Psychol Sci. Author manuscript; available in PMC 2021 August 15.

Published in final edited form as:
Psychol Sci. 2021 May 01; 32(5): 668–681. doi:10.1177/0956797620975781.

Ageing increases prosocial motivation for effort

Patricia L. Lockwood[a,b,c,d,*], **Ayat Abdurahman**[b,c,e], **Anthony Gabay**[a,b,c], **Daniel Drew**[b,c], **Marin Tamm**[b,c], **Masud Husain**[#b,c], **Matthew A. J. Apps**[#a,b,c,d]

[a]Centre for Human Brain Health, School of Psychology, University of Birmingham

[b]Department of Experimental Psychology, University of Oxford, Oxford OX1 3PH, United Kingdom

[c]Wellcome Centre for Integrative Neuroimaging, Department of Experimental Psychology, University of Oxford

[d]Christ Church, University of Oxford Centre for Human Brain Health, School of Psychology, University of Birmingham

[e]Department of Psychology, Downing Street, Cambridge, CB2 3EB

[#] These authors contributed equally to this work.

Abstract

Social cohesion relies on prosociality in increasingly ageing populations. Helping others requires effort, yet how willing people are to exert effort to benefit ourselves and others, and whether such behaviours shift across the lifespan, is poorly understood. Using computational modelling we tested the willingness to exert effort into ‘self’ or ‘other’ benefitting acts in younger (age 18-36) and older adults (55-84, n=187). Participants chose whether to work and exert effort, (between 30-70% of maximum grip strength) for rewards (2-10 credits) accrued for themselves or prosocially for another. Younger adults were somewhat selfish, choosing to work more at higher effort levels for themselves, and exerted less force into prosocial, compared to self-benefitting, work. Strikingly, compared to younger adults, older people were more willing to put in effort for others and exerted equal force for self and other. Increased prosociality in older people has important implications for human behaviour and societal structure.

Keywords

Prosocial behaviour; ageing; effort; motivation; reward; computational modelling

---

[*]Correspondence should be addressed to: Patricia L. Lockwood, Centre for Human Brain Health, School of Psychology, University of Birmingham, B15 2TT, United Kingdom. p.l.lockwood@bham.ac.uk.

Author contributions

P.L.L, M.A.J.A and M. H. designed study. P.L.L, A. A., D. D & M.T collected data. P.L.L, M.A.J.A, A. A., and A. S. G analysed data. P.L.L, A. A., A.S.G. M.H and M. A. J. A wrote paper.

Declaration of interests

The authors have no competing interests

Europe PMC Funders Author Manuscripts

Europe PMC Funders Author Manuscripts

Introduction

The world's population is ageing. As people age social interactions are vital for sustaining health and wellbeing, with social isolation significantly detrimental to physical and mental health (Fratiglioni et al., 2004). Social cohesion depends on motivation, and people being willing to incur costs to help others (Fehr & Fischbacher, 2003). Many prosocial behaviours have been extensively studied in children and young adults (Eisenberg et al., 2005; Imuta et al., 2016), with conclusions about the boundaries of human prosociality largely based on these populations alone. However, much less is known about them in older adults. As a result, it is unclear how prosocial behaviour changes across the lifespan, and whether older adults are sufficiently motivated to perform effortful helping behaviours that may be vital for maintaining social bonds.

Do levels of prosociality change between younger and older adults? Social-emotional selectivity theory suggests that people become more empathic as they age and as a result may become more prosocial (Carstensen, 2006). Moreover, the ageing brain undergoes profound neurobiological changes with loss of dopamine transmission (Samanez-Larkin & Knutson, 2015), a neurotransmitter system that has been linked to higher selfishness and lower prosociality (Crockett et al., 2015), of up to 10%, per decade. At the population level, older adults donate more money to charity (*UK Giving*, 2012), but lab based studies using economic games such as the dictator game as proxy measures of prosocial behaviour have shown both greater transfer of money compared to younger adults (Engel, 2011) and no difference between age groups (Rieger & Mata, 2013; Roalf et al., 2011).

However, the designs of such studies may mask real changes in social motivation and conflate potential mechanisms. Firstly, the personal cost in these paradigms is always financial. Yet, older adults putatively value economic rewards differently, may have higher accumulated wealth (Mayr & Freund, 2020), and importantly, many every day prosocial acts do not come at a financial cost (Cameron et al., 2019; Inzlicht & Hutcherson, 2017). Secondly, these tasks cannot distinguish changes in self or other-regarding preferences – more money for the other person equates to less money for self. As a result, older adults may or may not show differences in prosocial behaviour because they are more motivated to benefit another person, or more trivially, they may simply value their own monetary gains less. Finally, it is plausible that older adults might 'virtue signal' and make prosocial choices, but be unwilling to incur the real costs required by effortful altruistic acts. Only by disentangling self and other motivation, and by examining costs that are not financial, can we test whether older adults show shifts in levels of prosociality.

One cost that is a crucial factor influencing social behaviour is effort. Typically people are averse to exerting effort, with rewards 'devalued' or discounted by the amount of effort required to obtain them (Chen et al., 2019; Chong et al., 2017; Hartmann et al., 2013; Klein-Flugge et al., 2015; Pessiglione et al., 2018; Shenhav et al., 2017). However, although rarely investigated, many helping acts are also effortful. Whether it is the physical cost of opening the door for the person behind you, or the effort of helping a colleague with their work, these acts require prosocial motivation – a willingness to exert effort to benefit another. Importantly, theoretical accounts of effort, suggest that there are at least two critical

Europe PMC Funders Author Manuscripts

components. First, you must decide whether you are willing to exert effort (Manohar et al., 2015), and second, you have to energise actions appropriately to obtain the desired outcome. A previous study suggested that although young adults did chose to help others (prosocial behaviour) they were ‘self-biased’ in their motivation, choosing to put in higher levels of physical effort to gain rewards for themselves than for another person (Lockwood et al., 2017; Mosner et al., 2017). Younger adults also put in less energy into prosocial actions than identical self-benefitting ones. Importantly, several studies have suggested that ageing is associated with increased apathy, a reduction in motivation and goal directed behaviour (Van Reekum et al., 2005). Therefore, compared to younger adults, older adults may be even less willing to engage in highly effortful prosocial acts.

In order to disentangle how motivated older adults are to benefit themselves and others, we test two groups of adults one younger and one older, on a physical effort-based decision-making paradigm (Lockwood et al., 2017). On each trial participants are given a choice between two options, a higher effort (30-70% of their maximum voluntary contraction [MVC] measured on a handheld dynamometer) higher reward (2-10 credits) work option that varies on each trial, or a lower effort (0% MVC), lower reward (1 credit) rest option (see Figure 1). After choosing, participants must squeeze to the required level of force in order to obtain the credits. If they succeed, the credits are banked and equate to a bonus payment at the end of the study – if they fail, they get nothing from that trial. Importantly, on half of the trials participants chose between these two options where they put in the force, and they get the reward, but on ‘other’ trials, the participant made the choice and put in the effort, but the reward was given to the other person. Crucially, this task can independently measure effort sensitivity and reward sensitivity, both for self-benefitting and other-benefitting behaviours. Using this design in combination with computational modelling allowed us to examine how much people devalue rewards by effort for themselves and for others in terms of their effort-based decisions and also the degree to which their actions were energised.

Methods

Open Practices Statement

All data and code used to analyse the data and reproduce the figures is openly available at: [OSF https://osf.io/guqrm/]. The experiment was not formally pre-registered.

Participants

Seven participants were excluded from the study because they reported a disbelief in the deception. There was missing data from 1 participant due to technical error and 1 participant did not complete the full experiment and was excluded from analyses. This left a final sample of 187 participants, 95 younger adults (aged 18-36, M=24, 56 female) and 92 older adults (aged 55-84, M=69, 43 female). The sample size was based on a previous study in younger adults (Lockwood et al., 2017) and a power calculation that showed we had 91% power to detect a medium effect size (d=0.5) with at least 92 participants in each group. We aimed to test approximately equal numbers of older and younger adults. We initially chose our age ranges to be 20-35 and 60-85. During testing we found that three people were aged under 20 (youngest age 18) and four were younger than 60 (youngest aged 55), making the age ranges look wide.

However excluding these individuals did not change any analysis (see Supplementary tables S1-S3) and therefore we decided to include them in the final sample. Participants were recruited through university databases, social media and the community. All participants provided written informed consent and the study was approved by the local Ethics Committee and National Health Service Ethics. Exclusion criteria included previous or current neurological or psychiatric disorder (as reported by the participants), non-normal or non-corrected to normal vision and for the older sample scores above on the Addenbrook Cognitive Examination that would indicate potential dementia (cut-off score = 82). Participants were paid at a rate of £10 per hour and were told they and the other participant would receive an additional bonus payment of up to £5 at the end of the experiment based on the number of credits that they earned.

Design

The task structure was the same as described in Lockwood et al. (Lockwood et al., 2017). Participants completed 150 trials. They completed 75 decisions for themselves and 75 decisions for the other person. 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%, 70% maximum voluntary contraction (MVC)) and level of reward (2, 4, 6, 8 or 10 credits; Figure 1). Moreover, we specifically designed the study to minimise any potential effects of fatigue interacting with our effects of interest. Participants were only required to squeeze for 1 second out of a 3 second window to achieve the reward, in 10 second duration trials, and only when they decided to accept the offer. Moreover, many of the ‘work’ trials were not very demanding (<50% of MVC) and three breaks were provided in the experiment. Finally, we counterbalanced trials in a manner such that the same amount of self and other trials with equal effort and reward levels were presented in ‘mini-blocks’ of 50 trials, such that any potential fatigue effects, if they were to occur, should equally affect our experimental conditions.

Apparatus

Stimulus presentation was programmed on a PC using MATLAB (The Math-Works Inc., USA) and Psychtoolbox. Force was recorded using a hand-held TSD121B-MRI (BIOPAC Systems Inc., USA). The PC screen provided subjects with real-time visual feedback on the force being exerted.

Procedure

Role assignment procedure—To ensure that participants believed that their choices and effort exerted resulted in outcomes for another person they were told that there was a second participant taking part in the experiment, but did not see the other participant (who was in fact a confederate) following the procedure described in Lockwood et al (Lockwood et al., 2017). Participants were told that selecting a ball from a box would randomly assign them to the different roles, either Player 1 or Player 2. Player 1 would play the role of the decider, which meant they would make decisions that affected both themselves and Player 2, whereas Player 2 would be a receiver which meant they would only make decisions affecting themselves. Participants were handed a 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 who was handed a second glove but remained behind the other side of the door at all times, without ever being seen by the participant. Participants were asked to place their hands in front of the door and 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. This method ensured that participants could not be influenced by the age of the receiver participant. We also used names for the receiver participant that were gender matched to the decider participant. To ensure that the two groups did not perceive the receiver participant differently, we asked participants to rate on a scale from 0-9 'How similar do you feel to the other participant' and 'How much do you like the other participant?'. There were no significant differences between groups in ratings of similarity ($t(184) = -.86$, $p=.39$; Cohen's $d = -0.12$ [-0.41 – 0.16]) or liking ($t(184) = -.40$, $p=.69$, ; Cohen's $d = -0.06$ [-0.35 – 0.23]).

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 that. This measurement was then used as a subject specific threshold for the levels of effort required to obtain rewards in the main task, and was repeated twice. Despite being thresholded in a subject specific manner and therefore controlling for any potential baseline differences in strength across groups, we also tested whether there were any significant differences between groups in the initial force exerted. We found no statistically significant difference between older (0.99 volts, SD = 0.32) and younger adults (1.12 volts, SD = 0.62) in MVC (Man-Whitney U = 4029, $p=.357$, 95% CI for Rank Biserial Correlation = [-0.239, 0.088]). In addition, this measure of MVC was done before participants received any instruction as to the nature of the task, to ensure they were not influenced to squeeze less than their maximum to be able to collect more rewards in the task.

In the experimental task, participants made decisions between a baseline low effort (0% of MVC) option that gained 1 credit and a variable offer in which more credits (2, 4, 6, 8 or 10 credits) were available but also required more force (30%, 40%, 50%, 60%, 70% of the MVC – represented by segments in a pie chart). The effort and reward levels were varied independently over trials, with each effort-reward combination sampled three times for each recipient. There were 150 trials in total, with 75 Self trials where participants chose between the offer and the baseline for themselves and 75 Other trials when they made these decisions for the other person. To obtain the rewards on each trial, participants had to apply a force that exceeded the required level for a total of 1s out of a 3s window. Failure to do resulted in 0 credits being delivered. The offer of 1 credit was used for the baseline condition to ensure that there was a clear incentive to choose the baseline if the value was not considered worth it, rather than choosing the offer and then not exerting any effort at all. If a choice was not selected 0 credits were delivered. All trials, regardless of the choice made (or if no response was made), lasted for the same duration. This ensured that choices were not influenced by

Europe PMC Funders Author Manuscripts

discounting effects of temporal delay rather than effort. Indeed, success rates were very high in the main experiment (98% success in younger adults and 97% success in older adults), indicating that subjects were almost always able to achieve the required amount of force. The fact that failure rates were so low also helps to rule our potential effects of risk aversion, 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 the 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 “rest”. 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 this credit would not count towards their payment, and they did not choose whether to opt out of exerting the effort.

Questionnaire assessments and demographics—Older adults were screened for dementia using the Addenbrookes Cognitive Examination (ACE-III) (Hsieh et al., 2013). A brief screening tool, ACE-III examines five cognitive domains; attention, memory, language, fluency and visuospatial abilities. The ACE-III is scored out of 100 and a cut-off score of 82/100 denotes significant cognitive impairment.

Post-task rating—After the experiment, participants were asked two questions about how positive they felt when receiving rewards for themselves and for the other participant. Participants indicated their rating of positivity for receiving rewards by using a sliding scale ranging between 0 (‘not at all’) to 10 (‘very positive’). Post-task ratings were administered using the Qualtrics platform.

Results

Groups were matched on gender (p =.108) and years of education (mean education younger adults = 15.4 (SD = 16.5), range = 11-17; mean education older adults = 15.0 (SD = 2.77) range = 6 -20), p =.203).

Older adults devalue rewards by effort less than younger adults, particularly when other people will benefit

We fitted a computational model of effort discounting to each participants choice behaviour to examine the rate at which the two groups discounted rewards by effort. It has previously been shown (Lockwood et al., 2017) that this model allowed us to parameterise people’s motivation using separate ‘K’ parameters for self (‘Kself’) and other (‘Kother’) trials, plus an additional ‘noise’ parameter characterizing the stochasticity of choices (β) (Figure 2a,b). We used this previously validated model to assess whether there were differences in the discounting rate as a function of group (younger and older) and recipient (Kself and Kother). The k parameter precisely quantifies the rate at which rewards are devalued by effort with higher k parameters indexing steeper discounting, or lower motivation, and lower k parameters indicating shallower discounting, or higher motivation.

Europe PMC Funders Author Manuscripts

We analysed the estimated k parameters using robust linear mixed-effects regression that is robust to the influence of outlier data (using the *rlmer* function from the robustlmm package in R (Koller, 2016)). With the estimated k parameters from the model as the outcome variable, we defined recipient, group, and their interaction as fixed effects, and included a subject-level random intercept. This analysis showed a significant recipient x group interaction (b = -0.039 [-0.067 – -0.011], z = -2.739, p = 0.006) that was driven by lower discounting in the older compared to younger adults particularly during the ‘other’ compared to ‘self’ condition (Figure 2c) (Young vs old k for other, Z= 4.90 p <0.001; Young vs. old K for self Z=3.20 p=0.001). There were also main effects of recipient (b = -0.037 [-0.057 – -0.017], z = -3.656, p < 0.001) and group (b = 0.065 [0.045 – 0.084], z = 6.445, p < 0.001). To account for possible floor effects driving the interaction we also conducted an additional analyses excluding any k values less than <0.01, and all results remained the same (see supplementary table S4). Therefore, older adults were more prosocial, devaluing rewards by effort less steeply particularly when the other person would benefit.

Older and younger adults still distinguish between self and other in choices

Could this be because older adults simply cannot distinguish self and other trials? We next examined whether older adults differentiated between self and other at all by comparing the self and other discount parameters separately in the two groups. Wilcoxon signed rank tests showed that both groups distinguished between self and other in their choices, with young (Z=-7.74, p <0.001, 95% CI for Rank-Biserial Correlation = [-0.949, -0.876]) and older (Z=-6.40, p<0.001, 95% CI for Rank-Biserial Correlation = [-0.849, -0.653]) adults having significantly higher discount parameters for other compared to self. This replicates the findings of Lockwood et al. (Lockwood et al., 2017) in the younger adults, but extends them to older adults, showing that although older adults are more motivated for others compared to younger adults, they are still more motivated to benefit self than other.

To further support the notion that older adults can still distinguish between self and other, but show less of a self-bias in their choices, and also to test if our model has good explanatory power in the current sample, we performed a model comparison (Lockwood & Klein-Flugge, 2019). We compared our chosen model to a range of other possible models with either separate or singular k parameters and β parameters for self and other trials. We also compared different plausible mathematical functions that could account for discounting behaviour in this task (linear, parabolic and hyperbolic (Chen et al., 2019; Chong et al., 2017; Hartmann et al., 2013; Lockwood et al., 2017)). This resulted in two classes of models, one that had the same (K) to characterise discounting on self and other trials (models 1-6) and one class with separate K’s (models 7-12, Fig 2b and See **SI Appendix text**). Within these models, we tested a further two classes of models that characterized whether separate parameters for levels of noise (β, softmax) (models 4-6, 10-12), or single parameters for noise (models 1-3, 7-9) best explained behaviour. Models were fitted to behavioural data using the softmax function (See Supplementary Materials text for further model fitting details).

As predicted, the winning model in both younger and older adults was the same parabolic model as reported previously (Lockwood et al., 2017) and in the analyses outlined above in which separate parameters characterised the devaluation of rewards for self and other trials (Figure 2a,b). Note that this winning model was able to explain behaviour (had the lowest BIC score) in the majority of participants (younger 69.5% of participants, older 68.5% of participants), but was very close in BIC score to an alternative model that also had separate discount parameters but also separate betas, a pattern we also found in our previous study (See Supplementary Materials text). We also further validated our winning model in two ways. First we calculated the median R-Squared for the model and found the model was able to explain 86% (SD 11%) of the variance in older adults and 85% (SD 10%) of the variance in choices in younger adults. We also performed a parameter recovery (Lockwood & Klein-Flugge, 2019; Palminteri, Wyart, & Koechlin, 2017) to show that parameters from our best fitting model were recoverable in simulated data based on our schedule. We showed good recovery of the 3 parameters (kSelf = 93%, kOther, 93%, beta 77%, **See SI Appendix text for further details**). Together these analyses show that our winning model could accurately describe behaviour in both young and older adults.

To support these model-based analyses, we analysed the choice data with a generalised linear mixed-effects model on the choice behaviour using the *glmer* function from the lme4 package in R (Bates et al., 2015). Analyses of the choice data in this way also enabled us to test separately for the influences of effort and reward on choices, which are combined together in the computational ‘k’ parameter analysis. With choice coded as a binary outcome variable, we defined group, recipient, effort level, reward level, and their interactions as fixed effects. We included a subject-level random intercept. We tested the fixed-effects for statistical significance using a Type II Wald chi-square test. Mirroring the model-based results, we observed a significant group*recipient*effort*reward interaction ($X^2_{(16)} = 27.774$, p=0.034) suggesting differential influences of recipient, effort and reward between the two groups (See Figure 3i, Table S5). Related to the 4-way interaction, we also observed two-way interactions between group and reward, group and effort, group and recipient (all p’s<.05; see SI Appendix text and, Table S5 and Table S6 for full statistical details). Notably, the group x effort interaction showed that it was at higher levels of effort (levels 3-6) that the young and older groups differed (Table S6, Figure 3 a-c) and the group x recipient interaction showed that the older adults chose to put in more effort for other compared to self overall (Table S6). Moreover, as we manipulated reward and effort levels independently we could also rule out that the rewards were perceived as differentially salient for self and for other, driving our effects, as we observed no significant recipient x group x reward interaction. Instead it was the interaction between effort level, reward and recipient that distinguished the two groups. Finally, there was a significant group x recipient interaction for the total number of points won for self and other, with older adults winning relatively more points for the other person (349.38, SD = 9.42) compared to younger adults (300.02, SD = 95.76; Cohen’s d = 0.72 [0.42 – 1.01]; group X recipient, p=.003.

Therefore, across model parameters, model comparison and mixed model statistical analyses our results were consistent: older adults’ prosocial decisions differed from younger adults not because of trivial changes in their sensitivity to money or decision noise, but because they evaluate rewards and effort differently when making prosocial decisions. In summary, older adults were more motivated to choose to exert higher levels of effort for higher rewards when others will benefit.

Older adults show no self-bias when energising actions

A second crucial aspect of prosocial behaviour is, after we have decided to help someone, to what extent we actually energise the actions required. In previous work it has been shown that younger adults energise their actions less when another person will benefit compared to themselves at higher levels of effort (Lockwood et al., 2017). Since we found that older adults were more prosocially motivated, do they also energise their actions to the same degree when someone else is the beneficiary?

To answer this, we used the *lmer* function in lme4 (Bates et al., 2015) to run a linear mixed effects model to predict the force that participants exerted on each trial. For this analysis, we normalised participants force as a proportion of their maximum to account for between-subject variability in force exerted and calculated the area under the curve for the 3 second window in which they exerted force. Our model predicted normalised force as a continuous variable with a subject-level random intercept. Effort level, reward level, recipient, group and their interactions were included in the model. Intriguingly, we found a significant 3-way interaction between group, effort and recipient ($X^2{}_{(4)} = 25.956$, $p<.001$) (Figure 4a,b, Table S7 and Table S8). This showed that at higher levels of effort young adults exerted more force when rewards benefitted themselves than others (Group x recipient interaction significant at effort levels 4,5 and 6, all *ps*<.012, see Supplementary Materials text and Table S7 and Table S8). Older adults showed no difference in force exertion between self and other, suggesting a loss of the self-bias compared to younger adults. There was also a significant interaction between group x effort x reward ($X^2{}_{(16)} = 27.579$, $p=.035$), two-way interactions for the effects of group x recipient, group x effort, recipient x effort, and main effects of effort, reward and recipient (all ps<.05, see Supplementary Materials, Table S8 for post-hoc comparisons). Importantly, there were no differences between the groups in the percentage that they were successful, once they had chosen to work for self and other (Young adults mean success rate = 0.98 (SD 0.03), Older adults mean success rate = 0.97 (SD 0.05), $p=0.107$, Cohen's $d = 0.24$ [-0.04 – 0.53) and no significant effects of group, recipient, or their interactions, when running a model predicting success on each trial (group: $X^2{}_{(1)} = 0.519$, $p = 0.471$; recipient: $X^2{}_{(1)} = 0.855$, $p = 0.355$; interaction: $X^2{}_{(1)} = 1.535$, $p = 0.215$). Finally, we ran an analysis also excluding trials where participants failed, but all results remained significant (see supplementary table S9). This suggests that differences in the energisation of action between the two groups were not driven by increased failure rates.

Individual differences in self-reported positivity and decision-making

Socio-emotional selectivity theory argues that as people get older they focus more on their emotional states, such as empathy (Carstensen, 2006). Such an account would predict that individual differences in effort discounting (k) might be related to how positive people felt when obtaining rewards for others. Moreover, theoretical accounts of prosocial behaviour have suggested that one motivation for prosocial behaviour is a feeling of 'warm-glow', namely gaining self-relevant emotional reward from helping another person (Andreoni, 1990). However, whether older adults experienced greater positivity at helping others in our

Europe PMC Funders Author Manuscripts

Europe PMC Funders Author Manuscripts

study compared to younger adults, and whether this sense of 'warm glow' is maintained across the lifespan is unknown. Finally, we also sought to test age relevant differences in how positive participants felt at putting in effort to reward themselves, and whether such positivity was correlated with their willingness to put in effort for their own benefit. As we observed that a self-bias decreased in older adults, we sought to examine whether there was still an association between feelings of positivity and choosing to help oneself in older adults. Therefore, after completion of the main task, participants rated on a 10-point scale 'How positive did you feel when you won credits for the other participant / yourself?" with 0 being 'not at all' and 10 being 'very positive'. One participant in the older group did not complete the self-report ratings, leaving a sample of n=91 for that group.

In younger adults, the discounting parameters for self and other were both significantly negatively associated with the respective subjective rating, with self-discounting (k) related to subjective positivity for self ($r(93) = -0.328$, $p=0.001$, 95% CI = [-0.136, - 0.497]) and other discounting related to subjective positivity for other ($r(93) = -0.382$, $p=.0001$, 95% CI = [-0.196, -0.542], Figure 5). The more positive people felt when getting rewards for themselves or the other person the more effort they put in (indexed by lower discounting) for self and other respectively. However, in older adults whilst other k was significantly correlated with positivity winning credits for others ($r(89) = -0.326$, $p=0.002$, 95% CI = [-.128, -.498]), self k was not significantly associated with self-rated positivity ($r(89) = 0.115$, $p=0.277$, 95% CI = [-.093, 0.314]). Importantly, the difference in strength of correlations for self k and self positivity was significantly different between groups (z=3.06, $p=0.002$; using *paired.r* function in the psych package (Revelle & Revelle, 2015)). This suggests that feelings of positivity at rewarding others are related to the balance of effort exerted and reward gained in both younger and older adults. However, whilst feelings of positivity at rewarding self are related to a balance of effort and reward in younger adults, older adults discounting for self was not related to how positive it made them feel.

We next examined whether this difference between groups in positivity ratings and association with k was related to changes in how participants felt overall when putting in effort to win reward for self and other. There were no differences between groups in overall mean ratings of positivity at rewarding self and other, as both younger adults reported feeling more positive when winning credits for themselves compared to others (self mean = 7.39, SD=1.36, other mean = 6.79, SD=1.61, $t_{(94)} = 3.29$, $p=0.001$, $d= 0.34$ [0.13 – 0.55) and older adults also felt more positive when winning rewards for themselves than others (self mean = 7.46, SD=1.27, other mean =7.13, SD=1.47, $t_{(90)} = 2.75$, $p=0.007$, $d=0.29$ [0.08 – 0.50]) but with no significant interaction between groups (Z=-1.596, $p=0.111$).

Discussion

Many prosocial behaviours require the motivation to exert effort. Here we show that older people, compared to younger people, are more prosocially motivated in two crucial aspects of behaviour. Firstly, computational modelling and mixed effects models show that older adults discount rewards by effort less when benefitting others, and thus are more willing to choose highly effortful prosocial acts. Secondly, whereas younger adults show a self-bias, energising highly effortful actions that benefited themselves more than others, older adults

Europe PMC Funders Author Manuscripts

do not. Thus, prosociality was not only increased in older adults decisions, but also in how much energy they allocated to self and other benefitting acts. Finally, we observed individual differences in the relationship between discounting in the two groups and their feelings of positivity at helping themselves and others. Positive feelings towards rewarding others were correlated with the willingness to put in effort for others in both younger and older adults, consistent with a maintained sense of ‘warm glow’ across the lifespan, but only in younger adults did the willingness to put in effort for self correlate with how positive the rewards made them feel. Overall, these findings show, across several indices, that older adults are more prosocial than younger adults and have a reduced self-favouring bias in their effort-based decision-making. Therefore, prosocial behaviour could fundamentally shift across the lifespan.

Studies examining lifespan changes in prosocial behaviour have been mixed. Here we show that older adults might be more prosocial in social interactions than younger adults, as suggested by some studies using economic games (Sze et al., 2012). However, our approach was able to show that this effect is not because older adults value money differently per se, as the cost was not money, but effort. Moreover, this effort cost was adjusted to each person’s capacity, and was manipulated independently from reward in separate self and other conditions, so we were able to identify changes in sensitivity to a cost between a self-benefitting and a prosocial act. Importantly, both in choice behaviour and in the energisation of actions, there were significant differences between young and older adults in their sensitivity to the effort cost that differed between self and other. These findings highlight the necessity to examine effort, and self and other motivation independently, in order to understand specific lifespan changes in prosocial behaviours. In addition, these results highlight the importance of comparing people’s willingness to put effort into different types of behaviour, and not treat motivation as a uni-dimensional construct. Indeed, some studies in the cognitive domain have found the older adults are more effort averse than younger adults when it comes to cognitive effort (Hess & Ennis, 2012; Westbrook et al., 2013), and also that cognitive and physical efforts are valued differently (Chong et al., 2017). Dissecting the different components of effort-based decision-making in various contexts will be crucial for accurately quantifying and unpacking the mechanisms underlying multiple facets of people’s motivation (Ang et al., 2017; Cameron et al., 2019; Chong et al., 2017; Inzlicht & Hutcherson, 2017; Kool & Botvinick, 2018; Lockwood, Hamonet, et al., 2017).

Why might older adults be more prosocial when deciding to put in effort and energising their actions? There are several possible explanations both at the biological and sociocultural level. Socioemotional selectivity theory posits that as people grow older their time horizon shrinks, leading to changes in motivational goals and shifts in priority driven by changing of emotional needs (Beadle et al., 2013; Carstensen, 2006). Evidence in support of this is provided by the observation that antisocial and aggressive behaviours significantly decrease across the lifespan. Young adults (age 16-24) have the highest rates of homicide (“Homicide in England and Wales—Office for National Statistics”) and several studies have suggested that criminal activity increases during adolescence and declines in older adulthood (Liberman, 2008). As levels of antisocial behaviour and criminality lessen across the lifespan it is plausible that such changes would, in parallel, be associated with increased prosociality. However, we did not find much evidence of changes between age groups being

Europe PMC Funders Author Manuscripts

linked to higher emotional reactivity. In both groups, how willing someone was to choose to put in effort for another person was positively correlated with how positive they felt when winning points for the other person, with no significant difference in the strength of correlation. This would not be entirely consistent with a socio-emotional selectivity account, which would argue for a stronger prioritisation of this emotional response in older adults. Intriguingly, these results do show that a sense of 'warm glow', being linked to how much you will help others, is maintained across the lifespan, with the caveat that ratings of positivity might be susceptible to experimenter demand effects.

Such findings, as well as the reduced difference between motivation for self and other in both choices and force exerted, suggest older adults may have lost an emotionally driven self-bias that could lead to older adults putting in more effort for other compared to self, relative to younger adults. There is considerable evidence that young adults show 'self-biases' in many aspects of cognition and behaviour, where they prioritise self-relevant compared to other relevant information, when directly compared. This includes effort, as shown here, but also when learning which of their actions get themselves rewards, which arbitrary stimuli belong to them, and also biases on many forms of memory and attention (Lockwood, Apps, Valton, Viding, & Roiser, 2016; Lockwood et al., 2018). Existing studies of ageing changes in self-bias have been somewhat mixed. One study found an increased emotional egocentricity bias in older adults (Riva et al., 2016), measured by the incongruency of self and other emotional states. Another study suggested a reduced self-bias in an associative matching task in older compared to younger adults (Sui & Humphreys, 2017). Here by independently manipulating costs and benefits for self and other we suggest that when it comes to motivation to exert effort, older adults become less self-biased. Future work should begin to distinguish what aspects of the self-bias are increased and which decline.

In this study we specifically focused on willingness to exert physical effort that benefits others that may relate to everyday real-world effortful prosocial acts. Prosocial acts also include behaviours such as doing charitable work or donating money to charity. However voluntary work can be affected by the amount of time people have available to sacrifice, and monetary donations depend on wealth, key issues in ageing research on prosocial behaviour (Mayr & Freund, 2020). In our task one major strength was that putting in effort to give rewards to others has no impact whatsoever on the participants own payment at the end. Nevertheless, future studies could try to link prosocial effort to everyday prosocial acts, perhaps through measures such as experience sampling, to translate these findings outside the lab. Moreover, studies could include a measure of perceived wealth to see whether any differences explain variance in how much participants value the monetary rewards on offer. It would also be intriguing to link willingness to exert effort to measures that may quantify social isolation in older adults, such as their social network size, to examine whether those adults that choose to put in more effort to help others have larger or smaller social networks than younger adults.

Willingness to be prosocial can be affected by social norms such as reciprocity and acceptance (Gintis et al., 2003). We specifically designed our study to minimise these effects by ensuring that participants never met face to face, were instructed that they would leave the building at different times, and that their identity would never be revealed. However, it could be that social norms are internalised differently across different ages and cultures. It would be interesting for further studies to try to manipulate different social norms to examine the effect on prosocial choice and force exerted. A strength of the task is that both people's explicit choices and their implicit energisation of action can be measured to provide complimentary insights into prosocial motivation. It would also be important for future studies to examine whether the nature of the receiver changes people's prosociality, depending perhaps on their age, closeness or whether they are perceived as part of an in-group or an out-group. Further research could also examine whether possible increases in empathy between age groups are linked to differences in willingness to help others, as previous research suggests that older adults have greater empathic concern for people in need compared to younger adults, although they do not show a benefit from imagining helping others in the same way as younger adults (Sawczak et al., 2019), that also dovetails with research showing an important link between empathy and motivation (Cameron et al., 2019; Lockwood, Ang, et al., 2017). Finally, we note that our results are from a single, albeit well-powered, study, and future work should seek to replicate our effects.

Overall, we show that older adults are more prosocial than younger adults in two core components of motivation. Moreover, different emotional considerations may drive decisions to put in effort to help oneself and others in younger and older adults. Understanding the trajectory of social behaviour across the lifespan can inform theoretical accounts of the nature of human prosociality as well as theories of healthy ageing, and ultimately in the long term, help to develop strategies for scaffolding lifelong health and wellbeing.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgements

This work was supported by a Medical Research Council Fellowship (MR/P014097/1), a Christ Church Junior Research Fellowship and a Christ Church Research Centre Grant to P. L. L.; a BBSRC David Phillips Fellowship (BB/R010668/1) and a Wellcome Trust ISSF grant awarded to M.A.J.A; a Wellcome Trust Principal Fellowship to MH; NIHR Biomedical Research Centre, Oxford. The Wellcome Centre for Integrative Neuroimaging is supported by core funding from the Wellcome Trust (203139/Z/16/Z). We thank Pierre Petitet and Luke Priestley for assistance with data visualisation and Annika Kienast for her help in recruitment.

Data and code availability

All data and code used to analyse the data and reproduce the figures is openly available at: [OSF https://osf.io/guqrm/]

References

Andreoni, J. Impure Altruism and Donations to Public Goods: A Theory of Warm-Glow GivingThe Economic Journal. Vol. 700. JSTOR; 1990. 464–477.

Ang Y-S, Lockwood P, Apps MAJ, Muhammed K, Husain M. Distinct Subtypes of Apathy Revealed by the Apathy Motivation Index. PLOS ONE. 2017; 72 (1) e0169938 doi: 10.1371/journal.pone.0169938

Bates D, Mächler M, Bolker B, Walker S. Fitting Linear Mixed-Effects Models Using lme4. Journal of Statistical Software. 2015; 7 (7)

Beadle JN, Sheehan AH, Dahlben B, Gutchess AH. Aging, Empathy, and Prosociality. The Journals of Gerontology Series B, Psychological Sciences and Social Sciences. 2013; :1–10. DOI: 10.1093/geronb/gbt091

Cameron CD, Hutcherson CA, Ferguson AM, Scheffer JA, Hadjiandreou E, Inzlicht M. Empathy is hard work: People choose to avoid empathy because of its cognitive costs. Journal of Experimental Psychology General. 2019; 748 (6) :962–976. DOI: 10.1037/xge0000595

Carstensen LL. The Influence of a Sense of Time on Human Development. Science. 2006; 372 (5782) :1913–1915. DOI: 10.1126/science.1127488

Chen X, Voets S, Jenkinson N, Galea JM. Dopamine-dependent loss aversion during effort-based decision-making. The Journal of Neuroscience. 2019; :1760–19. DOI: 10.1523/JNEUROSCI.1760-19.2019

Chong TT-J, Apps M, Giehl K, Sillence A, Grima LL, Husain M. Neurocomputational mechanisms underlying subjective valuation of effort costs. PLOS Biology. 2017; 15 (2) e1002598 doi: 10.1371/journal.pbio.1002598 [PubMed: 28234892]

Crockett MJ, Siegel JZ, Kurth-Nelson Z, Ousdal OT, Story G, Frieband C, Grosse-Rueskamp JM, Dayan P, Dolan RJ. Dissociable Effects of Serotonin and Dopamine on the Valuation of Harm in Moral Decision Making. Current Biology. 2015; 25 (14) :1852–1859. DOI: 10.1016/j.cub.2015.05.021 [PubMed: 26144968]

Eisenberg N, Cumberland A, Guthrie IK, Murphy BC, Shepard SA. Age Changes in Prosocial Responding and Moral Reasoning in Adolescence and Early Adulthood. Journal of Research on Adolescence. 2005; 15 (3) :235–260. DOI: 10.1111/j.1532-7795.2005.00095.x [PubMed: 20592955]

Engel C. Dictator games: A meta study. Experimental Economics. 2011; 14 (4) :583–610.

Fehr E, Fischbacher U. The nature of human altruism. Nature. 2003; 425 (6960) :785–91. DOI: 10.1038/nature02043 [PubMed: 14574401]

Fratiglioni L, Paillard-Borg S, Winblad B. An active and socially integrated lifestyle in late life might protect against dementia. The Lancet Neurology. 2004; 4 :343–353.

Gintis H, Bowles S, Boyd R, Fehr E. Explaining altruistic behavior in humans. Evolution and Human Behavior. 2003; 24 (3) :153–172.

Hartmann MN, Hager OM, Tobler PN, Kaiser S. Parabolic discounting of monetary rewards by physical effort. Behavioural Processes. 2013; 100 (0) :192–196. DOI: 10.1016/j.beproc.2013.09.014 [PubMed: 24140077]

Hess TM, Ennis GE. Age differences in the effort and costs associated with cognitive activity. The Journals of Gerontology Series B, Psychological Sciences and Social Sciences. 2012; 67 (4) :447–455. DOI: 10.1093/geronb/gbr129 [PubMed: 22131365]

Homicide in England and Wales—Office for National Statistics. (n.d.). Retrieved August 27, 2019, from https://www.ons.gov.uk/peoplepopulationandcommunity/crimeandjustice/articles/homicideinenglandandwales/yearendingmarch2018#what-do-we-know-about-suspects

Hsieh S, Schubert S, Hoon C, Mioshi E, Hodges JR. Validation of the Addenbrooke's Cognitive Examination III in frontotemporal dementia and Alzheimer's disease. Dementia and Geriatric Cognitive Disorders. 2013; 36 (3–4) :242–250. DOI: 10.1159/000351671 [PubMed: 23949210]

Imuta K, Henry JD, Slaughter V, Selcuk B, Ruffman T. Theory of mind and prosocial behavior in childhood: A meta-analytic review. Developmental Psychology. 2016; 52 (8) :1192–1205. DOI: 10.1037/dev0000140 [PubMed: 27337508]

Inzlicht M, Hutcherson CA. Psychology: People work less hard for others. Nature Human Behaviour. 2017; 1 (7) 0148 doi: 10.1038/s41562-017-0148

Klein-Flugge MC, Kennerley SW, Saraiva AC, Penny WD, Bestmann S. Behavioral modeling of human choices reveals dissociable effects of physical effort and temporal delay on reward devaluation. PLoS Computational Biology. 2015; 11 (3) doi: 10.1371/journal.pcbi.1004116

Koller M. robustlmm: An R Package for Robust Estimation of Linear Mixed-Effects Models. Journal of Statistical Software. 2016; 1 (6)

Kool W, Botvinick M. Mental labour. Nature Human Behaviour. 2018; 2 (12) :899–908. DOI: 10.1038/s41562-018-0401-9

Liberman, A. The long view of crime: A synthesis of longitudinal research. Springer; 2008.

Lockwood PL, Ang Y-S, Husain M, Crockett MJ. Individual differences in empathy are associated with apathy-motivation. Scientific Reports. 2017; 7 (1) 17293 doi: 10.1038/s41598-017-17415-w [PubMed: 29229968]

Lockwood PL, Apps MAJ, Valton V, Viding E, Roiser JP. Neurocomputational mechanisms of prosocial learning and links to empathy. Proceedings of the National Academy of Sciences. 2016; 113 (35) :9763–9768. DOI: 10.1073/pnas.1603198113

Lockwood PL, Hamonet M, Zhang SH, Ratnavel A, Salmony FU, Husain M, Apps MAJ. Prosocial apathy for helping others when effort is required. Nature Human Behaviour. 2017; 1 0131

Lockwood PL, Klein-Flügge MC. Computational modelling of social cognition and behaviour—A reinforcement learning primer. Social Cognitive and Affective Neuroscience. doi: 10.1093/scan/nsaa040

Lockwood PL, Wittmann MK, Apps MAJ, Klein-Flügge MC, Crockett MJ, Humphreys GW, Rushworth MFS. Neural mechanisms for learning self and other ownership. Nature Communications. 2018; 9 (1) 4747 doi: 10.1038/s41467-018-07231-9

Manohar SG, Chong TT-J, Apps MAJ, Batla A, Stamelou M, Jarman PR, Bhatia KP, Husain M. Reward Pays the Cost of Noise Reduction in Motor and Cognitive Control. Current Biology. 2015; 25 (13) :1707–1716. DOI: 10.1016/j.cub.2015.05.038 [PubMed: 26096975]

Mayr U, Freund A. Do We Become More Prosocial as We Age, and if So, Why? Current Directions in Psychological Science. 2020; doi: 10.1177/0963721420910811

Mosner MG, Kinard JL, McWeeny S, Shah JS, Markiewitz ND, Damiano-Goodwin CR, Burchinal MR, Rutherford HJV, Greene RK, Treadway MT, Dichter GS. Vicarious Effort-Based Decision-Making in Autism Spectrum Disorders. Journal of Autism and Developmental Disorders. 2017; 47 (10) :2992–3006. DOI: 10.1007/s10803-017-3220-3 [PubMed: 28699053]

Palminteri S, Wyart V, Koechlin E. The Importance of Falsification in Computational Cognitive Modeling. Trends in Cognitive Sciences. 2017; 21 (6) :425–433. DOI: 10.1016/jztics.2017.03.011 [PubMed: 28476348]

Pessiglione M, Vinckier F, Bouret S, Daunizeau J, Le Bouc R. Why not try harder? Computational approach to motivation deficits in neuro-psychiatric diseases. Brain: A Journal of Neurology. 2018; 141 (3) :629–650. DOI: 10.1093/brain/awx278 [PubMed: 29194534]

Revelle W, Revelle MW. Package ‘psych.’. The Comprehensive R Archive Network. 2015

Rieger M, Mata R. On the Generality of Age Differences in Social and Nonsocial Decision Making. The Journals of Gerontology: Series B. 2013; 70 (2) :200–212. DOI: 10.1093/geronb/gbt088

Riva F, Triscoli C, Lamm C, Carnaghi A, Silani G. Emotional Egocentricity Bias Across the Life-Span. Frontiers in Aging Neuroscience. 2016; 8 doi: 10.3389/fnagi.2016.00074

Roalf DR, Mitchell SH, Harbaugh WT, Janowsky JS. Risk, reward, and economic decision making in aging. Journals of Gerontology Series B: Psychological Sciences and Social Sciences. 2011; 67 (3) :289–298.

Samanez-Larkin GR, Knutson B. Decision making in the ageing brain: Changes in affective and motivational circuits. Nature Reviews Neuroscience. 2015; 16 (5) :278–289. DOI: 10.1038/nrn3917 [PubMed: 25873038]

Sawczak C, McAndrews MP, Gaesser B, Moscovitch M. Episodic simulation and empathy in older adults and patients with unilateral medial temporal lobe excisions. Neuropsychologia. 2019; 135 107243 doi: 10.1016/j.neuropsychologia.2019.107243 [PubMed: 31698010]

Shenhav A, Musslick S, Lieder F, Kool W, Griffiths TL, Cohen JD, Botvinick MM. Toward a Rational and Mechanistic Account of Mental Effort. Annual Review of Neuroscience. 2017; 40 :99–124. DOI: 10.1146/annurev-neuro-072116-031526

Sui J, Humphreys GW. Aging enhances cognitive biases to friends but not the self. Psychonomic Bulletin & Review. 2017; 24 (6) :2021–2030. DOI: 10.3758/s13423-017-1264-1 [PubMed: 28315168]

Sze JA, Gyurak A, Goodkind MS, Levenson RW. Greater Emotional Empathy and Prosocial Behavior in Late Life. Emotion (Washington DC). 2012; 12 (5) :1129–1140. DOI: 10.1037/a0025011

UK Giving. 2012. https://www.cafonline.org/about-us/publications/2012-publications/uk-giving-2012

Van Reekum, Ra; Stuss, DTb; Ostrander, Lc. Apathy: Why care? Journal of Neuropsychiatry and Clinical Neurosciences. 2005; 17 (1) :7–19. DOI: 10.1176/appi.neuropsych.17.1.7

Westbrook A, Kester D, Braver TS. What Is the Subjective Cost of Cognitive Effort? Load, Trait, and Aging Effects Revealed by Economic Preference. PLoS ONE. 2013; 8 (7) doi: 10.1371/journal.pone.0068210

Europe PMC Funders Author Manuscripts

Europe PMC Funders Author Manuscripts

Statement of Relevance

Social interactions are crucial for maintaining health and wellbeing, particularly in older adults where social isolation is a major public health challenge. Social interactions are fundamentally shaped by how willing people are to put in effort to help others. Here we tested the willingness to do effortful helping actions in two groups of adults, one younger and one older. We find that older adults choose to put in more effort to help others compared to younger adults. Strikingly, unlike younger adults, older adults also put as much energy into actions to help themselves and others. These findings suggest that older adults become more prosocially motivated, and use relatively more energy when helping others. Therefore, the fundamental nature of human prosociality changes across the lifespan with important implications for theories of prosocial behaviour as well as our understanding of healthy ageing.

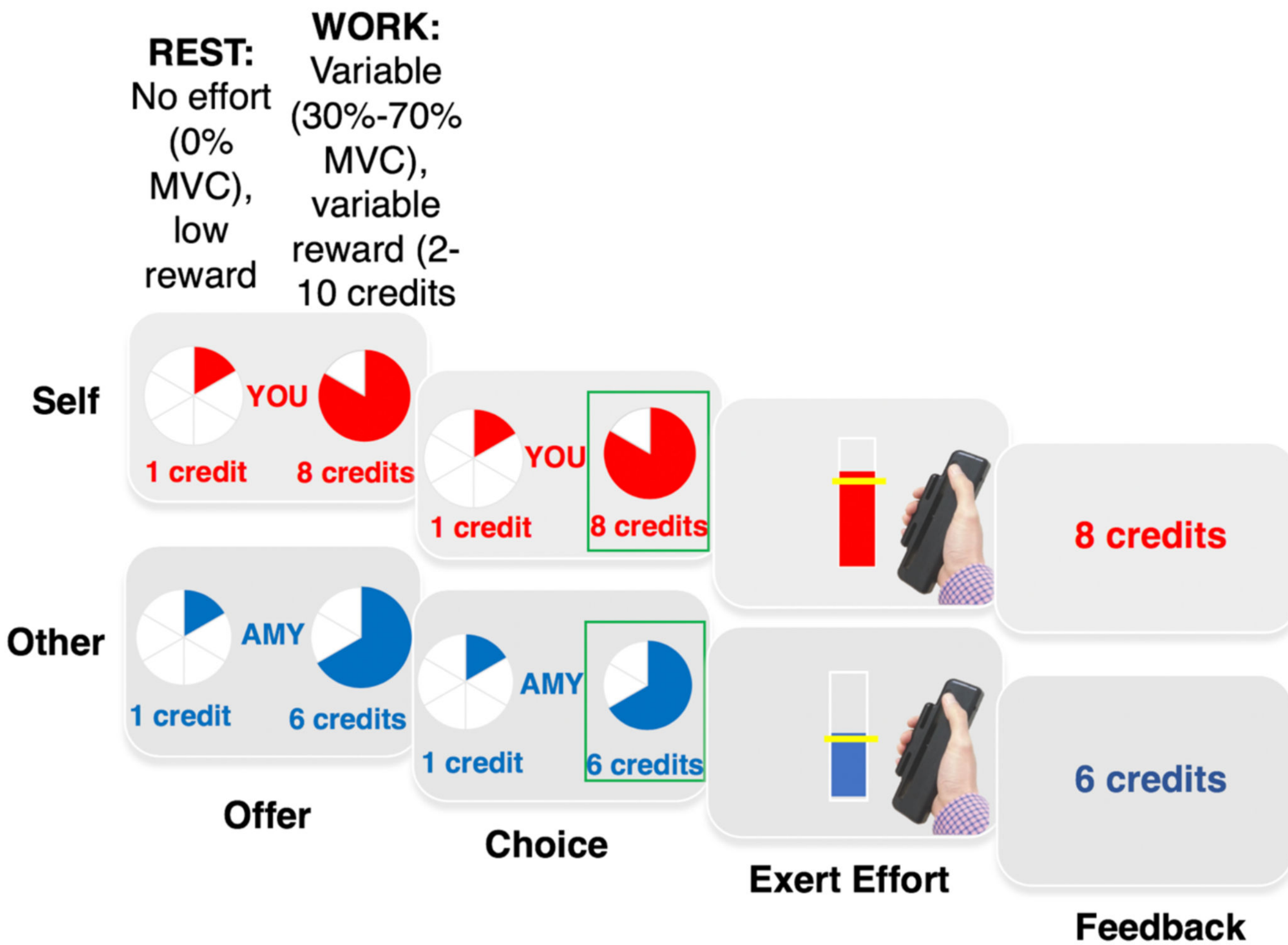

Figure 1. Prosocial motivation measure.

Participants were assigned to 'Player 1' at the beginning of the testing session and told that they would be making decisions that impacted on another player, who they knew was also in the testing session but they would not meet face to face (see methods). Maximum voluntary contraction (MVC) was measured by asking participants to squeeze as strongly as they could on a hand held dynamometer at the beginning of the experiment. On each trial they were presented with a 'rest' option where they would have to put in no effort (0% MVC) but would receive a low reward of 1 credit vs. a 'work' option which was always more effort (30%-70% MVC) but also more reward (2-10 credits). After making their selection they then had to exert the required force to the correct degree to receive the reward. Visual feedback of the amount of force was displayed on the screen. They were informed that they would have to reach the required force level for at least 1 second out of a 3 second window over the yellow line. Participants then saw the outcome which corresponded to the offer they chose, unless they were unsuccessful where 0 credits would be displayed. Crucially, on 'self' trials participants made the choice, exerted the effort and received the reward, but on 'other' trials participants made the choice, exerted the effort and the other participant received the outcome. Participants completed 150 trials, 75 for themselves and 75 choosing for the other person.

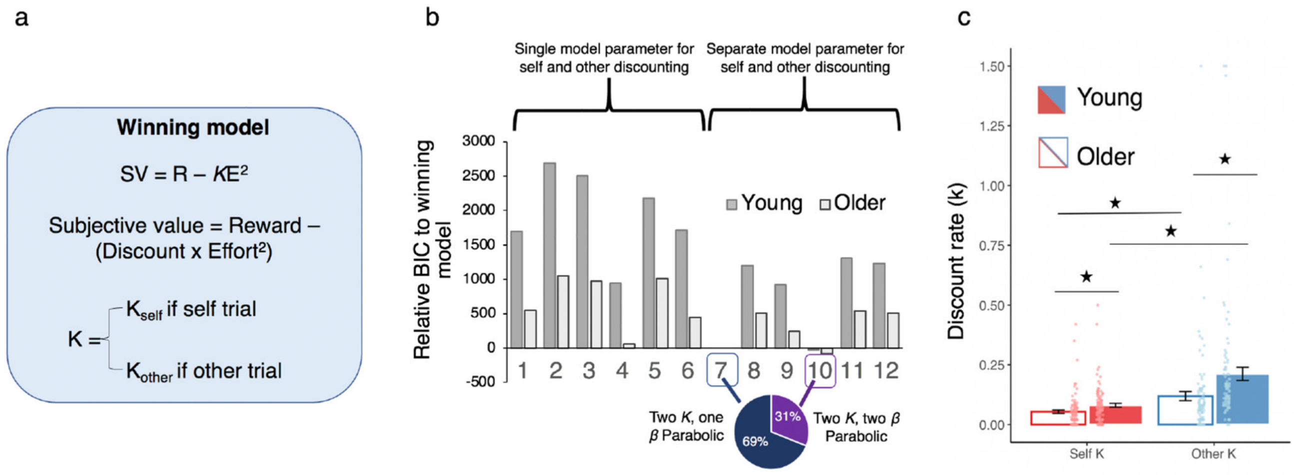

Figure 2. Older adults discount rewards by effort less than younger adults, particularly for others.

(a) The discount rate (k) parameters were estimated by a parabolic model with separate parameters for self and other trials that had the best fit to participants choice behaviour. This model stated that the subjective value (SV) of a chosen offer was based on the level of reward on offer (R), subtracted from the estimated discount function for each participant (K), multiplied by the effort on offer (E), squared. (b) Full model comparison of parabolic, linear and hyperbolic discounting functions with either single (models 1–6) or separate discount (K) parameters (models 7–12) for self and other and/or single or separate noise (β) parameters for self and other. A parabolic model with separate parameters for self and other discounting, but a single noise parameter, best explained behaviour in the majority of subjects in both groups (model 7), which was determined by this model having the lowest summed BIC score, in combination with explaining behaviour in the highest proportion of participants. The pie chart shows the proportion of participants that the winning model explains behaviour for (blue) compared with the same model with separate noise parameters (purple). Graph displays relative BIC to model 7. (c) Comparison of the discount parameters from this winning model showed that older adults devalued rewards by effort less steeply particularly when someone else would benefit, compared to younger adults (recipient x group interaction, (b = -0.039 [-0.067 – - 0.011], z = -2.739, p = 0.006)). Note all results remained significant when excluding any outliers >3SDs from the mean k value. Asterisks denote significant difference at p<.01. Error bars show +/-SEM.

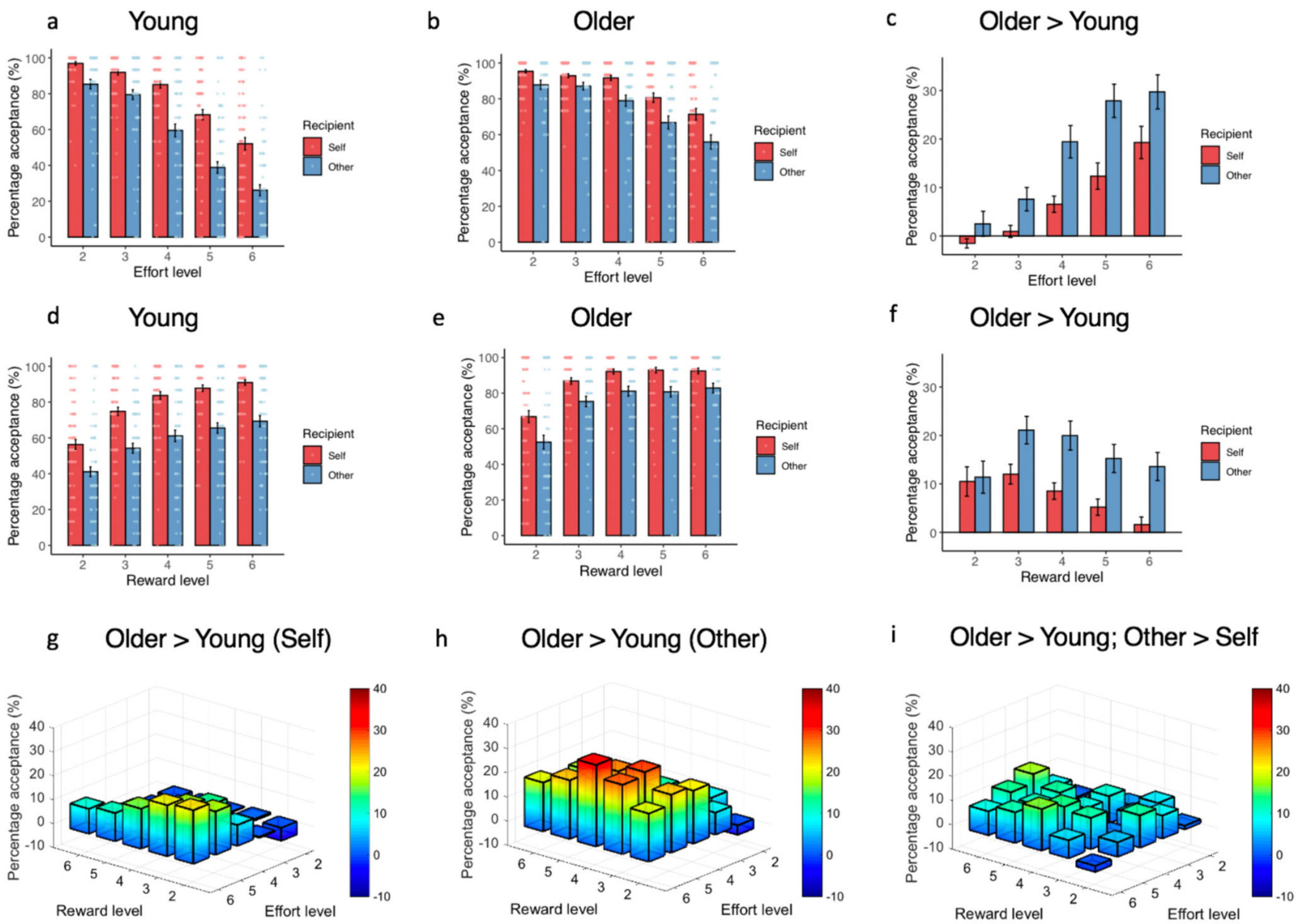

Figure 3. Acceptance rates for choices of ‘working’: Effort and reward varies by age group.

(a) Percentage chosen to work in young adults for different levels of effort. (b) Percentage chosen to work in older adults. (c) Difference in percentage acceptance between young and older adults across effort levels. (d) Percentage chosen to work in young adults for different reward levels. (e) Percentage chosen to work in older adults for different reward levels. (f) Differences in percentage chosen to work in younger adults compared to older adults for different reward levels. (g) 3D plot of choices to work across different effort and reward levels in young compared to older adults for the self condition. (h) 3D plot of choices to work across different effort and reward levels in young compared to older adults for the ‘other’ condition. (i) 3D plot of choices to work across different effort and reward levels in older adults, compared to younger adults, plotted for choices to help other compared to self. Error bars show +/- SEM.

Europe PMC Funders Author Manuscripts

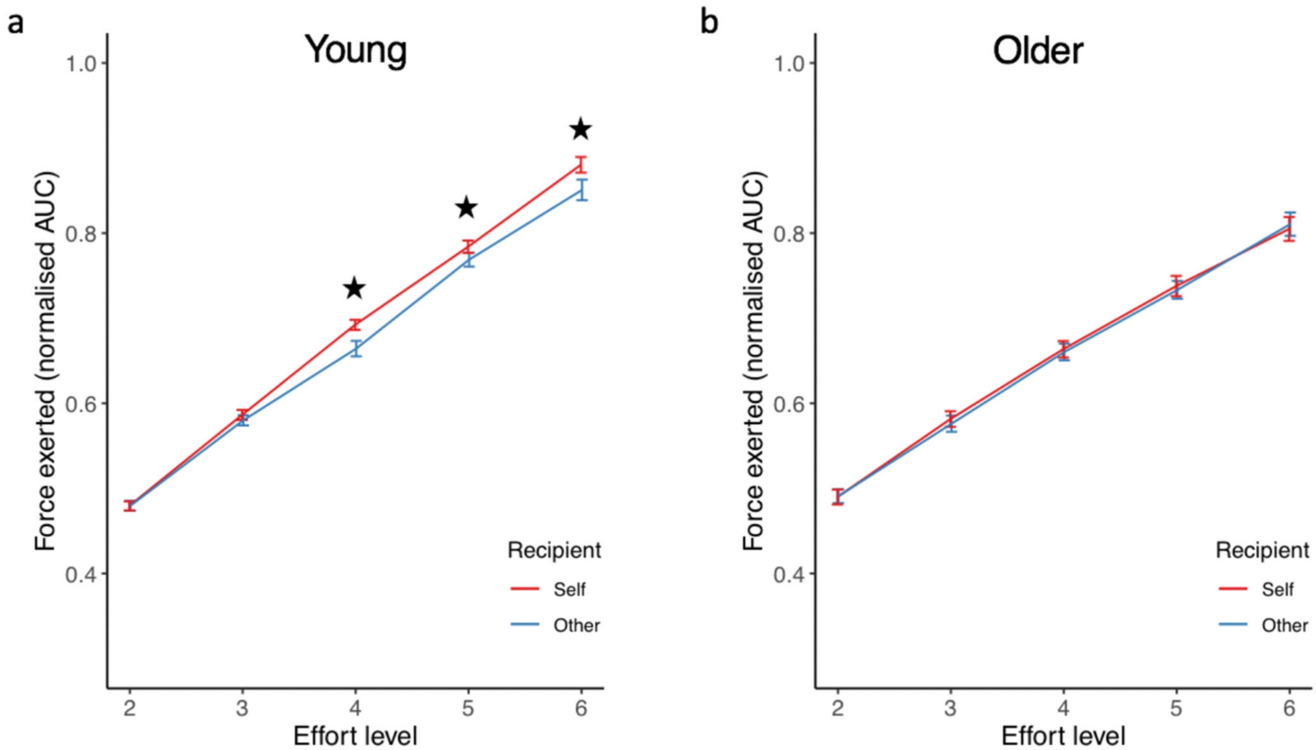

Figure 4. Young adults but not older adults show superficial prosociality.

Panels show the mean area under the curve (AUC) during the 3s force period across effort levels normalised to participants maximum level of force exerted across trials. (a) Replication of Lockwood et al., (Lockwood et al., 2017) showing over-energisation of force at higher effort levels for self compared to other (b) Older adults showed no difference in amount of force exerted for self and other at any of the effort levels. Overall there was a significant group x recipient x force interaction that reflected these group differences in energisation ($X^2_{(4)} = 25.956$, $p<.001$). Post-hoc comparisons showed a group x recipient interaction was significant at effort levels 4,5 and 6 (all *ps*<.012). Error bars show +/- SEM. For plot displaying all data points see Supplementary Materials Figure S1.

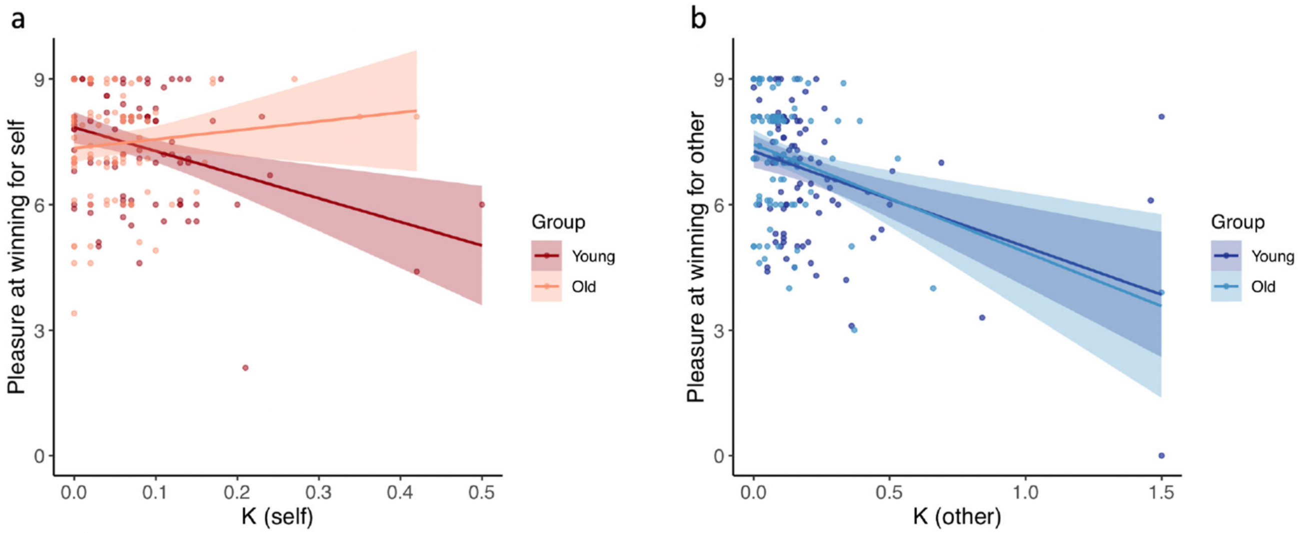

Figure 5. Correlations are stronger between individual differences in discounting and subjective feelings of positivity for helping oneself in younger compared to older adults.

We examined correlations between discount parameters (k) for self and other and self-reported subjective positivity at helping self and other. Participants rated on a 10-point scale from 'not at all positive' to 'very positive' how positive they felt when winning credits for self and when winning credits for other at the end of the experiment. (a) In younger adults, both self k and other k correlated with self and other positivity ratings (all ps=0.001). (b) In older adults only ratings for others correlated (p=.002) and not self (p=.277). The correlations between self k and positivity were significantly stronger in younger compared to older adults (Fishers r to Z value = 3.06, p=.002). All results remained significant when excluding any outliers > 3SDs from the mean. Therefore, older adults' motivation to put in effort to help themselves is not correlated with how positive it makes them feel.