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# Rewarding altruism

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## Abstract

In this work we examine studies from different disciplines which lead us to hypothesize that human altruism can be intrinsically rewarding and, given its plasticity, is modulated by social contexts. We address several investigations on neural and endocrine processes, as well as the beneficial effects that altruistic behaviour and social support have on immunity, life expectancy and stress levels, among other advantages. Considering this evidence, we propose a model of social cooperation that presents phase transition in an imperfect supercritical pitchfork bifurcation. The manuscript proposes a potential beneficial role of altruism that could account for its occurrence among non-kin and beyond reciprocity. The model presented here allows the experimental testing of this hypothesis under different cultural and social conditions. This contribution sheds new light on the theoretical discussion about the origin and development of altruism in humans.

*Keywords:*

Cooperation, Plasticity, Cultural conditioning

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## Introduction

Human beings have a noticeable tendency for altruistic behaviour, which emerges in the early stages and develops throughout life (e.g. Batson and Shaw, 1991; Fehr and Fischbacher, 2003; Warneken and Tomasello, 2006). This extended human behaviour has elicited much theoretical discussion among scientists (e.g. Fehr and Fischbacher 2003; Warneken and Tomasello, 2009), since altruism is regarded as a costly act that confers benefits on other individuals whilst decreasing one's reproductive fitness (e.g. Hamilton, 1964). Thus, it is expected to occur only among kin, in situations where others also cooperate (i.e. reciprocal altruism), or when it promotes reputation (e.g. Trivers, 1971). However, there is much evidence to show that altruism occurs widely among non-kin, and can be beneficial for immunity, life expectancy, stress reduction, etc. (Brown et al., 2005; Pace et al., 2009; Schwartz et al., 2003; Klapwijk and Van Lange, 2009). This evidence suggests that human altruism might be intrinsically rewarding, allowing reconsideration of the emphasis placed on its cost (see Fig.1, where, for clarity, we schematized the costs/benefits of altruistic behaviour).

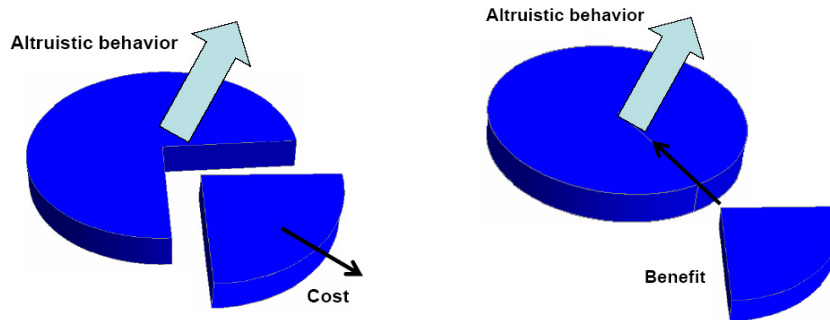


Figure 1: Left: Classical view: altruism as a costly activity. Given a certain amount of energy, resources, etc., altruistic behavior will decrease these by a fraction. Right: new evidence show that altruistic behavior might be beneficial. In the figure we have schematized this by a gain in the fraction of resources, energy, well being, etc.

Altruism seems to be grounded in neurobiological processes (Singer and Steinbeis, 2009; Lutz et al., 2008); for example, rewarding neural networks are activated during cooperative behaviours (Moll et al., 2006; Harbaugh et al., 2007; Moll 2008). Certain neuropeptides and hormones involved in helping behaviour and social bonding can lessen stress levels and anxiety (Brown et al., 2009; Uvnas-Moberg, 1998; Light et al., 2005). The immune system

is affected by the quality and extent of social networks, i.e. social support diminishes the probability of virus infection (e.g. Cohen et al., 1997, 2003; Pressman et al., 2005) and positively influences physiological profiles (Coan et al., 2006; Ryff and Singer, 1998). The emergence of altruism during childhood and its potential intrinsic benefits have not been thoroughly considered in previous theoretical debates, nor have they been modelled from their basic roots. In view of these aspects, the controversy of cost-benefit trade-offs requires some revision. In this contribution we will discuss the ontogenetic development of altruism and its contextual modulation, presenting a model that shows how abrupt transitions to higher states of cooperation can be possible when considering rewarding aspects of altruism in human beings.

## **Biological Aspects**

### *Altruism from ontogeny*

Several investigations have revealed that throughout ontogeny, small children have an intrinsic motivation to help non-kin adults, not based on reward expectation, reciprocation or reputation cultivation (Warneken and Tomasello, 2006, 2008, 2009). Infants show a variety of altruistic behaviours such as comforting, sharing, informing, and instrumental helping. They tend to comfort distressed persons, responding to their emotional needs (Bischof-Köhler, 1988, 1991; Johnson, 1982; Zhan-Waxler et al., 1992). Experiments with children between one and two years of age have shown that they share objects with both familiar and unfamiliar individuals (Rheingold et al., 1976, Hay et al., 1991). Instrumental helping in children has been demonstrated in several experimental settings in which they tend to help an unfamiliar adult who has trouble achieving his goal (Rheingold, 1982; Warneken and Tomasello, 2006, 2008; Warneken et al., 2007). Moreover, 3 to 10-month-olds prefer helping situations to neutral or hindering ones, i.e. they choose goal facilitators over hampering behavior (Hamlin et al. 2007, 2010). In older children (6 to 10-year-olds), a preference for cooperative rather than competitive games has been recorded (Garaigordobil 2003, 2005).

### *The embedded hypothesis*

Human life is embedded in social contexts. Social environments are crucial for human existence and survival, which is evidenced by the predisposition and need to contact others from early stages (e.g. Spitz, 1965; Bowlby,

1969; Decety and Batson, 2007). Newborn infants actively look for experience and communication with others (Trevvarthen, 2004), and children have an intense interest in people. For example, learning is affected by social interaction, as demonstrated in experiments where children learned more from humans than from machines (Meltzoff et al., 2009). This condition of need of others is reflected in a variety of structural and functional mechanisms such as resonance systems, shared neural circuits, and neuroendocrine processes. Emotional resonance between self and other provides the basic mechanism through which empathy later develops (Decety and Meyer, 2008). Empathy refers to the affective response that results from the understanding of another’s emotional state (Eisenberg and Eggum, 2009) and is essential for both the creation and long term stability of social bonds (Watt, 2005). The empathy-altruism hypothesis states that pro-social motivation is associated with feeling empathy (Batson et al., 1988; Batson and Moran, 1999; Batson and Ahmad, 2001; Batson, 2008; Van Lange, 2008; Rumble et al., 2009). As an example, it was experimentally observed that altruism was greater in empathic than in non-empathic conditions (Van Lange, 2008). Moreover, in a prisoner’s dilemma game, altruistic responses were also increased under high empathy conditions (Batson and Ahmad, 2001). Recently, different studies have addressed some physical correlates of empathy and altruism (e.g. Singer and Lamm, 2009; Lutz et al., 2008). Overlapping brain activation patterns were found when feeling an emotion and when observing it in another person (De Vignemont and Singer, 2006; Hein and Singer, 2008; Singer and Lamm, 2009). Resonance systems involving sensorimotor cortices and limbic and paralimbic structures are part of the neural basis of empathy (e.g. Watt, 2005; Singer, 2006; Singer and Lamm 2009). Data from different studies show that the anterior cingulate cortex and the anterior insula are involved in empathic and compassionate states (Lutz et al., 2008). It has been found that brain release of endocrine substances is related to altruistic behaviour (e.g. Brown et al., 2009; Hafen et al., 1996a, b). For example, dopamine has been linked to cooperative behaviour (Rilling et al., 2002), serotonin promotes social cooperation (Wood et al., 2006), and oxytocin appears to mediate cooperation by allowing approach and helping behaviour (Kirsch et al., 2005). Oxytocin is positively associated with empathic ability (Domes et al., 2007), trust (Baumgartner et al., 2008), and in combination with social support, decreases stress levels (Heinrichs et al., 2003). In one experimental study it was found that the administration of oxytocin increases monetary donations (Kosfeld et al., 2005), and progesterone levels have been related

to closeness and willingness to help, being part of the neuroendocrine basis of social bonds (Brown et al., 2009). As mentioned above, extended social networks positively affect the immune system (e.g. Cohen et al., 1997, 2003; Pressman et al., 2005), diminishing the probability of virus infection (e.g. Cohen and Janicki-Deverts, 2009; Cohen et al. 2003; Pressman et al., 2005; Coan et al., 2006). Furthermore, social support positively influences physiological parameters such as heart rate, systolic blood pressure, serum cholesterol, uric acid, and urinary nor- epinephrine (Coan et al., 2006; Ryff and Singer, 1998). These numerous contributions illustrate how social contact and helping behaviour can be beneficial to health. In fact, altruism is likely to emerge from healthy states, as evidenced by studies showing that people feeling well are more sensitive to others' needs and more likely to cooperate (Kunce and Shaver, 1994, Van Lange et al., 2007). In addition, self confidence in small children can be increased through cooperative games (Garaigordobil and Berrueto, 2007). In line with this, the interdependence psychological theory goes beyond the individual-level perspective, highlighting the importance of interpersonal processes (Rusbult and Van Lange, 2008).

#### *Modulation and Context dependence*

Several studies demonstrate that altruism is highly affected by social influence. In this sense, altruistic behaviour, which develops throughout ontogeny, can be encouraged or weakened through socialization. For instance, it has been found in an experimental study that material rewarding of altruistic acts interferes with intrinsic motivation to help in 20-month-olds. Those children who received a material reward after helping were subsequently less likely to help in a following instance compared to infants who had previously received social praise or non-reward (Warneken and Tomasello, 2008). Several studies show how social support, emotional security or positive priming increase motivation to help others (e.g. Bay-Hinitz et al., 1994; Mikulincer and Shaver, 2001, 2005; Mikulincer et al., 2003, 2005). Altruistic behaviours can be promoted by both dispositional and experimentally induced attachment-security, i.e., a sense based on expectations that key people will be available and supportive in times of need (Mikulincer and Shaver, 2005). By studying the effect of social contexts, Eisenberg and Fabes (1998) have found that practice in assisting others seems to foster pro-social tendencies. Similarly, an experimental study conducted on children showed that during cooperative games, aggression decreases and cooperation increases, whereas after competitive games the opposite occurs (Bay-Hinitz et al., 1994). Another

study demonstrated that cooperative games increased cognitive capacities and altruistic behavior (Garaigordobil and Berrueto, 2007). Other experimental studies showed that violent multimedia reduces helping behaviour, while increasing aggressive reactions towards others (e.g. Anderson and Dill, 2000; Anderson and Bushman, 2001; Bartholow and Anderson, 2002; Bushman and Anderson, 2009). As proposed by Eisenberg (1983), socializers' practices affect children's pro-social behaviours, including altruism.

### Consequences on human cooperation and social dynamics

As discussed above, altruistic behaviour is, in the initial stages, an intrinsic rewarding activity. This simple, but profound, assertion leads to important qualitative changes in the emergence and maintenance of cooperation (or its opposite, defection). To see how this affects the dynamics of a given population of individuals, we will write an evolution equation for the fraction of cooperators,  $x$ . The main new feature is that for small values of  $x$  there will be always a positive rate that induces cooperation, independently of any external influence. This positive rate,  $b$ , will be suppressed when a certain level of cooperation is reached, due to the fact that the trade-off between the gain and cost - of effort, energy, etc of doing it - declines. So the dynamics, up to first order in  $x$ , must be of the form

$$\frac{dx(t)}{dt} = b - \alpha x(t) + \mathcal{O}[x(t)^2] \quad \text{with } b, \alpha > 0. \quad (1)$$

Now, keeping this in mind and following Hofbauer, J., Sigmund, K., (1998) and Helbing, D., Lozano, S., (2010), we can write a replicator like equation

$$\frac{dx(t)}{dt} = f(x) = [c - x(t)][1 - x(t)] \{ \lambda_1[1 - x(t)] - \lambda_2 x(t) \}, \quad (2)$$

with  $0 < c < \lambda_1/(\lambda_1 + \lambda_2) < 1$ . From this equation we can see immediately that, in Eq. (1),  $b = \lambda_1 c$  and  $\alpha = \lambda_1 + 2\lambda_1 c + \lambda_2$ .

One important insight of this equation is that near the origin Eq.(1) is valid and, as a consequence, the symmetry between cooperation and defection is broken, leading to an imperfect supercritical pitchfork bifurcation (Guckenheimer and Holmes, 1983), Fig. 2.

As can be seen, this equation has up to three stationary solutions

$$\{x_1, x_2, x_3\} = \{c, \lambda_1/(\lambda_1 + \lambda_2), 1\}, \quad (3)$$

$x_1$  and  $x_3$  stables, and  $x_2$  unstable. In this system low or full levels of cooperation are possible. In general the final state of the system will depend on the initial condition. If  $x(0) > x_2$  the system will evolve to the state of complete cooperation,  $x_3 = 1$ . In contrast if  $x(0) < x_2$  the system will evolve to a final fraction of cooperation given by  $x_1 = c$ .

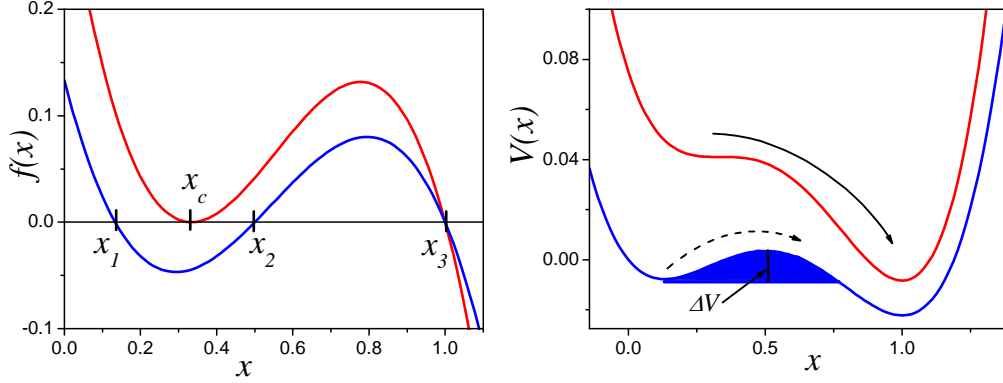


Figure 2: Left: Function of the system's dynamics  $f(x)$ . The zero's of this function indicate the stationary solutions (stable for  $x_1$  and  $x_3$ ). The blue line is a typical supercritical condition, and the red show the critical solution  $x_c$ , where  $x_1$  and  $x_2$  have coalesced. Right: Potential representation of the dynamics. Notice that in  $x_1$  the potential has its local minima; the global equilibrium of the system for  $x_2 < (c + 1)/2$  is always  $x_3$ , higher levels of cooperation, see the text.

Another important aspect of this dynamics, is that the system can *jump* from states of low to high levels of cooperation. In our framework, this can be achieved by three different mechanisms. One is given to fluctuations, as also pointed out in Helbing et. al (2010) referring to phase transitions in prisoner's dilemma games. If the system is in a supercritical condition, as illustrated by the blue line in Fig. 2, and under fluctuations  $\xi(t)$ , the system's dynamics will be given by

$$\frac{dx(t)}{dt} = -\frac{dV(x)}{dx} + \sqrt{\epsilon}\xi(t). \quad (4)$$

Where  $\epsilon$  is the amplitude of the noise and  $V(x)$  is the potential function

$$V(x) = -\int^x f(y)dy. \quad (5)$$

Preparing the system near the left well of this potential, low cooperation, which is always a local minima for  $x_2 < (c + 1)/2$ , as we can see from the difference on the potential at  $x_1$  and  $x_3$

$$V(x_3) - V(x_1) = \frac{1}{12}(c - 1)^3(\lambda_1(c - 1) + \lambda_2(c + 1)), \quad (6)$$

the system will end up in the global stable equilibrium  $x_3$ , full cooperation, in a typical time  $\tau$

$$\tau \propto \text{Exp}[|V(x_1) - V(x_3)|/\epsilon]. \quad (7)$$

That is, depending on the environmental fluctuations (cultural, political, historical issues, etc) the social system will have more opportunities to make an abrupt transition to a more cooperative, and always more stable, society.

The second way to have a more cooperative society, is tuning the parameters  $\lambda_1$  and  $\lambda_2$ . We can make a coalescence of the stable solution  $x_1$  and the unstable one  $x_2$ , in a saddle node bifurcation type. This mean that, for a given inherent rewarding parameter  $c$  we can have a set  $\lambda_1, \lambda_2$  that satisfied  $c = \lambda_1/(\lambda_1 + \lambda_2)$ , i. e.  $x_1 = x_2$ . In this case, the only stable equilibrium is  $x_3$ , a full cooperative society. This extreme situation, of course, is difficult to achieve due to the typical opportunities for cheating and non cooperative behavior, that lead  $x_2$  to be greater than  $x_1$ . Finally the third way of reaching higher levels of cooperation is the already mentioned context, history or, using a mathematical language, the initial condition of the system.

The situation discussed in this section is just an example of the possible consequences of the intrinsic altruistic behaviour as a rewarding activity. Another situations, like dynamics embedded in networks, inclusion of punishment, etc., is out of the scope of the present contribution and they will be the subjects of future research.

## Discussion

### *Environmental and cultural conditioning*

It has been proposed that the development of an organism is not just the result of an internal autonomous program displayed in an external environment, but a consequence of its interaction intricacy (e.g. Oyama, 1985; Lewontin 1983, 1997; Odling-Smee et al., 2003). This perspective goes beyond the clear-cut separation between organism and environment, which is

particularly important for human beings, for whom environments are intrinsically social (e.g. Vygotsky, 1978; Lewontin and Levins, 2007). As demonstrated by Warneken and Tomasello (2009), it is unlikely that young children could be calculating kinship, reciprocity, mating opportunities or cultivating their reputations.

As altruism is a plastic behaviour modulated by culture, altruistic or defect responses are susceptible to the influence of social contexts in which development is occurring. For example, as reported by Fehr and Fischbacher (2003), public goods or prisoner dilemma economic game experiments have been conducted on individuals whose value system (e.g. wealth related to success) biases their decision making. In consequence, the recorded behaviour and interpretation of results will be conditioned by people's experience within a certain cultural background. This is why findings of altruism in small children (Warneken and Tomasello 2006, 2009) are so pivotal, as infants are less conditioned by socio-cultural factors than adults. This supports the hypothesis that humans are predisposed to cooperate and contact others. Notice how the model depicts this idea by introducing a positive rate of cooperation at, and near the origin. This parameter captures the intrinsic motivation to cooperate and interact with others, leading to important qualitative changes in the dynamics of the system, allowing higher levels of cooperation, and facilitating abrupt changes towards cooperation. Here, cultural modulation occurs not only at the individual level, increasing or decreasing the rate of intrinsic cooperation  $b$ , but also at the collective level. A given society will have its particular set of  $\lambda$ 's parameters that capture the degree of cooperation, taking into account the strategies of others, and obviously these parameters will be profoundly codetermined by the cultural background.

### *Final Comments*

We propose that altruism results from the reciprocal interplay between the biological structure and socio-cultural environments unique to humans. Cognitive approaches have provided evidence of the close coupling between these, cutting across brain-body-world boundaries (e.g. Varela et al 1991, Thompson and Varela, 2001; Glenberg, 2006; Niedenthal 2007, Colombetti and Thompson, 2008). In this work we have brought together diverse studies accounting for beneficial effects of altruistic behaviour and social support related to immunity, physiology, psychology, etc (Ryff and Singer 1998; Seligman, 2002; Cohen et al. 2003; Batson et al. 2004) as well as relevant qualitative changes that these can bring to the dynamics and stationary

states of a given population. This manuscript presents the beneficial role of altruism that could account for its occurrence among non-kin and beyond reciprocity, which contribute to the existing body of knowledge on this topic. It would be particularly interesting for this hypothesis to be experimentally tested utilizing the model presented here under diverse cultural and social conditions.

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