paper we only consider subjects with complete and reliable observations in both decisions. This involves excluding from the sample those subjects with missing values in any of the two decisions and those making inconsistent choices (i.e. following non-monotonic patterns or making multiple switching between acceptance and rejection) as responders in the UG. Finally, we excluded those subjects transferring more than 50% of the pie in the DG (5.3% in Study 1 and 3.4% in Study 2) since our interest is in fairness-based versus spite-based behavior; transfers above the equal split, although obviously generous, cannot be easily linked to any fairness norm. The resulting sample sizes used in the analyses are *n*=754 in Study 1 and *n*=623 in Study 2.

An English translation of the experimental instructions for Study 1 (only minor adjustments were made for Study 2) can be found in section S3. In Study 1, these instructions were read aloud by the interviewer and subjects had to write their decisions on a decision sheet which was subsequently introduced in a sealed envelope (see Figure S1 for an English translation of the decision sheet). For Study 2, procedures were computerized using an online web-based system.

Figure S1. Decision sheet (Study 1)



Dictator Game
[BLUE decision]

"Mark with a circle the number of Euros you want to send to the other person"

0	**2**	**4**	**6**	**8**	**10**	**12**	**14**	**16**	**18**	**20**

Ultimatum Game (responder) - strategy method
[YELLOW decision]

"Mark the **A** with a circle in case you accept. If you reject the proposed division, mark the **R**"

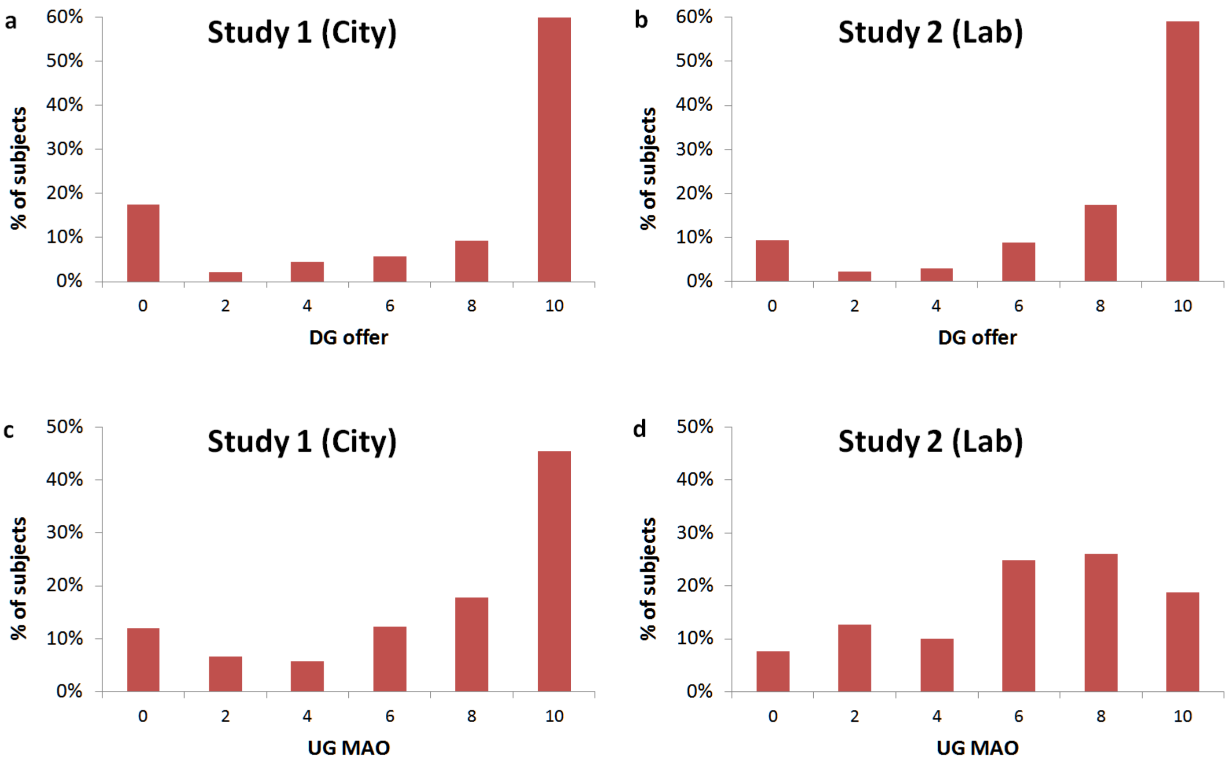
Other: **20** You: **0**	Other: **18** You: **2**	Other: **16** You: **4**	Other: **14** You: **6**	Other: **12** You: **8**	Other: **10** You: **10**
A R	**A R**	**A R**	**A R**	**A R**	**A R**

S2. Supporting analyses

The average (±SD) DG offer and UG MAO were, respectively, €7.40±3.87 and €7.07±3.53 in Study 1, and €7.99±3.18 and €6.10±3.04 in Study 2. This behavior is consistent with previous findings [S4, S5]. Figure S2 presents the histograms of DG (panels a and b) and MAO (panels c and d) decisions for the final sample of both studies. It can be observed that the distributions of choices in the DG were similar in the two studies although €0 transfers were more frequent in Study 2 while €8 (40% of the pie) transfers were more frequent in Study 2.

On the other hand, the distribution of MAOs clearly differs between studies, particularly, in terms of the subjects' willingness to reject any unequal offer, which constitutes the focus of the paper. While 45.49% of subjects in Study 1 set their MAO at €10 (i.e. rejecting any offer below the equal split), the percentage sharply decreases to 18.78% in Study 2. Students in Study 2 appear to be "less strict" responders as MAOs of €6 or €8 were chosen more frequently. We do not think however that these differences discredit our basic results, but rather the opposite; as we discuss later, despite of using two samples with different rejection behavior, the relationship between the subjects' willingness to reject unequal offers in the UG and their behavior in the DG follows an almost identical pattern in the two studies.

Figure S2. Distribution of subjects' choices in the games



In terms of rejecting very low offers, nevertheless, the differences between Study 1 and Study 2 are less striking. Offers of €4 or less would be rejected by 75.6% and 69.7% of subjects, respectively. This is also congruent with previous literature as rejection rates up to 80% have been observed for offers below 25% of the stake [S4].

In Tables S1 (Study 1) and S2 (Study 2) we present the estimations of the models used to support the results of the paper. In all regressions, the dependent variable is the likelihood to reject an unequal offer in the UG, that is, whether the subject set her MAO at €10. We present Probit estimates for the comparison between "unfair" (DG transfer=0) and "remaining" (0<transfer<10) dictators, between "fair" (transfer=10) and "remaining" dictators, and between "unfair" and "fair" dictators. The coefficients together with their standard errors and p-values are displayed for each comparison.

Table S1. Impact of DG behavior on the likelihood to reject unequal offers (Study 1)

	(1)	(2)	(3)	(4)
unfair – remaining	0.446*	0.424*	0.481*	0.457*
	(0.157)	(0.151)	(0.163)	(0.156)
p-value	0.005	0.005	0.003	0.003
fair – remaining	0.647**	0.628**	0.631**	0.610**
	(0.124)	(0.120)	(0.129)	(0.124)
p-value	0.000	0.000	0.000	0.000
unfair – fair	-0.201	-0.204	-0.150	-0.153
	(0.131)	(0.124)	(0.136)	(0.129)
p-value	0.123	0.100	0.271	0.234
order effects	YES	NO	YES	NO
pseudo R^2	0.0565	0.0275	0.0705	0.0399
log likelihood	-490.208	-505.274	-470.687	-486.208
LR (chi^2)	58.71**	28.58**	71.44**	40.39**
Controls	no	no	yes	yes
observations	754	754	735	735

Notes: Probit estimates. Standard errors in brackets. *, ** indicate significance at the 0.01 and 0.001 levels, respectively. In columns (3) and (4), controls are: age, gender, household income, educational level, and cognitive abilities. The sample is reduced (19 observations) due to missing values in control variables.

In column (1) of both tables we show regressions controlling for the order in which decisions were made. These are the results reported in the main text. Column (2) presents estimates for regressions without controlling for order effects. In columns (3) and (4) we repeat the same regressions adding a set of controls consisting of basic socio-demographic variables (age, gender, educational level, and household income) and a proxy for cognitive abilities (number of correct responses to a series of simple mathematical questions). The samples are slightly reduced for the regressions displayed in columns (3) and (4) due to missing values in control variables. As it can be observed, results are robust to all of these specifications in both studies. “Fair” and “unfair” dictators’ likelihood to reject unequal offers in the UG is not significantly different while both groups are significantly more likely to reject unequal offers than the "remaining" dictators. We also checked the effect of clustering standard errors by interviewer in Study 1, as in [S1]. *P*-values slightly increase in all cases but none of the significant comparisons exceeds *P*=0.013. Two-tailed Fisher's exact tests also yield nearly identical results (departures from the *p*-values shown in column (1): unfair vs. remaining, *P*=0.007; unfair vs. fair, *P*=0.114 in Study 1; unfair vs. fair *P*=0.324 in Study 2).

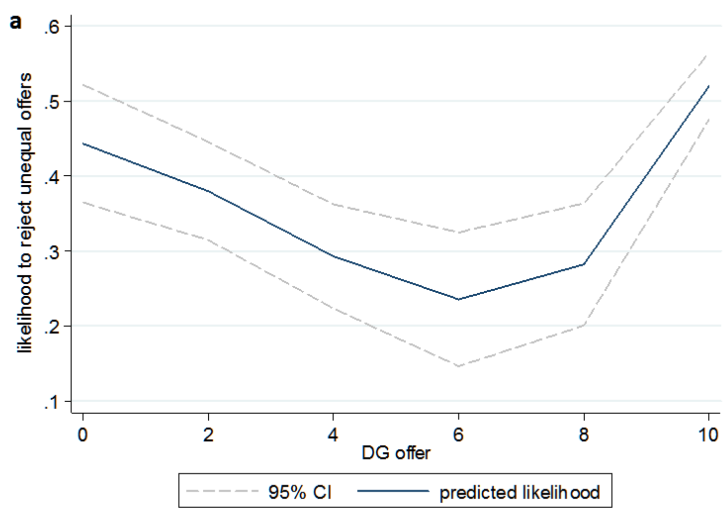
Table S2. Impact of DG behavior on the likelihood to reject unequal offers (Study 2)

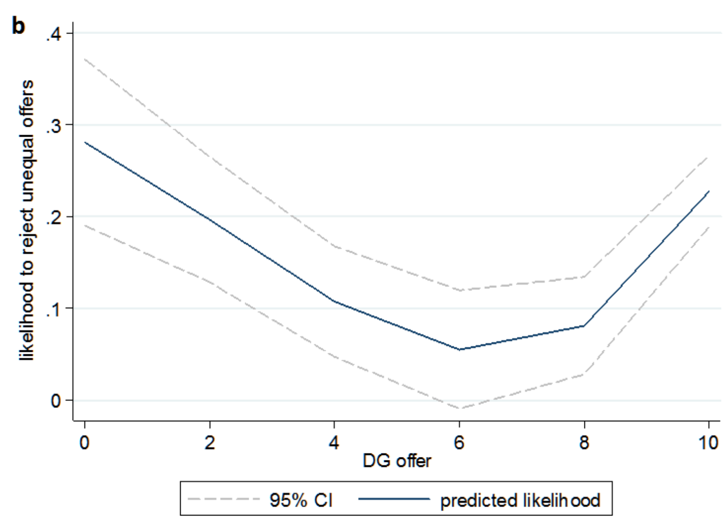
	(1)	(2)	(3)	(4)
unfair – remaining	0.834**	0.835**	0.769*	0.788**
	(0.227)	(0.216)	(0.233)	(0.221)
p-value	0.000	0.000	0.001	0.000
fair – remaining	0.653**	0.650**	0.609**	0.612**
	(0.155)	(0.148)	(0.157)	(0.150)
p-value	0.000	0.000	0.000	0.000
unfair – fair	0.181	0.186	0.160	0.176
	(0.196)	(0.187)	(0.202)	(0.192)
p-value	0.356	0.321	0.428	0.360
order effects	YES	NO	YES	NO
pseudo R^2	0.0784	0.0412	0.0865	0.0473
log likelihood	-277.328	-288.522	-270.708	-282.314
LR (chi^2)	47.19*	24.80**	51.24*	28.03**
Controls	no	no	yes	yes
observations	623	623	615	615

Notes: Probit estimates. Standard errors in brackets. *, ** indicate significance at the 0.01 and 0.001 levels, respectively. In columns (3) and (4), controls are: age, gender, household income, and cognitive abilities (educational level is constant in this study). The sample is reduced (8 observations) due to missing values in control variables.

Among the control variables included in the regressions of columns (3) and (4) only the coefficients of the subject's age and educational level are statistically significant. In both studies, older subjects are more likely to reject unequal offers. For columns (3) and (4), respectively, the coefficient of age reports a *p*-value of 0.038 and 0.039 in Study 1 and of 0.052 and 0.059 in Study 2. The coefficients of educational level are also positive and the *p*-values are 0.074 and 0.044, respectively, in Study 1 (in Study 2, educational level was constant across subjects as all were university students). These relationships, although only marginally significant in some cases, can partially explain why the proportion of subjects setting their MAO at €10 is higher in Study 1, since subjects were on average older and less educated in that sample.

Figure S3. Rejection of unequal splits as a function of DG offers. (a) Study 1, (b) Study 2





In Figure S3 we plot the subjects' likelihood to reject an unequal offer in the UG as a function of their transfers in the DG using a fractional polynomial model. The predictions of the model for Study 1 are displayed in panel a, and those for Study 2 in panel b. We observe that the above results are not due to the aggregation of subjects offering an amount between €0 and €10 within the group of "remaining" dictators. Specifically, Figure S3 shows that, in both studies, dictators offering €6 are the least likely to reject an unequal offer and that the likelihood increases as we move either to the left ("unfair" dictators) or to the right ("fair" dictators). A quadratic regression analysis (not reported) also reveals a significant U-shaped relationship (in all cases, both the linear and the quadratic term report P=0.000). As mentioned earlier, the fact that subjects in Study 2 are less likely to set their MAO at €10 does not imply any change in terms of the relationship between such behavior and subjects' offers in the DG. This supports the existence of both spite- and fairness-driven punishers in the UG, even across very different samples.

S3. Game instructions (Study 1)

In this part, you are going to take decisions with real money. This money comes from a national research project and it is specifically for this purpose. The money you will earn depends on 5 decisions that you are going to take later. Your decisions are totally independent to each other. You have to take the decisions that you prefer in each situation, without taking into account your decisions on the other situations. You are going to be paid from only one decision.

We will make a draw in which 1 out of 10 persons will earn the real amount of money corresponding to the decision s/he has taken. Moreover, the decision that really "pays" among the 5 will be drawn randomly. For this reason, think carefully your decisions because if you are drawn, what you have declared will be what is going to be taken into account for your payment. In case you are drawn, we will make your payment within some days.

The money you earn might also depend on the decisions of other person. We explain: for the 5 decisions you are going to be paired with another person. For each decision, your pair will be different and randomly selected. This person is another interviewee but none of you can identify the other, only that it is a person also living in Granada – not even we know who s/he is. Anonymity is totally guaranteed. This is why in this part, not even we are going to know the decisions you make. For this reason, I am going to give you a sheet to write down your answers. Afterwards, you enclose your answers to an envelope, without letting us look at them. When I ask you, do not say by word of mouth your decisions; just fill the answer sheet.

Dictator Game:

For this decision we give you 20€ in order for you to divide it between you and the other person. From this amount you can send to the other person the share you want, that is, you can send nothing, everything, or just a part. Obviously, the part that you do not send is for you to keep. How much money do you send to the other person? In the **BLUE** table you have to mark with a circle the number of euros you want to SEND to the other person. You can only choose even numbers: (0, 2, 4,…, 20).

Ultimatum Game (responder):

In this part we give you 20€ in order for you to divide it between you and the other person. One of you is going to propose how to divide it, while the other can either accept or reject the proposed division. If s/he rejects it, none of the two will earn anything. For example: the one who decides the division sends 4€ to the other, keeping 16€ for him/herself and the other accepts it. Then the one who divides earns 16€ and the other, who accepts the division, earns 4€. Contrary, if s/he does not accept the proposal none of the two will earn anything. Understood? Decisions:

If you are the one who receives the money sent by the other person, you can accept or reject the division. In **YELLOW** table you have to mark the **A** with a circle in case you accept. If you reject the proposed division, mark the **R** but do not say by word of mouth. If s/he sends you:

- 0€ and keeps 20€, do you accept or reject the proposed division (A or R in the first cell of the YELLOW table). Remember that a rejection means that nobody earns anything.
- …
- 10€ and keeps 10€ (A or R in the last cell of the YELLOW table)

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