Prosocial apathy for helping others when effort is required

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Prosocial acts—those that are costly to ourselves but benefit others—are a central component of human cooperation. While the financial and moral costs of prosocial behaviors are well understood1-4, everyday prosocial acts do not typically come at such costs. Instead, they require effort. Here, using computational modeling of an effort-based task, we show that people are prosocially apathetic. They are less willing to choose to initiate highly effortful acts that benefit others compared with those benefiting themselves. Moreover, even when choosing to initiate effortful prosocial acts, people exhibit superficiality, exerting less force into the actions that benefit others than those that benefit themselves. These findings were replicated, and were present whether the other person was anonymous or not, and when choices were made to earn rewards or avoid losses. Importantly, the least prosocially motivated people had higher subclinical levels of psychopathy and social apathy. Thus, although people sometimes 'help out', they are less willing to benefit others and are sometimes 'superficially prosocial', which may characterize everyday prosociality and its disruption in social disorders.

Our willingness to be prosocial—to perform acts that benefit others—is a central component of human social and moral behaviour. Prosocial behaviours are argued to be a key driver of bonding within groups and to facilitate social cohesion1-5. Acts of prosociality are often reduced in those with criminal levels of psychopathy, in healthy individuals lower in empathy and after brain damage6-13. Prosociality has commonly been investigated in terms of people's willingness to benefit others when these acts come at a personal cost14-16. Typically, these costs have been financial, such as when donating to other individuals or charities6, or moral, such as when deciding whether to profit from others' harm16. Yet, in day-to-day life, financial and moral costs are often negligible. Instead, prosocial acts require motivation to exert effort. Here, we use computational modeling to precisely characterize how effort costs influence motivation to benefit ourselves and other people.

Theoretical accounts of motivation highlight that there are at least two key components that define willingness to exert effort. First, before an action is performed, its costs and benefits are evaluated15-20. When the rewards are high, or the effort costs are low, the value of a behaviour is high and people are motivated to choose to perform that action. However, when the rewards are low or the effort required is high, the subjective value of the reward is reduced. Recent accounts suggest that such 'devaluation' or 'discounting' of rewards by effort can be quantified using computational modeling approaches17-21. Using such models, it is possible to precisely characterize the form that the devaluation takes, and the extent to which each individual devalues rewards by effort costs. Second, once chosen, actions must be energized to such a degree that they are sufficiently forceful22-30 to obtain the desired outcome. While this framework has been used extensively to provide quantifiable measures of motivation to reward oneself, surprisingly, such models have not been applied to understand how we motivate actions that benefit others.

Are people prosocial or are they more selfish when it comes to putting in effort for others? To our knowledge, there are no studies that have quantified either the willingness or the force exerted when people have to put in physical effort for others' benefit. However, the results of studies using economic games are often consistent with a largely selfish view of human behaviour23,31. While individuals are willing to cooperate and share financial resources with others, they still value their own financial gains above those of other people32,33. In contrast, studies of moral decision-making have painted a more positive picture of human behaviour. When individuals trade off a financial cost to themselves against a number of painful shocks delivered to them or to an anonymous stranger, they appear to be 'hyperaltruistic'4,5. They are willing to pay more money to avoid painful shocks being delivered to another person than they are to themselves. Thus, if prosocial effort costs are like moral choices, people might be more willing to exert effort to benefit others over and above themselves and therefore should be hypermotivated to benefit others. In contrast, if effort costs are treated similarly to financial costs, people may be prosocially apathetic and far less willing to work to benefit others.

Levels of prosociality and motivation can vary considerably between people. Variability in apathy, the willingness to exert goal-directed behaviours, is thought to be key to understanding variability in motivation33-35. Multiple lines of evidence suggest that, as well as being common in several neurological and psychiatric disorders, apathy is also present to varying degrees in the general population33,34-38. This dimensional approach to understanding psychiatric and clinical disorders is consistent with the research domain criteria approach to uncovering the mechanisms of psychopathology in health and disease39. Notably, recent research has shown that people with high levels of the behavioural apathy show a reduced willingness to exert effort to benefit themselves27,40, whereas those who are more socially apathetic report less engagement in social behaviours41. Here, we use the term ‘prosocial apathy’ to refer to reduced motivation to put in effort for others’ benefit relative to one’s own benefit.

Outside the domain of motivation, moral and financial prosocial choices often vary considerably between individuals22,41-42. For example, levels of psychopathic traits are negatively correlated with

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trait measures of prosociality and self-reported enjoyment of prosocial interactions. However, the significance of such trait-level associations for behaviour is unclear. For these reasons, we also tested whether those high in psychopathic traits or social apathy are less willing to exert effort to benefit others.

To examine whether people are hypermotivated or apathetic when choosing or energizing acts that benefit other individuals, we designed an effort-based decision-making task based on rodent, primate and human research. Across two studies, participants decided whether or not they were willing to exert an offered level of effort for rewards, and subsequently executed the chosen effort (Fig. 1). To precisely quantify effort, we used different levels of grip force, with levels of effort scaled as a percentage of each individual’s maximum voluntary contraction (MVC). Participants made choices between a baseline of no effort (0% of the MVC), a low-reward option (1 credit) and a variable ‘offer’, which was higher in reward (2–10 credits) but also higher in effort (30–70%). We also examined the choices made and force exerted when participants avoided losing rewards (2–10 credits) if they chose the ‘offer’.

Once they had made their choice, participants were required to squeeze a handle to the required degree of force. Crucially, in half of the trials they made choices to earn payment for themselves (the ‘self’ condition) and in the other half of the trials they had the option of putting in effort to reward another person (the ‘other’ condition). Using computational modelling approaches, we quantified how willing people were to choose to exert effort to benefit themselves versus others, and used a mathematical function to characterize the discounting of reward. We also examined how energized people’s actions were by measuring the force exerted at each level of effort. We could therefore test our key questions of whether effort is costlier when benefitting others or ourselves and whether trait levels of apathy and psychopathy explain individual differences in prosocial apathy.

Using analyses of variance (ANOVAs) with regard to the proportion of acceptance of the ‘variable offer’, we first examined whether willingness to choose to put in effort to obtain rewards differs by the agency (self or anonymous other) of the beneficiary. In study 1, there was a significant agent × effort interaction (F(4,188) = 11.21, P < 0.001; Fig. 2a), as well as main effects of effort and agent (effort: F(4,188) = 128.01, P < 0.001; agent: F(4,7) = 54.93, P < 0.001). Thus, as the offer increased in effort, people were less willing to choose it. However, this effect was further exaggerated when another person was the beneficiary, with a greater reduction in willingness to exert higher levels of effort for the other person. Therefore, when the costs are low, people are willing to choose to benefit both themselves and others. However, when the costs are high, people are less willing to put in effort to help others than themselves. In investigating whether people are less incentivized by rewards for others, we found a significant main effect of reward (F(5,188) = 52.05, P < 0.001) and agent (F(4,7) = 54.93, P < 0.001) and an agent × reward interaction (F(20,351) = 6.34, P < 0.001). Thus, as the rewards increased, people were more incentivized for self versus other (Fig. 2a).

In study 2, we aimed to replicate the findings of study 1 and also to examine whether prosocial motivation could be increased by changing the nature of the other person and the rewarding incentives. Previous studies suggest that prosocial behaviour can be affected by whether it is public or private. For example, the introduction of an audience increases levels of prosociality, while anonymity reduces it. Therefore, we examined whether or not face-to-face contact with the person who would receive the outcomes increases the effort exerted for others. In addition, we included an avoid loss condition, as studies of moral harm have often used negative valence to the benefit on offer (for example, losing money to avoid harm). Moreover, previous research has suggested that self-motivation can be increased when the aim is to avoid the loss of rewards, rather than to earn them. Thus, study 2 allowed us to examine three questions. (1) Do the effects of effort replicate when minimal contact is made with another person whom the participant is led to believe is the ‘other’ person? (2) Is there a loss-aversion effect that results in higher levels of prosocial motivation? (3) Is there still an increased willingness to exert higher levels of effort when avoiding losses?

First, examining the win session only (Fig. 2b), we replicated the findings of study 1 for effort (agent × effort interaction: F(4,176) = 18.02, P < 0.001), but not for reward (agent × reward interaction: F(4,176) = 2.22, P = 0.069). This suggests that even when participants met the person
who would be receiving the outcomes, their prosocial motivation did not increase in terms of the effort they were willing to expend. Moreover, in this analysis, effort levels were collapsed across reward and the variable offer was always associated with an effort cost. Thus, the interaction between agent and effort across both studies suggests that it is a reduced willingness to exert effort for others that consistently drives reduced choices of ‘offers’ for others and not only a reduced sensitivity to the rewards that others will receive.

Analysis of behaviour from the losing session (Fig. 2c) showed that framing the task as avoiding losses for self and other did not change motivation. Again, participants were less willing to choose to put in effort to avoid losing money for the other person compared with themselves at increasing levels of effort (agent × effort interaction: $F_{5,24} = 13.59, P < 0.001$). They also demonstrated significantly lower loss sensitivity for others compared with themselves (agent × reward interaction: $F_{3,18} = 3.10, P = 0.017$). These findings were also replicated when including winning and losing in the same ANOVA model (see Supplementary Results). Comparing choice behaviour between studies 1 and 2, we did not find a significant sample × agent × effort interaction ($F_{4,24} = 2.13, P = 0.08$).

Next, to precisely quantify the subjective influence of effort on rewards for self and other, we created a range of computational models that characterized how rewards were being devalued by the amount of effort. This approach allowed us to quantify people’s motivation to put in effort to reward others using a single parameter that meaningfully characterized how motivation was influenced by the balance between effort and reward. The model also allowed us to use this parameter to test for associations between discounting rates and self-report measures, which can provide more interpretable results than using individual difference measures as covariates in ANOVAs that contain multiple factors with multiple levels.

Models were fitted to behavioural data using the ‘softmax’ function (see Methods and Supplementary Methods). Each model contained idiosyncratic parameters characterizing the degree to which a reward was devalued by effort ($K$), and noise parameters characterizing the stochasticity of choices ($\beta$). Two features were varied to create the model space. First, we varied the mathematical function that characterizes the form of the discounting (that is, whether rewards are devalued linearly, hyperbolically or parabolically by physical effort$^{22–24}$). Second, we compared models that tested whether people devalue or discount rewards by effort to the same degree on self and other trials, or instead used separate discounting rates. We therefore created two classes of model that had either the same parameters to characterize discounting ($K$) on self and other trials (models 1–6) or separate ones (models 7–12; Fig. 3). Within these models, we tested a further two classes of model that characterized whether separate parameters for levels of noise ($\beta$, ‘softmax’) (models 4–6 and 10–12) or single parameters for noise (models 1–3 and 7–9) best explained behaviour.

The winning model in study 1 was a parabolic model in which separate parameters characterized the devaluation of rewards for self and other trials, but had a single noise parameter (model 7; Fig. 3a). This model was best able to explain participants’ choices when correcting for the number of parameters in the models. The Bayesian information criterion (BIC) scores of this model were very close to a parabolic model that had separate discounting parameters for self and other but also separate parameters for noise (BIC two discount, one noise parameter: 5591.69; BIC separate $K_{\text{self}}$ and $K_{\text{other}}$, one noise parameter: 5574.28; Fig. 3a,d). However, the choice behaviour of most participants (32 out of 48) was explained better by the model with a single noise parameter. Thus, devaluation of rewards by effort for self and other can be characterized using equation (1) as follows:

$$SV = R - KE^2$$

$$K = \begin{cases} K_{\text{self}} & \text{if self trial} \\ K_{\text{other}} & \text{if other trial} \end{cases}$$

In this model, $SV$ is the subjective net-value of a variable offer of given effort ($E$) and reward ($R$). The extent to which rewards are subjectively discounted is dependent on the discount parameter ($K$), which is different on self and other trials. A high $K$ value indicates that participants are discounting rewards by the effort to a higher degree.
The winning model (model 7) was replicated with the winning session data from study 2 (BIC = 3671.72; Fig. 3b) and in most participants (33 out of 45 people) compared with the separate noise model (model 10). Furthermore, the same model was again replicated as the best fitting model to the avoiding loss session in study 2 (BIC = 3597.85; Fig. 3c), and in most participants (40 out of 45 participants). We also ran model comparisons with the combined winning and losing data from study 2 to test whether separate win and loss parameters were also needed to explain participants’ behaviour. This additional family of models also showed that separate parameters were needed to explain self and other discounting, but also that separate parameters were needed to explain the discounting of rewards and losses (see Supplementary Fig. 1).

To support the univariate analyses outlined at the beginning of the results, we also compared the discounting parameters from the model for self and other. The discounting parameters were higher for other compared with self in both studies and also for the winning data (one participant was excluded from study 2 (win) due to a very poor model fit resulting in a K value greater than 3 s.d. above the mean; Wilcoxon signed-rank test: study 1 $K_{	ext{win}} > K_{	ext{loss}}$, critical $z$ value, $z=5.60$, $P<0.001$; replicated in study 2 (win): $z=5.01$, $P<0.001$, and in study 2 (loss): $z=4.41$, $P<0.001$). However, the parameters were also correlated, albeit only weakly, in study 1, suggesting that there is some baseline level of motivation that affects discounting for both self and other (study 1: Spearman rank correlation coefficient, $r=0.26$, $P=0.08$ (marginal); study 2 (win): $r=0.39$, $P=0.008$; study 2 (loss): $r=0.35$, $P=0.017$). We also compared discount rates for self and other across the two samples. Intriguingly, we found that participants discounted rewards by effort for others to a lesser degree in study 2 compared with study 1 ($z=-2.83$).
but not lifestyle antisocial traits (relation with affective–interpersonal (core) psychopathic traits showed that there was a correlation with behavioural apathy. Individuals high in psychopathic traits have consistently been found to have lower levels of motivation with strong psychometric properties (see Supplementary Methods).

The AMI divides apathy into three different domains: behavioural activation (self) motivation, emotional sensitivity and social (other) motivation. Our main hypothesis was that individuals who were less willing to put in effort on the ‘other’ trials would show higher levels of social apathy on the AMI. Consistent with this view, there was a significant positive correlation between levels of social apathy on the AMI and ‘other’ K values from the model ($r = 0.22, P = 0.03$). Previous studies have shown that willingness to put in effort to obtain rewards for ourselves correlates with behavioural activation. In line with these studies, we found that people who had higher discounting for ‘self’ (‘higher self’ K values) also had higher levels of behavioural activation apathy on the AMI ($r = 0.34, P = 0.002$). In contrast, there was no correlation between the ‘other’ K parameter and the behavioural activation subscale. Thus, variation in willingness to exert effort for others in the task appears to relate specifically to everyday self-reported social apathy, whereas willingness to put in effort to benefit ourselves relates to behavioural apathy.

Another key individual difference that may affect willingness to help others is our level of psychopathic traits. Psychopathy is a disorder characterized by a constellation of cognitive and behavioural atypicities, including callousness, shallow affect, lack of guilt, antisocial behaviour and impulsivity. In the typical population, psychopathic traits can be reliably measured, with these traits existing on a continuum and often mirroring associations with related constructs that are found in clinical samples. Individuals high in psychopathic traits have consistently been found to be less willing to engage in prosocial behaviours.

In contrast, they may also engage in behaviours associated with impulsivity and antisociality. Psychopathic traits are therefore prototypically linked to selfish behaviour and a reduced willingness to help others relative to oneself. On this basis, we predicted that psychopathic traits would be associated with a lower willingness to put in effort for rewards for others relative to oneself. As hypothesized, the difference in the discounting parameters between motivation for other and self ($K_{other} - K_{self}$) was correlated with the total psychopathy scores ($r = 0.24, P = 0.02$; $K_{other} = 0.05, P = 0.66$; $K_{self} = r = -0.15, P = 0.15$). Follow-up analyses to determine if this effect was associated with specific aspects of psychopathy showed that there was a correlation with affective–interpersonal (core) psychopathic traits ($r = 0.23, P = 0.03$; $K_{other} = r = 0.10, P = 0.37$; $K_{self} = r = -0.10, P = 0.35$), but not lifestyle antisocial traits ($r = 0.09, P = 0.40$; $K_{other} = r = -0.12, P = 0.28$; $K_{self} = r = -0.19, P = 0.08$; see Supplementary Methods).

Thus, those higher in psychopathic traits devalue rewards by effort to a greater degree when another person is the beneficiary, relative to when they are putting in effort to help themselves. These findings suggest that there might be benefits of using our paradigm to understand prosocial deficits in clinical disorders.

To assess whether participants energized their actions to the same degree when choosing to exert effort for others, we ran linear regressions to predict the area under the curve (see Methods) of the force applied in each trial. Only trials for which participants chose the variable offer were included in this analysis (since these were the only trials for which they chose to put in effort). In study 1, we found an agent × effort interaction, indicating that as the amount of effort required increased there was a greater difference in the total amount of force exerted (average $β = -0.04, agent × effort interaction: $P < 0.001$). Reduced levels of force exerted at the higher levels of effort for others, relative to self, drove this effect (Fig. 4a). There were also main effects of effort, agent and reward (effort: $β = 0.86, P < 0.001$; agent: $β = -0.05, P < 0.001$; reward: $β = 0.04, P < 0.001$). Thus, in study 1, the force exerted increased as the effort required increased, but this happened to a lesser degree when effort was exerted to benefit another person.

These findings were replicated in study 2 for winning (agent: $β = -0.08, P < 0.001$; effort: $β = 0.85, P < 0.001$; reward: $β = 0.05, P < 0.001$; agent × effort interaction: $β = -0.03, P < 0.001$). However, for losses there was a main effect of agent on the force exerted ($β = -0.06, P < 0.001$), but no significant interaction between agent and effort ($β = -0.02, P = 0.14$). Given the effects of effort across studies 1 and 2, and the interactions between effort and agent when rewards were won in both studies, these results consistently show that people apply less grip force when exerting effort to reward others compared with themselves. Moreover, when benefitting others, at higher levels of effort, prosocial acts are energized to a lesser degree when rewards are monetary (see Supplementary Fig. 2).

There is considerable debate in philosophy, economics and psychology as to whether humans are truly prosocial; that is, whether they are willing to suffer costs to themselves to benefit others. While empirical studies have quantified how willing people are to donate to charity or to individuals, or to cooperate with others, a crucial factor of everyday prosocial acts is that they come at the cost of quantities of effort that must be exerted. Here, we derived a computational model, through Bayesian model comparison approaches, that characterizes how motivated people are to exert effort to benefit themselves versus others. On two different metrics of effort, which were set to people’s own levels of strength, we found that people are, in fact, prosocially apathetic. Although they will perform prosocial acts, they choose to do so less frequently than acts that benefit themselves (Fig. 2). Moreover, even after choosing to do so, they put in less force (Fig. 4). These effects were replicated across two studies, in which either rewards could be won or losses avoided, and were present whether the other person was completely anonymous or not.

To characterize the subjective influence of effort on rewards for self and other, we examined a range of computational models that describe how rewards are devalued by the amount of effort required to obtain them. The winning model was a parabolic discounting model with separate parameters for devaluation of rewards for self and other person trials and a single noise parameter (Fig. 3). This was robust across studies, regardless of whether people had to exert effort to gain reward or to avoid losing it. Moreover, there was a significant correlation between levels of self-reported social apathy and the model discount (K) values for how people devalued reward for another person. The difference in the discounting parameters between motivation for self and other also correlated with affective–interpersonal psychopathic traits, consistent with...
greater discounting of rewards for others compared with self in people who have higher levels of psychopathy.

Overall, these results extend recent research examining the boundaries of prosocial behaviour. Economic theories posit that humans are inherently self-interested and predict that a rational agent would not exhibit any prosocial behaviours unless there were a benefit to themselves. However, research into moral dilemmas has shown that people can be hyperaltruistic and desire to prevent harm to others more than they desire to prevent harm to themselves. Prosocial motivation therefore does not appear to completely accord with classical economic theories or research examining prosocial behaviour in terms of moral decisions. Instead, people are willing to put in effort to help others, suggesting that they can be altruistic, but they are less motivated to do so than for themselves, which we refer to as prosocial apathy.

A plethora of research has now shown that while we can process information about others, when the same information pertains to ourselves, it is processed with greater fidelity and speed. People therefore show a 'self-bias' for many sources of information. In the prosocial domain, this self-bias is also observed when people learn to perform actions that help others, with individuals being faster to learn which actions will benefit themselves. Our results suggest that there may be a similar self-bias for motivation to exert effort. People are willing to exert effort for others and to energize prosocial acts, but to a lesser degree than they will for themselves.

One important benefit of our design is that we had two metrics of prosocial motivation: both choices and the measurement of force. We were therefore able to identify a previously unobserved, but intuitive, phenomenon: people show 'superficial prosociality'. They indicate they are willing to put in effort to help others, but when it comes to performing a prosocial act, they do not put in effort to the same degree as if they were doing it for their own benefit. Thus, strikingly, we find that even when people show seeming willingness to benefit others, they are not in fact as motivated to benefit another person, particularly when the effort required is high (Fig. 4). Moreover, although we found consistent results across both metrics, there was no a priori reason to expect this to be the case.

It could be argued that the participants in our study were simply complying with a social norm—that prosocial acts should not be directed towards strangers. However, such a norm would logically operate at all levels of reward and effort. That is, people should always choose not to benefit another, regardless of whether the other person will get a small or large reward. We found consistent interactions between effort and agency in people’s decisions, but less consistent reward by agency effects. At low levels of effort, people were relatively similar in their willingness to choose to exert effort to benefit self or other, compared with at higher levels of effort, when the disparity in motivation between self and other was greater. Similar interaction effects were also present in participants’ energization of actions that benefitted self or other. Thus, their willingness to exert effort for others depended on the costs of acting, suggesting that they were being influenced by the costs and not simply using a heuristic that benefiting strangers is undesirable.

Figure 4 | Reduced force when exerting effort to help others. When choosing the experimental option for other, participants applied less grip force than when applying force to reward themselves. a. Force exerted as the total area under the curve during the ‘effort period’ on each trial (top panel). Participants applied less grip force when rewarding the other person compared with self at the higher levels of effort. In a linear regression, agent, reward, effort and the agent × effort interaction were all significant predictors of force exerted (all P < 0.001). b, Reduced force when rewarding others was replicated in study 2 (top). As in study 1, agent, reward, effort and the agent × effort interaction were significant predictors of force exerted (all P < 0.001). c, Participants also applied less force when avoiding losses for others compared with self (top). Agent, reward and effort were again all significant predictors of force exerted (all P < 0.001). The asterisks show significant β weight (P < 0.001) and the error bars show s.e.m. Together, these results show that people are superficially prosocial, even after choosing to exert effort, participants apply less grip force to reward other people than they apply to reward themselves.
There is emerging evidence that the systems in the brain that might be crucial for computing the subjective value of exerting effort, and guiding our choices of whether it is worth allocating resources, are partially distinct from those that are engaged in mobilizing the resources that are required to actually execute the actions\(^{26,29,30,34}\). It is therefore striking that we found evidence of reduced motivation to benefit others relative to self in both the choices and the energization of actions. This result also throws into question whether the hyperaltruistic behaviours observed for morally driven prosocial acts\(^{35}\) may also be due to those studies only examining choice behaviours. Perhaps, if the metrics of people’s actual energization of acts that prevent harm to self versus other were examined, their superfluity might lead to a reduction in our assessment of how altruistic people are.

Prosocial acts can be driven by the reputation of another person or by the possibility that prosocial acts will be reciprocated\(^{31,32,43,47–49}\). To maintain experimental control, we tried to limit the effects of reputation and reciprocity by keeping the other participant anonymous in study 1, and by informing the participant that the other person would not know how much money had been earned or lost in study 2. We also did not observe any interactions between participant gender and the willingness to exert effort for self or other, suggesting similar levels of prosocial motivation in males and females. These results show that regardless of context, people are less motivated to incur costs to benefit others. However, we found increased motivation for benefitting others in study 2 compared with study 1, suggesting that meeting face to face with another person may increase prosocial motivation, even if it still does not lead to the same levels of motivation as when benefitting ourselves. Future studies that manipulate social context, such as the reputation of the other person or the reciprocity of acts, or that examine the allocation of effort between individuals may be able to determine whether prosocial motivation can be raised to an equal or higher level than self-motivation. By examining these effects in ecologically valid situations, the generalizability of our results across the spectrum of social situations could be determined.

An alternative account of prosocial behaviour has come from the notion that people experience a ‘warm glow’ or ‘vicarious reward’ from acts that benefit others. This hypothesis is motivated by the fact that the areas of the brain that process rewards that others receive overlap with those that process one’s own rewards\(^{60–71}\). This could potentially account for one element of the results presented here; specifically, that participants were motivated to perform acts that benefit others at all. However, it cannot account for why people show less motivation to benefit others. Intriguingly, there is growing evidence that there are areas of the brain that play important roles in processing information specifically about costs and benefits that pertain to others and not to ourselves\(^{66,72–73}\). The anterior cingulate gyrus and the subgenual anterior cingulate cortex have been shown to process this information only when processing the costs and benefits for others, and not ourselves, and when learning to be prosocial\(^{16,69,72,74–76}\). These regions also show variability in processing such information that correlates with trait levels of empathy—a crucial driver of prosocial behaviour\(^{7,62,73}\). Moreover, there is growing evidence that the exertion of effort to cooperate or compete with others is driven by separable neural circuits\(^{77}\). This would suggest that processing information about the benefits for others might be encoded in a separate system, which may motivate prosocial acts, and its variability drives individual differences in prosocial motivation.

Although, overall, the participants were prosocially apathetic, we also provide evidence that this tendency varies between people\(^{4,17,40,41,42}\). While self-reported levels of behavioural activation apathy were associated with an increased devaluation of rewards for self, thus replicating previous findings\(^{57,40}\), social apathy related specifically to how motivated people were to put in effort for others. Moreover, apathy in the self or social domain only related to willingness to exert effort in the self or other domain, respectively. This suggests that a key component of social apathy might be the lack of willingness to engage in effortful social acts, which can be characterized by a specific computational measure. Previous studies have also suggested that self-reported levels of prosociality are lower among those with high psychopathic traits\(^{42–44}\). Here, we show that lower prosocial motivation on the behavioural level is also apparent in those with higher levels of affective—interpersonal psychopathic traits. Such findings hold promise for using this measure in future studies to precisely quantify levels of prosocial motivation in individuals with clinical levels of apathy and psychopathy.

Using computational modelling on an effort-based decision-making task, we have shown that people show a self-bias in motivation. They are less willing to choose to put in effort for others and, subsequently, they energize prosocial acts less than similarly effortful self-benefiting acts. We also show that people can be superficially prosocial, which means they are willing to put in effort to help others, but energize the same actions to a lesser degree than they would do if they were the beneficiary. These effects, replicated across two studies, were present both when the other person was fully anonymous and when they had met face to face, and also occurred regardless of whether the aim was to win more money or to avoid losses. Such effects were correlated with individual differences in apathy and psychopathy, highlighting the potential for this framework to enlighten our understanding of prosocial behaviour and its links to disorders of social cognition.

**Methods**

**Study 1. Participants.** Fifty-three participants aged 19–35 years old (mean age: 24.4, s.d.: 4.0, 31 females) took part. Participants were recruited through university databases. The sample size was based on a study by Crockett et al.\(^{43}\), with additional participants to account for potential exclusions after testing (see below). All participants provided written informed consent and the study was approved by the Oxford University Medical Sciences Inter Divisional Research Ethics Committee. Exclusion criteria included previous or current neurological or psychiatric disorders (as reported by the participants) and non-normal or non-corrected-to-normal vision. Five participants were excluded from the study because they reported a disbelief in the deception. Participants were instructed that the money they would receive at the end of the experiment, as well as the earnings of the confederate participant, would depend on their task performance and would vary between £10 and 15.

**Design.** Participants completed 5 blocks of 30 trials (150 total) comprised of random decisions for themselves and the other person. Decisions were included to avoid participant fatigue. Each trial involved a choice between a baseline option that consisted of gaining 1 credit for no effort or an alternative experimental ‘offer’ that varied in the level of effort (30, 40, 50, 60 or 70% MVC) and the level of reward (2, 4, 6, 8 or 10 credits; Fig. 1).

**Apparatus.** Stimulus presentation was programmed on a PC using MATLAB version 2011b (MathWorks; http://www.mathworks.com/) and Psychtoolbox version 3 (http://psychtoolbox.org/). Force was recorded using a hand-held TSD121B-MRI (BIOPAC Systems). The PC screen provided subjects with real-time visual feedback on the force being exerted.

**Procedure.** Study 1 began with role assignment. To ensure that participants believed that their choices were truly resulting in outcomes for another person, they were told that there was a second participant taking part in the experiment, even though they did not see the other participant (who was in fact a confederate). This followed the procedure described by Crockett et al.\(^{45}\). Participants were told that selecting a ball from a box would randomly assign them to the different roles. Participants were handed a black glove and told not to speak so that the identity of either participant could not be uncovered. A second experimenter arrived in the room, bringing the confederate participant with them. The confederate participant was handed a second glove, but they remained behind the other side of the door at all times without ever being seen by the participant. The participants were asked to place their hands in front of the door and to wave to one another to ensure it was clear that there was another person there. The experimenter then tossed a coin to decide who would pick from the box first. Each participant selected a ball and was told which role in the experiment they were assigned to.
**Task procedure.** During the task procedure, participants were asked to grip a handheld dynometer with as much force as possible to determine their MVC. This ensured that although individuals differ in their strength, the effort levels used in the experiment would be relative to their MVC. This measurement was then used as a subject-specific threshold for the levels of effort required to obtain rewards in the main task. In the experimental task, participants made decisions between a baseline low effort (0% of the MVC) option that gained 1 credit and a variable offer in which they had a 24% chance of getting 0 (equivalent to winning 1 point) for 0% MVC or a variable offer where the offers were available 6, 8 or 10 credits (equivalent to winning 1 point) for 0% MVC, 24%, 48% or 72% MVC (equivalent to winning 1 point) for 0%, 24%, 48% or 72% MVC and 6, 8 or 10 credits (equivalent to winning 1 point) for 0%, 24%, 48% or 72% MVC. The fact that the failure rates were so low also helps to rule out the potential effects of risk aversion (for example, ref. 7), that may interact with effort discounting, as participants had a very high probability of receiving the rewards from the options they chose.

Prior to the decision-making task, participants experienced each effort level three times across 18 trials. They also learnt to associate each level of effort with the elements in a pie chart. They were instructed that if only one element of the pie chart was shown then 0% force was required and that this was the baseline offer, equivalent to a ‘res’. However, they still had to grip the dynamometer in their hand. During the training session, only 1 credit was on offer and participants were instructed that this credit would not count towards their payment. In the training session, participants did not choose whether to opt out of exerting effort.

**Study 2. Participants.** Fifty-eight participants (mean age: 25.7, s.d.: 6.1, 31 females) took part in two sessions. The sample size was based on study 1. Participants were recruited through university databases. All participants provided written informed consent and the study was approved by the Oxford University Medical Sciences Inter Divisional Research Ethics Committee. Thirty-nine participants were excluded from the study because they showed a strong disinhibition in the deception. Exclusion criteria included previous or current neurological or psychiatric disorders (as reported by the participants) and non-normal or non-corrected-to-normal vision. Participants were instructed that the money they would receive at the end of the experiment, as well as the earnings of the confederate participant, would depend on their task performance and would vary between £15 and 25.

**Design.** There were two additions to the design of study 1. First, although participants performed a session where the aim was to win points, as in study 1, they were also included a second session, where the aim was to avoid losing points. Second, to avoid participant fatigue, they performed these sessions on separate days (at least one day apart) in a counterbalanced order across participants. In the loss session, participants made decisions between a baseline option of −9 credits (equivalent to winning 1 point) for 0% MVC or a variable offer where the offers would be losing 0, −2, −4, or −6 credits for themselves or the other participant. If participants chose to accept the experimental option but did not obtain the reward, they lost 10 credits. The incentive structure was therefore identical, but the framing was distinct.

**Procedure.** In study 2, we used a role assignment procedure where participants met another participant face to face. This allowed us to examine whether increasing the familiarity and removing the anonymous nature of the other players made people less prosocially apathetic. At the beginning of the experiment, the participants were introduced to another participant who was in fact a confederate of the experiment. The two participants were instructed that they would be asked to perform different tasks and that only one of them would be in charge of determining the extra amount of money that both would earn (Fig. 1c).

**Studies 1 and 2. Statistical analyses of behavioural data.** Analyses of behavioural data were performed in SPSS 22 (IBM). We examined differences between conditions in choice behaviour for effort and reward and self versus other using separate repeated measures ANOVAs. For the comparison between self and other discounting (K) rates from the model comparison, we used Wilcoxon signed-rank tests as the data were not normally distributed. For participants who never chose the variable offer, their discount (K) values were set to 0, as they did not discount rewards by effort (four participants in study 2). We also examined bivariate associations between $K_{self}$ and $K_{other}$ using Spearman’s non-parametric correlation coefficient, also due to non-normality of the data. For the correlations between psychometric scores and computational parameters, we only performed planned comparisons that were a priori and hypothesis driven. On the basis of previous findings, we hypothesized that discount rates only for others would be associated with social apathy15, and that discount rates only for self would be associated with behavioural apathy17–20. For correlations with psychopath traits, we assessed the correlation with the total score and report the correlations with the two subscales as exploratory follow-up analyses. All comparisons were corrected for the false-discover rate using the Benjamini and Hochberg false-discover rate procedure21.

**Data availability.** The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Author contributions
P.L.L., M.A.J.A. and M.Husain designed the study, P.L.L., M.Hamonet, S.H.Z., A.R., F.U.S. and M.A.J.A. collected the data, P.L.L. and M.A.J.A. analysed the data, and P.L.L., M.A.J.A. and M.Husain wrote the paper.

Additional information
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Competing interests
The authors declare no competing interests.