1   Cooperative phenotype predicts climate change belief and pro-environmental behaviour

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Abstract

Understanding the psychological causes of variation in climate change belief and pro-environmental behaviour remains an urgent challenge for the social sciences. The "cooperative phenotype" is a stable psychological preference for cooperating in social dilemmas that involve a tension between individual and collective interest. Since climate change poses a social dilemma on a global scale, this issue may evoke similar psychological processes as smaller social dilemmas. Here, we investigate the relationships between the cooperative phenotype and climate change belief and behaviour with a representative sample of New Zealanders ($n = 897$). By linking behaviour in a suite of economic games to self-reported climate attitudes, we show robust positive associations between the cooperative phenotype and both climate change belief and pro-environmental behaviour. Furthermore, our mediation analyses support a motivated reasoning model in which the relationship between the cooperative phenotype and pro-environmental behaviour is fully mediated by climate change belief. These findings suggest that common psychological mechanisms underlie cooperation in both micro-scale social dilemmas and larger-scale social dilemmas like climate change.

Keywords: cooperation, climate change belief, pro-environmental behaviour, motivated reasoning

Cooperative phenotype predicts climate change belief and pro-environmental behaviour

Climate change belief varies considerably across individuals, both within and between countries[1,2]. While the majority of people in developed countries accept the reality of anthropogenic climate change, considerable minorities are either undecided, accept that the climate is changing but deny a human role, or deny that it is changing at all[3–5]. Individual differences also exist in the uptake of pro-environmental behaviour such as energy conservation[6,7] and environmental activism[8]. Understanding the underlying psychological causes of this variation will help us determine whether and how increased numbers can be encouraged to act.

One psychological mechanism that could explain variation in climate change belief and pro-environmental behaviour is a general willingness to cooperate in social dilemmas. Social dilemmas are classes of social interaction in which an actor's self-interest is at odds with the group's collective interest[9]. A classic example is the commons dilemma[10], often associated with Hardin's "tragedy of the commons"[11]. When a resource is collectively-held, individuals must choose between maximising their own benefit (i.e., defecting) or restraining themselves to sustain the resource for everyone (i.e., cooperating). Maximising individual benefit delivers short-term profits, but eventually leads to the collapse of the resource.

Studies using incentivised behavioural economic games have revealed a general psychological preference for cooperation in micro-scale social dilemmas that is temporally stable[12,13], heritable[14,15], and captured by a single underlying latent variable that is found across a variety of cultures[13,16,17]. Dubbed the "cooperative phenotype", this measure of an individual's willingness to cooperate in micro-scale social dilemmas correlates with self-reported moral values, positive views regarding real-world cooperation (i.e., paying taxes), and manifest helping behaviour[13].

Given what we know about the preferences, beliefs, and behaviours of individuals

59 with cooperative phenotypes in smaller social dilemmas, it is conceivable that much of this

60 knowledge can be applied to climate change beliefs and pro-environmental behaviour. This

61 is because climate change shares the structure of a social dilemma, albeit at a much larger

62 scale. Self-interested behaviour erodes the shared commons of a stable climate, delivering

63 individually beneficial results that are eventually ruinous for all[18]. In contrast, tackling

64 climate change requires extensive cooperation on a global scale. Parties must take on

65 personal costs in order to support the public good of a stable climate, and ensure that such

66 behaviour is shared by sufficient numbers to achieve its aim[19,20].

67   Evidence suggests that common psychological mechanisms are used to navigate both

68 micro-scale and larger scale social dilemmas. For example, Rustagi et al.[21] conducted

69 two-player public goods games in forest commons user groups and found that groups with

70 a greater share of conditional cooperators (defined as those whose extent of cooperation is

71 positively correlated with their beliefs about the cooperativeness of their peers) in the

72 games had a significantly higher percentage of crop trees per hectare. In other words,

73 cooperators in the economic games were more successful at cooperating to manage large

74 forest commons.

75   Here, we consider an analogous question concerning the much larger, more complex

76 social dilemma of climate change. We predict that individual differences in the cooperative

77 phenotype will explain variation in both pro-environmental behaviour and belief in climate

78 change. Those unwilling to engage in costly cooperation, especially where interactions are

79 short-lived and future benefits small or non-existent, will be less willing to behave

80 pro-environmentally, as doing so involves paying personal costs to benefit the collective. In

81 addition, work on motivated reasoning[22,23] suggests that non-cooperators will also be less

82 likely to believe in the reality of climate change: cognitively, it is easier to justify

83 uncooperative behaviour by refusing to admit that there is a social dilemma at all.

84   Although these predictions arise naturally from research in behavioural economics,

85 they have not yet been formally tested. While economic games are often used to model the

86 social dilemma of climate action[19,20], no studies have yet looked at the link between

87 gameplay and pro-environmental behaviour, and only one paper at the link between

88 gameplay and climate change belief[20]. In that case, all games were explicitly framed to

89 participants as "climate dilemmas", preventing any investigation of an association between

90 climate change belief and the micro-scale social dilemma structure of the games alone.

91   In this pre-registered study (https://osf.io/d8t46/), we combined data on

92 self-reported climate change belief and pro-environmental behaviour from a longitudinal

93 study of attitudes and values with an expanded suite of the economic games used to

94 estimate individuals' cooperative phenotypes. Given the structural similarity between

95 micro-scale social dilemmas and environmental problems, we first hypothesised that the

96 cooperative phenotype would predict pro-environmental behaviour. Second, in line with

97 our argument for motivated reasoning, we also hypothesised that the cooperative

98 phenotype would predict climate change belief, and that pro-environmental behaviour

99 would fully mediate this relationship. In testing these hypotheses, we aimed to establish

100 whether the relationships between the cooperative phenotype and climate change belief

101 and behaviour are independent of factors previously shown to relate to climate attitudes,

102 such as socio-demographic variables (e.g. gender, age, education, and political

103 affiliation[24–26]) and personality dimensions (e.g. extraversion, agreeableness,

104 conscientiousness, openness, and honesty-humility[27–30]).

105   Participants were sampled from the New Zealand Attitudes and Values Study, a

106 nationally representative survey of registered voters in New Zealand containing

107 socio-demographic data, personality scales, and measures of self-reported

108 pro-environmental behaviour (one item) and climate change belief (three items).

109 Participants were screened for eligibility before playing a suite of incentivised one-shot

110 economic games online with other participants in real-time ($n = 897$). We used four

111 economic games commonly utilised in behavioural economics to model different micro-scale

112 social dilemmas. Three games, previously used to validate and estimate the cooperative

113 phenotype[13], measured cooperation (Dictator Game, Trust Game, Public Goods Game). A

114 fourth novel game measured coordination (Stag Hunt Game). The cooperative phenotype

115 was estimated by fitting confirmatory factor analyses to the data from all four of these

116 economic games, before running a series of structural equation models testing our main

117 hypotheses (see Online Methods for further details).

Results and Discussion

119   In line with our pre-registered hypotheses, we found a significant positive relationship

120 between the cooperative phenotype and self-reported pro-environmental behaviour

121 (unstandardised $b = 0.75$, 95% CI [0.09 1.40], $r = 0.10$, $p = .025$; Figure 1a). Individuals

122 who cooperated more in our economic games modelling micro-scale social dilemmas were

123 more likely to report engaging in pro-environmental behaviour than individuals who

124 cooperated less. We also found a positive relationship between the cooperative phenotype

125 and climate change belief ($b = 1.08$, 95% CI [0.43 1.74], $r = 0.16$, $p = .001$; Figure 1b).

126 Individuals who cooperated more were more likely to believe in anthropogenic climate

127 change than individuals who cooperated less. This positive relationship held when

128 separately analysing the individual items making up the climate change belief latent

129 variable: belief in the reality of climate change ($b = 1.04$, 95% CI [0.29 1.78], $r = 0.14$, $p = $

130 .006), belief that climate change is human-caused ($b = 1.03$, 95% CI [0.33 1.73], $r = 0.14$, p

131 $= .004$), and concern about climate change ($b = 1.09$, 95% CI [0.38 1.80], $r = 0.14$, $p = $

132 .003).

133   In order to investigate the relationship between these effects and other potential

134 causal factors, we re-ran our models controlling for socio-demographic and personality

135 variables previously shown to predict climate change belief. Regarding socio-demographic

136 variables, the relationship between the cooperative phenotype and self-reported

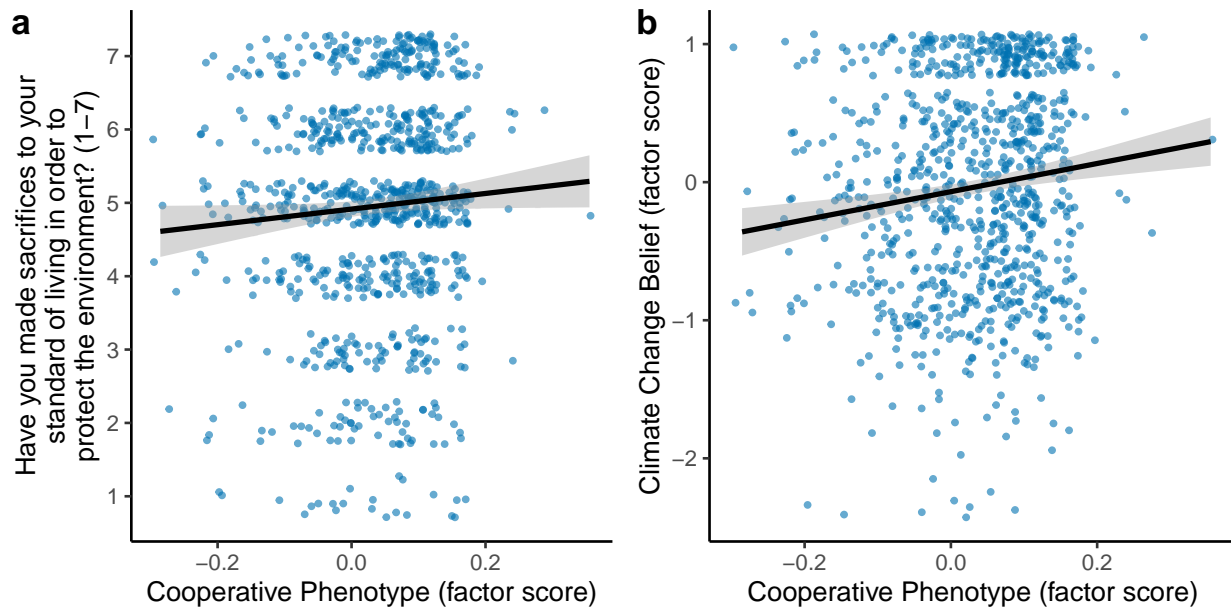137 pro-environmental behaviour was robust to controls for age, gender, ethnicity, and

Figure 1. *Cooperative phenotype positively predicts both pro-environmental behaviour (a) and belief in climate change (b).* "Cooperative phenotype" is a latent variable captured by cooperative decisions in the Dictator Game, Public Goods Game, Trust Game, and Stag Hunt Game. "Climate change belief" is a latent variable captured by three self-report items measuring belief in the reality of climate change, belief that climate change is human caused, and concern about climate change. For visualisation ease, regression lines and 95% confidence interval shaded areas are predictions from least-squares regressions without covariates.

education, but was attenuated by political party supported (Figure 2a). We found the same attenuating effect of political party for climate change belief (Figure 2b). Regarding personality variables, the relationship between the cooperative phenotype and self-reported pro-environmental behaviour was robust to controls for extraversion, conscientiousness, neuroticism, and openness, but was attenuated by agreeableness, honesty-humility, and narcissism. In contrast, the relationship between the cooperative phenotype and climate change belief was robust to the inclusion of all personality covariates, suggesting that this result is independent of previously identified personality effects[27–30].

To test for an effect of motivated reasoning - whereby the cooperative phenotype affects pro-environmental behaviour and thus one's willingness to believe in the reality of
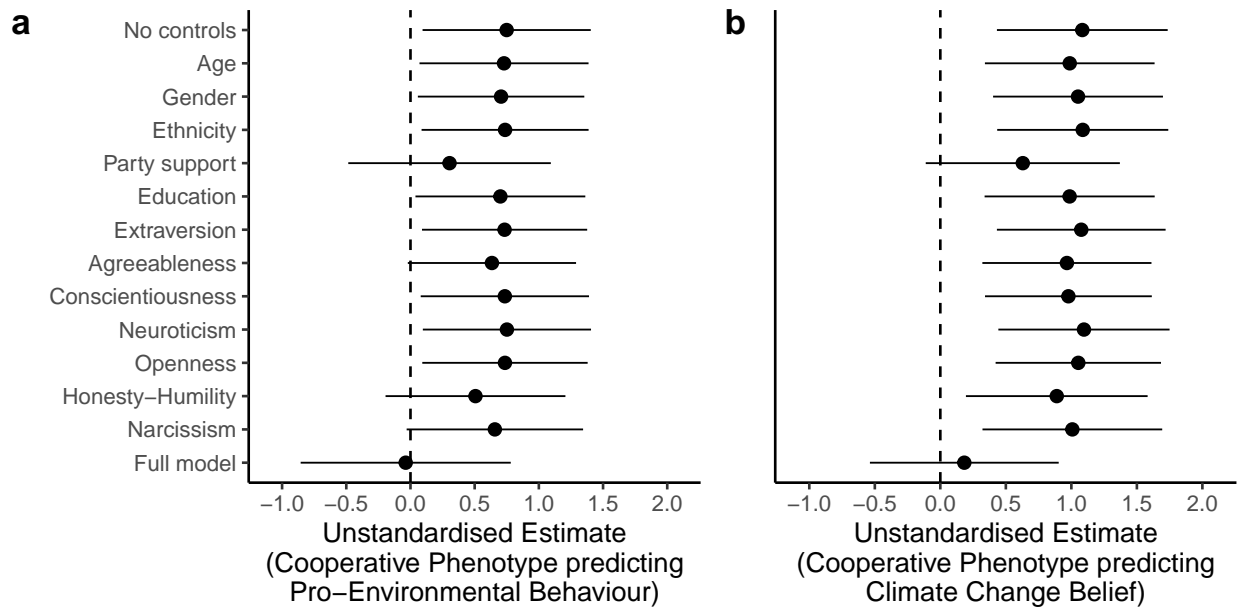
Figure 2. *Controlling for socio-demographic and personality variables.* (a) The unstandardised estimate for the relationship between the cooperative phenotype factor and pro-environmental behaviour, across various models controlling for different socio-demographic and personality variables. (b) The unstandardised estimate for the relationship between the cooperative phenotype factor and climate change belief. Lines represent 95% confidence intervals.

148 climate change - we fitted a mediation model investigating whether pro-environmental

149 behaviour fully mediated the relationship between cooperative phenotype and climate

150 change belief. This model fitted the data well (RMSEA = 0.038; SRMR = 0.052; CFI =

151 0.987; Figure 3). However, in contrast to our hypothesised full mediation, we found only a

152 partial mediation effect. Regressing pro-environmental behaviour on the cooperative

153 phenotype was statistically significant ($b = 0.76$, 95% CI [0.10 1.43], standardised $\beta = 0.10$,

154 $p = .025$), as was regressing climate change belief on pro-environmental behaviour ($b =$

155 0.37, 95% CI [0.32 0.42], $\beta = 0.43$, $p < .001$). However, while including pro-environmental

156 behaviour as a mediator did decrease the unstandardised parameter for the direct path

157 between cooperative phenotype and climate change belief, this relationship remained

158 significant ($b = 0.77$, 95% CI [0.19 1.36], $\beta = 0.12$, $p = .010$). Some, but not all, of the

159   relationship between cooperative phenotype and climate change belief can be explained by

160   pro-environmental behaviour as a mediator. This pattern of results held when controlling

161   for all socio-demographic and personality covariates except agreeableness, honesty-humility,

162   and narcissism, which attenuated the path from the cooperative phenotype to

163   pro-environmental behaviour, and political party support, which attenuated both paths

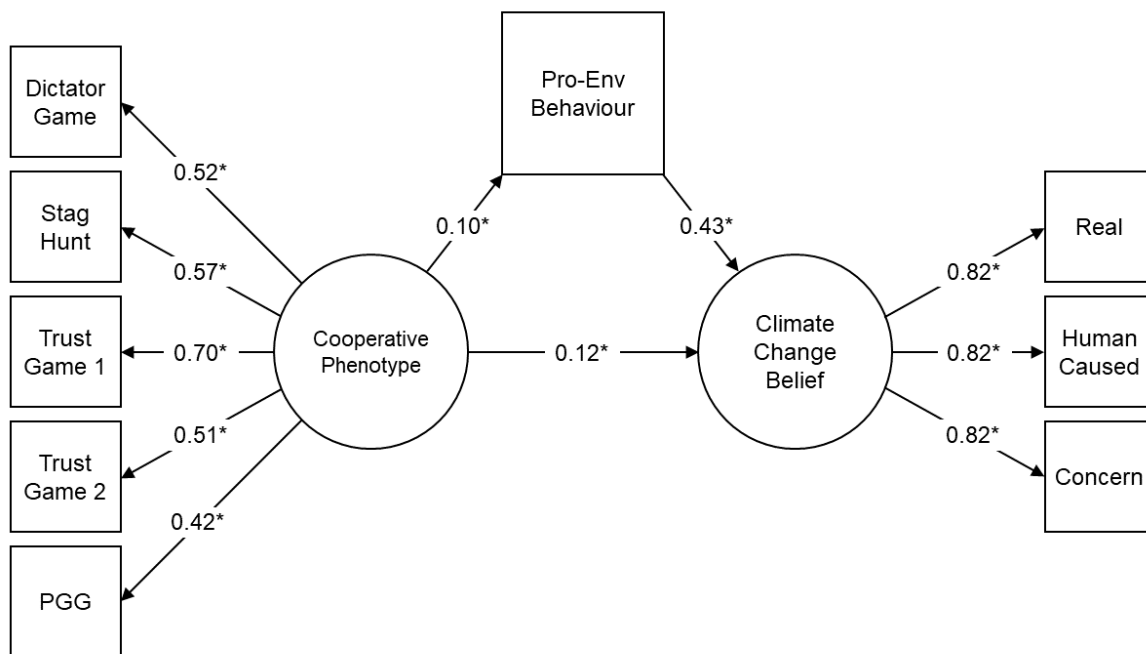164   from the cooperative phenotype to climate change belief and behaviour.

*Figure 3. Structural equation mediation model (*n = 897*).* Regressing the climate change belief factor on the cooperative phenotype factor, partially mediated by pro-environmental behaviour. *Note:* this visualisation does not include paths from the full model predicting game behaviour from game comprehension. Numbers are standardised parameter estimates; *p < 0.05.

165   An alternative motivated reasoning account could be that people directly update

166   their belief in climate change based on their cooperative preferences, which in turn causes

167   pro-environmental behaviour. To explore this, we swapped the climate change belief and

168   behaviour variables in an exploratory reversed mediation model. This reversed mediation

169 model fitted the data slightly better than the initial model (Δ SRMR = -0.014; Figure 4).

170 In contrast to the previous model, there was a full mediation effect. Regressing climate

171 change belief on the cooperative phenotype was significant ($b = 1.06$, 95% CI [0.42 1.70], β

172 $= 0.16$, $p = .001$) as was regressing pro-environmental behaviour on climate change belief

173 ($b = 0.50$, 95% CI [0.44 0.57], $\beta = 0.44$, $p < .001$). Moreover, including climate change

174 belief as a mediator fully attenuated the significance of the direct path between the

175 cooperative phenotype and pro-environmental behaviour ($b = 0.23$, 95% CI [-0.39 0.86], β

176 $= 0.03$, $p = .467$), showing that any effect of the cooperative phenotype on

177 pro-environmental behaviour is fully mediated by climate change belief. These results

178 therefore provide greater support for an alternative motivated reasoning model in which

179 the cooperative phenotype directly predicts belief in climate change, which in turn

180 encourages pro-environmental behaviour[31]. This pattern of results held when controlling

181 for all socio-demographic and personality covariates except political party support, which

182 attenuated the path from the cooperative phenotype to climate change belief.

183   The attenuating effect of political party support throughout all of our main analyses

184 suggests that the cooperative phenotype and political party support share common

185 variance. In a final exploratory analysis, we regressed the cooperative phenotype onto

186 political party support. In particular, we analysed reported support for the major political

187 parties in New Zealand: the progressive Green Party, the centre-left Labour Party, the

188 centre-right National Party, and the socially conservative New Zealand First Party. We

189 found that, relative to Green Party supporters, significantly lower cooperative phenotype

190 scores were found for supporters of both National ($b = -0.09$, 95% CI [-0.13 -0.05], $p <$

191 .001) and Labour ($b = -0.05$, 95% CI [-0.09 -0.01], $p = .007$) parties. This suggests that the

192 broad prosocial tendency tapped by the cooperative phenotype may also explain some of

193 the variance in political party support, which is itself an important predictor of climate

194 change belief and pro-environmental behaviour.

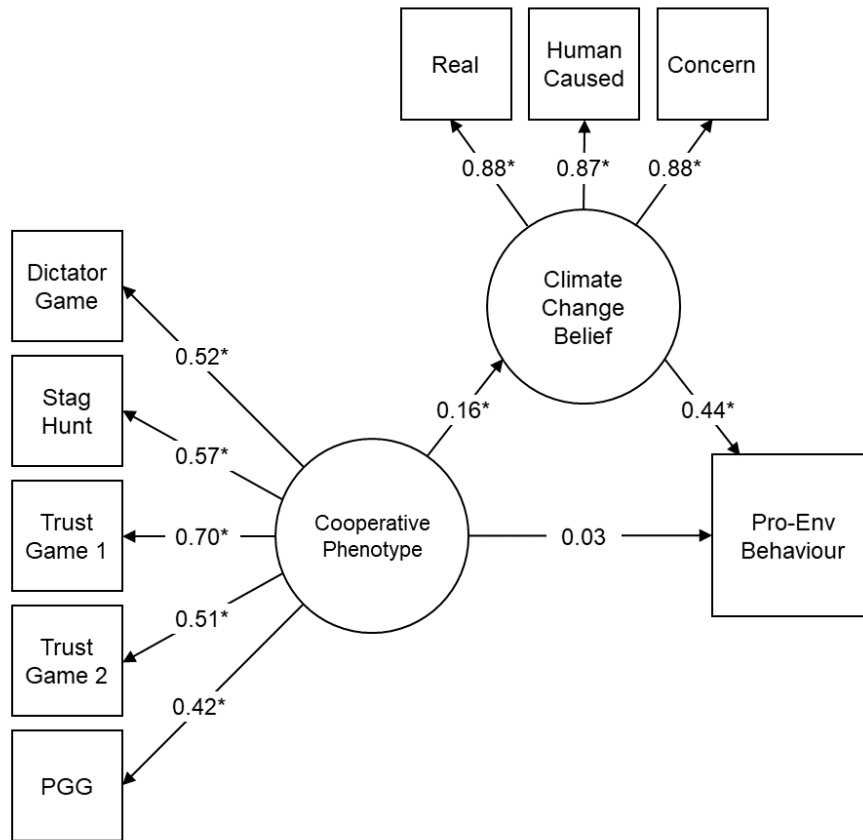195   Overall, these results demonstrate that the cooperative phenotype has positive,

Figure 4. *Reversed structural equation mediation model (*n = *897).* Regressing pro-environmental behaviour on the cooperative phenotype factor, fully mediated by the climate change belief factor. *Note:* this visualisation does not include paths from the full model predicting game behaviour from game comprehension. Numbers are standardised parameter estimates; *$p < 0.05$.

significant relationships with both pro-environmental behaviour and climate change belief. The more an individual cooperates in micro-scale social dilemmas, the more likely they are to both report cooperating in the large-scale dilemma of climate change and to believe in its reality. In contrast to claims that a positive link between economic gameplay and climate change belief was simply the result of the game's explicit framing[20], our results suggest that this previously observed correlation was due in part to more general similarities between the game's payoff structure and that of the large-scale social dilemma of climate change. In addition, these results bolster support for the external validity of anonymous one-shot economic games as measures of real-world cooperation, a link which has been previously questioned[32].

Despite this, the effect sizes linking the cooperative phenotype to climate change belief and pro-environmental behaviour were small. This likely reflects the complexity of these variables and the numerous interacting factors that produce them[33]. A tendency to cooperate in anonymous one-shot social dilemmas is only one aspect of how people form beliefs and act in the real world. Moreover, effect sizes for relationships between behavioural tasks and self-report measures tend to be small[34]. Nevertheless, the explanatory power of the cooperative phenotype on climate change belief and behaviour is comparable to other socio-demographics deemed important in previous work, such as age, gender, and ethnicity[24,26] (Supplementary Figure S1).

In our models, the variable that explained the largest proportion of variance in both climate change belief and behaviour was political party support (Supplementary Figure S1). This corroborates research highlighting that political affiliation can be a strong predictor of climate change belief[24], even in New Zealand, where climate change is not as politicised as in the US. The relationships between the cooperative phenotype and our dependent variables were also consistently attenuated by the inclusion of political party support (Figure 2). This was because New Zealand political parties differed significantly in the cooperative phenotypes of their supporters: we found supporters of the progressive

environmentally-focussed Green Party had significantly higher cooperative phenotype scores than supporters of both the centre-right National Party and the centre-left Labour Party. More work is needed to understand why individuals with different social preferences are drawn to different ends of the political spectrum[35]. Despite only small differences between political parties, these between-group differences can potentially have a dramatic effect when it comes to the formation of policy. For example, while centre-right National supporters may only slightly favour motorway construction over investment in rail, and vice versa for centre-left Labour, these small between-group differences can become magnified during the process of in-group deliberation[36] leading to group opinions more extreme than those held by any individual members. Similarly, slightly higher cooperative phenotype levels in the Green Party as opposed to National or Labour may provide the between-group differences necessary for group polarisation to produce divergent policy on climate change.

Our findings show that how people in a developed Western democracy feel about climate change and whether or not they engage in pro-environmental behaviour is shaped in part by a general cooperative preference that is expressed in even abstract micro-scale social dilemmas. This same preference also appears to shape or be shaped by political party support, though the causal relationships between these variables remain unclear. Future work should seek to clarify the causal links, perhaps by exploiting longitudinal study designs that identify causation through changes over time. Research should also evaluate the generalisability of these findings across cultures. Regardless, if we are correct that the same psychological mechanisms underlie cooperation in both micro-scale and large-scale social dilemmas, then many of the behavioural nudges shown to promote cooperation in micro-scale social dilemmas[37], such as reputation[38,39], social norms[40], sanctioning[41,42], and stable localised interactions[43], also have the potential to encourage people to believe in and act on climate change. Dedicated policy-based research programs[44] will be required to determine whether these factors could also be applied to promote cooperation in the large-scale social dilemma of climate change.

Methods

Power analysis

In order to determine a minimum size for our sample, we conducted a power analysis using existing data from a previous study[13], setting our effect size from the smallest significant correlation between economic game play and real-world cooperation ($r = 0.15$). To detect this correlation effect size with statistical power of 0.95, the power analysis software G*Power[45] suggested a sample size of 571 participants. We aimed to sample 1000 participants, considerably more than suggested.

Participants and sampling

Participants were sampled from the ongoing New Zealand Attitudes and Values Study, a nationally-representative longitudinal study drawn from the New Zealand electoral roll. We included participants in our sample frame who: had completed Wave 9 and/or Wave 10 ($n = 8095$); had not subsequently withdrawn from the New Zealand Attitudes and Values Study at the time of sampling ($n = 7833$); had indicated that they were willing to take part in further online studies ($n = 4181$); had a valid email ($n = 4040$); lived in New Zealand ($n = 3955$); were younger than 70 at the time of sampling ($n = 3374$); and had a valid phone contact ($n = 3345$). Out of this total of 3345 participants, we attempted to contact 3063 about a further study on "economic decision-making in groups". Initial contact was successful for 2731 participants.

Following contact, participants who agreed to take part were sent follow-up emails to arrange a time to take part in a battery of online economic games. 1686 participants either dropped out of the study at this stage (were uninterested, unavailable, or ceased replying) or were excluded for failing to complete the games. In order to focus on the largest population at a single time slice, we only retained participants from Wave 9 ($n = 1045$). Finally, participants were excluded for taking too little (less than 5 minutes) or too much

(more than 50 minutes) time to complete the games, or for failing to answer the relevant items on climate change belief and pro-environmental behaviour. This left us with a final sample of 897 participants (612 females; age M = 51 years, SD = 12 years).

Materials

New Zealand Attitudes and Values Study measures. Main dependent variables and covariates were taken from Wave 9 of the New Zealand Attitudes and Values Study. Climate change belief was assessed with three items[5]: "Climate change is real"; "Climate change is caused by humans"; and "I am deeply concerned about climate change". Items were rated on a 7-point Likert scale, from 1 (strongly disagree) to 7 (strongly agree). Pro-environmental behaviour was assessed using a single item[46], rated on the same 7-point Likert scale: "Have you made sacrifices to your standard of living (e.g., accepted higher prices, driven less, conserved energy) in order to protect the environment?"

In addition, we used data on a number of key socio-demographic variables (age, gender, ethnicity, education level, and political party support). Political party support was assessed on 7-point Likert scales for each major New Zealand party[47]. These were then converted into a single categorical variable, reflecting the party with the highest support. Education was assessed on a 10-point ordinal rank scale in accordance with the New Zealand Qualifications Framework[48]. We also used mean scores for self-report items measuring seven key personality dimensions: extraversion, agreeableness, conscientiousness, neuroticism, openness to experience, honesty-humility, and narcissism. Self-report personality items were taken from the Mini-IPIP6[49] and rated on 7-point Likert scale. See Supplementary Materials for full self-report items from the New Zealand Attitudes and Values Study.

Economic games. Eight economic games were conducted using oTree software[50]. These were selected to replicate existing research and are largely identical to those used in a previous study[13]. The games all involve one-shot decisions between multiple players for

301 points corresponding to real world stakes (1 point = NZD $0.035), with the strategy

302 method used to induce responses across all possible roles. Game code and a copy of the

303 text for the games can be found online at https://osf.io/d8t46/. While the full study also

304 contained games that measure norm-enforcing punishment, in this study we focus on the

305 four games that measure cooperation and coordination.

306   Three games measure cooperation, in which participants must choose between

307 individual pay-off and taking on a personal cost in order to benefit others.

308 • *Dictator Game.* Player A receives 100 points and must decide how many (if any) to

309   transfer to Player B, who is passive. Any points not transferred are kept by Player A.

310 • *Trust Game.* Players A and B both receive 50 points. Player A starts and, with the

311   understanding that the transferred amount will be tripled, is given the choice to

312   transfer all 50 points to Player B. If Player A transfers their 50 points, Player B

313   receives 150 points, taking their total to 200. Player B then has the option to transfer

314   0-150 points back to Player A.

315 • *Public Goods Game.* Four players receive 100 points each, and are given the option to

316   contribute 0-100 points into a common pool. Players decide at the same time, then

317   the amount in the common pool is doubled and shared evenly amongst all four

318   players. Each player finishes with the amount they retained after the decision to

319   contribute, as well as their share from the common pool.

320   The final relevant game focuses on coordination, and replaces the destructive All-Pay

321 Auction Game used in previous work[13] in order to see if the cooperative phenotype extends

322 to coordination behaviour.

323 • *Stag Hunt Game.* Four players each receive 50 points. Players choose between

324   contributing 30 points into a shared group project or contributing nothing. Decisions

325   are made simultaneously. All points in the group project are doubled and distributed

326   evenly amongst the players, but only if all players contributed. Failing this, all points

327   in the group project are lost. Each player finishes with their share from the group

328   project, plus the points they retained following their contribution.

Procedure

330   Data collection for economic game responses took place weekly between the 18th of

331 February 2019 and the 25th of July 2019, utilising a staggered recruitment model.

332 Following expressions of interest in an initial phone call, participants were emailed further

333 information and asked to complete a Qualtrics survey. This allowed participants to specify

334 their availability for testing in a specific session the following week, while excluding

335 respondents who lacked adequate Internet access, a quiet place to participate in the study,

336 or a New Zealand bank account (for payment purposes).

337   Game sessions took place on midweek evenings from 6 to 8 pm, and varied in size

338 between 14 and 97 participants. At the specified time of testing, participants received an

339 email containing a link to oTree. Once on the website, participants entered their unique

340 code before filling out a consent form informing them of ethical approval, their

341 confidentiality and right to withdraw, and how they would be reimbursed. Following

342 agreement, participants then read information about the economic games, including the

343 real-world stakes and real-time matching with other participants.

344   The eight games were then presented in a random order, with participants reading

345 specific instructions and answering comprehension questions for each game in turn before

346 providing responses for all possible roles in the game. Once the games had been completed,

347 participants entered a waiting lobby until all other participants were finished. The software

348 then calculated payoffs for each game by randomly matching participants in each session.

349 Players were shown a summary screen with payoffs for each game as well as their total

350 accumulated payoff.

351   In situations where sessions did not contain multiples of four (due to drop-out or

352   availability), simulated players were used to make up the shortfall with their responses

353   based on median responses from previous work[13]. Participants were informed of this

354   possibility at the end of gameplay: "In the rare event that we could not find a participant

355   to match you with, we have instead matched you with average decisions based on previous

356   research."

357   Each participant's final payoff consisted of the accumulated payoffs from all eight

358   games (between NZD $10 and $35; M = $25.20, SD = $2.45), plus a fixed $20 show-up fee.

359   Name and bank account details were collected at the end of the study, encrypted and

360   stored online before being decrypted on a local computer for payment.

361   Participants took an average of 22 minutes to complete the eight games (SD = 7

362   mins, range = 6-47 minutes). There was a 55 minute threshold for game completion. Due

363   to the demands of real-time matching between participants, those who took longer than 55

364   minutes were progressed to the waiting lobby, and treated as if they were simulated players.

365   Participants who timed out still received the $20 show-up fee, but no bonus payment.

366   **Statistical analyses**

367   Our pre-registered analyses consisted of confirmatory factor analyses and structural

368   equation modelling (https://osf.io/d8t46/). We fitted confirmatory factor analyses (CFAs)

369   to both the economic game data and our measures for climate change belief. We estimated

370   the "cooperative phenotype" as a latent variable with factor loadings from the Dictator

371   Game, Trust Game (Give), Trust Game (Return), Public Goods Game, and Stag Hunt

372   Game. We estimated "climate change belief" as a latent variable with factor loadings from

373   three items: "Climate change is real"; "Climate change is caused by humans"; and "I am

374   deeply concerned about climate change".

375   We then fitted a series of structural equation models testing our main hypotheses.

376 First, we regressed the "cooperative phenotype" on pro-environmental behaviour. Second,

377 we regressed the "cooperative phenotype" on "climate change belief". Third, we ran a

378 mediation analysis testing whether pro-environmental behaviour mediated the relationship

379 between "cooperative phenotype" and "climate change belief", and subsequently reversed

380 this mediation in an exploratory analysis. For all hypotheses, we controlled for the

381 following variables: age, gender, ethnicity, political party support, education, extraversion,

382 agreeableness, conscientiousness, neuroticism, openness to experience, narcissism, and

383 honesty/humility.

384 All analyses were conducted in R Version 4.0.2[51]. The *lavaan* package[52] was used for

385 fitting confirmatory factor analyses and structural equation models, the *ggplot2* package[53]

386 was used for visualisation, and the *drake*[54] and *papaja*[55] packages were used to reproducibly

387 generate the manuscript.

Competing Interests

We declare that none of the authors have competing financial or non-financial interests.

Data Availability

A copy of the anonymous data reported in each New Zealand Attitudes and Values Study publication is available from Professor Chris Sibley (c.sibley@auckland.ac.nz) upon request from appropriately qualified researchers. Such data will be provided with the explicit understanding that it is used solely for the purposes of replicating or otherwise checking the validity of analyses reported in scientific papers analysing New Zealand Attitudes and Values Study data.

Code Availability

Python code for the incentivised behavioural tasks and R code for the statistical analyses, figures, and manuscript generation are publicly available at https://osf.io/d8t46/.

Ethics Statement

Ethical approval for this study was granted by the University of Auckland Human Participants Ethics Committee (ref: 021666).

Acknowledgements

Author Contributions

All authors conceived of and designed the study. DK and SC collected behavioural data and conducted all statistical analyses. CGS managed survey data collection. DK, SC, and QDA wrote the paper with input from CGS and AC.

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Supplementary Materials

Supplementary Results

Confirmatory factor analyses (CFAs).   Before testing our hypotheses, we fitted two CFA models. In order to assess the "cooperative phenotype"[1], we fitted a confirmatory factor analysis model that loaded participant responses across our five game outcomes (Cronbach's $\alpha = 0.54$): the Dictator Game, Trust Game (Give), Trust Game (Return), the Public Goods Game, and the Stag-Hunt Game. Instead of removing participants who failed the games' respective comprehension questions by listwise deletion, we took advantage of the structural equation modelling approach and controlled for comprehension by including each different game's comprehension question in the model. We then investigated model fit using two popular absolute measures of fit. The Root Mean Square Error of Approximation (RMSEA) was 0.05, indicating a good model fit[2], and the Standardized Root Mean Square Residual (SRMR) was 0.05, also indicating a good model fit[3]. This step was important to validate our further analyses.

We then fitted a CFA model that loaded participant responses to our three different measures of climate change belief (Cronbach's $\alpha = 0.85$): whether climate change is real, whether it is caused by humans, and the degree to which it is a concern. The model was just-identified, and therefore was perfectly fit to the data (RMSEA = 0.00; SRMR = 0.00).

Proportion of variance explained.   Analyses of the variation explained by our models (R^2) reveal that cooperative phenotype alone accounts for 1.02% of the variation in pro-environmental behaviour and 3.62% of the variation in climate change belief. Similar patterns hold for both of these models: while the variation explained by cooperative phenotype is small, it is comparable to that explained by other variables in our sample that have been shown to be significant predictors of climate change belief, such as age, gender, and ethnicity[4] (Supplementary Figure S1). For example, in our sample, age accounts for

0.06% of the variation in climate change beliefs, while gender accounts for 0.15% and
ethnicity accounts for 0.99% of the variation in comparison to 3.62% for cooperative
phenotype. However, not only does political party support attenuate the effect of
cooperative phenotype on both climate change belief and pro-environmental behaviour, it
also accounts for a far larger proportion of the variance in these variables: 2.93% for
climate change belief, and 7.70% for pro-environmental behaviour.
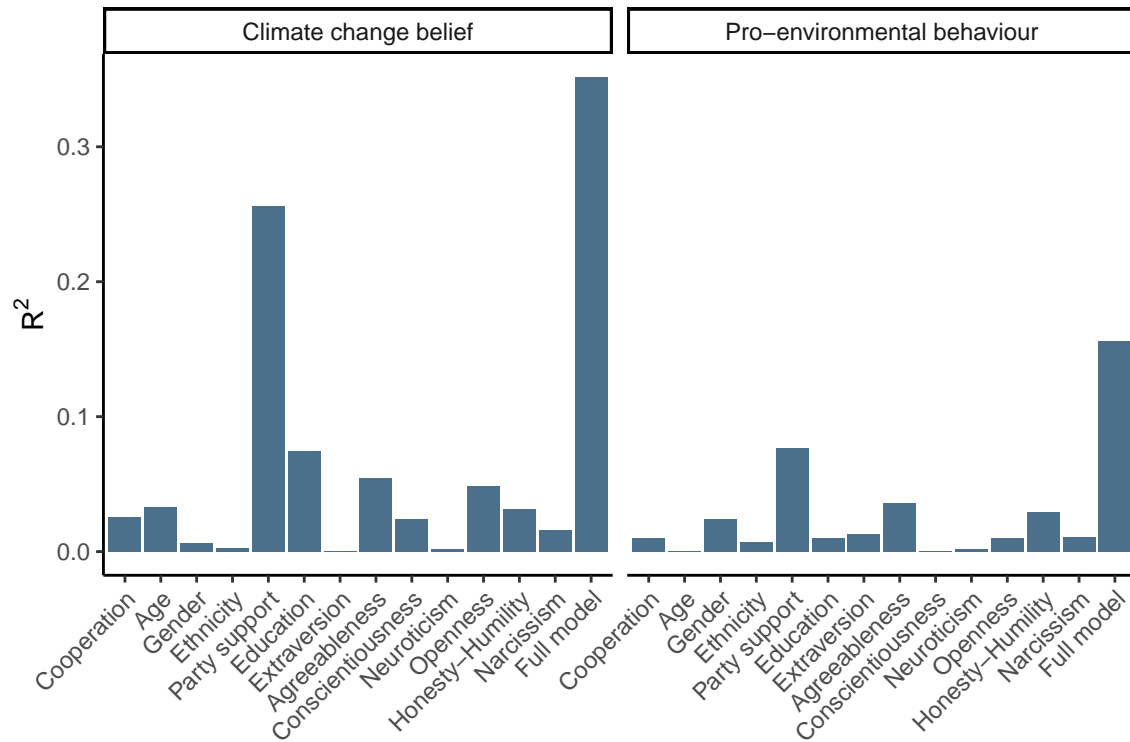
Supplementary Figures

Figure S1. *Histograms comparing the proportion of variance in our dependent variables explained (R^2) by the cooperative phenotype, various socio-demographic and personality controls individually, and their combination in the full model.*

576 **Supplementary Tables**

Table S1

Self-report items from the New Zealand Attitudes and Values Study.

Item	Description / Text
Climate change belief	Climate change is real
	Climate change is caused by humans
	I am deeply concerned about climate change
Pro-environmental behaviour	Have you made sacrifices to your standard of living (e.g., accepted higher prices, driven less, conserved energy) in order to protect the environment?
Age	What is your date of birth?
Gender	What is your gender? (open-ended)
Ethnicity	Which ethnic group do you belong to? (NZ census question)
Education level	NZ Reg (0-10 education ordinal rank)
Political party support	Please rate how strongly you oppose or support each of the following political parties... the National Party
	Please rate how strongly you oppose or support each of the following political parties... the Labour Party
	Please rate how strongly you oppose or support each of the following political parties... the Green Party
	Please rate how strongly you oppose or support each of the following political parties... the NZ First Party
Extraversion	Am the life of the party
	Don't talk a lot (reversed)
	Keep in the background (reversed)

	Talk to a lot of different people at parties
Agreeableness	Sympathize with others' feelings
	Am not interested in other people's problems (reversed)
	Feel others' emotions
	Am not really interested in others (reversed)
Conscientiousness	Get chores done right away
	Like order
	Make a mess of things (reversed)
	Often forget to put things back in their proper place (reversed)
Neuroticism	Have frequent mood swings
	Am relaxed most of the time (reversed)
	Get upset easily
	Seldom feel blue (reversed)
Openess to experience	Have a vivid imagination
	Have difficulty understanding abstract ideas (reversed)
	Do not have a good imagination (reversed)
	Am not interested in abstract ideas (reversed)
Narcissism	Feel entitled to more of everything
	Deserve more things in life
Honesty/Humility	Would like to be seen driving around in a very expensive car (reversed)
	Would get a lot of pleasure from owning expensive luxury goods (reversed)

Supplementary References

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