The Role of Competition, Earned Money and Personal Characteristics in Climate Games

Judit Mokos[1,2•], Zsóka Vásárhelyi[1,3•], Zoltán Kovács[4], Adrienn Král[1], Hubert János Kiss[5,6○], István Scheuring[1○*]

• Shared first authors
○ Shared last authors

.

[1*]Institute of Evolution, HUN-REN Centre for Ecological Research, Hungary, Konkoly Thege Miklós út 29-33 , Budapest, 1121,Hungary.
[2]Department of Ethology, ELTE, Eötvös University, Pázmány Péter sétány 1/c, Budapest, 1117, Hungary.
[3]Institute of Ecology and Botany, HUN-REN Centre for Ecological Research, Alkotmány út 2-4., Vácrátót, 2163, Hungary.
[4]Department of Plant Taxonomy, Ecology and Theoretical Biology, ELTE, Eötvös University, Pázmány Péter sétány 1/c, Budapest, 1117, Hungary.
[5]Institute of Economics, HUN-REN Centre for Economic and Regional Studies, Tóth Kálmán u. 4., Budapest, 1097, Hungary.
[6]Department of Economics, Corvinus University of Budapest, Fővám tér 8, Budapest, 1093, Hungary.

*Corresponding author(s). E-mail(s): scheuring.istvan@ecolres.hu;
Contributing authors: mokjud@gmail.com; zsokavasarhelyi@gmail.com; z.kovacs1009@gmail.com ; adrienn.kral@gmail.com ; kiss.hubert.janos@krtk.hun-ren.hu;

Abstract

Using different variants of the classic climate game, we investigate the role of competition and the source of endowment (windfall vs. earned). Participants completed a detailed personality test (including climate attitudes and economic preferences) before the experiment and were asked about their strategies afterwards. We find that competition did not significantly affect whether groups

reached the target, even though the probability of achieving the common goal was lower in the presence of competition. Participants cooperated more when they had to earn the endowment. Based on the pre-experiment questionnaire, participants who viewed their personal actions as more important and effective in combating climate change were more likely to cooperate in the climate game, while the rest of the measured personality items did not exhibit a consistent pattern. Analysis of the post-experiment survey indicates that those who aimed to maximise earnings contributed less to the common pool. In contrast, those who believed the goal was achievable and aimed to achieve it contributed more to the common pool throughout the game.

Keywords: cooperators, free-riders, climate change attitude, threshold public goods

Acknowledgements

We are grateful to Ágnes Pintér, Tünde Lénárd, Flóra Samu, and Melinda Tir for the z-tree help, and Melinda Tir, Eszter Orosz, and Heléna Hönich for providing, and helping with the experimental infrastructure.

Statements and Declarations

Funding

"This work was supported by HUN-REN (Grant numbers [ELKH SA-50/2021]. Hubert J. Kiss acknowledges support by the Hungarian Academy of Sciences, Momentum Grant No. LP2021-2.).

Competing Interests

The authors have no relevant financial or non-financial interests to disclose.

Author Contributions

JM, HJK, ZK, IS, and ZsV contributed to the study conception and design and wrote the manuscript. AK performed all communication with the participants. JM, HJK, IS, and ZsV conducted the experiments. JM and HJK performed all statistical tests. ZsV programmed the experiment. JM, HJK, IS, and ZsV wrote the article, and all authors read and approved the final manuscript.

Data Availability

Data is attached as electronic supplementary material.

1 Introduction

Climate change is one of the greatest challenges that humankind has ever faced. The dramatic changes that are already alarming and are likely to occur in the future call for immediate action. However, solving this problem requires a collective effort from all countries, especially the industrialised nations that are largely responsible for it (IPCC Core Writing Team and Lee, H. and Romero, J., 2023a,b). The international community has agreed to keep global warming below 2°C, necessitating significant emission reductions (IPCC Core Writing Team and Lee, H. and Romero, J., 2023a,b). Achieving this collective goal is challenging because the benefits of short-term efforts are only realised over the long term. Moreover, these efforts are made by individual actors competing in a global market, while the long-term benefits, shared among contributors and free riders alike, are realised as a public good (Raihani and Aitken, 2011; Nordhaus, 2019).

The situation is a textbook example of a social dilemma, since the benefits—namely, preventing a climate catastrophe—are non-excludable, while contributing countries must invest individually and voluntarily (Milinski et al, 2008). Consequently, the temptation not to invest enough to reduce greenhouse gas emissions makes climate change negotiations a prime example of a common-pool resource dilemma.

Threshold public goods games are often used to study collective risk social dilemmas related to climate change. In these games, participants form a group of k persons and play an n-round game. Before the first round, each participant receives a private endowment, from which they can contribute to the common fund in each round. Throughout the game, players are perfectly informed about the past and present contributions of their fellow group members, including their own. If the amount of money in the common fund reaches a certain threshold by the end of the game, the players retain all the remaining money they did not contribute. However, if the target is not reached, each player either loses all their money with a specified probability or forfeits a predetermined percentage of their money for certain, regardless of their previous contributions to the public fund.

Using this game as a framework, Milinski et al (2008) investigated the effect of varying the risk of losing money if the target contribution is not met. They have shown that the higher the risk of losing money, the higher the level of cooperation within the group. Additionally, other factors such as wealth heterogeneity, the presence of an intermediate target (Milinski et al, 2011), information transfer between players, and even verbal commitments have been explored in various studies (Tavoni et al, 2011; Dannenberg et al, 2015). According to these studies, wealth heterogeneity lowers the probability of reaching the target, whereas an intermediate target increases it. Surprisingly, subsequent papers found that wealth heterogeneity alone does not diminish success chances (Brown and Kroll, 2017; Vicens et al, 2018; Brown and Kroll, 2021). However, these experiments also revealed that poorer participants disproportionately invest more towards success than wealthier ones. We note that in the experiment by Vicens et al (2018), all groups succeeded, whether wealth was equal or unequal, likely because successful groups funded a specific reforestation program. This well-defined local goal might have spurred more cooperative behaviour. Barrett and Dannenberg (2012) have shown in another experiment that threshold uncertainty, i.e. not knowing

the exact contribution needed to succeed reduces success chances, while uncertainty about the consequences of failure actually increases them. Conversely, when poorer players stand to lose more—a more realistic scenario—wealth inequality significantly lowers success rates (Burton-Chellew et al, 2013; Brown and Kroll, 2021). Similarly, not knowing others' contribution levels significantly reduces the chances of success (Kumar and Dutt, 2019). Theoretical studies have shown that threshold uncertainty undermines cooperation in non-iterated threshold public goods games (McBridge, 2006, 2010; Pacheco et al, 2014), although it can increase the contribution if the benefit of the public good is sufficiently high (McBridge, 2006, 2010). Consistent with theoretical considerations (Archetti, 2009; Pacheco et al, 2014), experiments by Milinski et al (2016) also showed that increasing group size reduces the probability of achieving success. In sum, setting intermediate goals, communication, uncertainty about the severity of consequences, and breaking cooperating parties into smaller groups all contribute to the success of efforts.

Although the key articles mentioned above have examined many fundamental aspects of how people behave in the climate game, real-life situations naturally differ from experimental scenarios in several additional ways that are worth exploring.

In the above experiments, subjects receive an endowment as a windfall (not earned) gain and then make decisions using it. It is known, however, that subjects behave differently when they have to earn the endowment that they use in the experiment. In particular, an earned endowment is more likely to be seen as part of the subject's wealth rather than as a windfall gain. Thus, in experiments involving issues such as altruism, fairness, or social dilemmas, it is possible that how the endowment is obtained will affect the subject's behaviour (Cherry et al, 2002; Kroll et al, 2007; Spraggon and Oxoby, 2009). Furthermore, studies so far have only examined how the financial status of the players affects the outcome of the game, whereas in reality, the players (i.e., the countries) are in an additional economic competition with each other. Thus, those who invest more in climate change mitigation may be at a competitive disadvantage. Finally, although some of the previous articles have sought to explore the preferences and personality characteristics behind players' decisions (e.g., Vicens et al (2018); Kumar and Dutt (2019)), many aspects have remained unexplored.

Consequently, we designed an experimental study within the threshold public goods dilemma framework, focusing on: 1) how pronounced competition among group members modifies the willingness to contribute to the cooperative effort, and 2) whether earning the endowment modifies the subjects' contribution strategy. Additionally, we investigate how the subjects' personality characteristics and preferences determine their behaviour during the game.

2 Methods

The experiment was approved by the National Psychological Research Ethics Committee. Our project was preregistered on OSF.[1]

[1] The reference number is left out because of the anonymity request of the journal, but we can share it with the editor if needed, and naturally, we will include it in the published paper.

2.1 Experimental design

We designed an experimental framework building on the classical climate game described above Milinski et al (2008). Subjects randomly form 6-person groups and play 10 rounds of a threshold public goods game. We introduce two modifications to the basic game: *Competition among group members* and *Earned initial endowment* (see Table 1). Overall, our modifications yield 4 experimental setups (see Table 1). In the basic game, the initial endowment is 3000 MU (Monetary Units[2]), equivalent to about 8 EUR in local currency at the time of the experiment. Subjects can invest 0, 150, or 300 MU per round, and the threshold is 9000 MU. If a group reaches the threshold within 10 rounds, members receive their remaining budget. However, if the threshold is not met, they only receive 50% of their remaining budget. The experiment was implemented using the economic experiment toolbox, z-Tree (Fischbacher, 2007).

	No competition (N)	**Competition (C)**
Windfall money (W)	WN (basic game)	WC
Earned money (E)	EN	EC

Table 1 Summary of the experimental setup

2.1.1 Competition vs. No competition

Compared to the baseline, the first treatment (Competition) introduces more pronounced competition among players: if the threshold is not reached, participants receive different percentages of their funds. This treatment models the scenario where those having higher amounts of money suffer less in times of hardship due to more money left over for mitigation (Milinski et al, 2011; Burton-Chellew et al, 2013). Specifically, in groups of six, the two players with the highest amount of spare money receive 90% of their remaining funds, the 3^{rd} and 4^{th} receive 50%, and the two with the lowest sum in their pocket can take home only 10%. In case of a tie, both players receive the higher percentage of money. Note that the more cooperative a player is, the more they lose if the threshold is not reached. If the threshold is reached, everyone receives 100% of their remaining endowment.

2.1.2 Earned money vs. Windfall money

Relative to the baseline, the second variant requires participants to earn the money they play with. This is done using the standard real-effort task of counting zeros in a matrix (Abeler et al, 2011). Players in the Earned Money treatment must achieve a minimum of 10 correct counts within a 3-minute time interval to be able to earn money

[2]MU is used instead of the name of the local currency because of the journal's anonymity policy.

at the end of the game. To control for the effect of an additional task, players in the Windfall treatment also complete the matrix task, but no meaning is attached to it.

2.1.3 Pure Nash equilibria, and human behaviour

Although players generally do not follow easily recognisable strategies in the lab, we provide some predictions for their behaviour.

In the no-competition setups (WN and EN), the game exhibits numerous Nash equilibria (Nash, 1950). Any strategy profile qualifies as a Nash equilibrium if the sum of player contributions exactly meets the required threshold and each player earns more by achieving the target than by failing to do so. An evident symmetric pure cooperative strategy, which we call the fair sharer strategy, is for each player to contribute 150 MU in every round. In addition to this cooperative Nash equilibrium, the completely selfish strategy (everyone contributes 0 MU each round) also yields a Nash equilibrium, since anyone who deviates from this strategy will get less money if the others continue with the completely selfish strategy. Since in the experiment, players lose 50% of the remaining amount if they do not reach the target, the pure fair sharer and the selfish (each participant contributing 0 MU in each round) homogeneous strategies give players an equal gain of 1500 MU.

However, in the competition setups (WC and EC), contributing zero in each round is not only a Nash equilibrium but also a dominant strategy, because players will receive 90% of their endowment, which is 2700 MU (given that in the event of a tie, the players involved receive the higher amount, which we did not advertise explicitly though). Therefore, these competition setups are adversarial to achieving the target.

In spite of the existence of these selfish Nash equilibria, which are relatively easy to detect, players hardly ever choose them in experimental situations (see e.g. (Milinski et al, 2008; Barrett and Dannenberg, 2012; Milinski et al, 2016)). We note in advance that in our experiment, despite zero contribution being a dominant strategy, only 6 players (4.17%) adopted this strategy in the competition setup, and similarly, only 6 players chose this strategy in the payoff neutral non-competitive setups. That is, even though pure defection is a dominant strategy in the competitive case, no more participants have chosen it than in the setups where pure defection makes the same profit as the fair sharer strategy.

2.1.4 Hypotheses

We hypothesised that

- competition among group members reduces the likelihood of achieving the target,
- using earned money reduces contributions to the collective fund.

We also formulated some conjectures about how items in the pre-experimental questionnaire regarding individual characteristics are associated with individual contributions. We hypothesised that, ceteris paribus, individuals who:

- care more about the climate,
- value the future more highly (i.e., discount it less),
- believe they shape their own circumstances (have an internal locus of control),
- are less tolerant of risks,
- exhibit greater altruism,

- are more cooperative,
- are more trusting,
- possess more positive civic attitudes,

would contribute more.

2.2 Participants, anonymity and remuneration

Participants were adults recruited primarily from universities and through social media. The person who communicated with them and created the numerical IDs for the participants never met them in person. Meanwhile, those of us conducting the experiments never knew personal details of the participants, only their numerical IDs.

For the analysis of the game, we used data from 12 groups per treatment (which somewhat exceeded the numbers used in Milinski et al (2008) or Dannenberg et al (2015)), totalling 288 participants over 18 years of age. Participants who completed the questionnaire and arrived at the agreed time received 2000 MU. Furthermore, within the game, they had a chance to earn up to 3000 MU. We paid the remuneration in food vouchers. (For more details, see the Supplementary Material.)

2.3 Questionnaires

The prerequisite for participating in the climate game (and thus receiving the remuneration) was completing an online questionnaire at least 48 hours before playing the game. We implemented this procedure for two reasons: i) To avoid priming participants by having them complete the questionnaire and play the game in rapid succession. ii) To ensure we had both sets of data for all participants. The questionnaire was created using Google Forms.

This questionnaire primarily comprises elements either already validated in the subjects' mother tongue or translated for this study, by us. In addition to demographic data, the questions target the following constructs: climate change attitude including two sub-scales, climate beliefs and climate intentions (Christensen and Knezek, 2015), delay discounting (based on Falk et al (2018)), locus of control (Pearlin et al, 1981), risk-taking (Gneezy and Potters, 1997; Crosetto and Filippin, 2013), altruism (based on Falk et al (2018)), trust (based on the generalised trust question asked in the World Values Survey; see, e.g. Johnson and Mislin (2012)), competitiveness (based on Orosz et al (2018)) and cooperativeness (based on our own questions, as there is no consensual test in the literature). The Supplementary Material contains details about the questionnaire, including the wording of the items.

Immediately after the climate game, participants completed a short questionnaire about their decision-making process during the game and assessed the number of other players they may have known. For identification in both questionnaires, participants used their assigned numerical IDs. The complete pre- and post-experiment questionnaires are available in the Supplementary Material.

2.4 The experimental session

Each participant was provided with their own desk and laptop for the game. Participants were seated with sufficient distance between them to prevent viewing each

other's screens, and they were additionally separated by cardboard dividers. The session began with a 3-minute test where players counted zeros in a 5x5 matrix (Abeler et al, 2011). Subsequently, participants were randomly assigned to groups of 6 players, with each participant receiving a pseudonym, following the protocol of Dannenberg et al (2015).

At this point, players received detailed instructions about the game and were required to correctly answer three check-up questions before proceeding to the game itself. These questions assessed players' understanding of the rules and their ability to calculate outcomes in various scenarios. (For the exact questions, see the Supplementary Material.)

One round of the climate game consisted of the following two steps:

(i) The contribution phase, where each participant decided whether to donate 0, 150, or 300 MU to the common fund.

(ii) The outcome phase, where each participant viewed a table displaying:
- The contributions of their group members in all previous rounds
- The current amount of money in the common fund
- Their remaining individual budget

Thus, players had complete information not only about their group's standing but also about the previous moves of all group members.

2.5 Statistical analysis

All statistical tests were independently performed by two of the authors, one using R and the other using Stata for data analysis. Data cleaning was carried out using R. To test the differences between the four treatment groups in terms of success or failure in the game, we conducted Fisher's exact test. We utilised the Wilcoxon rank-sum test to determine whether there were significant differences in total group contributions across treatments. To understand how items in the pre-experimental survey and post-experimental questions are associated with individual contributions, we used random-effects OLS panel regressions.

3 Results

As outlined in our experimental design, our primary objective is to investigate how the source of the endowment (windfall versus earned) and the presence of competition influence group success.

3.1 Frequency of reaching the target

As shown in Figure 1a, the success rate of groups varies across different settings. Consistent with intuition and our pre-registered hypothesis, the competitive situation reduces the proportion of successful groups. However, contrary to our hypothesis, having to earn the endowment appears to increase the success rate. It is important to note that while these trends are observable, they did not reach statistical significance in any comparison, likely due to the small sample size. The success rates with the

corresponding p-values for the comparisons are as follows (two-sided and one-sided Fisher's exact tests, respectively):

- WN versus WC: 66.67% versus 33.33%; p=0.22, (0.11);
- EN versus EC: 83.33% versus 66.67%; p=0.64 (0.32);
- WN versus EN: 66.67% versus 83.33%; p=0.64 (0.32);
- WC versus EC: 33.33% versus 66.67%; p=0.22 (0.11).

We can compare success rates between groups in the windfall versus earned money treatments, ignoring whether there is competition. In the windfall treatments, the success rate was 50%, compared to 75% in the earned money treatments. The p-values for these comparisons were 0.135 in the two-sided Fisher's exact test and 0.068 in the one-sided Fisher's exact test, respectively.

If we disregard the source of the endowment and focus solely on the role of competition, we observe different success rates: 75% in treatments without competition versus 50% in those with competition. According to Fisher's one-sided exact test, the difference in success rates is marginally significant (p-value = 0.068), whereas the two-sided test indicates no significant difference (p-value = 0.135).

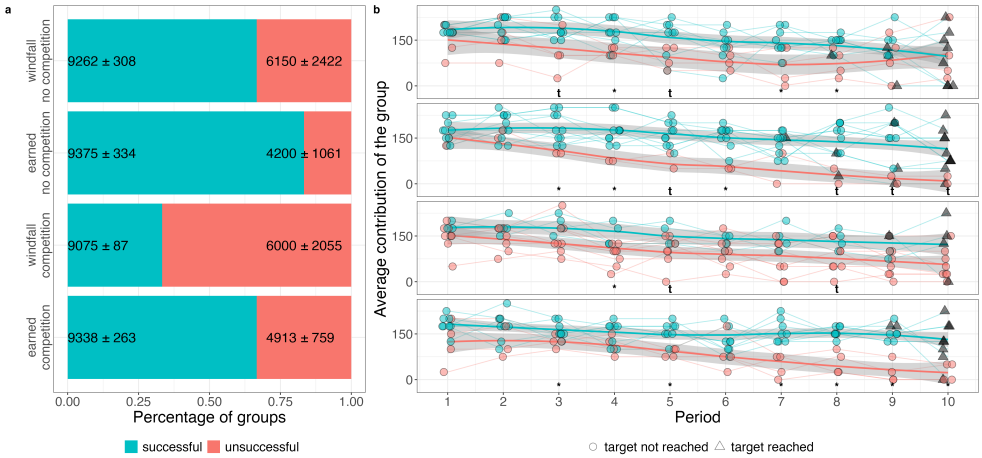

Fig. 1 Frequency of success and contribution dynamics across different settings. a) The percentage of successful (reaching the target) and unsuccessful (not reaching the target) groups for each treatment. Percentages are calculated based on 12 groups per setting. The average sum of contribution at the end of the game and its standard deviation are depicted in both the successful and unsuccessful groups. b) The dynamics of average contributions/groups over each round of the game for all treatments. Thin lines connect the average group contributions from round to round. Dots indicate rounds where the contribution level has not yet reached the target, while triangles denote rounds where it has been reached. Solid bold lines with grey backgrounds represent the average contributions and their standard deviations for successful (green) and unsuccessful (red) groups separately. Rounds where contributions differ significantly between successful and unsuccessful groups are marked with $*$ near the horizontal axis. Rounds showing a trend-level difference ($0.05 < p < 0.1$) are denoted by t.

3.2 Group contribution

Next, we analyse the total group contribution throughout the game. In treatments with windfall money, groups contribute more in the absence of competition (8225 MU vs. 7025 MU, p = 0.0632, Wilcoxon rank-sum test). For earned endowments, groups without competition seem to contribute more than groups with competition, though the difference is less pronounced and non-significant (8512.5 MU vs. 7862.5 MU, p = 0.5004, Wilcoxon rank-sum test). When comparing treatments without competition, the variation in group contributions between windfall and earned money is minor (8225 MU vs. 8512.5 MU, p = 0.2545, Wilcoxon rank-sum test). However, in treatments with competition, groups with earned money contribute more (7862.5 MU vs. 7025 MU, p = 0.0835, Wilcoxon rank-sum test). When comparing group contributions in windfall versus earned money conditions (while ignoring the 'no competition' versus 'competition' dimension), groups contribute more in the earned money scenario (8187.5 MU vs. 7625 MU, p = 0.0315, Wilcoxon rank-sum test). When comparing the 'no competition' and 'competition' scenarios (and disregarding whether the endowment is windfall or earned), there is no significant difference in group contributions (8368.75 MU vs. 7443.75 MU, p = 0.1015, Wilcoxon rank-sum test).

As illustrated in Figure 1b, the contribution dynamics of successful and unsuccessful groups show both similarities and differences. Across all settings and regardless of success or failure, average group contributions decrease over time. However, individual group contribution dynamics can vary more substantially. A general phenomenon, previously demonstrated in other studies (Gürdal et al, 2024; Herrmann et al, 2008), is that groups that are ultimately successful tend to make larger initial contributions compared to those that are ultimately unsuccessful. While this trend is evident in our experiment, the difference was not statistically significant. The contribution disparity between successful and unsuccessful groups becomes significant around the fourth round of the game, and then again around the seventh to eighth round (see Fig. 1b). Notably, failing groups contribute considerably less when the money has been earned beforehand, primarily due to more intensive reduction in contributions during the final 3-4 rounds. This phenomenon is most pronounced in the money earned-cum-competition treatment (see Fig. 1b).

We should also note that while in the conditions with competition successful groups only start reaching the threshold in the 9^{th} round, in conditions without competition, groups reaching the threshold appear as soon as the 7^{th} round (see Fig. 1b).[3] Also, in the windfall money treatments (WN and WC) we can see high average contributions in the last rounds in groups which, despite these efforts, did not meet the target by the 10^{th} round, which are mostly missing in the earned money treatments. At the same time, in groups that eventually succeeded in meeting the target, high average contributions in the last rounds are present in all conditions.

[3] We use the test of proportions to compare the share of groups that reach the target, separating groups into competition and non-competition setups. No statistical difference is observed in rounds 7, 9, or 10 (p-value > 0.26 in each case). However, a marginal difference appears in round 8 (p-value = 0.0736). When combining rounds 7, 8, and 9, the difference remains insignificant (p-value = 0.2673).

3.3 Individual contributions

Figure 2 presents the standardised coefficients from a random-effects panel regression, with individual contribution as the dependent variable. This figure specifically highlights the impact of items from the pre-experimental questionnaire and the post-experimental questions by displaying only their corresponding coefficients. However, each panel regression also incorporates various control variables: experimental factors (experimenter, date, and location dummies), sociodemographics (gender, age, type of settlement, educational status, and field of study dummies in case of university students), and game-related variables (treatment dummies, round, lagged group contribution, percentages of over- and under-contributions in previous rounds, and the lagged standard deviation of contributions).[4]

Since participants completed the pre-experimental questionnaire at least 48 hours before the experimental session, we can confidently state that the questionnaire did not influence their behaviour during the experiment. The measured personality characteristics can be regarded as inherent to the participants, and the experimental behaviours resulted from the interaction of their personalities and their reactions to the experimental situation. Conversely, the measurements from the post-experimental questionnaire were most likely influenced by the prior experimental setting, including the general situation, the specific condition, the group's success or failure, and the behaviour of group members.

We analyse three sets of dependent variables. The first set includes all rounds. The second set covers only the first three rounds. The final set encompasses just the first round, which does not constitute a traditional panel regression.

For the pre-experimental questionnaire, we standardised responses across all participants to enable a direct comparison of their associations with individual contributions. An exception was made for our measure of delay discounting: 57% of participants were willing to wait an additional month for minimal compensation and were categorised as *patient*, while the remaining participants, who required higher compensation, were categorised as less patient.

The coefficients for trust, altruism, cooperation, locus of control, and competition are not significantly different from zero for any of the dependent variables. Thus, even though the direction of these coefficients may be consistent and intuitive (as in the cases of trust and altruism) and align with our pre-registered expectations, we conclude that these factors did not predict decision-making in our laboratory setting. The only variable with a consistent and significant coefficient across all dependent variables relates to climate intentions. Individuals scoring one standard deviation higher on climate intentions (believing that they can contribute to averting climate change) tend to contribute approximately 15 MU more per round, *ceteris paribus* (as shown in Fig. 2 left panel). Furthermore, some variables show a significant association with contributions in the lab, but only for specific dependent variables. In particular, climate beliefs consistently exhibit a negative coefficient, implying that a belief in climate change negatively correlates with individual contributions in the lab—contrary to our pre-registered expectations. However, this only becomes significant when considering

[4]Over-/under-contribution is defined as whether a participant contributed more or less than the average in a given round.

the entire game. Likewise, risk tolerance consistently shows a negative coefficient, suggesting that those more comfortable with risk are less likely to contribute to the common project, as hypothesized in our pre-registration. Yet, this coefficient is only significant in the first round, indicating that other factors, perhaps related to game dynamics, gain importance in subsequent rounds. Delay discounting, captured by the *Patient* dummy variable, also shows a consistent pattern where patient participants contribute less to the common project, contrary to our pre-registered expectations. However, the significance of this coefficient is limited to rounds 1-3.

For the post-experimental questions, responses were standardised at the treatment level. This approach was adopted because random assignment to a treatment and participation in the game could influence participants' responses. Self-identifying as a conditional cooperator or viewing other team members as cooperators consistently positively correlates with individual contributions. However, the coefficients for these variables are not significant for any of the dependent variables, suggesting that these factors may not be crucial for understanding choices in the experiment.[5]

Viewing other team members as competitors does not show a consistent relationship with individual contributions, as the sign of the coefficient varies across different dependent variables. Nevertheless, a significant negative coefficient emerges when considering the entire game, suggesting that a more competitive mindset does not enhance individual contributions.

Responses to three questions show consistent patterns. Participants scoring one standard deviation higher in *initial optimism* (believing at the outset that they would reach the target) tend to contribute significantly more per round to the common project. However, the strength of this association diminishes as we expand the scope of the rounds considered. This trend is not surprising, given that initial optimism is most relevant at the beginning of the game, whereas the dynamics of the game may play a greater role in later rounds. A stronger association is observed in participants' drive to *reach the goal*, with those scoring one standard deviation higher contributing approximately 20 Monetary Units (MU) more per round—this is significant at the 5% level. Conversely, the intention to maximise unspent money at the end of the game had a negative impact; participants scoring one standard deviation higher on this question contributed around 20 MU less per round, also significant at the 5% level (see Fig. 2 middle panel).

So far, we have analysed the relationships between the pre- and post-experimental questionnaires and the experimental outcomes separately. However, if analysed together, we can gain a better understanding of the interaction between participants' baseline personality characteristics and their attitudes specifically evoked by the experimental situation they experienced. When analysing pre- and post-experimental items together, the significant associations previously observed with climate intentions vanish. However, significant coefficients related to the post-experimental questions persist (see Fig. 2, right panel).[6]

[5] We did not pre-register any hypotheses regarding the post-experimental questions.

[6] The disappearance of significant associations between the pre-experimental items and contribution decisions, when both sets of items are analysed together, may be due to correlations among these items. Figure S1 in the Supplementary Material shows that climate intentions are significantly correlated with initial optimism, maximising the amount of money at the end of the experiment, the desire to reach the goal, and viewing other team members as cooperators or rivals, at the 5% significance level.

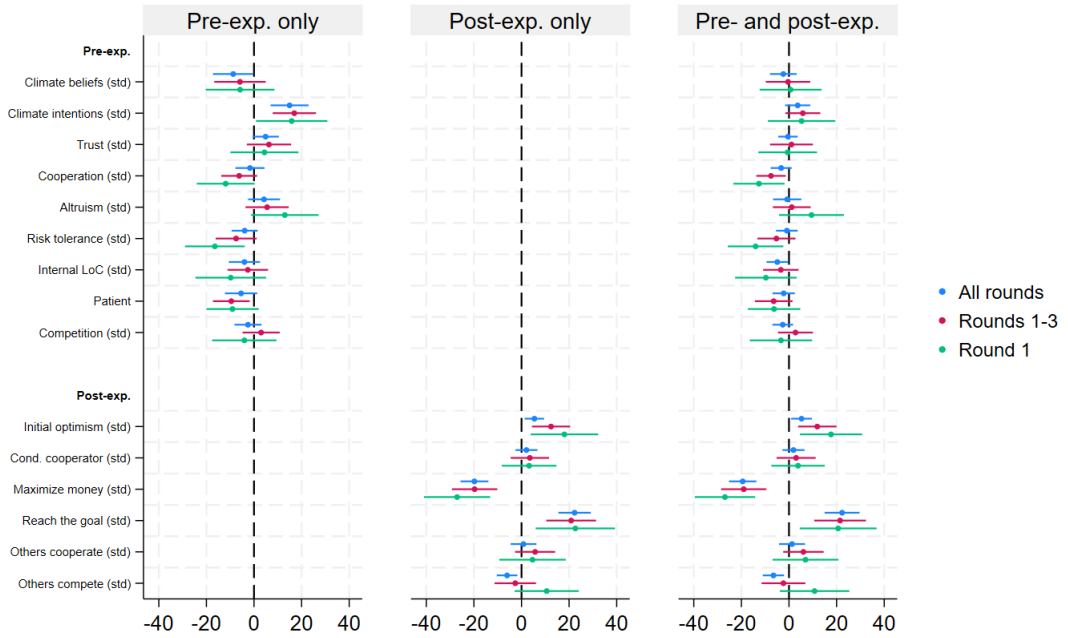

Fig. 2 Coefficient plots with 95% confidence intervals on the associations between answers to pre- and post-experimental questions and contribution decisions. Random-effects panel regression, with individual contributions as the dependent variable. std denotes standardised variables over treatments for variables related to the game and the post-experimental questions, and overall participants for the pre-experimental measures. Additional variables: experimental controls, sociodemographics, game-related variables. Experimental controls include experimenter, date, and location dummies. Sociodemographics: gender, age, type of settlement, education, and field of study dummies. Game-related variables: treatment dummies, round, lagged group contribution, % of over- and under-contributions in previous rounds, lagged standard deviation of contributions.

4 Discussion

Our experiment had three main objectives: 1) to investigate whether monetary competition influences success in the climate game; 2) to determine if the nature of the initial endowment—specifically, whether it is a windfall or earned—affects success; and 3) to identify which personality characteristics and strategies influence decisions during the game.

Our results indicate that monetary competition, similar to other factors leading to inequality studied previously, reduces the probability of achieving a common goal. However, due to the relatively low number of repetitions, this result is not statistically significant. While this result is not surprising, it is interesting to note that only 6 out of 144 participants in this experimental setting did not contribute anything to

the common pool, despite this being a high-return strategy. (Similarly, in the non-competitive case, only 6 of the 144 participants followed this purely selfish strategy.) This suggests that fully exploiting others is not an attractive behaviour, even when it offers clear financial benefits. Purely selfish behaviour is likely avoided due to concerns about losing reputation (Milinski et al, 2002, 2006), self-image (Filiz-Ozbay and Ozbay, 2014) and/or imitation due to reciprocity of conformity (Burlando and Guala, 2005), which are concerns that arise even when players are anonymous.

Based on our experimental results, individuals seem less willing to risk losing the money they have earned, which increases the chances of success in the climate game. This implies that decision-makers should emphasise to taxpayers that they have worked for their wealth, and that contributing to the green transition is a way to protect against the risk of losing it.

Our results indicate that subjects who view their personal actions as more important and effective in combating climate change (scored higher on the climate intentions scale) are more likely to cooperate in the climate game, despite the experiment not explicitly referencing climate issues. Interestingly, recognising climate change as a significant anthropogenic problem (scoring lower on the Climate belief scale) did not correlate with cooperation levels. These results are noteworthy from a number of perspectives. Earlier research by Burton-Chellew et al (2013) demonstrated that those who contributed more in a game explicitly framed in a climate change context also claimed to be less sceptical about climate change in a questionnaire administered after the game. Claessens et al (2022) find that cooperative attitudes are strongly positively correlated with both belief in climate change and pro-environmental behaviour. Moreover, the effect of cooperative attitudes on pro-environmental behaviour is mediated by climate change beliefs.

In contrast, our game was not placed in a climate change context, yet climate change intention was the only variable consistently showing a positive relationship with contribution, despite our measuring many other personality characteristics. Contrary to expectations, neither altruism, cooperation, competition, risk-taking propensity, nor trust showed any relationship (positive or negative) with contribution willingness throughout the entire game. This suggests that the climate change intention questionnaire might be measuring a specific type of cooperative willingness, as it includes questions on how potent participants consider themselves in mitigating climate change.

Analysis of the post-experiment questionnaire confirmed that players reported following distinct strategies (at least in retrospect) that significantly influenced their level of cooperation. Those who aimed to maximise revenue followed a more selfish strategy and contributed less to the common pool. In contrast, those who believed that the goal was achievable and aimed to achieve it were more cooperative and contributed more to the common pool throughout the game. This result supports the view that citizens of countries who see the fight against climate change as a common goal and are confident of success will be more willing to support it. Therefore, the communication of decision-makers should reinforce this perspective.

As is the case with such experiments in general, our experiment differs from the real climate change situation in a number of ways, such as 1) everyone in the experiment knows exactly how much contribution is needed to avoid disaster and when it will

occur (but see Raihani and Aitken (2011); Dannenberg et al (2015)), 2) the game is between only a few players (but see Milinski et al (2016)), 3) costs and payoffs are immediate (but see Jacquet et al (2013)), 4) there is no way to punish or regulate non-cooperative behaviour (but see Fehr and Gächter (2019); Góis et al (2019)), 5) players start at the same monetary level and have equal impact on reaching the target (but see Tavoni et al (2011); Burton-Chellew et al (2013); Brown and Kroll (2017, 2021)), 6) players participate in the game anonymously, thus their actions don't affect their reputation (but see Rockenbach and Milinski (2006); Milinski et al (2006)), 7) there is no way of making negotiations and commitments and setting intermediate targets (but see Milinski et al (2011); Barrett and Dannenberg (2012); Milinski et al (2016)). However, the effects of the differences listed here have already been investigated in previous experimental works, as indicated in the introduction and here with the cited references. Unfortunately, with the exception of the last two points, i.e. reputation, negotiations and commitments, the neglected details in reality reduce the likelihood of achieving the target, i.e., solving the climate crisis.

5 Conclusion

In summary, our experiments confirm that the economic competition, which is a significant factor in the climate crisis, makes it less likely for the necessary investments to materialise. Additionally, we found, surprisingly, that participants are more cooperative with money they earn than with windfall gains. Interestingly, among several personality traits, only climate change intentions were positively related to cooperative behaviour during the experiment. The results of the post-experiment questionnaire revealed that participants' underlying motivations significantly influenced their cooperative behaviours: income maximisers played less cooperatively, while those aiming to achieve a common goal were more cooperative.

Our results suggest that support for investments to prevent climate catastrophe can be enhanced by emphasising the protection of earned wealth, involving taxpayers in local actions, and highlighting a shared investment goal.

References

Abeler J, Falk A, Goette L, et al (2011) Reference points and effort provision. Am Econ Rev 101(2):470–492. https://doi.org/10.1257/aer.101.2.470

Archetti M (2009) The volunteer's dilemma and the optimal size of a social group. J Theor Biol 261:475–480. https://doi.org/10.1016/j.jtbi.2009.08.018

Barrett S, Dannenberg A (2012) Climate negotiations under scientific uncertainty. Proc Nat Acad Sci U S A 109(43):17372–17376. https://doi.org/10.1073/pnas.1208417109

Brown T, Kroll S (2017) Avoiding an uncertain catastrophe: climate change mitigation under risk and wealth heterogeneity. Clim Change 141:155–166. https://doi.org/10.1007/s10584-016-1889-5

Brown T, Kroll S (2021) Inequality hinders group efforts to avoid environmental disasters. Q Open 1:1–16. https://doi.org/10.1093/qopen/qoab006

Burlando RM, Guala F (2005) Heterogeneous agents in public goods experiments. Exp Econ 8:35–54. https://doi.org/10.1007/s10683-005-0436-4

Burton-Chellew MN, May RM, West SA (2013) Combined inequality in wealth and risk leads to disaster in the climate change game. Clim Change 120:815–830. https://doi.org/10.1007/s10584-013-0856-7

Cherry TL, Frykblom P, Shogren JF (2002) Hardnose the dictator. Am Econ Rev 92(4):1218–1221. https://doi.org/10.1257/00028280260344740

Christensen R, Knezek G (2015) The climate change attitude survey: Measuring middle school student beliefs and intentions to enact positive environmental change. Int J Env Sci Educ 10(5):773–788. https://doi.org/10.12973/ijese.2015.276a

Claessens S, Kelly D, Sibley CG, et al (2022) Cooperative phenotype predicts climate change belief and pro-environmental behaviour. Sci Rep 12(1):12730. https://doi.org/10.1038/s41598-022-16937-2

Crosetto P, Filippin A (2013) The "bomb" risk elicitation task. J Risk Uncertainty 47:31–65. https://doi.org/10.1007/s11166-013-9170-z

Dannenberg A, Löschel A, Paolacci G, et al (2015) On the provision of public goods with probabilistic and ambiguous thresholds. Env Res Econ 61:365–383. https://doi.org/10.1007/s10640-014-9796-6

Falk A, Becker A, Dohmen T, et al (2018) Global evidence on economic preferences. Q J Econ 133(4):1645–1692. https://doi.org/10.1093/qje/qjy013

Fehr E, Gächter S (2019) Altruistic punishment in humans. Nature 415:137–140. https://doi.org/10.1038/415137a

Filiz-Ozbay E, Ozbay EY (2014) Effect of an audience in public goods provision. Exp Econ 17:200–214. https://doi.org/10.1007/s10683-013-9363-y

Fischbacher U (2007) z-tree: Zurich toolbox for ready-made economic experiments. Exp Econ 10(2):171–178. https://doi.org/10.1007/s10683-006-9159-4

Gneezy U, Potters J (1997) An experiment on risk taking and evaluation periods. Q J Econ 112(2):631–645

Gürdal MY, Torul O, Yahşi M (2024) The seeds of success: the pivotal role of first round cooperation in public goods games. J Econ Sci Assoc pp 1–23. https://doi.org/10.1007/s40881-023-00153-3

Góis A, Santos F, Pacheco J, et al (2019) Reward and punishment in climate change dilemmas. Sci Rep 9:16193. https://doi.org/10.1038/s41598-019-52524-8

Herrmann B, Thoni C, Gachter S (2008) Antisocial punishment across societies. Science 319(5868):1362–1367. https://doi.org/10.1126/science.1153808

IPCC Core Writing Team and Lee, H. and Romero, J. (2023a) Climate Change 2023: Synthesis report. Contribution of Working Groups I, II and III to the sixth assessment report of the Intergovernmental Panel on Climate Change. IPCC, Geneva, Switzerland, https://doi.org/10.59327/IPCC/AR6-9789291691647.001

IPCC Core Writing Team and Lee, H. and Romero, J. (2023b) Climate Change 2023: Synthesis report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC, Geneva, Switzerland, https://doi.org/10.59327/IPCC/AR6-9789291691647

Jacquet J, Hagel K, Hauert C, et al (2013) Intra- and intergenerational discounting in the climate game. Nat Clim Change 3:1025–1028. https://doi.org/10.1038/nclimate2024

Johnson ND, Mislin A (2012) How much should we trust the world values survey trust question? Econ Letters 116(2):210–212. https://doi.org/10.1016/j.econlet.2012.02.010

Kroll S, Cherry TL, Shogren JF (2007) The impact of endowment heterogeneity and origin on contributions in best-shot public good games. Exp Econ 10:411–428. https://doi.org/10.1007/s10683-006-9144-y

Kumar M, Dutt V (2019) Collective risk social dilemma: Role of information availability in achieving cooperation against climate change. J Dyn Decision Making 5:1–12. https://doi.org/10.11588/jddm.2019.1.57360

McBridge M (2006) Discrete public goods under threshold uncertainty. J Public Econ 90:1181–1199. https://doi.org/10.1016/j.jpubeco.2005.09.012

McBridge M (2010) Threshold uncertainty in discrete public good games: an experimental study. Econ Gov 11:77–99. https://doi.org/10.1007/s10101-009-0069-8

Milinski M, Semmann D, Krambeck H (2002) Reputation helps solve the 'tragedy of the commons'. Nature 415:424–426–3998. https://doi.org/10.1038/415424a

Milinski M, Semmann D, Krambeck H, et al (2006) Stabilizing the earth's climate is not a losing game: supporting evidence from public goods experiments. Proc Natl Acad Sci U S A 103:3994–3998. https://doi.org/10.1073/pnas.0504902103

Milinski M, Sommerfeld RD, Krambeck HJ, et al (2008) The collective-risk social dilemma and the prevention of simulated dangerous climate change. Proc Nat Acad

Sci U S A 105(7):2291–2294. https://doi.org/10.1073/pnas.0709546105

Milinski M, Röhl T, Marotzke J (2011) Cooperative interaction of rich and poor can be catalyzed by intermediate climate targets: A letter. Clim Change 109:807–814. https://doi.org/10.1007/s10584-011-0319-y

Milinski M, Hilbe C, Semmann D, et al (2016) Humans choose representatives who enforce cooperation in social dilemmas through extortion. Nat Commun 7:10915. https://doi.org/10.1038/ncomms10915

Nash J (1950) Equilibrium points in n-person games. Proc Natl Acad Sci U S A 36:48–49

Nordhaus W (2019) Climate change: The ultimate challenge for economics. Am Econ Rev 109:1991–2014. https://doi.org/10.1257/aer.109.6.1991

Orosz G, Tóth-Király I, Büki N, et al (2018) The four faces of competition: The development of the multidimensional competitive orientation inventory. Front Psychol 9:779. https://doi.org/10.3389/fpsyg.2018.00779

Pacheco JM, Vasconcelos VV, Santos FC (2014) Climate change governance, cooperation and self-organization. Phys Life Rev 11(4):573–586. https://doi.org/10.1016/j.plrev.2014.02.003

Pearlin LI, Menaghan EG, Lieberman MA, et al (1981) The stress process. J Health Soc Behav pp 337–356

Raihani N, Aitken D (2011) Uncertainty, rationality and cooperation in the context of climate change. Clim Change 108:47–55. https://doi.org/10.1007/s10584-010-0014-4

Rockenbach B, Milinski M (2006) The efficient interaction of indirect reciprocity and costly punishment. Nature 444:718–723. https://doi.org/10.1038/nature05229

Spraggon J, Oxoby RJ (2009) An experimental investigation of endowment source heterogeneity in two-person public good games. Econ Letters 104(2):102–105. https://doi.org/10.1016/j.econlet.2009.04.012

Tavoni A, Dannenberg A, Kallis G, et al (2011) Inequality, communication, and the avoidance of disastrous climate change in a public goods game. Proc Nat Acad Sci U S A 108(29):11825–11829. https://doi.org/10.1073/pnas.1102493108

Vicens J, Bueno-Guerra N, Gutiérrez-Roig M, et al (2018) Resource heterogeneity leads to unjust effort distribution in climate change mitigation. PloS ONE 13(10):e0204369. https://doi.org/10.1371/journal.pone.0204369