Beneficial effects of human altruism

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ABSTRACT

In this work we review converging evidence from several lines of research which suggests that altruism in humans can be intrinsically rewarding. Various investigations illustrate how human altruism can have beneficial effects on health and wellbeing. In this contribution we propose a model that includes positive effects of altruism. These beneficial effects lead to significant changes in the dynamics of the system, favouring higher levels of altruism and facilitating abrupt changes towards cooperation. In the present model, social modulation occurs at both individual and collective levels. The potential beneficial role of altruism proposed here may account for its occurrence among non-kin and beyond reciprocity.

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1. Introduction

Several studies from different disciplines suggest that human altruism is an extended human behaviour which can be intrinsically beneficial (Moll et al., 2006). Social neuroscience investigations have shown that rewarding neural networks are activated during cooperative behaviours (Harbaugh et al., 2007; Moll, 2008). Helping others activates the same brain regions as those activated when receiving rewards or experiencing pleasure (Rilling et al., 2002). Moreover, certain neuropeptides and hormones involved in helping behaviour and social bonding can lessen stress levels and anxiety (Brown et al., 2009). Both the immune and autonomous nervous systems are positively affected by the quality and extent of social networks (Pressman et al., 2005; Kok and Fredrickson, 2010).

Altruism in human beings is a highly plastic trait which arises at an early stage and develops throughout life (Fehr and Fischbacher, 2003). During ontogeny, small children tend to help non-familiar adults without expecting reward, reciprocation or reputation cultivation (Warneken and Tomasello, 2009). Infants show a variety of altruistic behaviour such as comforting, sharing, informing, and instrumental helping. They tend to console distressed persons, responding to their emotional needs (Zahn-Waxler et al., 1992), share objects with both familiar and unfamiliar individuals

(Rheingold et al., 1976; Hay et al., 1991), and help persons to achieve their goals (Warneken and Tomasello, 2006). Furthermore, 3 to 10-month-old prefer helping situations to neutral or hindering ones (Hamlin et al., 2007, 2010).

The presence of altruism during childhood and its potential intrinsic positive effects have not been thoroughly considered in previous theoretical debates, nor they have been modeled from these basic roots. In this contribution we present a model that includes beneficial effects of altruism, by introducing a positive rate of cooperation. This enables abrupt transitions to higher states of altruism, possible when considering the internal rewarding characteristics of this trait.

Before describing the model, we will examine the empathic basis of altruism and its plasticity under different social conditions, so as to bridge individual and collective aspects.

2. Empathy and altruism

Human beings have a predisposition and need to contact others (Trevarthen, 2004; Decety and Batson, 2007). This condition of necessity is reflected in a variety of structural and functional mechanisms such as resonance systems, shared neural circuits, and neuro-endocrine processes. Emotional resonance between self and other provides the basic mechanism through which empathy later develops (Decety and Meyer, 2008). Empathy refers to the capacity that enables people to experience others' feelings and includes the cognitive component of distinguishing between self and others' emotional states (Bird et al., 2010). This is essential for both the

creation and long term stability of social bonds (Watt, 2005). Neurobiological studies on empathy have shown overlapping brain activation patterns when feeling an emotion and when observing it in another person (Singer and Lamm, 2009). This phenomenon has been proposed as the main proximate mechanism for altruism (Batson and Shaw, 1991; de Waal, 2008). Some authors have suggested that empathy leads either to empathic concern (sympathy) or personal distress, the former implying feelings of sorrow and worry for the other and the latter related to a self-focus aversive reaction (Decety and Meyer, 2008; Eisenberg and Egumm, 2009). Considering this conceptual differentiation, altruism is likely to arise from empathic concern. The empathy-altruism hypothesis states that pro-social motivation is associated with feeling empathy (Batson et al., 1988; Batson and Moran, 1999; Van Lange, 2008; Rumble et al., 2009). Experiments where empathic concern was induced showed that high empathic conditions increased altruistic responses (Van Lange, 2008).

Willingness to help others has been correlated with brain activation patterns similar to those activated during empathic states (e.g. Singer and Lamm, 2009; Lutz et al., 2008). Motivation to help can increase vagal tone as it decelerates heart rate (Kok and Fredrickson, 2010). This connection between body correlates and social bonding is also evidenced in the endocrine system, given that certain hormones are closely related to prosocial behaviour (Brown et al., 2009). Oxytocin, for example, 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; Barraza and Zak, 2009). It also appears to mediate cooperation by allowing approach and helping behaviour (Kirsch et al., 2005). Progesterone levels have been related to closeness and willingness to help, being part of the neuroendocrine basis of social bonds (Brown et al., 2009). Dopamine has been linked to cooperative behaviour (Rilling et al., 2002), and serotonin promotes social cooperation (Wood et al., 2006). Moreover, increased sociability and concern for others' wellbeing can improve immune system and stress responses (Cohen et al., 2003; Pressman et al., 2005; Pace et al., 2009; Cohen and Janicki-Deverts, 2009).

The plasticity of altruistic behaviour has been demonstrated in several studies showing how it is highly affected by social contexts. Social support, emotional security and positive priming increase motivation to help (Mikulincer and Shaver, 2005; Mikulincer et al., 2005). The practice of assisting others seems to foster pro-social tendencies (Eisenberg and Fabes, 1998). Similarly, cooperative games can enhance altruistic behaviour, and decrease aggression (Garaigordobil and Berrueco, 2007). In contrast, violent multimedia can reduce helping behaviour (Bushman and Anderson, 2009), and material rewarding of altruistic acts can hinder small children motivation to help (Warneken and Tomasello, 2008).

3. Modelling intrinsic benefits

As discussed above, altruistic behaviour can be considered as an intrinsically 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 always be a positive rate that induces cooperation, independent 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 gain and cost changes, i.e. the effort, energy, etc., of doing it decreases. So the dynamics, up to first order in x, must be of the form

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

Following Hofbauer and Sigmund (1998) and Helbing and Lozano (2010), we can write a replicator-like equation

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

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. 1.

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

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

x_1 and x_3 stable, 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 $x_1 = c$.

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 two different mechanisms. One is given to fluctuations, as also pointed out by Perc (2006) referring to phase transitions and coherence resonance in spatial prisoner's dilemma games. If the system is in a supercritical condition, as illustrated by the blue line in Fig. 1, and under
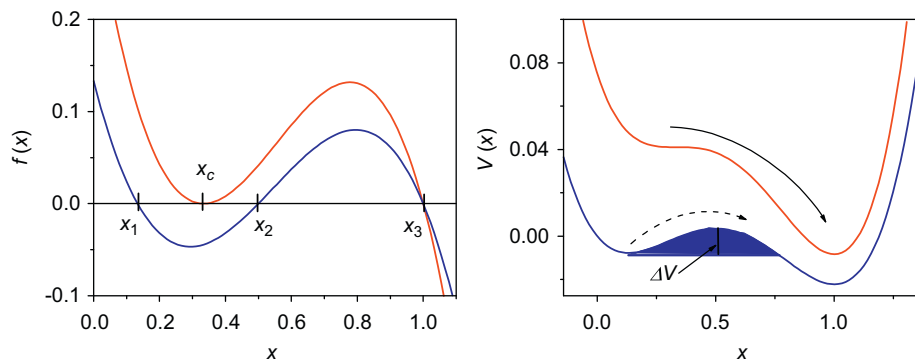

Fig. 1. Left: function of the system's dynamics $f(x)$. The zeros of this function indicate the stationary solutions (stable for x_1 and x_3). The blue line is a typical supercritical condition, and the red shows the critical solution x_c, where x_1 and x_2 have coalesced. Right: potential representation 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, inducing higher levels of cooperation, see the text. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

fluctuations $\xi(t)$, its dynamics will be given by

$$\frac{dx(t)}{dt} = -\frac{dV(x)}{dx} + \sqrt{2\varepsilon}\xi(t). \tag{4}$$

where 2ε is the amplitude of the noise, say a centered Gaussian white noise, and $V(x)$ is the potential function

$$V(x) = -\int^x f(y)\,dy. \tag{5}$$

Given the stochastic equation (4), which is the replicator equation (2) under fluctuation, we can write an evolution equation for the probability of finding the system with a given fraction of cooperation, i.e.

$$\frac{\partial P(x,t)}{\partial t} = \frac{\partial[V'(x)P(x,t)]}{\partial x} + \varepsilon\frac{\partial^2 P(x,t)}{\partial x^2}, \tag{6}$$

which is the Fokker–Planck equation of Eq. (4) using the Ito's calculus (Van Kampen, 2007). The stationary solution for this evolution equation will be

$$P_s(x) = \mu \exp[-V(x)/\varepsilon], \tag{7}$$

where μ is a normalization constant.

The consequences of our hypothesis can also be seen at the population level, since it allows us to understand high cooperative behaviours taking into account the different values of c. Fig. 2 shows how the stationary distribution can go from bimodal to unimodal, changing only this parameter.

Another point to consider is the time taken to produce a change in behaviour, from low to high cooperation. To evaluate this we need to measure the mean escape time τ from the left well, the low cooperation attracting potential. After a straight forward calculation we can derive

$$\tau(x) = \frac{1}{\varepsilon}\int_c^x dy\,\exp[-V(y)/\varepsilon]\int_{-\infty}^y dz\,\exp[-V(z)/\varepsilon], \tag{8}$$

which can be approximated by

$$\tau \propto \exp[|V(x_1)-V(x_2)|/\varepsilon] = \exp[\Delta V/\varepsilon]. \tag{9}$$

This means that the time taken to change from a defector to a cooperator will exponentially decrease with the size of the effective potential barrier th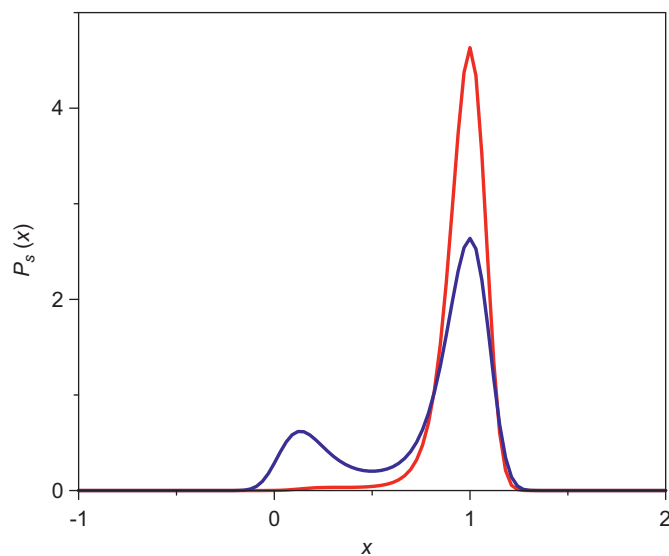at the defector sees from his position, near values of $x = c$. That is, environmental fluctuations (cultural, political, historical issues, etc.) affect the opportunities the social system has to make an abrupt transition to a more cooperative, and always more stable society, but the likelihood of this transition occurring depends on the particular parameter c (notice that this time can be of an order of magnitude which varies with c, Fig. 3).

The second way to have a more cooperative society is to tune parameters λ_1 and λ_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 means that for a given inherent rewarding parameter c we can have a set λ_1, λ_2 that satisfies $c = \lambda_1/(\lambda_1 + \lambda_2)$, i.e. $x_1 = x_2$. In this case, the only stable equilibrium is x_3, a fully cooperative society. This extreme situation, of course, is difficult to achieve due to the typical opportunities for cheating and non-cooperative behaviour, making x_2 greater than x_1.

The situations discussed in this section are just simple examples of the possible consequences of considering altruistic behaviour as an intrinsically rewarding activity. Other situations, such as dynamics embedded in networks (Szabó and Fáth, 2007), inclusion of punishment (Sigmund et al., 2010; Szolnoki et al., 2011), or moral and immoral behaviour (Helbing et al., 2010), etc., lie outside the scope of the present model and will be the subject of future research.

4. Discussion

In this work we have brought together diverse studies that describe positive intrinsic effects of altruistic behaviour and social support on immunity, physiology and psychology (e.g. Brown et al., 2005; Cohen and Janicki-Deverts, 2009; Kok and Fredrickson, 2010), as well as relevant qualitative changes that these can bring to the dynamics and stationary states of a given population. We present a model that includes beneficial aspects of human altruism as well as evidence describing changes in altruistic behaviour when cooperative activities and attachment security priming are conducted. The model considers altruism as a malleable behaviour greatly affected by social context, where social modulation occurs not only at an individual level, increasing or decreasing the rate of cooperation, but also at a collective level. A given society will have its particular set of parameters that capture the degree of cooperation, taking into account the
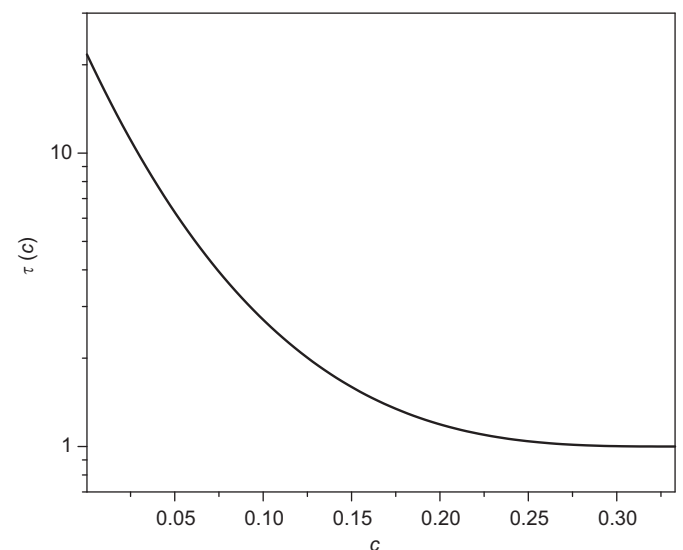

Fig. 2. Stationary probability distribution for the two cases shown in Fig. 1. The blue line corresponds to a typical supercritical situation while the red one is the solution when there is no potential barrier, such as the red line in Fig. 1. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Fig. 3. First passage time for change of behaviour. Notice how the time is greatly affected by changes in c, proportional to b in Eq. (1).

strategies of others, and obviously these parameters will be profoundly codetermined by social environments. As altruism is modulated by culture (Gächter et al., 2010), altruistic or defect responses are susceptible to the influence of social contexts. Thus, when public goods or prisoner dilemma economic game experiments are conducted on adults whose value system influences their decision making, the recorded behaviour and interpretation of results are conditioned by people's experience within a certain cultural background.

Altruistic behaviour has elicited much theoretical discussion among scientists (Fehr and Fischbacher, 2003), since altruism has been defined as a costly act that confers benefits on other individuals whilst decreasing one's reproductive fitness (Hamilton, 1964). Therefore, altruism is expected to occur only among kin, in situations where others also cooperate (i.e. reciprocal altruism), or when it promotes reputation (Trivers, 1971). Evolutionary game dynamics have been extensively used for studying the evolution of cooperation (Szabó and Fáth, 2007). Mathematical models have been formulated to analyze cost and benefit trade-offs in terms of fitness (Nowak, 2006), where individuals performing better would have more offspring, thus increasing their frequency in the population (Roca et al., 2009). Recent models in public goods games show that both external rewards and punishment enhance cooperation in a society (Hilbe and Sigmund, 2010; Szolnoki and Perc, 2010). Moreover, it has been proposed that a good way of increasing cooperation would be to use a reward first (the carrot), and a punishment later (the stick) (Hilbe and Sigmund, 2010). However, these models do not seem to account for the pro-social behaviour observed when players know that reputation building is not possible (Hilbe and Sigmund, 2010). The model presented in this paper, then, which considers that altruism and social support can be beneficial for health (Brown et al., 2005; Cohen and Janicki-Deverts, 2009) could partly explain its frequent incidence among unrelated individuals and in situations not involving reciprocity. In this way, altruism might have an intrinsic positive component, calling for reconsideration of the emphasis placed on its cost. It has been proposed that both positive and negative incentives (i.e. rewards and punishment) induce cooperation in a population (Hilbe and Sigmund, 2010). However, these incentives are costly, whereas intrinsic benefits are not. Hence, if altruism were evaluated not only in terms of costly acts, but its intrinsic beneficial effects were to be considered, greater understanding of its extensive occurrence could be attained.

Acknowledgements

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