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Luck framing supports the avoidance of collective disaster when inequalities in vulnerability exist

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ABSTRACT

Collective action problems describe situations such as climate change in which the efforts of multiple individuals are required to achieve joint outcomes. Many of these problems feature a threshold (e.g. limiting global warming to 1.5 °C above pre-industrial levels) that must be achieved in order to avoid a collective disaster (e.g. catastrophic climate change) that may affect individuals to varying degrees. Here we adapt a collective action game called the *collective-risk social dilemma* in which players in small groups make successive financial contributions towards a group target in order to avoid disaster. We investigate the extent to which different levels (resilient vs. vulnerable) and sources (luck vs. merit) of vulnerability to the disaster influence efforts to avoid it. We find that luck framing supports the avoidance of disaster: 76 % of groups with luck-based inequalities successfully achieve the group target compared with 40 % of groups with merit-based inequalities. This difference is driven by higher contributions towards the target from players whose level of vulnerability is determined by luck rather than merit. We also find that despite having different levels of vulnerability to the disaster, resilient and vulnerable players contribute similarly towards the group target. Our findings highlight the potential importance of luck framing in collective action problems that involve individuals with different levels of vulnerability to a collective risk. We discuss implications for policymakers and groups seeking to solve such problems.

1. Introduction

Under the 2015 Paris Agreement almost 200 countries committed to working together to limit global warming to 1.5 °C above pre-industrial levels. Together, they acknowledged that achieving this target would require a significant and costly reduction in global greenhouse gas emissions. Together, they agreed in principle to share this financial burden fairly between them. And yet according to a recent report published by the United Nations Environment Programme (2024) global temperatures under existing policies are set to increase by 2.6-3.1 °C by the end of this century. For climate change as well as many other collective action problems, there is a difference between agreeing to share the burden and agreeing *how* to share the burden.

Why is it proving so difficult to agree how to share the burden of reducing emissions? A core principle of the Paris Agreement is that countries have *common but differentiated responsibilities* to limit global warming. This principle is designed to take into account the unique circumstances of every country to ensure that the burden is distributed fairly. There are at least three challenges associated with this goal of universal fairness, however. One is that beliefs about what fairness means differ considerably across the world (Almås et al., 2024; Blake et al., 2015; Cappelen et al., 2020; Schäfer et al., 2015). A second is that individuals often exhibit self-serving interpretations of what constitutes their fair share of the burden (Hine & Gifford, 1996). A third is that what is individually perceived to be fair might be insufficient to collectively bear the full burden – in other words, fairness might not be enough (Malthouse et al., 2023).

In the context of international climate change, these fairness-related challenges are complicated by the range of inequalities that exist between countries. Some are wealthier than others, for example, and some are more vulnerable to the immediate effects of global warming (Brooks et al., 2005; Fankhauser & McDermott, 2014; Kotchen, 2018; Page, 2008; Stern, 2007). These inequalities complicate the question of what is fair because they afford multiple possible views of fairness and

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responsibility (Ringius et al., 2002; Linnerooth-Bayer, 2013). In turn, citizens and representatives of different countries may bring certain views of fairness into focus through a self-serving lens (Anderson et al., 2017; Brick & Visser, 2015; Carlsson et al., 2013; Kriss et al., 2011; Lange et al., 2010). In doing so, they may generate disagreement about what exactly represents a fair share of the burden for any given country – which is why inequalities between individuals have generally been shown to undermine group coordination and cooperation in collective action problems (Zelmer, 2003; Anderson et al., 2008; Suchon & Theroude, 2022; Yang & Konrath, 2023).

The majority of this research on inequalities in collective action problems has, however, focused primarily on the effect of wealth inequalities. In experimental settings, this has generally involved assigning participants to groups, giving some participants a higher endowment than others, and then giving these participants the opportunity to make individually costly but collectively beneficial contributions towards a public good (e.g., see Tavoni et al., 2011). Here we focus instead on the effect of inequalities in group members' vulnerability to a collective risk – a subject that has received relatively little attention in recent years, despite featuring increasingly often in the climate change debate. To our knowledge, only two studies have empirically investigated the effect of inequalities in vulnerability on group coordination and cooperation. The first study was a climate bargaining game conducted by Mahajan et al., (2022) who reported a negative effect of unequal vulnerability on coordination (bargaining success rates were significantly lower among individuals with unequal vs. equal vulnerability); but no effect on cooperation (less vulnerable individuals did not exploit more vulnerable bargaining partners). The second study was a threshold climate change game conducted by Reindl (2022) who reported no effect of unequal vulnerability on coordination (threshold success rates were the same in groups with equal vs. unequal vulnerability); but a significant effect on cooperation (more vulnerable players contributed more towards a group target sum than less vulnerable players). Other studies have empirically investigated the effect of inequalities in vulnerability but only in conjunction with inequalities in wealth (Burton-Chellew et al., 2013; Gampfer, 2014). The present study contributes to this limited body of evidence regarding the effects of inequalities in vulnerability in collective action problems such as climate change mitigation.

As well as investigating the effects of different *levels* of vulnerability between group members in a collective action problem, this study also investigated the effect of different *sources* of inequalities in vulnerability to a collective risk. Specifically, we compared the effect of luck-based and merit-based vulnerability on group coordination and cooperation. In doing so we extended existing research on the effect of luck-based and merit-based inequalities in wealth, which has generally found that in many parts of the world –in particular Western, Educated, Industrialised, Rich, and Democratic (WEIRD) regions (Henrich et al., 2010)– people tend to develop an intuition that wealth inequalities caused by variation in merit are fairer than those caused by luck or other factors beyond individuals' control (Hook & Cook, 1979; Almås et al., 2010; Starmans et al., 2017; Cappelen et al., 2020). In turn, these different perceived causes of wealth inequalities have been shown to influence people's preferences for wealth redistribution (Alesina et al., 2001; Almås et al., 2020; Almås et al., 2024). However, it was unclear from existing research whether participants would respond to luck-based or merit-based inequalities in vulnerability to a collective risk similarly to equivalent inequalities in wealth. One possibility was that meritocratic fairness views would prevail, meaning less vulnerable participants in our luck-based treatment would cooperate more than those in our merit-based treatment. Previous authors have found this to be the case in similar studies: participants were less motivated to redistribute wealth following choice-based (as opposed to luck-based) exposure to risk (Cappelen et al., 2013); and low-risk individuals were less willing to share risk with others when it was endogenously (rather than exogenously) assigned (Cettolin & Tausch, 2015). Another possibility was that less vulnerable participants' willingness to support more vulnerable participants would depend on the choices they made to protect themselves from the collective risk (Mollerstrom et al., 2015).

The main motivation for addressing this gap in the research was that many vulnerable countries need financial support to protect themselves against climate change, and the amount of support offered may depend on the extent to which they are perceived to be responsible for their vulnerability. Representatives of more vulnerable countries are seemingly aware of this and often point out that they are in no way responsible for their precarious position.[2] On the other hand, in recent years several organisations have developed indices that rank countries according to their climate change vulnerability (Chen et al., 2024). These rankings are generally determined by a combination of factors that might be considered luck-based (e.g. those relating to topography and demography) and merit-based (e.g. those relating to infrastructure, institutions, and 'readiness'). Understanding the effects of beliefs about different causes of vulnerability is therefore critical for achieving cooperation and coordination in both international climate change negotiations and other problems featuring collective risks.

The focus of this pre-registered study (https://osf.io/9ujw6) is the examination of how luck-based and merit-based inequalities in vulnerability to a collective risk influence efforts to avoid it. We investigated this subject empirically by adapting a public good game known as the *collective-risk social dilemma* (Milinski et al., 2008). This game was designed to represent the burden-sharing problem of limiting global warming sufficiently to prevent dangerous climate change but it also applies to several other collective action problems. In the standard version of the game, participants are assigned to small groups and are each given an initial endowment. They then choose how much of their endowment to contribute towards a group target sum over the course of 10 rounds. If as a group they contribute enough within the 10 rounds to achieve the target, everyone gets to keep what's left of their endowment. If they fail to achieve the group target, however, they face a collective risk of losing their remaining funds. Therein lies the dilemma for each individual that similarly lies under the surface of the Paris Agreement: the more I contribute, the more likely my group is to succeed in achieving the target, but the less money I have left at the end of the game.

We adapted the collective-risk social dilemma in three ways in order to isolate and explore the effects of inequalities in vulnerability on group success rates, individual contributions towards the target, and people's beliefs about what was fair. First, we introduced different *levels* of vulnerability by making participants either resilient or vulnerable to the collective risk. We did this by randomly assigning participants to groups made up of two resilient players (who faced a 50 % chance of losing their remaining funds if the group failed to achieve its target) and two vulnerable players (who faced a 90 % chance of losing theirs) both of whom received an initial endowment of £10. This meant that we defined vulnerability in terms of the probability of loss (following Milinski et al., 2008) rather than the magnitude of loss (following Reindl, 2022). Second, we introduced different *sources* of vulnerability by assigning groups to one of two treatments: in our merit treatment, participants' level of vulnerability was determined by their performance in an effort task; in our luck treatment, it was determined by a lottery (see Methods section for more details). Third, after informing participants whether they were resilient or vulnerable (and whether this was caused by merit or luck) we asked them what they thought would be a fair total contribution towards the group target of £24 from resilient and vulnerable players. We elicited these judgements because participants' beliefs have frequently been shown to predict behaviour in economic games (Gächter et al., 2017; Wyss et al., 2023). Together, these adaptations enabled us to explore how different levels and causes of vulnerability to a collective risk

[2] As Walton Webson, Chair of the Alliance of Small Island States, recently put it, "Our islands are bearing the heaviest burden of a crisis we did not cause" (Harvey, 2022).

influenced people's efforts to avoid that risk both as a group and individually. This represents the main contribution of this study. Below we outline our main hypotheses and their theoretical foundations.

1.1. Main hypotheses

Our first hypothesis (H1) dealt with differences in group success rates between treatments. Our principal prediction was that groups in our luck treatment would achieve the target more often than groups in the merit treatment. Our secondary predictions were that successful groups in the luck treatment would achieve the target in fewer rounds, and unsuccessful groups in the luck treatment would get closer to achieving the target compared with successful and unsuccessful groups in the merit treatment. These predictions were primarily based on evidence relating to the importance of luck and merit as the perceived causes of wealth inequalities noted by several researchers (e.g., Alesina et al., 2001; Alesina et al., 2004; Alesina et al., 2018; Frank, 2016; Konow, 2000; Koo et al., 2023; Markovits, 2019; Sandel, 2020). According to these researchers, individuals who perceive luck (rather than merit) as the primary cause of inequality are generally more motivated to redistribute wealth or reduce existing inequalities, particularly in WEIRD cultures (Gonzalez et al., 2022; Son Hing et al., 2011). But while it has been shown that people's preferences for redistribution are often stronger when inequalities are luck-based as opposed to merit-based, these findings are based on spectators whose own income was unaffected by their distributive choices (Ålmas et al., 2020; Ålmas et al., 2024). This may explain why similar differences in preferences have not always emerged in lab-based collective action problems in which people's choices directly affect their income. In a recent study by Malthouse et al. (2023), for example, participants given a higher endowment contributed similarly towards a group target sum regardless of whether their endowment was determined by luck or merit. In the present study, however, we anticipated a stronger luck treatment effect on the basis that people are less accustomed to thinking about their vulnerability to a collective risk than about their wealth in their everyday lives. We expected this to have two practical implications for participants who became resilient (vs. rich) through luck in our collective action game. First, they would be less likely to feel immediately entitled to their resilience (vs. wealth). Second, they would be less likely to blame more vulnerable (vs. poor) players for their precarious position. We expected both of these mechanisms to lead to higher contributions in the luck treatment, which would ultimately drive higher group success rates among luck-based groups.

We set out our expectations regarding contribution behaviour more specifically under H2, which were that: (a) resilient players in the luck treatment (the 'lucky resilient') would contribute more towards the group target than those in the merit treatment (the 'deserving resilient'); and (b) vulnerable players in the luck treatment (the 'unlucky vulnerable') would contribute more than those in the merit treatment (the 'deserving vulnerable'). The first prediction about resilient players (a) followed the reasoning above: namely that the lucky resilient would feel less responsible for their resilience than the deserving resilient and would therefore be more willing to contribute to the group effort. The second prediction about vulnerable players (b) was based on existing literature indicating that making people feel responsible for their lower status may increase their reluctance to contribute to the common good (Sandel, 2020).

Regardless of the cause of inequalities in vulnerability, we expected resilient players to contribute less towards the group target than vulnerable players (H3). This prediction was predominantly based on standard economic theory, since the former had more to gain financially from free-riding than the latter (Samuelson, 1954). As resilient players faced only a 50 % chance of losing their remaining funds in the event of group failure, free-riding offered a higher expected value (£10 × 50 % = £5) than contributing fairly towards the group target of £24 (£10 - £6 = £4) assuming risk neutrality. In contrast, free-riding vulnerable players could expect to take home only (£10 × 10 % =) £1 if their group failed. If resilient players acted in line with this standard economic theory, they would adopt a free-riding strategy for at least as long as they needed to contribute more than £5 to achieve the target. But even if they did not adopt this strategy, we still expected them to contribute less than vulnerable players for three reasons. First, resilient players might expect other resilient players to free-ride and therefore free-ride themselves as a strategic response (Fischbacher & Gächter, 2010). Second, resilient players were found to contribute less than vulnerable players in a similar climate change game conducted by Reindl (2022). Third, there are many real-world examples of resilient countries not contributing enough to protect more vulnerable countries from the effects of climate change.

Our final two hypotheses related to participants' fairness judgements, which we elicited after they knew their level of vulnerability (as well as its source) but before the game began. We asked participants two questions to elicit their first-order normative beliefs: 1) what they thought would be a fair total contribution from resilient players; and 2) what they thought would be a fair total contribution from vulnerable players. As noted above, several authors have reported that – in WEIRD countries in particular – inequalities caused by variation in merit are generally perceived to be fairer than those determined by luck (Alesina et al., 2001; Son Hing et al., 2011; Schäfer et al., 2015; Starmans et al., 2017; Gonzalez et al., 2022; Almås et al., 2024). For H4, therefore, we expected responses to the first question of what would be fair for resilient players to contribute to be lower in the merit treatment compared with the luck treatment, since the deserving resilient had earned their resilience in a way that the lucky resilient had not. Equally, we expected the reverse to be true when it came to the second question of fair contributions from vulnerable players: responses would be lower in the luck treatment than the merit treatment, since the deserving vulnerable were responsible for their precarious position whereas the unlucky vulnerable were not. At the same time, we expected participants' responses here to reflect self-serving bias (Brick & Visser, 2015; Hine & Gifford, 1996; Kriss et al., 2011; Lange et al., 2010). In practice, this would mean that resilient players would judge it fair that resilient players contribute less towards the group target than vulnerable players; and vice versa – which may undermine group coordination (Babcock & Loewenstein, 1997).

Our last hypothesis (H5) was that what participants judged to be fair would not be enough to solve the collective-risk social dilemma. This was based on the insufficiency of fairness in many real-world collective action problems, including climate change. Under the principle of *common but differentiated responsibilities*, for instance, countries submit climate commitments that they judge to be fair in the form of Nationally Determined Contributions (NDCs) (Rajamani et al., 2021). But according to a recent United Nations Environment Programme (2024) report, these contributions are collectively not enough. The report states that limiting global warming to 1.5 °C requires an estimated 42 % reduction in global emissions by 2030 relative to the 2019 level; but even ifall NDCs are fully implemented, emissions will decrease by just 10 %. At the same time, fairness has also been shown to be insufficient in the lab. In a recent implementation of the collective-risk social dilemma featuring wealth inequalities, participants' judgements about what would be fair for rich and poor players to contribute was not enough to achieve the group target – if they acted according to what they thought was fair, they would collectively fail (Malthouse et al., 2023).

In summary, in this study we investigated whether groups with luck-based vulnerability were more successful in avoiding collective disaster than groups with merit-based vulnerability (H1). We then tested whether this was primarily driven by higher contributions towards the group target from lucky resilient (vs. deserving resilient) and unlucky vulnerable (vs. deserving vulnerable) participants (H2). In addition, we investigated whether resilient players contributed less than vulnerable players (H3) given that they had more to gain from free-riding. Lastly, we investigated whether the cause of participants' vulnerability influenced what they perceived to be fair (H4) and whether what was judged to be fair would be enough to solve the collective action problem (H5).

All statistical tests of these hypotheses (summarised in Table 1) were carried out in R and JASP (2020); we use a significance level of 5 % throughout; and data and coding scripts are available at https://osf.io/tn3ak/.

2. Methods

2.1. Participants

We sourced 164 participants from Prolific Academic, all of whom were over the age of 18. 14 % were aged 18–24; 27 % were aged 25–34; 27 % were aged 35–44; 19 % were aged 45–54; 9 % were aged 55–64; and 4 % were aged 65 or over. Our sample was well-balanced across genders: 53 % identified as female; 46 % identified as male; and 1 % identified as non-binary or another gender. We recruited participants who spoke English as a first language but did not screen for nationality because: a) groups aiming to solve real-world collective action problems such as climate change are rarely made up of individuals from only one country; and b) we did not have a strong hypothesis relating to nationality in this setting. In practice, 68 % of our participants were from the UK, 18 % were from the US, and the remainder came from a range of other countries (see data available at https://osf.io/tn3ak/ for a full breakdown). All participants received pro-rata payment of £7.50 per hour plus a bonus payment based on the funds they had left at the end of the game (total payment $M = £5.64$ and $SD = £2.62$). The experiment took 21 min to complete on average ($SD = 5.3$).

We initially collected data from 12 groups in each treatment condition in February 2022 on the basis of power calculations detailed in our pre-registration (available at https://osf.io/9ujw6) which indicated that this sample size would achieve 90 % power ($\alpha = .05$) for between-subjects effect sizes greater than $d = 0.34$ (an effect size detected in previous similar studies). After conducting a similar study ourselves, however, we judged that a minimum of 20 groups in each treatment was more appropriate and therefore increased our sample size to 164 participants (20 merit groups and 21 luck groups) in December 2022.[3] Our payment terms, data collection procedures, and experiment design remained the same in both cases and were all approved by the University of Warwick's Psychology Department Research Ethics Committee. Lastly, we recruited two additional samples from Prolific in January 2025 ($n = 75$) and February 2025 ($n = 105$) to better understand participants' comprehension of the game (see Supplementary Information for a detailed discussion).

Table 1
The table summarises our main hypotheses (PR = pre-registered) and our specific predictions associated with each. Pre-registered hypotheses are available at https://osf.io/9ujw6.

Hypothesis	Theme	Main Predictions
1 (PR)	Group Success Rates	Groups in the luck treatment will be more successful than groups in the merit treatment.
2 (PR)	Contributions/Cause of Vulnerability	A) The lucky resilient will contribute more than the deserving resilient; and B) The unlucky vulnerable will contribute more than the deserving vulnerable.
3 (PR)	Contributions/Level of Vulnerability	Resilient participants will contribute less towards the group target than vulnerable participants.
4 (PR)	Fairness/Cause of Vulnerability	A) Participants will judge it fair that the deserving resilient contribute less than the lucky resilient; and B) Participants will judge it fair that the deserving vulnerable contribute more than the unlucky vulnerable.
5	Sufficiency of Fairness	What participants judge to be fair will not be enough to solve the collective action problem.

[3] This represented a deviation from our pre-registered Bayesian 'optional stopping' approach, which was no longer needed once we were able to recruit a full sample.

2.2. Experiment design

Our experiment was programmed in oTree (Chen et al., 2016). We invited around 20 participants to join each online session and recruited them on a first-come-first-served basis. Once they had read an information sheet, completed the consent form, and provided their age and gender, we randomly assigned them to groups of four in either our merit or luck treatment and then gave them instructions for the game (see Supplementary Information).

We informed all participants that they would first complete a 5-min mental arithmetic task individually, which consisted of adding up sequences of five random two-digit numbers (an effort task previously used by many researchers such as Oswald et al., 2015). We also informed them that after this task they would play a 'collective risk game' in their group of four, at the start of which they would each be given £10. We informed participants that if their group succeeded in the game, they would each get to keep their remaining funds; but if their group failed then a computer-generated lottery would determine whether they would each get to keep or lose their remaining funds. We explained that their group would be made up of two 'resilient' players and two 'vulnerable' players. If they were resilient, they would face a 50 % chance of losing their remaining funds in the event of group failure; if they were vulnerable, they would face a 90 % chance of losing their remaining funds. We provided this same information to participants in both treatments.

We provided different information, however, about the effort task to participants in the merit and luck treatments. Participants in the merit treatment were informed that the group's two highest-scorers in the task would become resilient while the group's two lowest-scorers would become vulnerable in the collective risk game. Participants in the luck treatment were informed that a lottery would decide whether they became resilient or vulnerable. In other words, their performance in the task was irrelevant for the collective risk game, but we incentivised effort in order to achieve consistency with the merit treatment by telling these participants that the highest-scoring member of each group would receive a £1 bonus payment at the very end of the experiment. We also collected data for a third treatment focusing on uncertainty in which we told participants that their vulnerability would either be merit-based or luck-based. We include and discuss the results from this treatment in the Supplementary Information. In summary, our design ensured that the level of inequality in vulnerability was the same in every group whereas the source of this inequality was not.

After all four group members had completed the effort task, they learned whether they would be resilient or vulnerable in the game that followed. We reminded them that this was determined by merit or luck (depending on the treatment) and what their level of vulnerability meant in practice. We then explained the rules of the game in more detail using illustrations shown in Fig. 1 before testing their understanding with four multiple-choice questions. Participants had to answer all questions correctly before proceeding to the game, as in Tavoni et al. (2011). At the end of the pre-game questionnaire, we asked participants what they thought would be a fair total contribution from resilient and vulnerable players. These questions were placed after the comprehension questions to ensure that they reflected participants' judgements about what was fair rather than their understanding of the game. Once all four members of a group had completed these steps, the first round of the collective-risk social dilemma began.

In each of the 10 rounds of the game we asked participants independently how much of their endowment (£0/£0.50/£1.00) they would like to contribute towards the group target of £24. If a participant took

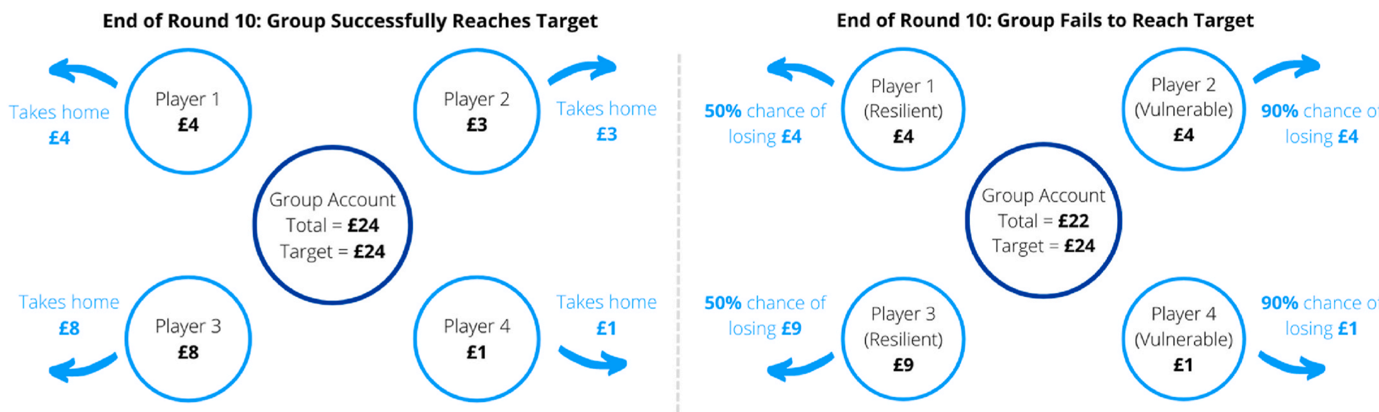

Fig. 1. Illustrations used in Participant Instructions.
This figure shows the illustrations shown to participants on the instructions page before they played the game. They highlighted how payoffs would depend on both individual contributions and group success. They also showed the different fates of resilient players (50 % chance of losing their remaining funds) and vulnerable players (90 % chance of losing their remaining funds) in the event of group failure.

more than 10 min to make a decision, they dropped out and their group was unable to complete the game. This happened on only one occasion in the very first round in the merit treatment, meaning dropouts were unlikely to have affected our results. We gave participants three contribution options because this is standard practice in the collective-risk social dilemma: it simplifies the game and represents a contribution constraint that often exists in natural settings (Milinski et al., 2008; Tavoni et al., 2011). We set the target at £24 because it required group members to each contribute £6 on average, or 60 % of their endowment. This target was more difficult than in previous iterations of the game (e.g., Milinski et al., 2008; Tavoni et al., 2011) because in a recent similar study (Malthouse et al., 2023) consistently high group success rates made it difficult to disentangle differences in group success rates between treatments. At the start of every round we told participants the round number, how much the group had contributed towards the target of £24, and how much of their £10 endowment they had remaining. After 10 rounds we told participants whether their group was successful or not, and as a manipulation check we asked them how they thought their player type (resilient/vulnerable) was determined. In the luck treatment, 45 out of the 63 participants who provided valid responses answered correctly that their level of vulnerability was determined randomly (71.4 %); in the merit treatment, 60 out of 70 (85.7 %) answered correctly that it was based on their effort task performance. This indicated that almost a third of participants in the luck treatment believed that their vulnerability was not determined purely by luck, although this figure might be inflated due to the leading nature of the question. Lastly, we informed participants in unsuccessful groups whether they had survived the collective risk and therefore whether they would receive their remaining funds as a bonus payment.

3. Results

Our results relating to our principal H1 prediction showed that groups in our luck treatment were almost twice as successful in avoiding the disaster as groups in our merit treatment. While 76 % of luck-based groups achieved the target, just 40 % of merit-based groups did ($\chi^2(1) = 5.5$, 95 % CI [−0.64, −0.08], $p = .019$, $BF_{10} = 5.4$, *Cohen's* $h = 0.75$, two-sided chi-squared test/Bayesian contingency table).[4] This Bayes Factor of 5.4 constitutes moderate evidence in favour of our hypothesis (Held & Ott, 2016). Fig. 2A illustrates this difference in group success rates, while Fig. 2B shows that the effect of the luck treatment on contribution behaviour was evident from the very first round, in which luck-based groups ($n = 21$) collectively contributed £3.02 on average while merit-based groups ($n = 20$) contributed £2.43 ($W = 97.5$, $p = .003$, $BF_{10} = 7090$, two-sided Mann-Whitney-Wilcoxon (MWW) and Bayesian Mann-Whitney U (BMW) tests). Furthermore, a logistic regression model indicated that higher contributions from the group in the first round were positively related to group success ($\beta = 1.13$, 95 % CI [0.11, 2.31], $z(40) = 2.05$, $p = .040$, $n = 41$, see SI Table 1.2 for full model details).

We did not, however, find evidence to support our secondary H1 predictions that: a) successful luck-based (vs. merit-based) groups would need fewer rounds to achieve the target; and b) unsuccessful luck-based (vs. merit-based) groups would come closer to achieving the target. Among successful groups, we did not detect a treatment effect on the average number of rounds taken to achieve the group target, which was 9.9 in both treatments ($n = 24$; $W = 64$, $p = 1$, $BF_{01} = 3.7$, two-sided MWW and BMW tests). This was because 21 out of the 24 successful groups (88 %) achieved the target in the final round. Equally, unsuccessful groups in the luck treatment did not come significantly closer to achieving the target ($M = £18.30$) than those in the merit treatment ($M = £16.33$) ($n = 17$; $W = 29$, $p = .916$, $BF_{01} = 3.7$, two-sided MWW and BMW tests). As shown in Fig. 2C, however, successful luck-based groups generally stayed further ahead of the required rate of contribution than successful merit-based groups; and unsuccessful luck-based groups generally remained on track to achieve the target for longer than those in merit-based groups.

H2 was that higher group success rates in the luck treatment would be driven by higher contributions towards the target from the lucky (vs. deserving) resilient and unlucky (vs. deserving) vulnerable. We tested this hypothesis via two-sided MWW/BMW tests and multilevel ordinal logistic regression models on contributions from resilient and vulnerable players separately.[5] The MWW/BMW tests included treatment as the independent variable and players' total contribution up to and including that round as the dependent variable. The multilevel models were designed to account for the nested structure of our data (since rounds were nested in individuals and individuals were nested in groups) and to investigate how contributions evolved over time in each treatment. These models therefore included fixed treatment and round effects and random group and individual effects (see SI Table 2.1 for full model

[4] This analytical approach represented a slight deviation from the approach outlined in our pre-registration, which was more appropriate for comparing three rather than two treatments. We similarly updated our approach for H2, H3, and H4; see Supplementary Information for results for all three treatments.

[5] This multilevel modelling approach was not specified in our pre-registration but is widely considered appropriate for nested data (see Aarts et al., 2014).

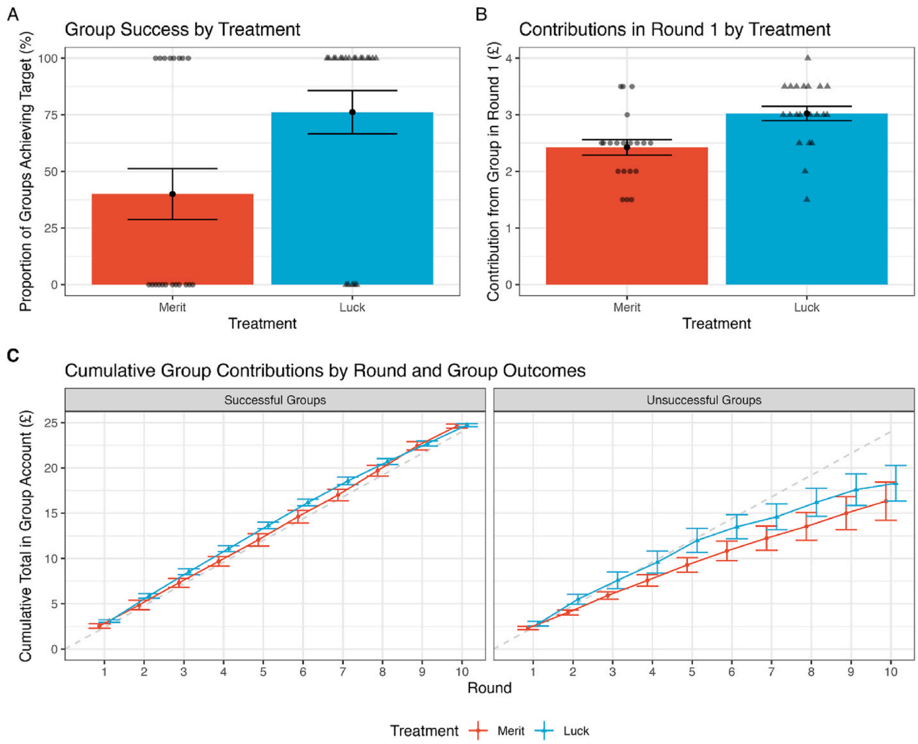

Fig. 2. Group Success Rates and Contributions: Merit vs. Luck Treatments Plot A shows the proportion of groups that were successful in each treatment. Points in the background represent groups, summary points show mean success rates, and error bars represent standard errors (where 100 represents group success and 0 represents group failure). Plot B shows round 1 contributions towards the target from the group as a whole in each treatment, with points in the background representing groups, summary points showing means, and error bars representing standard errors. Plot C shows cumulative contributions from successful and unsuccessful groups in each treatment towards the target over time, with the grey lines representing the required rate of contribution to achieve the target (£24) within 10 rounds.

details).

Our results revealed that both resilient and vulnerable players in our luck treatment generally contributed more than their peers in the merit treatment (see Fig. 3A). Table 2 summarises cumulative contributions and shows that this treatment effect dissipated over time, however. For example, the lucky resilient contributed significantly more than the deserving resilient up until the sixth round of the game (£3.24 vs. £2.55, $W = 1060$, $p = .041$, $BF_{10} = 1.7$, $n = 82$); and the unlucky vulnerable contributed significantly more than the deserving vulnerable up until the ninth round of the game (£5.08 vs. £4.10, $W = 1077$, $p = .027$, $BF_{10} = 2.6$, $n = 82$). These results highlighted the effect of luck-based vulnerability on contributions during the early rounds of the game; but also showed that this effect tended to weaken as groups approached either the threshold or the end of the game. Further analysis via multilevel models (see SI Table 2.1) – which accounted for variability at the group and individual level and for changes in contributions between rounds – revealed a positive effect of the luck treatment on contributions from both resilient players ($\beta = 1.45$, 95 % CI [0.08, 2.83], $z = 2.07$, $p = .038$) and vulnerable players ($\beta = 1.66$, 95 % CI [0.44, 2.87], $z = 2.67$, $p = .008$). Furthermore, a multilevel logistic regression model that controlled for variability at the individual level indicated that participants in the luck treatment were significantly more likely to contribute £1 (as opposed to £0 or £0.50) throughout the game than those in the merit treatment ($\beta = 0.47$, 95 % CI [0.07, 0.88], $z = 2.33$, $p = .020$). Together, these results supported our predictions under H2 that the lucky resilient and unlucky vulnerable would contribute more than their deserving counterparts.

H3 was that resilient players would contribute less towards the group target than vulnerable players. As illustrated in Fig. 3B, we did not find any evidence to support this hypothesis. For example, two-sided MWW and BMW tests indicated that resilient and vulnerable players contributed similarly in round 1 (£0.65 vs. £0.71, $W = 3065$, $p = .278$, $BF_{01} = 3.6$); rounds 1–3 (£1.83 vs. £1.88, $W = 3255$, $p = .720$, $BF_{01} = 5.5$); rounds 1–5 (£2.90 vs. £3.03, $W = 3183$, $p = .554$, $BF_{01} = 5.0$); and across all rounds (£5.18 vs. £5.54, $W = 3010$, $p = .246$, $BF_{01} = 3.9$; see SI Table 3.1 for a full comparison). The Bayes Factors here indicate that these results were 3.6–5.5 times more likely to be explained by the null hypothesis than by H3. Furthermore, a multilevel ordinal logistic regression model that controlled for treatment differences between rounds with fixed vulnerability and round effects and random individual and group effects (see SI Table 3.2 for full details) showed no overall differences between contributions from resilient and vulnerable players across both treatments ($\beta = 0.09$, 95 % CI [−0.43, 0.61, $z = 0.34$, $p = .735$). And a multilevel logistic regression model that controlled for variability at the individual level indicated that vulnerable players were no more likely than resilient players to contribute £1 (as opposed to £0 or £0.50) throughout the game ($\beta = 0.19$, 95 % CI [0.21, 0.59], $z = 0.95$, $p = .343$). Together, these results provided no evidence for H3.

Our final set of hypotheses (H4 and H5) dealt with fairness judgements. For H4 we found that judgements were not influenced by different sources of inequalities (see Fig. 4A). For example, participants in the merit treatment judged it fair that resilient players contribute £5.62, while those in the luck treatment judged it fair that resilient players contribute £5.72 ($n = 156$, $W = 3190$, $p = .565$, $BF_{01} = 5.2$, two-sided MWW/BMW test). Equally, participants in the merit (luck) treatment judged it fair that vulnerable players contribute £5.21 (£5.10) ($n = 156$, $W = 2831$, $p = .428$, $BF_{01} = 4.9$, two-sided MWW/BMW test). The modal fairness judgement about both resilient and vulnerable players was also the same across both treatments (£6). In summary, different causes of inequalities in vulnerability did not influence fairness judgements.

In our additional analysis of fairness judgements, we explored whether they reflected self-serving bias. We tested this by coding each response as 'same' if it concerned the same type of player as them (for

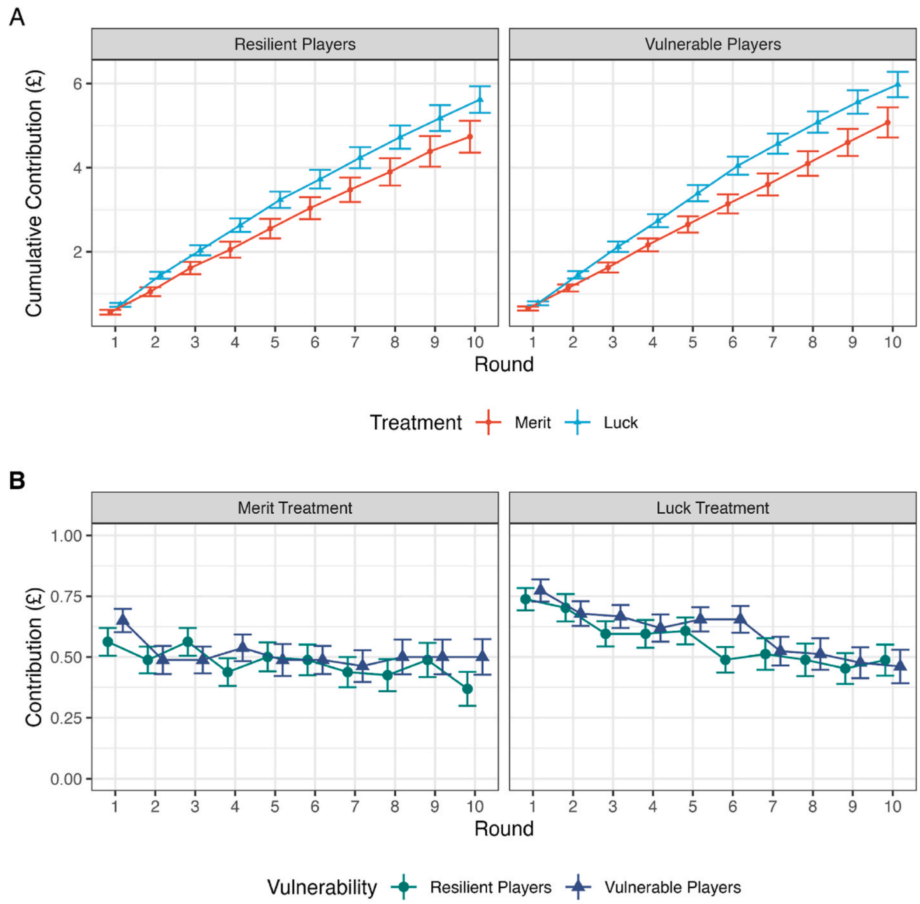

Fig. 3. Contributions by Cause and Level of Vulnerability Plot A shows cumulative contributions from deserving vs. lucky resilient players (left hand panel) and deserving vs. unlucky vulnerable players (right hand panel) in live rounds (those in which the target had not already been met). Points represent mean cumulative contributions in each treatment and bars represent the standard error. Plot B shows contributions from resilient and vulnerable players in each round across the merit and luck treatments, highlighting that they contributed similarly regardless of their cause of vulnerability. Points represent means and bars represent the standard error.

Table 2
Contributions from resilient and vulnerable players between treatments.

Vulnerability	Round	Mean Cumulative Contribution (Luck)	Mean Cumulative Contribution (Merit)	MWW Comparison (*p* value)	BMW Comparison (BF_{10})
Resilient Players	1	£0.74	£0.56	0.025*	1.1
	2	£1.44	£1.05	0.007**	3.1
	3	£2.04	£1.61	0.039*	1.5
	4	£2.63	£2.05	0.031*	1.7
	5	£3.24	£2.55	0.041*	1.7
	6	£3.73	£3.04	0.050	1.2
	7	£4.24	£3.48	0.058	1.3
	8	£4.73	£3.90	0.048*	1.3
	9	£5.18	£4.39	0.120	0.7
	10	£5.62	£4.74	0.087	0.8
Vulnerable Players	1	£0.77	£0.65	0.054	0.6
	2	£1.45	£1.14	0.011*	2.2
	3	£2.12	£1.63	0.009**	4.0
	4	£2.74	£2.16	0.012*	3.0
	5	£3.39	£2.65	0.010*	3.4
	6	£4.05	£3.14	0.008**	4.3
	7	£4.57	£3.60	0.013*	3.8
	8	£5.08	£4.10	0.027*	2.6
	9	£5.56	£4.60	0.059	1.6
	10	£6.00	£5.08	0.118	1.0

The table summarises the mean cumulative contributions from resilient and vulnerable players in both treatments shown in Fig. 3A. It also includes results of independent MWW and BMW tests to highlight differences that are statistically significant ($n = 82$ for each test). *p* values are starred as follows: <0.05*, <0.01**, <0.001***. Bayes Factors show support for H2.

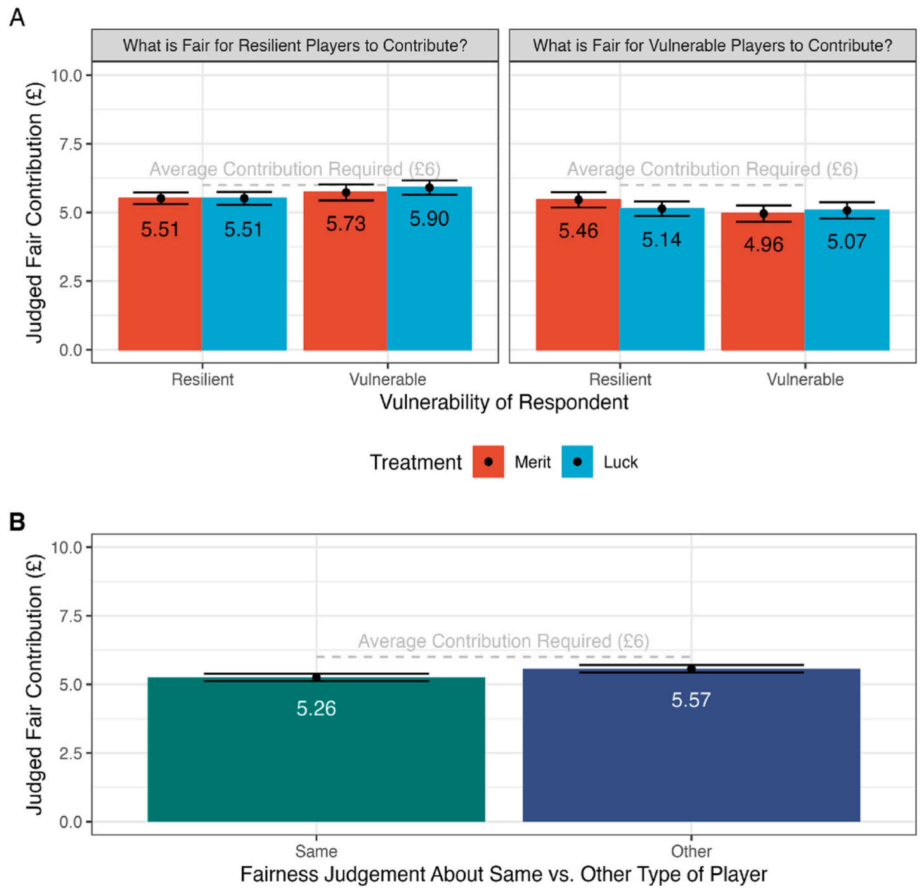

Fig. 4. Fairness Judgements and Self-Serving Bias
Plot A shows fairness judgements about resilient players (left panel) and vulnerable players (right panel). Bars show mean responses from resilient and vulnerable participants in the merit (red) and luck (blue) treatments with error bars representing standard errors. Both plots highlight the absence of a treatment effect on fairness judgements. Plot B shows mean aggregated responses from all players. The green bar (same) represents judgements from resilient players about resilient players and judgements from vulnerable players about vulnerable players. The blue bar (other) represents judgements from resilient players about vulnerable players and judgements from vulnerable players about resilient players. The difference between the bars shows that participants judged it fair that players like them should contribute less than the other type of player, in line with self-serving bias. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

example, if a resilient player was responding to the question of what was fair for resilient players to contribute) and 'other' if it concerned the other type of player (for example, if a resilient player was responding to the question of what was fair for vulnerable players to contribute). We found that when players were asked what would be fair for the same type of player as them to contribute the average response was £5.26. When they were asked the equivalent question about the other type of player, however, the average response was £5.57 ($n = 328$, $W = 10608$, $p = .035$, $BF_{01} = 1.7$, two-sided MWW/BMW test). These results indicated that participants overall judged it fair that they and others like them contribute less than others who were not like them.

Our final hypothesis (H5) was that people's beliefs about what was fair would not be enough to solve the collective-risk social dilemma. We investigated this hypothesis in two ways. First, we evaluated participants' responses on a collective level by testing whether they were significantly lower than £6 with a one-sample Wilcoxon signed rank test. Second, we evaluated participants' responses on an individual level by adding their responses to both questions together and multiplying this figure by two to calculate what they thought was fair for their group as a whole to contribute. We then tested whether this combined figure was on average lower than the group target of £24, as well as measuring the proportion of participants who provided insufficient fairness judgements.

Before conducting these tests, we first excluded 13 participants' responses that were both less than £1, which suggested that they thought the questions referred to round-by-round rather than total contributions. Having excluded these responses, we found that on a collective level participants judged it fair for resilient players to contribute £5.67 and vulnerable players to contribute £5.15 – both of which were less than the required average contribution of £6 ($Z = -2.46$, $p = .007$ and $Z = -5.38$, $p < .001$, respectively). Equally, on an individual level, participants' responses added up to less than £24 ($Z = -7.16$, $p < .001$) and 34 % provided judgements that were insufficient. These results provided evidence for H5. One explanation for these findings relates to self-serving bias, since splitting responses by participant vulnerability revealed that resilient players judged it fair that resilient players contribute £5.51 (which would mean £22.05 in total) and vulnerable players judged it fair that vulnerable players contribute £5.02 (which would mean £20.07 in total). An alternative explanation is a lack of comprehension (see SI 'Participant Understanding' section); although participants had to correctly answer that participants needed to contribute £6 on average before submitting their fairness judgements.

Lastly, it is worth noting that the relationship between participants' fairness judgements and their contributions was weak. We tested this with linear regression models, which indicated that resilient players' judgements about what was fair for resilient players to contribute did not predict either their round 1 contribution ($\beta = 0.06$, $t(73) = 1.1$, $p = .260$) or total contribution ($\beta = -0.02$, $t(73) = -0.1$, $p = .899$) towards the group target. Equivalent models for vulnerable players pointed to the same conclusion (round 1: $\beta = -0.02$, $t(79) = -0.6$, $p = .566$; total: $\beta = 0.24$, $t(79) = 1.9$, $p = .058$).

4. Discussion

Our principal finding was the powerful treatment effect on group success rates, which were almost twice as high in the luck treatment (76 %) compared to the merit treatment (40 %). This was driven by higher contributions towards the group target in the very first round of the game from luck-based groups (£3.02) vs. merit-based groups (£2.43). These early contributions were critical, since the total in the group account after one round was a significant predictor of group success, in line with much previous experimental research (e.g., Gürdal et al., 2024; Herrmann et al., 2008; Tavoni et al., 2011). In addition, resilient and vulnerable players in the luck treatment continued to contribute more than their peers in the merit treatment in subsequent rounds, despite the fact that almost a third of them reported that they believed their level of vulnerability to be at least partly merit-based. These reported beliefs suggest that our treatment effect, which dissipated as groups approached the target or the end of the game, represented the lower bound of a luck-based vulnerability effect.

Generalising our findings here would have important implications for real-world collective action problems. They suggest that if some individuals or nations are more vulnerable to a collective risk than others, a shared belief that vulnerability is determined by luck (i.e., factors beyond their control) rather than merit (i.e., factors within their control) may facilitate group coordination and cooperation. During international climate change negotiations, more vulnerable countries are often quick to argue that they are unfortunate to be bearing the brunt of climate change. We propose that as an international community we may be more likely to avoid a collective disaster if representatives from more resilient countries acknowledged the validity of this argument.

This difference in group success rates between our luck and merit treatments contrasted with findings from a previous similar study conducted by Malthouse et al. (2023). These authors focused on the effect of different causes of inequalities in wealth rather than vulnerability and reported no effect on group coordination or cooperation when wealth was determined by luck rather than merit. Our proposed explanation here is that people are more accustomed to feeling responsible for their wealth than for their vulnerability to a collective risk – even when both are determined by luck – which influenced their willingness to contribute to the joint effort.

Our second main finding is that resilient and vulnerable players contributed similarly towards the group target, contrary to what standard economic theory would predict. Resilient players faced only a 50 % chance of losing their remaining funds in the event of group failure and so in expectation stood to take home £5 by contributing nothing at all. Only three out of 82 participants (3.7 %) adopted this strategy, however, and resilient players' fairness judgements generally signalled their willingness to contribute to the joint effort. This finding that resilient players rarely exploited the vulnerability of their peers is inconsistent with previous experimental findings reported by Reindl (2022), who implemented vulnerability slightly differently, but is consistent with those reported by Mahajan et al., (2022) from a bargaining game. We propose that this finding might partly be explained by risk aversion among resilient players on the basis that they would rather avoid facing a 50 % chance of losing their £10. We also propose that it might be explained by compassion on the basis that resilient players may have recognised the precarious position of their more vulnerable peers, who faced a 90 % chance of losing everything in the event of group failure and therefore needed assistance (Adger & Nicholson-Cole, 2011; Dickinson et al., 2016; Dow et al., 2006). This shows that compassion can trump economic self-interest even in an abstract experimental task. Further research could therefore explore how to increase the motivating power of compassion as well as risk aversion as drivers of prosocial behaviour.

Our third main finding is that what people judged to be fair was not enough to solve the collective-risk social dilemma. In our comprehension test before the game, participants had to correctly identify that group members on average needed to contribute £6 each in order to achieve the group target of £24. And yet they then judged it fair that resilient players contribute £5.67 and vulnerable players contribute £5.15. In addition, more than a third (34 %) of participants' fairness judgements were insufficient, adding up to less than the group target. This finding may indicate a lack of understanding, but it might also be attributed to self-serving bias, since participants generally judged it fair that they contributed less than others – a pattern that has been documented in both the lab (e.g., Brick & Visser, 2015; Kriss et al., 2011) and the field (e.g., Lange et al., 2010). It also reflects real-world examples of fairness not being enough in collective action problems (Carpenter et al., 2016; United Nations Environment Programme, 2024). This highlights the need for further research to understand the roles of comprehension and self-serving bias as drivers of insufficient fairness judgements.

The extent to which it is possible to generalise these findings to real-world collective action problems such as climate change is one of the main limitations of this study. In recent years, several authors have raised concerns that individual behaviour in the lab does not necessarily translate to individual behaviour in the real world (e.g., Galizzi & Navarro-Martinez, 2019; Levitt & List, 2007). We maintain, however, that our findings are relevant to the extent that the *collective-risk social dilemma* captures the dynamics of climate change negotiations, which increasingly feature discussions about inequalities in vulnerability between countries. A second limitation related to generalisability is that our findings were based on a primarily WEIRD (Western, Educated, Industrialised, Rich, and Democratic) sample (Henrich et al., 2010). Given that beliefs about fairness differ considerably across the world (Blake et al., 2015; Cappelen et al., 2020; Schäfer et al., 2015) it is unclear whether our main finding regarding the importance of luck framing would transcend cultural differences and apply to the same extent in places where luck and merit are interpreted differently. A third limitation is that in natural settings inequalities in vulnerability rarely stand alone and are typically correlated with inequalities in wealth. These combined inequalities may generate an interaction effect on behaviour (as reported by Burton-Chellew et al., 2013; Gampfer, 2014; Reindl, 2022) that we could not detect within our existing design. A fourth limitation is that we did not include a baseline treatment with equal vulnerability between group members, and we are therefore limited to discussing only the effects of luck-based vs. merit-based inequalities. Lastly, a fifth limitation is that in the *collective-risk social dilemma* players' actions cannot cause direct negative externalities for others: they can only contribute or not contribute their funds. In the real world, however, individuals and governments can take actions such as increasing greenhouse gas emissions that might increase the vulnerability of others. Further research could therefore aim to incorporate the effect of behaviours that impose such externalities on others.

5. Conclusions

We reported that groups made up of individuals with different levels of vulnerability to a collective risk more successfully avoided disasters when their inequalities were framed as luck-based rather than merit-based. This was because luck framing prompted higher contributions towards the common good than merit framing. We also reported that more resilient players contributed similarly to more vulnerable players throughout the game, despite having less to lose in the event of group failure. Lastly, participants' fairness judgements were not influenced by luck or merit framing but did reflect self-serving bias and were insufficient to solve the collective action problem. Together, these findings indicate that emphasising the luck-based nature of vulnerability to shared risks in collective action problems may encourage people to contribute towards the group effort, which might ultimately prove the difference between success and failure.

CRediT authorship contribution statement

Eugene Malthouse: Writing – original draft, Visualization, Project administration, Investigation, Formal analysis, Data curation, Conceptualization. **Charlie Pilgrim:** Writing – review & editing, Methodology. **Daniel Sgroi:** Writing – review & editing, Supervision, Funding acquisition. **Thomas T. Hills:** Writing – review & editing, Visualization, Supervision, Resources, Funding acquisition.

Public significance statement

Some countries are more vulnerable to the effects of climate change than others. In this study we explore whether people's level of vulnerability (and whether they are responsible for their vulnerability) influences their efforts as a group to avoid a collective disaster in an online experimental game. We find that groups are less likely to avoid the disaster and people are less likely to support the joint effort when they feel responsible for their high or low level of vulnerability.

Data availability statement

Data is available at https://osf.io/tn3ak/.

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Declarations of competing interest

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jenvp.2025.102592.

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