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Reduced prosocial motivation and effort in adolescents with conduct problems and callous-unemotional traits

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Background: Prosocial behaviours – acts that benefit others – are of crucial importance for many species including humans. However, adolescents with conduct problems (CP), unlike their typically developing (TD) peers, demonstrate markedly reduced engagement in prosocial behaviours. This pattern is particularly pronounced in adolescents with CP and high levels of callous-unemotional traits (CP/HCU) who are at increased risk of developing psychopathy in adulthood. While a substantial amount of research has investigated the cognitive-affective mechanisms thought to underlie antisocial behaviour, much less is known about the mechanisms that could explain reduced prosocial behaviours in adolescents with CP. **Methods:** Here we examined the willingness to exert effort to benefit oneself (self) and another person (other, prosocial condition) in children with CP/HCU, CP and lower levels of CU traits (CP/LCU) and their TD peers. The task captured both prosocial choices, and actual effort exerted following prosocial choices, in adolescent boys aged 11–16 (27 CP/HCU; 34 CP/LCU; 33 TD). We used computational modelling to reveal the mechanistic processes involved when choosing prosocial acts. **Results:** We found that both CP/HCU and CP/LCU groups were more averse to initiating effortful prosocial acts than TD adolescents – both at a cognitive and at a behavioural level. Strikingly, even if they chose to initiate a prosocial act, the CP/HCU group exerted less effort following this prosocial choice than other groups. **Conclusions:** Our findings indicate that reduced exertion of effort to benefit others may be an important factor that differentiates adolescents with CP/HCU from their peers with CP/LCU. They offer new insights into what might drive low prosocial behaviour in adolescents with CP, including vulnerabilities that may particularly characterise those with high levels of CU traits. **Keywords:** Conduct problems; callous-unemotional traits; prosocial behaviour; affiliation.

Introduction

Adolescents with conduct problems (CP) display antisocial behaviour that incurs large individual and societal costs (National Collaborating Centre for Mental Health et al., 2013; Richards et al., 2009). They also demonstrate markedly reduced engagement in prosocial behaviour, or behaviours that voluntarily help others, relative to typically developing (TD) peers (Memmott-Elison, Holmgren, Padilla-Walker, & Hawkins, 2020). This is important, as engagement in prosocial behaviour is considered essential for human social and moral development, as well as both physical and mental wellbeing (Markiewicz, Doyle, & Brendgen, 2001; Post, 2005). However, prosocial and antisocial behaviour are not two ends of a single behavioural continuum and there is evidence for heterogeneity in prosocial behaviours among adolescents with CP (Hawley, 2003; Kokko, Tremblay, Lacourse, Nagin, & Vitaro, 2006). One important source of individual differences in this regard might relate to whether these adolescents also present with high levels of callous-unemotional (CU) traits – which include a diminished capacity for empathy, guilt and social affiliation (Viding & McCrory, 2019; Waller & Wagner, 2019). Recent studies have indicated that increased CU traits, but not CP symptoms, negatively predict prosocial behaviour in both questionnaire-based and experimental studies of adolescents with CP (Milledge et al., 2019; Sakai, Dalwani, Gelhorn, Mikulich-Gilbertson, & Crowley, 2012). One group-based study has also observed that adolescents with CP/HCU appear considerably less likely to choose prosocially than TD adolescents, whereas those with CP/LCU do not show a pronounced difference – falling between adolescents with CP/HCU and TD adolescents in their prosocial choice (Sakai et al., 2016). Evidence from a community sample indicates that this may be driven by a bias towards self-serving decisions in those with higher CU traits (Winters, Pettine, & Sakai, 2023). Together, studies indicate that a combination of CP and high CU traits may denote especially reduced prosocial behaviour. However, research examining information processing mechanisms associated with reduced prosocial behaviour in adolescents with CP, as well as the role of CU traits, is currently limited.

Furthermore, studies conducted to date with adolescents – including those with CP – may not be

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designed to capture more nuanced individual differences in prosocial behaviour. First, prior studies have typically assessed prosocial behaviours via a series of choices where prosocial options (those that benefit others) and less prosocial options (those that do not benefit others) are directly pitted against one another (e.g. Koenigs, Kruepke, & Newman, 2010; Sakai et al., 2012, 2016). With such a design, it is hard to disentangle the degree to which differences in prosocial behaviours are driven by heightened sensitivity to one's own benefit, or a reduced willingness to benefit others (although see Winters et al., 2023). Second, such tasks miss a crucial aspect of prosocial acts: they require effort (Contreras-Huerta, Pisauro, & Apps, 2020).

In the current study, we employed an adapted version of the 'Prosocial Effort Task' (Lockwood et al., 2017, 2021), a task originally developed for adults, to investigate prosocial behaviour in adolescent boys with CP/HCU, CP/LCU and TD controls. This task addresses the aforementioned issues in two ways. First, half of the task's trials allow participants to win points for themselves (self-benefitting trials), and half allow them to win points for another person (prosocial trials). Second, on each round, participants must first make a *choice* regarding whether they wish to make effort to win points (i.e. a choice between 'rest' and effortful 'work' options for themselves on self-benefitting trials; for another on prosocial trials). Crucially, they are then required actually *exert effort* in order to win those points (and thus, on prosocial trials, achieve a prosocial outcome) – as we commonly must do in day-to-day life. This task design also allows exploration of individual-level differences in *motivation* to engage in prosocial effort by looking at the degree to which participants devalue rewards by the effort it takes to obtain them and whether this differs when choosing to engage in trials for themselves and for others. We therefore had three key outcome measures: (1) *choice* to make effort on prosocial and self-benefitting trials, (2) *the motivation* driving choices on self-benefitting and prosocial trials (i.e. discounting of the effortful work option based on the effort that is required to obtain the points on offer) and (3) *effort exerted* following choices.

Based on initial experimental evidence of reduced prosocial behaviours in those with higher CU traits (Milledge et al., 2019; Sakai et al., 2016), we hypothesised that relative to age-matched TD controls, boys with CP/HCU would, on average: (a) make fewer prosocial choices, (b) show reduced prosocial motivation (i.e. stronger devaluation of reward by effort for the other relative to the self) and (c) make less prosocial effort. Given initial evidence that CP/LCU may display less pronounced reduction in their prosocial behaviour than CP/HCU peers (Milledge et al., 2019; Sakai et al., 2012, 2016), we predicted that their impairment in prosocial behaviour would be milder, but did not have a strong prediction as to whether or not they would differ significantly from the TD group.

Methods

Participants

The study involved 105 boys aged 11–16, who were recruited within London and the Home Counties from both mainstream (N = 4, mean deprivation decile = 6.6, decile range = 1:10) and specialist provision schools for pupils with behavioural difficulties (N = 13, mean deprivation decile = 4, decile range = 2:8). Information sheets were sent to parents of participants, giving them the opportunity to opt their child out of the study. An 'opt-out procedure' was approved by the Institutional Review Board (University College London Research Ethics Committee; Project ID number: 0622/001), as the research was noninvasive and considered to be in the public interest. Participants all received age-appropriate information sheets, which were verbally explained, and informed assent was obtained prior to participation. This protocol was in line with General Data Protection Regulation recommendations.

Teachers were given screening questionnaires to: (a) classify current CP; (b) measure CU traits; (c) quantify symptoms that commonly co-occur with CP and (d) provide demographic information (date of birth) and information regarding specialist education provision. This allowed us to identify pupils who were eligible to take part and assign participants to groups. Exclusion criteria for all participants included a parent or teacher report of a formal autism spectrum disorder diagnosis or the presence of learning difficulties (<70 on our measure of IQ). Data from 12 CP and one TD participant were excluded prior to descriptive analyses based on these criteria. Five additional CP participants were subsequently removed from main analyses lack of task understanding/compliance or for missing more than 80% data resulting in inaccurate estimates from our computational model. Thus, final group Ns for descriptive analyses were: 30 CP/HCU; 36 CP/LCU; 33 TD and final group Ns for main analyses were: 27 CP/HCU; 34 CP/LCU; 33 TD. More details on age and demographic details of our groups can be found in Table 1. For details on how we determined our sample size, see Appendix S1.

Measures of participant characteristics

Participants with CP had to meet age appropriate cut-offs on the teacher-version of the *Child and Adolescent Symptom Inventory* (CASI-4R) Conduct Disorder Scale (Gadow & Sprafkin, 2005). According to the CASI manual, these cut-offs for teacher ratings are: a score of 3+ (ages 10–12), 4+ (ages 12–14) and 6+ (ages 15–16).

We assessed CU traits using the *Inventory of Callous-Unemotional Traits* (ICU), teacher-version (Essau, Sasagawa, & Frick, 2006). Participants with CP who met our inclusion criteria (N = 66) were then further split to HCU and LCU groups based on whether their ICU score was higher than (CP/HCU; N = 30) or lower than/equal to (CP/LCU; N = 36) the group median of 37. We used a median split approach for the following reasons: (a) group-centric analyses make it easier to interpret the clinical relevance of findings; (b) this approach has, in the past, successfully identified groups of children with CP who have different social-cognitive processing patterns (e.g. Roberts et al., 2020; Schwenck, 2012; Viding et al., 2012) and (c) effects of CU traits do not always emerge as interactions and can instead lead to suppressor effects in correlational analyses, making it difficult to interpret the findings (Frick, 2012, p. 20). Based on prior published research, a score of 37 on the teacher-rated ICU represents a clinically meaningful cut-off for HCU (Docherty, Boxer, Huesmann, O'Brien, & Bushman, 2017).

All typically developing (TD) participants who met inclusion criteria (N = 33) were required to score below the CP median (37) on the ICU, within normal range for the CASI (≤2) and below the cut-off of 16 for total difficulties on the SDQ (according to scoring norms; Youth in Mind, 2016).

Table 1 Group matching and participant characteristics data

	CP/HCU $N_{descriptives}$ = 30			CP/LCU $N_{descriptives}$ = 36			TD $N_{descriptives}$ = 33				
	Mean (*SD*)	Min–Max	$N_{complete}$	Mean	Min–Max	$N_{complete}$	Mean	Min–Max	$N_{complete}$	*p* Value	Post hoc*
IQ (full score)[a,b]	86.43 (9.12)	75.00–109.00	30	87.89 (12.41)	70.00–115.00	36	96.45 (14.14)	74.00–124.00	33	.002**	3 < 1, 2 < 1
Age (years)[c]	13.51 (1.34)	11.37–15.92	30	13.70 (1.31)	11.31–16.69	36	14.00 (1.06)	12.05–15.49	33	.299	–
Pubertal stage[a,d,e]	1:4:10:9:3	–	24	1:8:15:8:0	–	28	1:3:10:15:0	–	29	.111	–
Ethnicity[a,d,f]	10:4:1:2:2	–	19	18:2:2:2:0	–	24	13:1:5:7:2	–	28	.070	–
CASI conduct disorder[b,c]	10.05 (5.20)	4.00–20.00	30	6.48 (3.64)	3.00–18.00	36	0.27 (0.63)	0.00–2.00	33	<.0001**	1 < 2 < 3
ICU[b]	45.24 (5.66)	38.00–58.00	30	31.00 (4.98)	21.00–37.00	36	19.48 (6.06)	9.00–31.00	33	<.0001**	1 < 2 < 3
Alcohol use and disorders[a,d,g]	26:4:0	–	30	36:0:0	–	35	32:1:0	–	33	.030[h]	–
Drug use and disorders[a,d,i]	27:3:0	–	30	35:1:0	–	35	33:0:0	–	32	.070	–
SDQ hyper-activity[c]	8.07 (2.13)	4.00–10.00	30	6.97 (2.61)	1.00–10.00	36	1.73 (2.30)	0.00–10.00	33	<.001	1 < 2,1 < 3
SDQ peer problems[b,c]	2.80 (1.95)	0.00–7.00	30	3.00 (2.35)	0.00–9.00	36	1.38 (1.63)	0.00–5.00	33	<.001**	1 < 2,1 < 3
SDQ emotional problems[b,c]	3.00 (2.92)	0.00–10.00	30	3.47 (2.76)	0.00–10.00	36	1.18 (1.89)	0.00–7.00	33	<.001**	1 < 2,1 < 3
SDQ total difficulties[c]	20.39 (6.22)	7.00–37.00	30	17.52 (6.35)	3.00–37.00	36	4.59 (3.81)	0.00–12.00	33	<.05**	1 < 2,1 < 3

CASI, Child and Adolescent Symptom Inventory (Gadow & Sprafkin, 2005); CP/HCU, conduct problems and high levels of callous-unemotional traits; CP/LCU, conduct problems and low levels of callous-unemotional traits; ICU, Inventory of Callous and Unemotional traits (Essau et al., 2006); *N*, number of participants with complete measure; *SD*, standard deviation; SDQ, Strengths and Difficulties Questionnaire (Goodman, 1997); TD, typically developing. Where not stated, analyses were performed using one-way ANOVA and post hoc tests were Bonferroni corrected for multiple comparisons.
[a]Measure obtained at testing phase, child report.
[b]Assessed via three pairwise Wilcoxon rank sum test with continuity correction due to violation of ANOVA assumptions. Directionality inferred through visual inspection of means.
[c]Measure obtained at screening phase, teacher report.
[d]Assessed via chi square test, *p*-value computed for a Monte Carlo test (Hope, 1968). Post hoc tests were Bonferroni corrected for multiple comparisons.
[e]Counts for pubertal stages (prepubertal: early pubertal: midpubertal: advanced pubertal: postpubertal).
[f]Counts for self-identified ethnicity (White; mixed/multiple ethnic groups; Asian/Asian British; Black/African/Caribbean background; other ethnic group).
[g]Counts for AUDIT risk categories (low risk:increasing risk:higher risk:possible dependence).
[h]Significance at $p = .05$ did not remain after post hoc tests with Bonferroni correction.
[i]Counts for DUDIT risk categories (low risk:possible drug problems).
*1 = TD, 2 = CP/LCU, 3 = CP/HCU. **Results for comparisons smaller than or equal to this threshold.

Participants completed measures of IQ, pubertal development, substance (alcohol and drug) use and ethnicity. Groups were similar with respect to age, and self-reported pubertal status, substance use and ethnicity (Table 1; Appendix S2). Differences were observed between groups in average IQ (which was expected given the association of CP with lower cognitive ability; Moffitt, 1993; Nigg & Huang-Pollock, 2003), as well as teacher measures of social and emotional difficulties. Including these measures as covariates did not change any of our key findings (Appendix S3). Details on scales used for these measures, as well as internal consistency for all measures in our sample, can be found in Appendix S2.

Experimental design and procedure

Participants completed a shortened version of Lockwood et al.'s Prosocial Effort Task (Lockwood et al., 2017; details on task adaptation and piloting in Appendix S4). This task involved 72 experimental trials which comprised 36 decisions for participants themselves (henceforth 'self' trials) and 36 decisions for another boy at another school (henceforth 'other' trials). Each trial first required participants to make a choice between a baseline 'rest' option that offered 1 credit for no effort, and a variable 'work' offer that required more effort (30%, 43%, 57%, 70% of participants' Maximum Voluntary Contraction or 'MVC', established at baseline), but offered more reward (2–6 credits). Effort and reward levels for the work offer varied independently over trials. Once they made a choice, participants were then given the opportunity to make effort (to the degree required by their choice) by squeezing a handheld gripper for at least 1 s in order to obtain their credits. Credits earned in the game went towards real-life gift vouchers of up to £5 for the self and for the other. Crucially, this design allowed us to examine three key outcomes of interest for each trial type (self & other): (a) choice (of rest vs. work option), (b) motivation to make that choice (i.e. discounting of the work option based on the effort required to obtain the points on offer) and (c) actual effort exerted (which had to reach a specified threshold in order for points to be obtained). Full details on task design, procedure and apparatus can be found in Figure 1 and Appendix S4.

Quantification and statistical analyses

Participant demographic and characteristics data. Demographic details of the participant for matching and assessment of additional behavioural characteristics were analysed using one-way analysis of variance, chi-squared test or nonparametric equivalents where appropriate in SPSS (IBM Corp., 2020), and R (version 1.4.1717) using R studio (R Core Team, 2020; RStudio Team, 2015). For full summary of descriptive analyses, see Appendix S3.

Statistical analysis of behavioural data. Analyses of behavioural data were carried out using a combination of MATLAB (2019, The MathWorks Inc.) and R with R Studio. Analysis of behavioural data and computational parameters (see below) used (generalised) linear mixed-effects models (LMM; glmer/lmer function; lme4 package). In all statistical models, group was coded using treatment contrasts with group 'TD' and agent 'other' as the reference groups. For full details on all models, their specifications and assumption checks, please refer to Appendix S5.

To examine trial-by-trial choice behaviour, we ran a mixed-effects logistic regression. The model included the following fixed effects: recipient (self or other), effort level (squared to mirror the computational model results), reward and group

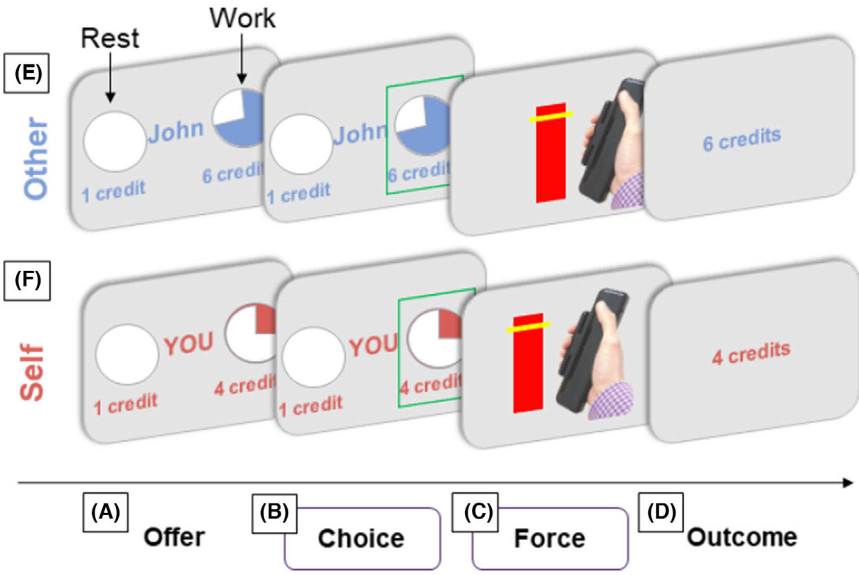

Figure 1 Experimental paradigm. Participants were presented on each trial with the following: (A) an *offer*: a rest option which required minimal effort (squeezing a handheld dynamometer with no resistance at 0% of their maximum voluntary contraction (MVC), corresponding to zero segments of the pie chart) for the low reward of 1 credit, or a work option which generated higher reward (2–6 credits) but also required more effort (30%, 43%, 57%, 70% of MVC) corresponding to 1–4 segments of the pie chart). Reward and effort levels of the work option varied independently on each trial. (B) A *choice* between rest and work options. (C) An opportunity to exert *effort* (apply force by gripping the dynamometer) to the required degree (marked by the yellow line). Participants had to squeeze the gripper for at least 1 s out of a 3 s window in order to receive the reward for that trial. They then (D) received *feedback* about the outcome of the trial, corresponding to the offer that they had chosen. They received 0 credits if they were unsuccessful or if they made no choice at stage B. Crucially, on other trials (E), participants received an offer, made their choice, exerted effort and received feedback on behalf of a fictional other named John – they were also informed that John would receive the credits gained. On self trials (F), participants received the offer, made their choice, exerted the effort and received the feedback on behalf of the self and, if they were successful, received the credits themselves. Participants completed 72 trials, 36 with outcomes for the self and 36 with outcomes for the other. Self and other trials were interleaved. Credits accrued contributed to real voucher rewards for the participant and (they believed) for the other

(CP/HCU, CP/LCU or TD), as well as a subject-level random variable.

To compare *k* parameters (estimated using computational models, more information below and in Appendix S6) we employed a GLMM using a gamma distribution with log link function to account for the nature of the data without transforming the raw scores. The terms were fixed effects of recipient and group as well as a subject-level random variable. β parameters, representing decision noise or stochasticity of choices, were compared using a linear mixed effects model (LMM). The model included group, recipient, and their interaction as fixed effects, and a subject-level random variable.

Force data were analysed using a linear mixed model (LMM) that predicted normalised force with fixed effects of recipient, effort level, reward and group, as well as a subject-level random variable.

Computational modelling of choice data. To explore whether choice was driven by reduced prosocial motivation in our sample, we fitted a range of computational models of effort discounting to the choice behaviour of each participant. In these models, a '*k*' parameter precisely characterised an individual's motivation by quantifying the rate at which rewards are discounted by the effort it takes to obtain them. A large *k* indicates steep reward by effort discounting (i.e. lower motivation to choose a particular option) and a small *k* indicates shallow discounting (i.e. a higher motivation to choose that option). An additional β parameter measures stochasticity/variance of choices. The best-performing model was a parabolic model with separate discount (*k*) parameters, as well as separate β parameters, for self and for other trials (Figure 2B,C). This is in line with prior studies using this task, where this model (model 10) is consistently among the models with the lowest BIC scores (Lockwood, Abdurahman, et al., 2021; Lockwood et al., 2017; Lockwood, Wittmann, et al., 2021). It is also very close to the winning model in past studies (Model 7), which had separate *k* parameters but a single β parameter. Importantly, our winning model showed a good fit to participants in all three groups (mean R^2 values: TD = 0.70, CP/LCU = 0.71, CP/HCU = 0.72), with no significant differences in fit between groups (Wilcoxon tests on R^2 between groups *z*s <.5, *p*s >.62). For more detail on model selection and comparison, see Appendix S6 and Figure 2D.

Results

Adolescents with conduct problems make fewer prosocial choices than typically developing adolescents

Participants across all groups made fewer prosocial, compared to self-benefitting, choices (main effect of recipient – OR = 7.01, CI = [5.54, 8.88], $p < .001$) (Figure 2A, Table S1). That is, they were considerably less likely to choose the work option on 'other' compared to 'self' trials, mirroring prior research (Lockwood et al., 2017). Notably, however, groups differed in the extent to which they demonstrated low prosocial choice (Group x Recipient interaction – χ^2 (2, $N = 94$) = 10.69, $p = .007$; Figure 2A). Specifically, both CP/HCU and CP/LCU groups made fewer choices of the work option for the other (relative to the self) compared to TD participants (CP/HCU vs. TD – OR = 1.70, CI = [1.20, 2.42], $p < .001$]; CP/LCU vs. TD – OR = 1.57, CI = [1.12, 2.20], $p = .010$). Adolescents in the CP/HCU group chose the work option on 81% of self-benefitting trials and just 41% of prosocial trials and those in the CP/LCU group chose similarly (80% vs. 44%) (Figure S1). This difference in choice for self and other was much smaller in the TD group, who were similar to CP groups in their choice of the work option on self-benefitting trials (80%), but chose the work option more frequently than CP groups on prosocial trials (52%) (post hoc Tukey comparisons of estimated marginal means from choice model: CP/HCU vs. TD – $p = .009$, CP/LCU vs. TD – $p = .025$, CP/HCU vs. CP/LCU – $p = .962$). Notably, the proportion of choices made for the self was similar between groups (confirmed by post hoc chi test comparing choice for self between groups – $\chi^2(2, 94) = 3.59$, $p = .166$). This gives strong indication that the low prosocial choice observed in our CP groups relative to our TD group is driven by reduced willingness to choose to make effort on behalf of others, rather than a general reduction in the willingness to exert effort. For full details on our choice results, see Appendix S7 and Table S1.

Adolescents with conduct problems are less motivated to choose to make prosocial effort

All participants, on average, showed higher reward by effort discounting for the other than for the self. In other words, participants were less motivated to choose to exert effort for the other than for themselves (Mean Ratio (MR) =3.06, 95% CI = [2.09, 4.48], $p < .001$; Figure 2E, Table S2). What is more, and in line with our choice data, CP/HCU and CP/LCU groups were both less motivated to make choices for the other (relative to the self) than their TD peers (CP/HCU vs. TD – MR = 2.01, CI = [1.13, 3.59], $p = .017$; CP/LCU vs. TD – MR = 1.73, CI = [1.01, 2.97], $p = .046$). CP/HCU and CP/LCU groups did not statistically significantly differ from one another ($p = .608$).

As our winning model also contained separate β (noise) parameters, we also compared whether stochasticity of choice differed between groups. In contrast to discounting results, there was no evidence that self–other differences in decision noise differed between the groups (group x recipient interaction *p*s >.38). All groups made significantly more noisy decisions when these benefitted another person, compared to themselves (β = .47, CI = [0.30, 0.65], $p < .001$; Table S3; Figure S2).

Adolescents with conduct problems and high CU traits demonstrated especially reduced prosocial effort

Participants in all groups exerted less force at higher effort levels on trials where they were working for the other than they did on trials where they were working for the self (χ^2 (1, $N = 94$) = 110.07, $p < .001$; Figure 2F, Table S4). However, the

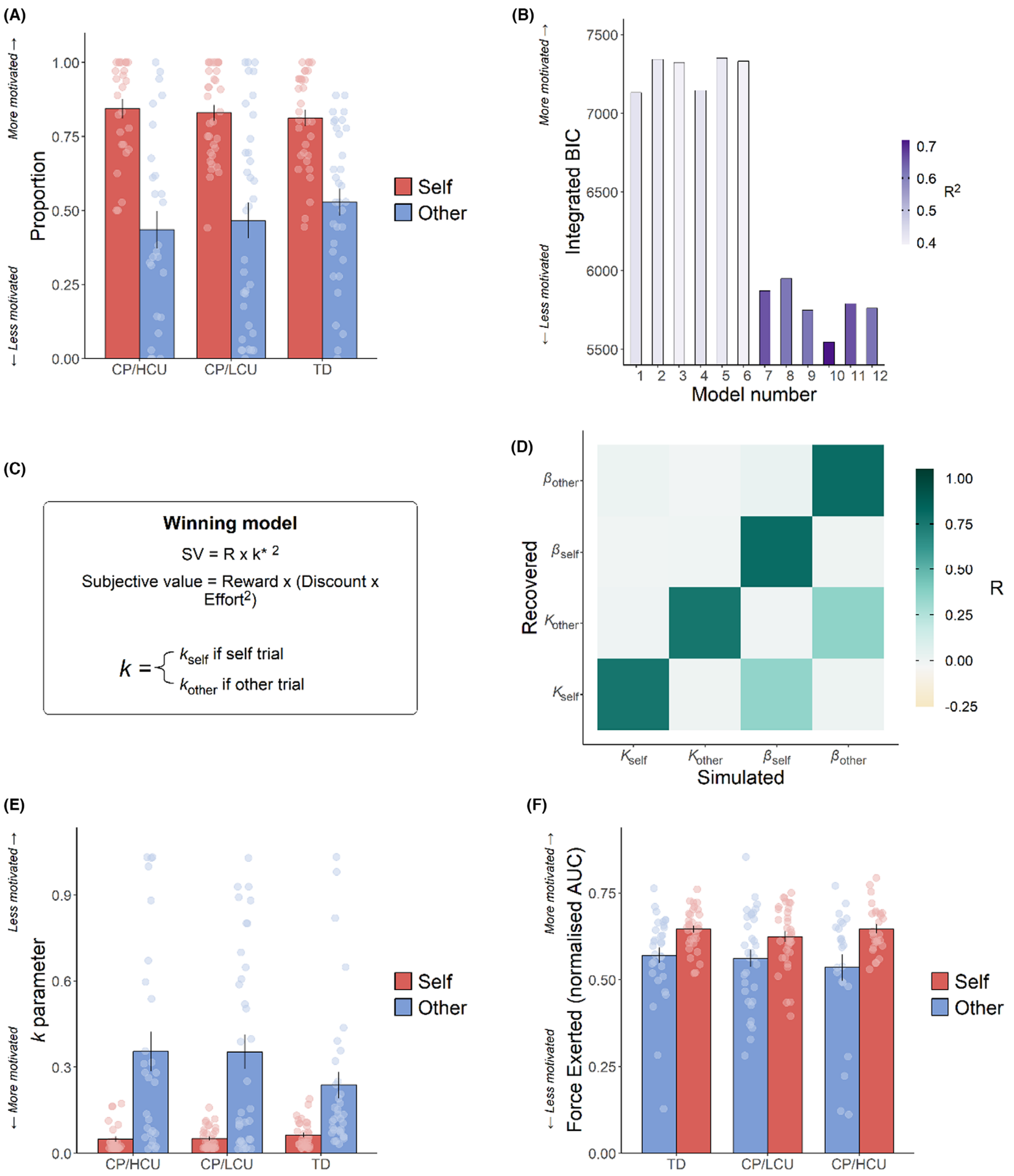

Figure 2 Prosocial choice, prosocial force and computational modelling of prosocial and self-benefitting decisions. AUC, Area under curve; BIC, Bayesian Information Criterion; CP/HCU, conduct problems and high levels of callous-unemotional traits; CP/LCU, conduct problems and low levels of callous-unemotional traits; TD, typically developing. (A) Participants in CP/HCU and CP/LCU groups showed a greater difference in proportion of offers accepted for the self versus the other than the TD group (CP/HCU vs. TD, p = .009; CP/LCU vs. TD, p = .025). (B) A range of computational models of effort discounting were compared. These varied in terms of whether models had a single or separate discount (k) parameter(s) for self and other trials (models 1–6 vs. models 7–12) and in the shape of the discount function: parabolic (Models 1, 4, 7, 10), linear (Models 2, 5, 8, 11) or hyperbolic (Models 3, 6, 9, 12). Model 10, that had separate choice stochasticity parameters (β) for self and other best fit our data according to the BIC criterion. This model was therefore selected as the winning model. Bars show model BIC. (C) Equation for winning parabolic model with separate discount (K) parameters and choice stochasticity (β) parameters that explained behaviour in most participants. (D) Parameter recovery (correlation between simulated and fitted parameters from the winning model) showed excellent recovery of the model parameters. (E) Participants in CP/HCU and CP/LCU groups showed higher reward by effort discounting for the other (relative to the self) than the TD group (CP/HCU vs. TD, p = .017; CP/LCU vs. TD, p = .046). (F) Force exerted (normalised areas under the curve during the effort period) for each group and recipient. Across effort and reward levels, all participants put in less effort for the other than they did for the self (p < .001), but the CP/HCU group showed this self-other difference in force to a larger extent than the CP/LCU (p < .014) and TD (p < .001) groups.

CP/HCU group demonstrated this reduced prosocial force to a greater extent than both CP/LCU and TD groups (CP/HCU vs. TD: $p < .001$, CP/HCU vs. CP/LCU: $p = .014$, CP/LCU vs. TD: $p = .722$). That is, even once they have chosen prosocially, CP/HCU adolescents exerted less effort for the other (vs. the self) than both CP/LCU and TD groups. This indicates that, although adolescents with CP/HCU and CP/LCU appear similar in their prosocial *choices*, they look very different when it comes to prosocial effort. For full details on our force results, see Appendices S7 and S8, Table S4.

We ran post hoc exploratory analyses to examine whether reduced prosocial effort observed in our CP/HCU group relative to CP/LCU and TD groups meant that they were also less successful in meeting the effort threshold to accrue a win for the other (relative to the self). All participants were less successful when making effort for the other than for the self (main effect of recipient – χ^2 (2, $N = 94$) = 48.55, $p < .001$). Interestingly, however, while our CP/HCU group was less successful overall than our TD group (main effect of group – χ^2 (2, $N = 94$) = 8.22, $p = .016$; post hoc Tukey comparisons of estimated marginal means: CP/HCU vs. TD – $p = .017$; CP/LCU vs. TD – $p = .079$; CP/LCU vs. TD – $p = .761$), we observed no group by recipient interaction ($p = .801$). In other words, despite our CP/HCU exerting less force for the other (vs. the self) relative to CP/LCU and TD groups, they are not showing this same difference in success in meeting the effort threshold. This implies that our CP/HCU group is still successful when working for the other, but putting in the bare minimum effort to do so (whereas other participants appear to put in more than the required amount of effort).

Discussion

Here we observed reduced prosocial behaviour in adolescent boys with conduct problems (CP). We also find heterogeneity among this group in an important facet of prosocial behaviour: prosocial effort. All boys with CP in our sample demonstrated reduced prosocial choices relative to typically developing (TD) peers. However, once having made a prosocial choice, boys with CP and high callous-unemotional traits (CP/HCU) stood out from both TD adolescents and boys with CP and low CU traits (CP/LCU) in their reduced propensity to make effort to benefit others. Our findings reveal shared vulnerabilities among adolescents with CP in mechanisms that facilitate prosocial engagement, but also highlight specific additional difficulties that may characterise those with HCU. They also emphasise the importance of looking at prosocial behaviours as multifaceted – requiring both good intentions and effortful follow through.

Our behavioural and computational modelling analyses revealed that all adolescents with CP in our study demonstrated reduced prosocial choice, and that this was driven by higher reward by effort discounting for others than for the self. Prior research that has looked at prosocial choices in adolescents with CP/HCU and CP/LCU (and which informed our hypotheses for the current study) observed that prosocial choices are especially reduced in those with HCU with an indication of possibly intermediate difficulties in those with LCU (Sakai et al., 2012, 2016). The fact that both CP/HCU and CP/LCU adolescents differed statistically from TD adolescents in our study could reflect our task design. Whereas prosocial choices in prior studies involved participants deciding how to split a financial reward between themselves and someone else, prosocial choices in our task involved choosing whether to exert *effort* to obtain financial reward. It is possible that different cognitive mechanisms are at play in these different types of prosocial decisions, and that participants with CP/LCU are more sensitive to effortful costs than financial costs alone when making prosocial decisions. Another way in which the current task differs from prior tasks used with these groups is that choices to benefit the self and choices to benefit the other were not directly pit against one another – that is, a gain to the self did not directly incur a loss to the other. Adolescents with CP/HCU are characterised by reduced affective empathy, as well as reduced responsivity to others' distress (Blair et al., 2004; Jones, Happé, Gilbert, Burnett, & Viding, 2010; Viding et al., 2012; Viding & McCrory, 2018). This may make this group less sensitive to gain/loss framing in choices for others than CP/LCU adolescents, who do not share these affective-processing deficits. Future work could investigate this further by examining how prosocial choice differs between CP/HCU, CP/LCU and TD adolescents on a task that directly contrasts prosocial choices that incur a gain and prosocial choices that inflict a loss to another, and seeing whether choice behaviour relates to measures of affective empathy.

However, while adolescents with CP/HCU and CP/LCU showed similarly reduced prosocial choices, these groups differed in their subsequent engagement in prosocial effort. Specifically, adolescent boys with CP/HCU differed from both those with CP/LCU and TD peers in the relative effort that they were willing to make for themselves versus someone else. This observation provides the first evidence that a reduced propensity to put effort into effecting prosocial actions may be linked to the particularly low levels of prosocial behaviour observed in CP/HCU (Foulkes, Neumann, Roberts, McCrory, & Viding, 2017; Frick, Ray, Thornton, & Kahn, 2014; Milledge et al., 2019; Viding & McCrory, 2019; Waller & Wagner, 2019). It also highlights the importance of sensitive task design that captures multiple aspects of prosocial behaviour when investigating adolescent CP.

Similar to healthy adults, all of our participants put more effort in to win points for themselves than they did for another person. This indicates that some degree of self-prioritisation is the 'norm'. However, the considerably greater difference in relative effort for the self and the other demonstrated by those with CP/HCU may be important in understanding atypical social affiliation in this group. Fairness and reciprocity are considered important hallmarks of human social behaviour, and adults and children alike tend to be strongly averse to unfair behaviour – even punishing others that violate fairness norms (Fehr & Gächter, 2000, 2002; McAuliffe, Blake, Steinbeis, & Warneken, 2017). Translated into real-life situations, an especially reduced willingness to put in effort for others relative to yourself may be viewed as unfair behaviour by peers, and thereby may contribute to difficulties in maintaining social relationships in adolescents with CP/HCU.

Participants in the CP/HCU group were still meeting the required effort threshold to win points for the other (as indexed by a lack of difference in success rates on 'other' trials between groups). However, they appeared to be putting in the bare minimum effort to do so. Achieving the same result as other groups (i.e. successfully meeting the effort threshold to win points) by exerting less effort could be argued to be efficient or even optimal behaviour. However, the outcome may not be the most important factor when it comes to prosocial behaviour and its role in social relationships. Research suggests that people consider personal sacrifice when engaging in prosocial behaviour to be more important than the outcome when they make social evaluations – presumably because sacrifice is taken as an important indicator of a person's moral character (Johnson, 2018). Given that CP/HCU is a profile associated with atypical social affiliation, and that only prosocial effort differentiated adolescents with CP/HCU from other groups, we speculate that putting effort into prosocial acts is one key aspect of facilitating good social connections with others. It is also possible that adolescents with CP/HCU are less sensitive to the social costs of not engaging in this effort. Future research could explore this further by investigating both peer perceptions of acceptability or likeability of adolescents who exhibit different forms of prosocial transgressions, as well as perception of adolescents with CP/HCU and CP/LCU of these same transgressions. This would give insight into how different facets of prosocial behaviour might contribute to social difficulties for adolescents with CP/HCU and CP/LCU, and has potential to inform intervention strategies for CP.

It is also interesting to consider the role of motivation in prosocial effort. Previous research has indicated a divergence between ability and propensity in CP/HCU: for example, adolescents with CP/HCU appear to be able to take the perspective of others, but seem less motivated to do so than their peers (Roberts et al., 2020). Similar results have been seen in adults with psychopathy (Drayton, Santos, & Baskin-Sommers, 2018). This study gives initial indication that adolescents with CP/HCU may also be characterised by a reduced propensity to engage in prosocial effort. Another interesting avenue for future research might therefore be to explore motivation for prosocial effort in adolescents with CP/HCU under different experimental conditions. For example, future studies could explore whether adolescents with CP/HCU engage in instrumental prosocial behaviour – in other words, whether they would be willing to make prosocial effort in situations where they stand to gain, as opposed to in a more general context such as the current experiment.

It is important to note some limitations to the current study. First, the study focused on males only, given the preponderance of CP in boys. Future work should also investigate these processes in girls with CP, especially given the findings that neurocognitive mechanisms underlying CP in females may not always be comparable to those seen in males (Freitag et al., 2018). Second, although we made extensive efforts to work with a wide range of schools and adolescents with a variety of backgrounds, we were unfortunately unable to obtain precise information regarding the representativeness of our sample as we did not collect parent data. Third, we were unable to provide precise data regarding parent opt-out rates due to our opportunity sampling approach of making contact via schools, and the fact that schools typically kept their own records of opt-outs which they did not provide to us for data protection reasons. Fourth, although this task documents potential mechanisms underlying reduced prosocial behaviour in boys with CP, we do not yet know how these mechanisms relate to real-life prosocial behaviour. Future studies could help to shed light on this by looking at ecological momentary assessments or observer-rated diary assessments of prosocial behaviour, and relate these to task performance metrics. A final limitation is that although our sample is typical of research with CP populations who are often hard to engage in research (see Appendix S1), it is important to note that our sample size is not large enough to identify small effect sizes and may be more prone to false positives.

Overall, the current study considerably extends our understanding of prosocial behaviour in adolescent boys with CP/HCU and CP/LCU in a number of important ways. Adolescents with CP/HCU, a vulnerable group that is at risk of developing psychopathy in adulthood, demonstrated especially reduced prosocial behaviour relative to other groups, exhibiting not only reduced prosocial choice but also reduced prosocial effort. This is in contrast to those with CP/LCU, who only showed reduced prosocial choice. These findings offer new insights into prosocial processing in CP/HCU and CP/LCU, and increase our understanding of what may drive especially low prosocial behaviour and atypical social affiliation in CP/HCU. These findings also demonstrate differentiation between adolescents with CP/HCU and those with CP/LCU on an important index of social cognition: prosocial effort. If replicated, these results could motivate further inquiry into behavioural training and intervention components that improve social functioning and reduce the risk of antisocial behaviour in adolescents with CP/HCU and CP/LCU.

Supporting information

Additional supporting information may be found online in the Supporting Information section at the end of the article:

Appendix S1. Sample size determination.
Appendix S2. Participant demographics and characteristics – additional information and analysis.
Appendix S3. Covariate analyses.
Appendix S4. Experimental design and procedure: further details.
Appendix S5. Main model specification & assumption checks.
Appendix S6. Model selection and comparison.
Appendix S7. Full description of results.
Appendix S8. Force model including negative curve.
Table S1. Choice model full summary. Related to results.
Table S2. Model predicting k parameters.
Table S3. Model predicting β parameters.
Table S4. Force model full summary.
Figure S1. Relative proportions of choices made for the 'self' and the 'other' by group.
Figure S2. Plot of stochasticity of choices by group.

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Data availability statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.All experimental code available upon request.

Ethical considerations

This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the University College London Research Ethics Committee (0622/001). Consent/assent procedures were in line with UK General Data Protection Regulations. For full information see p5.

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Key points

- Conduct problems (CP) in adolescence are characterised by antisocial behaviour and reduced prosocial behaviour. However, heterogeneity among adolescents with CP in prosocial engagement remains poorly understood.
- The current study examined three important facets of prosocial behaviour in adolescents with high versus low callous-unemotional traits (CP/HCU vs. CP/LCU) and typically developing (TD) adolescents: choice, motivation and effort.
- All adolescents with CP demonstrated reduced prosocial choice and motivation relative to TD adolescents. However, those with CP/HCU also demonstrated notably reduced engagement in prosocial effort that set them apart from both CP/LCU and TD peers.
- Differences among adolescents with CP in behaviours that foster positive interactions and social affiliation have noteworthy implications for intervention and training programmes to improve social functioning and decrease risk for antisocial behaviour in young people with CP.

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