# Regret, blame, and division of responsibility in games*

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September 26, 2024

**Abstract**

Although a powerful emotion affecting behavior, our understanding of regret in strategic interactions is limited. I argue that because responsibility is central in the experience of regret but also divided among players in games, people experience regret differently in games than in individual decision-making. I provide experimental evidence that, indeed, a player $i$'s regret (for not best-responding) is mitigated through blame put on another player $j$ for not playing—when available—a Pareto-improving (compared to $j$'s actual action) best-response to player $i$'s action. Remarkably, the tendency to blame elicited (through survey responses) in certain games predicts behavior in vastly different games. The results emphasize that models of individual decision-making may benefit from modifications when applied in games.

**Keywords**: regret theory, regret intensity, blame, responsibility, division of responsibility, alignment of interests, conflict of interest
**JEL classification codes**: C72, C92, D81, D90, D91

*I am grateful to Guillaume Fréchette for his valuable and continued guidance during the course of this project, to Erik Madsen and Sevgi Yuksel for insightful comments on previous drafts of this paper, and to Antonio Penta for his advising at Universitat Pompeu Fabra, where I started this project. I also thank Agata Farina, Ala Avoyan, Andy Schotter, Jose Apesteguia, Rosemarie Nagel, Séverine Toussaert, as well as participants at the 2023 North-American Economic Science Association Conference, 2023 Student Workshop in Experimental Economics Techniques (SWEET), the NYU Student Micro Theory Lunch, and NYU Informal Experimental Economics Seminar for helpful comments and discussions. I gratefully acknowledge financial support from the National Science Foundation via Doctoral Dissertation Research Grant SES-2146695, as well as support from the Center for Experimental Social Science (CESS).

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*[T]he intensity of regret depends on more than a simple comparison of 'what is' and 'what might have been'. It may depend also on the extent to which the individual blames himself for his original decision. [...] [T]he neglect of this dimension of regret—although a useful simplifying assumption for many problems—is a serious obstacle to the development and generalisation of regret theory. - Sugden (1985)*

# 1 Introduction

Regret theory has been a prominent model in decision theory since its formulation by Loomes and Sugden (1982) and Bell (1982). It poses that people choose between risky alternatives anticipating (and trying to mitigate) the regret that their choice may generate once the initially unknown state of the world is revealed.[1] Indeed, regret—be it anticipated or realized—has been shown to play an important role in investment behavior (Lin et al., 2006; Fogel and Berry, 2006; Huang and Zeelenberg, 2012; Frydman and Camerer, 2016; Fioretti et al., 2022), health decisions (Koch, 2014; Brewer et al., 2016), gambling and choice between lotteries (Loomes and Sugden, 1987; Zeelenberg et al., 1996; Zeelenberg, 1999; Sheeran and Orbell, 1999; Wolfson and Briggs, 2002; van de Ven and Zeelenberg, 2011; Araujo et al., 2024), as well as bidding in auctions (Engelbrecht-Wiggans, 1989; Engelbrecht-Wiggans and Katok, 2007, 2008, 2009; Greenleaf, 2004; Filiz-Ozbay and Ozbay, 2007, 2010; Ratan and Wen, 2016).

Despite the significant impact of regret on decision-making, little is known about how strategic—as opposed to single-agent—environments mediate the experience of regret, thereby shaping behavior. When introduced in games, (a player's) regret has so far been analyzed as if in a single-agent context with the other players' actions treated as the state of the world. I call this the *single-agent regret* approach. This approach has helped explain behavior in auctions (Engelbrecht-Wiggans, 1989; Engelbrecht-Wiggans and Katok, 2007, 2008, 2009; Greenleaf, 2004; Filiz-Ozbay and Ozbay, 2007, 2010; Ratan and Wen, 2016), the ultimatum game (Zeelenberg and Beattie, 1997), price competition (Renou and Schlag, 2010), the traveler's dilemma, centipede game, and asymmetric matching pennies (Halpern and Pass, 2012).

However, responsibility is central in the experience of regret but at the same time divided among players in games, which can make people experience regret differently in games than in individual decision-making. In the latter case, an outcome is *exclusively* the result of the agent's decision and "luck" (i.e., the initially unknown state of the world). On the other hand, in a game, the outcome is the result of the interaction of *multiple* agents; the other players' actions are not an impersonal, random state of the world but

[1] In the psychology literature, the importance of regret in decision-making has been discussed since at least Festinger (1964). A notion of regret can even be traced back to Savage's (1951) minimax (regret) principle, according to which an agent chooses the alternative that minimizes her maximum possible regret.

rather choices of real agents.[2] In such a setting, an agent may not experience feelings of regret in the same way or degree, as she may feel less responsible for the combined result of all the players' actions. Therefore, it is natural to study how regret and the division of responsibility jointly shape behavior in games.

To this end, I propose the *strategic regret* approach. This approach views (anticipated) regret as mediated by the division of responsibility (among players) for the outcome of a game.[3] In this perspective, blame put on another player mitigates one's own regret and self-blame. I build a simple model to derive testable predictions about how people experience regret and assign responsibility in strategic environments, and, in turn, how this affects their behavior. I then proceed to experimentally test these predictions. I show that, if appropriately adjusted to strategic environments, regret can provide novel insights, which are supported by the experimental results.

I model regret and blame in two-player games in the following way. When player $i$ (she) has not best-responded to player $j$'s (he) action, the former tends to experience regret. However, in cases where player $j$ has had available (but did not play) a *best-response* (to player $i$'s chosen action) which if chosen would have also benefited player $i$, then player $i$'s regret is mitigated through blame put on player $j$ (for not playing that best-response).

To see how strategic regret can affect behavior, consider the stag hunt game shown below:

| | stag | hare |
|---|---|---|
| stag | 1,1 | $-\lambda$,0 |
| hare | $0, -\lambda$ | 0,0 |

where $\lambda > 0$.[4] Suppose that player $i$ plays stag while player $j$ plays hare. In that case, given $i$'s action, $j$ could have best-responded by playing stag, causing a Pareto improvement. Thus, the tendency to blame the other player reduces the intensity with which $i$ may regret playing stag. On the other hand, player $j$ regrets not playing stag but has nothing to blame player $i$ for. Therefore, the propensity to blame makes stag more attractive by reducing the intensity of regret that it might generate while not affecting the magnitude of regret that hare might cause.

I acknowledge that blame is a complex phenomenon that cannot be fully captured by this modeling assumption. Although that another player's responsibility mitigates one's

[2]Indeed, in Lagnado and Channon's (2008) experiments, participants rated intentional actions as more causal and more blameworthy than physical events. Also, people are often more than willing to blame others and deny responsibility. For example, in order to avoid responsibility, they delegate selfish or unethical decisions (Hamman et al., 2010; Bartling and Fischbacher, 2011; Oexl and Grossman, 2013). They may blame others even if they are not responsible (Gurdal et al., 2013). "Luck" can also be a factor in games, but I restrict attention to games without chance moves.

[3]Although for brevity throughout the paper I refer to regret as realized regret, *anticipated* regret is what matters.

[4]The game is studied in detail in section 3.

regret and self-blame is intuitive,[5] an exhaustive and exact description of all situations where a player assigns (regret-mitigating) blame to another is not as obvious. However, the model still manages to deliver valuable new insights. In fact, the main purpose of this paper is *not* to prove that the exact formulation of strategic regret that I propose is the only reasonable or definitive one. Rather, the primary goal of this paper as a first step in developing the concept of strategic regret is to show how—a behaviorally plausible, simple, and conservative formulation of—strategic regret (i) differs from other models, particularly single-agent regret and standard social preferences, and (ii) can explain patterns of behavior that cannot be explained by those other models.

This formulation of strategic regret is conservative in the following sense. When performing counterfactual thinking, player $i$ perceives player $j$ as completely self-interested; she does not expect him to sacrifice *any* part of his payoff to benefit her. Thus, when compared to predictions under standard assumptions on preferences or under single-agent regret, theoretical results can be thought of as a conservative estimate of the effect that strategic regret can have.

Also, this formulation of strategic regret can *uniquely* (among existing models) explain existing experimental results. In a stag hunt game, Bolton et al. (2016) find that—holding fixed the probability with which the opponent plays stag—participants are more willing to play stag when they play against another person compared to when the other player's action is randomly chosen by the computer. Namely, the maximum probability with which the opponent can play hare with a participant still willing to play stag is (on average) lower when the opponent is a human than when it is a computer playing on behalf of a human. Strategic regret explains this finding as follows: a person that plays stag (i) may, in the former case, blame the other player (and regret less herself) if he does not also play stag, but (ii) cannot blame the computer in the latter case. Thus, stag is more attractive in the former case. To the best of my knowledge, no other model has been proposed that explains this finding.[6]

Although the ability to uniquely explain Bolton et al.'s (2016) finding already serves as strong evidence in favor of strategic regret, I use a novel experimental design to offer additional evidence. In the experiment, participants were asked to answer questions that measure the intensity of their regret and blame in *hypothetical* scenarios where they have

[5]It is also consistent with the decision justification (Connolly and Zeelenberg, 2002) and regret regulation (Zeelenberg and Pieters, 2007) theories suggesting that regret intensity is affected by justifications and feelings of self-blame. There has been substantive evidence in favor of these theories showing that regret intensity increases with the feeling of responsibility for having made a wrong decision (e.g., Zeelenberg et al., 1998; Inman and Zeelenberg, 2002; Pieters and Zeelenberg, 2005). At the same time, the assumption is consistent with the finding that regret mitigation due to diffusion of responsibility is a motive for people to make collective decisions (El Zein et al., 2019).

[6]Strategic regret also brings equilibrium predictions closer to experimental results in the traveler's dilemma introduced by Basu (1994) and in the Kreps game (Kreps, 1989; Goeree and Holt, 2001). The traveler's dilemma is studied in detail in sections 3 and Appendix A.2, while the Kreps game is studied in Appendix A.3.

played certain games (against other participants) and specific outcomes have materialized. Their answers to these survey questions reveal that, as strategic regret predicts, subjects (on average) blame the other side more and regret less when the other side has had available a Pareto-improving best-response than when not. Also, participants who blame more regret less, which indicates that blame assigned to the opponent indeed mitigates one's own regret.

However, measures of regret and blame based on survey questions may not necessarily imply that subjects anticipate regret and blame or that they take them into account when making strategic decisions. The second part of the experiment aims to argue that this is the case by showing that *unincentivized* survey answers predict *incentivized* play. In this part of the experiment, subjects played games commonly used in economics. Consistent with strategic regret predictions, subjects with stronger tendency to blame (as measured by their answers to the survey questions) the other player and regret less themselves (i) were more likely to play stag in the stag hunt game and (ii) chose higher numbers in the traveler's dilemma (than those less prone to blame).[7] Perhaps the most striking part of this result is that although the subjects' tendency to blame (and thus, regret less) was elicited through survey responses in games *vastly different* from the traveler's dilemma and the stag hunt game, these responses have predictive power over the participants' incentivized play in those two games.

Nevertheless, since blame is assigned to another player for not playing a Pareto-improving best-response—which implies consideration of both players' payoffs, participants with stronger tendency to blame may, for example, also be more altruistic. If so, then the predictive power of the propensity to blame over behavior in the traveler's dilemma and stag hunt game could be partly due to altruism, which—like the propensity to blame—should make people (i) more likely to play stag and (ii) choose higher numbers in the traveler's dilemma.[8] The experimental results rule out this alternative explanation; here is how. In the experiment, apart from the stag hung game and the traveler's dilemma, subjects also played the public goods game, prisoner's dilemma, and dictator game. More altruistic participants should (i) give more in the dictator game, (ii) be more likely to cooperate in the prisoner's dilemma, and (iii) contribute more in the public goods game. On the other hand, these predictions should not hold about participants with higher

[7] In the traveler's dilemma, two players simultaneously choose an integer (i.e., amount of money) each from a certain (exogenous) range. Then, each player receives the lowest of the two amounts, and, if the two chosen numbers differ, the player that has announced the lower (resp. higher) number of the two receives a bonus (resp. penalty), whose value is higher than 1. Suppose that player $j$ selects a significantly lower number than player $i$. The regret of player $i$ (for not undercutting player $j$) is mitigated because what happened is partly player $j$'s fault. Player $j$ could have best-responded by undercutting player $i$'s number by exactly one, causing a Pareto improvement. On the other hand, player $j$ regrets not undercutting player $i$ by exactly one but has nothing to blame player $i$ for. Thus, the propensity to blame tends to make players choose higher numbers.

[8] Even if this was the case, remember that—unlike strategic regret—standard other-regarding preferences cannot explain Bolton et al.'s (2016) finding.

propensity to blame, given that in these three games, a Pareto-improving best-response never exists, so there is—in theory—no scope for regret-mitigating blame. I show that, indeed, a stronger tendency to blame (as measured by the survey) does *not* predict (i) more giving in the dictator game, (ii) a higher likelihood to cooperate in the prisoner's dilemma, or (iii) a larger contribution in the public goods game. This indicates that the survey measure of the tendency to blame does not conflate blame with standard social preferences. Strategic regret is distinct from standard other-regarding preferences and can explain patterns of behavior that they cannot.

The plan of the paper is as follows. After a discussion of related literature, section 2 presents the model, and section 3 derives comparative statics predictions. Based on these, section 4 presents the experimental design and results. Section 5 concludes. Appendix A discusses extensions of the model and presents additional results. Appendix B presents supplementary analyses of the experimental data. Appendices C and D document the experimental procedure. Appendix E derives theoretical results under weaker assumptions. The proofs of all results are gathered in Appendix F.

**Related literature.** Several papers have considered regret in games. Renou and Schlag (2010) and Yang and Pu (2012) study minimax regret equilibria, while Halpern and Pass (2012) develop an alternative regret-based solution concept, iterated regret minimization. García-Pola (2020) combines regret minimization with level-$k$ reasoning. Other papers have incorporated regret to study behavior in specific settings. Linhart and Radner (1989), Engelbrecht-Wiggans (1989), Engelbrecht-Wiggans and Katok (2007, 2008, 2009), Greenleaf (2004), Filiz-Ozbay and Ozbay (2007), and Ratan and Wen (2016) incorporate regret in bilateral bargaining and auctions. Zeelenberg and Beattie (1997) find evidence of regret aversion in the ultimatum game. Namely, proposers who expected to receive feedback on the responder's minimum acceptable offer made lower offers compared to proposers who did not anticipate such feedback.

Accounting for how blame and the division of responsibility affect behavior in games by mitigating regret is the main contribution of this paper, as neither theoretical nor experimental work has previously considered this. However, there are a few more differences from existing theoretical work. For example, in Renou and Schlag (2010), Halpern and Pass (2012), and García-Pola (2020), the players' payoffs only depend on regret, while in this paper, players care about both baseline (e.g., material) payoffs and regret in the original spirit of Loomes and Sugden (1982).[9]

While following the single-agent regret approach, Battigalli et al. (2022) allow players

[9]Also, while I focus on the players' best-response correspondences, other papers study regret using particular solution concepts. For instance, Halpern and Pass (2012) assume players to know that the other players are regret minimizers—without common knowledge of rationality. Renou and Schlag's (2010) minimax regret equilibrium allows for inconsistent beliefs, while García-Pola (2020) studies regret under level-$k$ reasoning. I study equilibrium predictions in Appendix A.

to care about both baseline payoffs and regret. Allowing for chance moves, they study regret in extensive-form psychological games.[10] This modeling approach is necessitated by the fact that in an extensive-form game, a player's strategy is usually not observable (by the other players) after the game has ended. Thus, the authors leverage the psychological games framework to model each player's ex-post beliefs over the other players' strategies; these beliefs are central in a player's counterfactual thinking, which determines regret. Here I restrict attention to static games without chance moves, where strategies are ex-post observable. This removes the need to model ex-post beliefs and allows us to instead focus our attention on how blame and the division of responsibility affect regret and, in turn, behavior.

## 2 A model of two-player games with regret and blame

A (static) game is characterized by a tuple $G \coloneqq \langle N, (S_i)_{i\in N}, (u_i)_{i\in N}, (m_i)_{i\in N}\rangle$. $N \equiv \{1,\dots,n\}$ is a finite set of $n$ players. We will restrict attention to two-player games (i.e., $n=2$).[11] $S_i$ is player $i$'s finite action space and $S \coloneqq \times_{i\in N} S_i$ is the action profile space. $s \in S$ denotes an action profile. $u_i : S \to \mathbb{R}$ is player $i$'s Bernoulli *baseline* payoff function, which does not account for regret.[12] It is analogous to the choiceless utility function of Loomes and Sugden (1982). $m_i : S \to \mathbb{R}$ is player $i$'s Bernoulli *modified* payoff function, which accounts for regret and blame and is described below. Denote a mixed action of player $i$ by $\sigma_i$ and the space of player $i$'s mixed actions by $\Delta(S_i)$. $\sigma_i(s_i)$ is the probability with which $i$ plays action $s_i$. The baseline (resp. modified) payoff of player $i$ from a mixed action profile $\sigma \in \Delta \coloneqq \times_{i\in I}\Delta(S_i)$ is given by $u_i(\sigma) \coloneqq \sum_{s\in S} u_i(s)\prod_{k\in N}\sigma_k(s_k)$ (resp. $m_i(\sigma) \coloneqq \sum_{s\in S} m_i(s)\prod_{k\in N}\sigma_k(s_k)$).[13]

**Modified payoffs.** To describe the modified payoffs, we first need to define the *blame payoff* $u_i^b(s_i,s_j)$. This is the payoff that player $i$ could have received and blames player $j$ for not actually receiving.

**Definition 1.** The blame payoff for player $i$ (she), $u_i^b(s_i,s_j)$, given an action profile $(s_i,s_j)$ is the maximum baseline payoff that player $i$ can get (by playing $s_i$) if player $j$ (he) best-responds to $s_i$ to maximize his baseline payoff, provided that this maximum baseline

[10]Psychological game theory was introduced by Geanakoplos et al. (1989) and further developed by Battigalli and Dufwenberg (2009).

[11]Appendix A.4 extends the model to $n$-player games.

[12]In principle, payoffs given by $u_i$ need not satisfy any standard assumptions (e.g., equal monetary payoffs); strategic regret considerations can be applied in addition to other behavioral properties that $u_i$ accounts for. However, in the applications considered in this paper, baseline payoffs will indeed be assumed equal to monetary payoffs (with risk aversion discussed where necessary).

[13]Abusing notation, I write both pure and mixed actions inside $u_i$ and $m_i$.

payoff of player $i$ is higher than her payoff when $(s_i,s_j)$ is played;[14] otherwise $u_i^b(s_i,s_j)$ is equal to her payoff under $(s_i,s_j)$. That is, $u_i^b(s_i,s_j) := \max\left\{u_i^{ba}(s_i), u_i(s_i,s_j)\right\}$, where $u_i^{ba}(s_i) := \max_{s_j' \in PBR_j(s_i)} u_i(s_i,s_j')$, where $PBR_j(s_i) := \arg\max_{s_j' \in S_j} u_j(s_j',s_i)$ is player $j$'s pure best-response correspondence (in baseline payoff terms).

$u_i^{ba}(s_i) > u_i(s_i,s_j)$ means that player $j$ could have chosen an action $s_j'$ that would maximize her own baseline payoff given the action $s_i$ of player $i$ and at the same time increase player $i$'s baseline payoff. I postulate that in this case, player $i$ assigns part of the blame for the outcome of the game to $j$, which mitigates the intensity of $i$'s regret. Namely, the modified payoff is given by

$$m_i(s_i,s_j) := u_i(s_i,s_j) - r_i\left(u_i(s_i,s_j), u_i^{br}(s_j), u_i^b(s_i,s_j)\right) \tag{1}$$

where $r_i$ measures the regret of player $i$ through (i) the realized (baseline) payoff $u_i(s_i,s_j)$, (ii) the payoff she would achieve by best-responding, $u_i^{br}(s_j) := \max_{s_i' \in S_i} u_i(s_i',s_j)$, and (iii) the blame payoff, $u_i^b(s_i,s_j)$.[15] Unless otherwise stated, regret is given by

$$r_i\left(u_i, u_i^{br}, u_i^b\right) := \alpha_i \max\left\{u_i^{br} - \left[\beta_i u_i^b + (1-\beta_i)u_i\right], 0\right\}, \tag{2}$$

where $\alpha_i \geq 0$ measures the intensity with which player $i$ experiences regret.[16] $\beta_i \in [0,1]$ is player $i$'s *tendency (or propensity) to blame*. It measures the degree to which, when possible, player $i$ assigns part of the blame to player $j \neq i$ and player $i$'s own regret is mitigated. $\beta_i = 0$ corresponds to single-agent regret, while $\beta_i > 0$ to strategic regret. For $\beta_i = 0$, the regret function is as in Renou and Schlag (2010), Halpern and Pass (2012), García-Pola (2020), and Battigalli et al. (2022). In the first three papers, players only care about regret, which, loosely put, corresponds to $\alpha_i = \infty$. In Battigalli et al. (2022), players care about both baseline payoffs and regret, and the modified payoffs are as defined here for $\beta_i = 0$.

**Discussion of the strategic regret assumption.** Strategic regret is formulated under weak assumptions, in the sense that player $i$'s regret is mitigated only if some of the opponent's *best-responses* would have been beneficial to player $i$. When performing counterfactual thinking, player $i$ perceives player $j$ as completely self-interested. Under alternative formulations, player $i$ could assign blame to player $j$ simply due to the

[14] This means that when player $j$ has multiple best-responses to $s_i$, in the counterfactual that $i$ considers in assigning blame to $j$, the latter chooses the best-response that is most beneficial to $i$.

[15] Notice that—like the expected utility formulation of regret in Loomes and Sugden (1982)—this is an expected utility formulation of regret and blame. Particularly, even when players deliberately randomize, a player regrets and blames the other player with respect to their ultimately chosen pure actions. This formulation of regret is conceptually different from the one in Heydari (2024), where randomization mitigates the decision maker's responsibility and regret.

[16] Appendix E presents results under more general assumptions on $r_i$.

availability of an action—not necessarily a best-response—to $j$ that would have led to a Pareto improvement.

One could however argue that in some cases, player $i$ may not assign blame to player $j$ (when he has had available a Pareto-improving best-response), as he may only unintentionally have not best-responded. Yet, regret is also generated by a player's own unintentional non-best-response; it is thus natural to assume that a player attributes blame to others or oneself using common standards. Indeed, there is evidence that people blame others for unintentional behavior (Knobe and Burra, 2006) or even for outcomes that they are not responsible for (Gurdal et al., 2013). Also, explicit attribution of blame is not necessary, as blame can merely be a justification that mitigates player $i$'s self-blame.

Now, let us for a moment entertain the possibility that the availability to player $j$ of a Pareto-improving best-response exacerbates—rather than mitigates—$i$'s regret (e.g., by making her feel even worse that the two of them did not manage to coordinate on a Pareto superior outcome). Then, we would quickly reject this idea, as it would lead to diametrically opposite predictions (compared to the predictions of the adopted model), which are rejected by the experimental results of Bolton et al. (2016) and section 4.

Yet another possible formulation of strategic regret could pose that player $i$ blames player $j$ and does not regret her non-best-response to player $j$'s action when player $j$ has played a dominated action. Still, given that there are no dominated actions in the stag hunt game, this formulation of strategic regret would not, for example, explain Bolton et al.'s (2016) results, which, as we will see, the proposed formulation does.

## 3 Theoretical predictions of strategic regret

Under single-agent regret, best-response correspondences are the same as under baseline payoffs. To see this, notice that for $\beta_i = 0$, player $i$'s modified payoff becomes $m_i(s_i,s_j) = (1+\alpha_i)u_i(s_i,s_j) - \alpha_i u_i^{br}(s_j)$, where $u_i^{br}(s_j)$ is independent of $s_i$, and thus,

$$\arg\max_{s_i} m_i(s_i,\sigma_j) = \arg\max_{s_i} u_i(s_i,\sigma_j)$$

for any $\sigma_j$. Therefore, compared to standard assumptions on preferences (i.e., baseline payoffs), single-agent regret does *not* provide any new insights into strategic behavior.[17]

But can strategic regret, instead, help explain (subject-level) behavior? To answer this question, we will now derive predictions about how a player's attitudes towards regret and blame shape their behavior (i.e., best-response correspondence) in various games. We will see that strategic regret predicts that players who tend to blame more (i.e., have higher $\beta_i$'s) (i) choose higher numbers in the traveler's dilemma and (ii) are more willing

[17] This is true in the context of this model. Refer to the introduction for single-agent regret models that do offer such insights.

to play stag in the stag hunt game (with hare being a safe option). On the other hand, the propensity to blame does not affect behavior in public goods games, the prisoner's dilemma, or dictator games. These predictions form the basis of the experiment presented in section 4, where participants played one-shot versions of these games, so non-equilibrium predictions are particularly relevant for the development of our hypotheses.

The traveler's dilemma and stag hunt game are chosen for the following reasons. First, in these games, there is in theory scope for blame (i.e., outcomes of the game where $u_i^b > u_i$), so strategic regret may explain heterogeneity in participant behavior. Second, both games exhibit substantial heterogeneity in participant behavior in existing experiments, which makes a model that explains subject-level behavior most useful. Third, the two games are strategically very different: the traveler's dilemma is dominance-solvable (under standard assumptions on preferences), while the stag hunt game is a coordination game. This allows us to test whether strategic regret can help explain behavior in different strategic environments.

The public goods game, prisoner's dilemma, and dictator game fall—in theory—outside this range of strategic environments and will thus serve as placebos. In these games, there is no scope for blame, so the propensity to blame (as measured by the survey described in section 4) should *not* explain participant behavior. Placebo tests are useful for the following reason. Since blame is assigned to another player for not playing a *Pareto-improving* best-response—which implies consideration of both players' payoffs, participants with stronger tendency to blame may also be more altruistic. In that case, any predictive ability of the tendency to blame over behavior in the traveler's dilemma and stag hunt game could be partly attributed to other-regarding preferences. However, more altruistic participants should also (i) give more in the dictator game, (ii) be more willing to cooperate in the prisoner's dilemma, and (iii) contribute more in the public goods game. Thus, if the propensity to blame explains behavior in the traveler's dilemma and stag hunt game as predicted by strategic regret but does *not* predict (i) more giving in the dictator game, (ii) a higher likelihood to cooperate in the prisoner's dilemma, or (iii) a larger contribution in the public goods game, then the alternative explanation based on other-regarding preferences becomes less convincing.

### 3.1 The traveler's dilemma

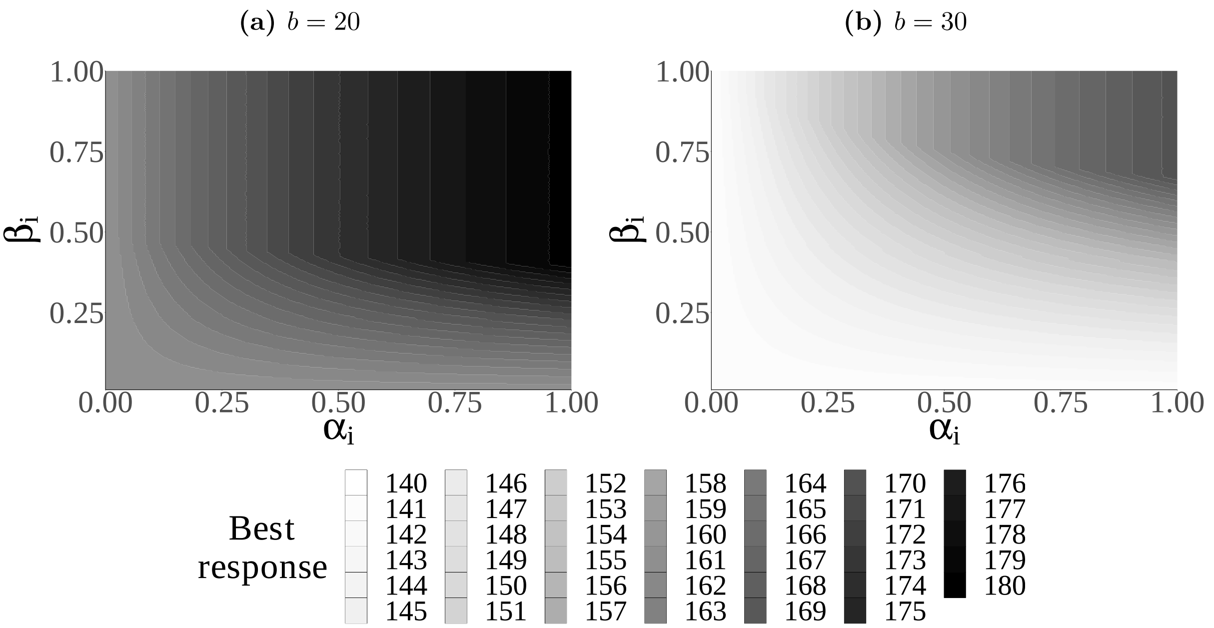
In the traveler's dilemma introduced by Basu (1994), two players simultaneously choose integers (i.e., amounts of money) from a certain range. Let that range be $\{80,81,\ldots,200\}$. Then, each player receives the lowest of the two chosen numbers. On top of this, if the two announced numbers are different, the amount received by the player that has announced the lower (resp. higher) number is increased (resp. decreased) by a bonus (resp. penalty) $b > 1$.

Claim 1 shows that a player $i$'s best-response (in terms of modified payoffs) to some fixed beliefs (weakly) increases with the degree $\beta_i$ to which the player tends to blame the other player. This is because the only case where $i$ blames player $j$ (and thus, experiences reduced regret) is when $j$ chooses a number that is lower than $i$'s by more than 1. In that case, $i$ blames $j$ for not undercutting her by one rather than by more than one. Thus, blame tends to make players choose higher numbers.

**Claim 1.** Let regret be given by $r_i(u_i, u_i^{br}, u_i^b) := \tilde{r}_i(u_i^{br} - [\beta_i u_i^b + (1 - \beta_i) u_i])$ for some $\tilde{r}_i : \mathbb{R}_+ \to \mathbb{R}_+$ with $\tilde{r}_i' \geq 0$ and $\tilde{r}_i'' \leq 0$. Then, in the traveler's dilemma, given any conjecture $\sigma_j$ over player $j$'s action, player $i$'s best-response is non-decreasing in $\beta_i$.

Figure 1 plots the best-response of player $i$ to uniform mixing by player $j$ as a function of $\beta_i$ and $\alpha_i$ under our canonical specification of regret given in (2) under different values of the parameter $b$. Darker grays correspond to higher best-responses. Indeed, the best-response is increasing in $\beta_i$ (for $\alpha_i$ high enough).[18] Thus, in the experiment, participants with stronger tendency to blame are expected to choose higher numbers.

**Figure 1:** The traveler's dilemma: best-response of player $i$ to uniform mixing by player $j$ as a function of $\beta_i$ and $\alpha_i$




*Notes:* $r_i\left(u_i, u_i^{br}, u_i^b\right)$ is given by (2). $\sigma_j(x) = 1/121$ for every $x \in \{80, 81, \ldots, 200\}$. In knife-edge cases where there are two best-responses, the lowest one is reported.

### 3.2 The stag hunt game

Figure 2 presents a stag hunt game with normalized payoffs, where $\Lambda, \lambda > 0$.

[18] Also, the best-response is increasing in $\alpha_i$ (for $\beta_i$ high enough) and decreasing in $b$.

**Figure 2:** A normalized stag hunt game

**(a)** Baseline/monetary payoffs

| | stag | hare |
|---|---|---|
| stag | 1,1 | $-\lambda$,$1-\Lambda$ |
| hare | $1-\Lambda, -\lambda$ | 0,0 |

**(b)** row player modified payoffs

| | stag | hare |
|---|---|---|
| stag | 1 | $-(\lambda+\alpha_1 \max\{\lambda-\beta_1(1+\lambda),0\})$ |
| hare | $1-(1+\alpha_1)\Lambda+\alpha_1\beta_1\max\{\Lambda-1,0\}$ | 0 |

The robustness of stag to strategic uncertainty is commonly measured by the maximum probability with which player $j$ can play hare with stag still being a best-response for player $i$. This probability is called the size of the basin of attraction of stag; denote it by $\text{BAS}_i$ (e.g., see Dal Bó et al., 2021). Under standard or single-agent regret preferences (i.e., $\alpha_i\beta_i = 0$), $\text{BAS}_i = \Lambda/(\lambda+\Lambda)$. Under strategic regret, $\text{BAS}_i$ is player-specific (due to $\alpha_i$ and $\beta_i$) and behaves as described in Claim 2.

**Claim 2.** The size of the basin of attraction of stag for player $i$, $\text{BAS}_i$, is (i) decreasing in $\lambda$ and increasing in $\Lambda$, (ii) increasing in $\alpha_i$ provided $\beta_i > 0$, and (iii) increasing in $\beta_i$ for $\beta_i \in [0, \lambda/(1+\lambda)]$ and constant in $\beta_i$ for $\beta_i \in [\lambda/(1+\lambda),1]$ provided $\alpha_i > 0$ and $\Lambda \leq 1$.[19]

Part (i) shows that the comparative statics of $\text{BAS}_i$ with respect to $\lambda$ and $\Lambda$ follow the same intuition as they do under baseline payoffs. Part (ii) shows that, while both hare and stag can cause regret (when the other player chooses stag and hare, respectively), the former type of regret dominates, which makes $\text{BAS}_i$ increasing in $\alpha_i$.

Part (iii) is our main focus. When player $i$ chooses stag and $j$ chooses hare, the former can blame the latter. Particularly, for $\Lambda \leq 1$, this is the only case where $i$ can blame $j$. Thus, for $\Lambda \leq 1$, the attractiveness of stag to player $i$ is increasing in the propensity to blame, $\beta_i$. In other words, the higher $\beta_i$ is, the less confident player $i$ needs to be that player $j$ will play stag for $i$ to also want to play stag. In the experiment, we will look at stag hunt games where hare is a safe option (i.e., $\Lambda = 1$), so participants with stronger tendency to blame are expected to play stag with higher frequency.

### 3.3 Weakly unilaterally competitive games

Although strategic regret affects behavior in the traveler's dilemma and stag hunt game, there are clearly games where it has no bite. One such class of games is weakly unilaterally competitive (WUC) games—a proper superset of strictly competitive games. For our purposes, and slightly more broadly defined than (originally) in Kats and Thisse (1992),

[19]If $\alpha_i > 0$ and $\Lambda > 1$, then $\text{BAS}_i$ is increasing in $\beta_i$ for $\beta_i \in [0, \lambda/(1+\lambda)]$ and decreasing in $\beta_i$ for $\beta_i \in [\lambda/(1+\lambda),1]$.

a (two-person) game is WUC if any unilateral change of action by player $i$ that results in a weak increase in $i$'s baseline payoff causes a weak decline in the baseline payoff of the other player.

**Definition 2.** A game is weakly unilaterally competitive (WUC) if for every player $i \in N$, every $s_i, s'_i \in S_i$, and every $s_j \in S_j$, $j \neq i$, if $u_i(s'_i, s_j) \geq u_i(s_i, s_j)$, then $u_j(s'_i, s_j) \leq u_j(s_i, s_j)$.

**Remark.** The dictator game, prisoner's dilemma, and public goods game—with payoffs increasing in (and only dependent on) monetary payoffs—are WUC.[20]

In a WUC game, there is no outcome where a player can blame another for not playing a Pareto-improving best-response, since such a best-response never exists. Therefore, every player $i$'s modified payoffs are independent of $\beta_i$. Particularly, modified payoffs under strategic regret are equal to those under single-agent regret, so best-response correspondences coincide with those under single-agent regret, which, as we have seen, always coincide with those under baseline payoffs.[21] Proposition 1 makes this simple observation.

**Proposition 1.** Consider any weakly unilaterally competitive game. For any player $i \in N$ and any action profile $s \in S$, $m_i(s)$ is constant in $\beta_i$, and thus, $\arg\max_{s_i} m_i(s_i, \sigma_j) = \arg\max_{s_i} u_i(s_i, \sigma_j)$ for every $\sigma_j \in \Delta(S_j)$.

This observation—that the tendency to blame plays no role in games with extreme conflict of interest—is particularly insightful when viewed against the analysis of the traveler's dilemma and the stag hunt game. In these games, there is (partial) alignment of interests and strategic regret *does* make a difference. In the traveler's dilemma, if we fix player $i$'s number, then both $i$ and $j$ prefer (in baseline payoff terms) that $j$ undercut $i$ by exactly one rather than by more than one. Similarly, in the stag hunt game, given that player $i$ plays stag, both $i$ and $j$ prefer that $j$ also play stag.

## 4 Experimental evidence on regret and blame in games

This section experimentally tests the strategic regret assumption (i.e., that blame assigned to the other player for not playing a mutually beneficial best-response mitigates regret) and the ensuing predictions.

[20] See section 4 for descriptions of (specific instances of) these games.

[21] Here we focus on two-player games, but the result still applies when the model is extended to $n$-player games as described in Appendix A.4. An $n$-player game is WUC if any unilateral change of action by a player $i$ that results in a weak increase in $i$'s baseline payoff causes a weak decline in the baseline payoff of every other player.

### 4.1 Experimental design

The sample consists of 254 participants (invited by email) from the subject pool of the Center for Experimental Social Science (CESS) at New York University.[22] Participants earned on average $22.2. The experiment was programmed in z-Tree (Fischbacher, 2007) and lasted approximately 90 minutes.[23] The experimental procedure is documented in detail in Appendices C and D; here I describe it briefly.

#### 4.1.1 Description of survey-type questions

Each subject was asked to describe their thoughts and emotions after having hypothetically played each game of those presented in Figure 3 by indicating their level of agreement to the statements presented in Table 1 using a Likert scale from 1 ("Not at all") to 7 ("Totally agree"). These questions comprise the Regret and Blame Scale (RBS), adapted to the strategic context from the Regret and Disappointment Scale (RDS) of Marcatto and Ferrante (2008), which was designed for individual decision-making. The RDS was modified so that disappointment with the turn of events beyond the subject's control is replaced by blame on the other player for her action.

**Table 1:** Composition of the Regret and Blame Scale (RBS)

| Question item | Response variable name |
|---|---|
| 1. I am sorry about what happened to me. | affective reaction |
| 2. I wish I had made a different choice. | regret |
| 3. I wish the other player had acted differently. | blame |
| 4. I feel responsible for what happened to me. | internal attribution |
| 5. The other player is the cause of what happened to me. | external attribution |
| 6. I am satisfied about what happened to me. | control |
| 7. Things would have gone better if (a) I had chosen differently, or (b) the other player had chosen differently. | choice between counter-factuals |

Specifically, each participant was asked to answer the RBS questions in each of the following four scenarios scenarios:[24]

(i) as row player, you have played $B$ and the column player has played $L$ in SAR1,

(ii) as row player, you have played $B$ and the column player has played $L$ in STR1,

(iii) as row player, you have played $T$ and the column player has played $L$ in SAR2,

(iv) as row player, you have played $T$ and the column player has played $L$ in STR2.

[22]A total of 25 sessions were conducted: 3 sessions with 4 participants each, 1 with 6 participants, 4 with 8 participants, 6 with 10 participants, 7 with 12 participants, 2 with 14 participants, and 2 with 16 participants each.

[23]Treatments 1–4 lasted approximately 90 minutes, while treatment 5 lasted approximately 105 minutes.

[24]In treatment 5 (see Table 2), only scenarios (ii) and (iv) were presented.

SAR is a mnemonic for single-agent regret, while STR for strategic regret. Game SAR1 (resp. SAR2) is the same as STR1 (resp. STR2) except for the column player's payoffs for outcomes ($B$,$M$) and ($B$,$R$) (resp. ($T$,$M$) and ($T$,$R$)). Given the hypothesized outcomes, in games SAR1 and SAR2 the column player does not have a best-response to the row player's action that also increases the row player's payoff, while in STR1 and STR2 she does.

Therefore, responses in the SAR items will function as a baseline and be compared to responses to STR items. According to strategic regret, participants should (in the scenarios described above) blame more the other player and regret less themselves in the STR games than in the corresponding SAR ones. The participants' regret and blame are measured by items 2 through 5 and 7. Item 1 measures the affective reaction of the subject, while item 6 is a control item. The answers to these two items should be negatively correlated.

**Figure 3:** Games in reference to which subjects answer the RBS items

**(a)** Game SAR1

| | $L$ | $M$ | $R$ |
|---|---|---|---|
| $T$ | 5,5 | 30,10 | 20,15 |
| $C$ | 0,15 | 10,10 | 50,5 |
| $B$ | 0,20 | 25,**15** | 40,**10** |

**(b)** Game SAR2

| | $L$ | $M$ | $R$ |
|---|---|---|---|
| $T$ | 10,15 | 25,**10** | 25,**10** |
| $C$ | 15,20 | 5,15 | 20,10 |
| $B$ | 15,10 | 20,15 | 10,20 |

**(c)** Game STR1

| | $L$ | $M$ | $R$ |
|---|---|---|---|
| $T$ | 5,5 | 30,10 | 20,15 |
| $C$ | 0,15 | 10,10 | 50,5 |
| $B$ | 0,20 | 25,**50** | 40,**40** |

**(d)** Game STR2

| | $L$ | $M$ | $R$ |
|---|---|---|---|
| $T$ | 10,15 | 25,**30** | 25,**30** |
| $C$ | 15,20 | 5,15 | 20,10 |
| $B$ | 15,10 | 20,15 | 10,20 |

*Notes:* the differences between SAR1 (resp. SAR2) and STR1 (resp. STR2) are in bold.

**Discussion of the RBS survey.** The RBS survey was not conducted with respect to the games that participants actually played for the following reasons. If it had been conducted on those games *before* the participants played the games, then the survey could have affected participant behavior in those games (e.g., by inducing them to think about the games in terms of regret and blame). This could artificially enhance the predictive power of survey responses over incentivized behavior. If, on the other hand, the survey was conducted on those games *after* the participants played the games, then the responses could reflect a combination of both realized and anticipated regret and blame, depending on how close the hypothetical outcome in the survey would have been to the realized outcome of each subject. Particularly, each subject's survey responses would depend on her specific experience playing the games, which would make survey responses incomparable across subjects. Last, any predictive power of survey responses over incentivized play will act as stronger evidence in favor of strategic regret if the survey responses refer to different games than those that participants played. Such cross-game predictive power will show that each individual's attitudes towards regret and blame—rather than features of each specific game—shape her behavior across a range of strategic environments, as suggested by strategic regret.

But—apart from being different from the games that participants played—what properties should the games used in the survey satisfy? First, they should be simple (e.g., have small action spaces) so that participants can more easily analyze them. This should limit the noise in survey responses. Second, no action should be (strictly) dominated, especially not those actions that are played in the hypothetical outcomes of the games. This ensures that the hypothetical scenarios that the participants were asked to consider are realistic. Third, for each game that does not allow for blame (e.g., SAR1), there should be a comparable game that does allow for it where the original game does not (e.g., like STR1 is comparable to SAR1). Two $2 \times 2$ games cannot be comparable and at the same time each satisfy the second property. Thus, $3 \times 3$ games are used, as seen in Figure 3.

Still, one may question whether people can accurately predict their emotions even in those simplest possible games.[25] However, what matters is *anticipated regret*. Thus, it is important that subjects not make any systematic errors (i.e., that depend on the game at hand) in reporting their regret anticipation.[26] Even if one is reluctant to believe that participants accurately predict emotional states, or even that they submit their true anticipated regret, it is hard to imagine why there could be systematic errors in the reporting of regret anticipation. Also, the results of section 4.2.2 on the predictive power of survey responses over incentivized play showcase the informativeness of the RBS survey.

#### 4.1.2 Experiment timeline and treatments

In treatment 1, subjects first completed the RBS survey with respect to SAR1 and SAR2. Then, they played 8 rounds of the traveler's dilemma (with the bonus/penalty parameter $b$ taking a different value in each round). Next, they played 8 rounds of the stag hung game with a safe option presented in Figure 4 with the cost $c$ of playing stag taking a different value in each round. Then, they played the Kreps game (Kreps, 1989; Goeree and Holt, 2001).[27] Finally, they completed the RBS survey with respect to STR1 and

[25] Indeed, there is evidence that people often fail to forecast future emotional states (e.g., see Gilbert et al., 1998).

[26] For example, they do not over-report their anticipated regret (compared to their true regret anticipation, *not* compared to actual regret that would be realized in the hypothetical scenarios) in STR games, while under-reporting it in SAR games.

[27] The analysis of the Kreps game is based on equilibrium predictions, which are not the main focus of the paper. Therefore, the experimental results on the Kreps game are discussed in Appendix A.3, after equilibrium predictions have been studied.

STR2.[28]

**Figure 4:** A stag hunt game with a safe option

| | stag | hare |
|---|---|---|
| stag | $200 - c$,$200 - c$ | $100 - c$,100 |
| hare | 100,$100 - c$ | 100,100 |

In treatment 2, participants first played the traveler's dilemma, then the stag hunt game, then completed the survey with respect to SAR1 and SAR2, then played the Kreps game, and finally completed the survey with respect to STR1 and STR2. This will allow us to test for order effects (e.g., whether the survey affected behavior in the games by priming subjects into thinking about regret and blame). The analysis in Appendix B.5 finds no evidence of order effects.

Treatments 3 and 4 were identical to treatment 1 except for the fact that instead of the stag hunt game, participants played the two- and four-player volunteer's dilemma of Diekmann (1985), respectively. A discussion of the volunteer's dilemma results requires a more general model of strategic regret and is thus relegated to Appendix A.5. The results show no predictive power of the propensity to blame over the likelihood to volunteer, although our simple model of strategic regret would predict those with higher tendency to blame to be less willing to volunteer. However, the confidence intervals are not tight. Also, Appendix A.6 presents a generalized model of strategic regret that explains the volunteer's dilemma results.

In treatment 5, participants first completed the RBS survey with respect to STR1 and STR2. Then, they responded to a dictator game survey (i.e., unincentivized play).[29] In the dictator game, each participant decided how to (hypothetically) divide 200 tokens between herself and another participant, where a token has a different value to each of the two participants (which changed from round to round). Next, they played 8 rounds of the traveler's dilemma, 8 rounds of the stag hunt game, and 8 rounds of a (two-player) public goods game. In the public goods game, each of two participants chose how many points to keep from an endowment of 200 points; the remaining points went to the group account. The points that the two players (simultaneously) put in the group account were multiplied by a factor $k \in (1,2)$ (taking a different value in each round) and then distributed equally

[28]The three games were placed in between the SAR and STR portions of the RBS survey so that participants (i) do not see the similar SAR and STR games too soon one after the other and (ii) do not consecutively answer too many survey-type questions, which could decrease their attention. Also, participants were required to spend at least 3 minutes in each game of Figure 3, reading the hypothetical scenario and responding to the survey in reference to the game.

[29]The dictator game is unincentivized so that (i) every participant can play as the dictator (which produces more data compared to the case where only half played as dictators) and, at the same time, (ii) strategic incentives and behavior are not distorted (e.g., due to reciprocal motivations), as could happen if an interactive protocol or one with role uncertainty was used (e.g., see Grech and Nax, 2020; Grech et al., 2022).

between the two players. Finally, they played 8 rounds of the prisoner's dilemma presented in Figure 5 with the cost $c$ of cooperating taking a different value in each round.

**Figure 5:** A single-parameter prisoner's dilemma

| | cooperate | defect |
|---|---|---|
| cooperate | 200,200 | $100-c$,$200+c$ |
| defect | $200+c$,$100-c$ | 100,100 |

Table 2 summarizes the different treatments.[30] In all treatments, there was random rematching without feedback between the rounds of each game. Participants were rewarded points for one randomly chosen round of each of the incentivized games in each treatment.[31] After they finished playing all the rounds of a game, participants saw (i) their own action in each round, (ii) the action of the participant that they were matched with in each round, (iii) which round was randomly selected for payment, and (iv) the points that they earned.[32]

**Table 2:** Summary of treatments

| | Treatment | Participants | Sessions |
|---|---|---|---|
| 1) | RBS SAR → TD → SH → KG → RBS STR | 52 | 6 |
| 2) | TD → SH → RBS SAR → KG → RBS STR | 48 | 5 |
| 3) | RBS SAR → TD → VD2 → KG → RBS STR | 50 | 5 |
| 4) | RBS SAR → TD → VD4 → KG → RBS STR | 52 | 4 |
| 5) | RBS STR → DG → TD → SH → PG → PD | 52 | 5 |

*Notes:* TD, SH, KG, DG, PG, and PD stand for the traveler's dilemma, stag hunt game, Kreps game, dictator game, public goods game, and prisoner's dilemma, respectively. VD2 and VD4 stand for the two- and four-player volunteer's dilemma, respectively.

## 4.2 Hypotheses and results

### 4.2.1 Testing the strategic regret assumption

First, we will test whether the availability to the column player of a Pareto-improving best-response makes the row player blame the column player more and regret less.[33]

[30] Subjects from the first four treatments of Table 2 were later invited to also participate in sections DG, PG, and PD of treatment 5. 22 participants returned for the additional sections.

[31] In treatments 1–4, there were three incentivized games, while in treatment 5, there were four.

[32] The feedback was placed at the end of all rounds of each game so that it came as soon as possible after the participants' decisions (since delayed feedback may alleviate regret), while not allowing for learning between the rounds of the game. Also, there were no practice rounds.

[33] Namely, it will be tested whether: (i) the responses to the regret and internal attribution items are on average lower for STR1 (resp. STR2) than for SAR1 (resp. SAR2), (ii) the responses to the blame and external attribution items are on average higher for STR1 (resp. STR2) than for SAR1 (resp. SAR2), (iii) the percentage of subjects that choose (a) in the counterfactual choice question is lower for STR1 (resp. STR2) than for SAR1 (resp. SAR2), and (iv) the responses to the regret and internal attribution items

**Hypothesis 1.** Participants regret less and blame more (as measured by their RBS survey responses) in STR games than in SAR games. Also, within each game, participants who blame more regret less (see section 2).

Figure 6 presents the participants' average responses for items 2 through 5 and 7.[34] All differences are as expected. Participants blame more and regret less in a game where according to the theory there is room for blame to mitigate regret (i.e., STR1 and STR2) than in a game where there is no room for blame (i.e., SAR1 and SAR2, respectively). At the same time, Figure 7 shows that within each game, the responses to the blame and external attribution items are negatively correlated with the responses to the regret and internal attribution items—particularly in STR games. This suggests that indeed blame assigned to the other player is the mechanism through which regret is reduced. Overall, there is strong evidence in favor of hypothesis 1.

#### 4.2.2 Testing the strategic regret predictions

While survey responses alone support the strategic regret assumption, we will now see that survey responses can explain incentivized play in games very different from those used in the survey, consistent with the theory. This will lend further support to strategic regret and its predictions in particular. At the same time, the predictive power of survey responses over incentivized behavior will increase confidence in the survey results themselves.

The following index will be used in testing the strategic regret predictions. For each subject $i$, an index of blame intensity is calculated as a single principal component from the subject's ten RBS survey responses to items 2 through 5 and 7 in the two STR games (5 items for each STR game):[35]

$$\text{Blame Index}_i \coloneqq \text{PC}\left(\left\{\begin{matrix}\text{regret}_{iSTRj}, \text{internal attribution}_{iSTRj}\\ \text{blame}_{iSTRj}, \text{external attribution}_{iSTRj},\\ \text{choice between counterfactuals}_{iSTRj}\end{matrix}\right\}_{j=1,2}\right).$$

A high index means that the participant blames more and regrets less.

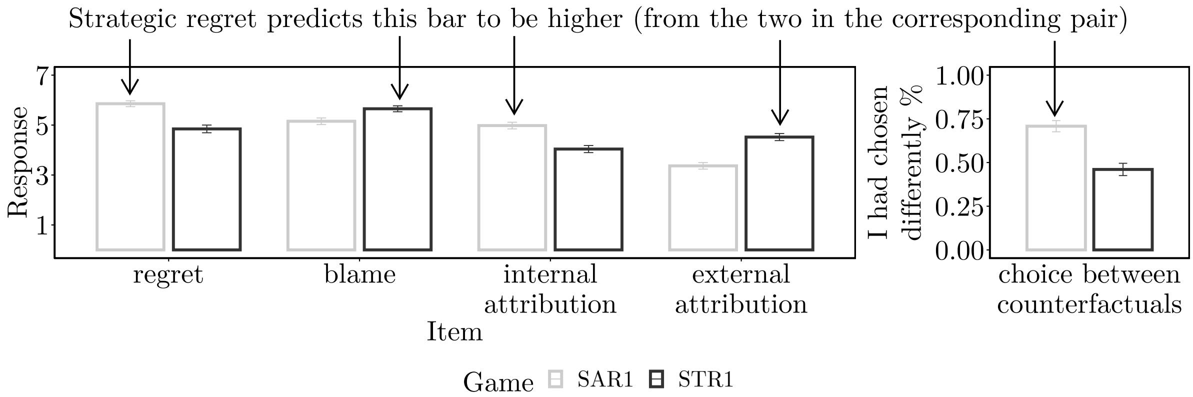
are negatively correlated (at a subject level) with the responses to the blame and internal attribution items—particularly in STR games. Points (i)–(iii) are based on aggregate data, while (iv) tests whether blame mitigates regret at a subject level.

[34]In Figure 6, only data from treatments 1–4 are used, where participants completed the RBS survey with respect to both the SAR and the STR games. Appendix B studies the affective reaction and control item responses. The two are negatively correlated, as expected.

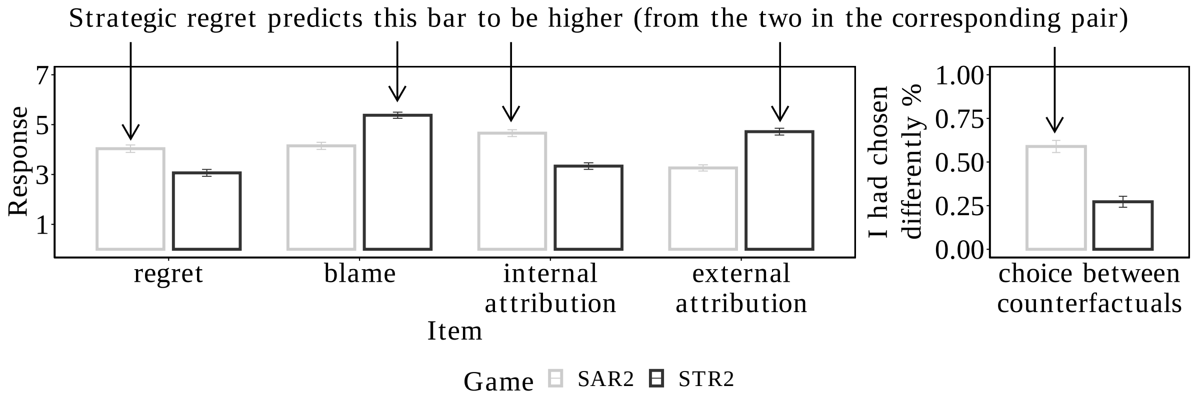
[35]choice between counterfactuals$_{iSTRj} = 1$ (resp. $= 0$) corresponds to the response "(a) I had chosen differently" (resp. "(b) the other player had chosen differently"). All the loadings in the principal components have the expected sign (see Table 9 in Appendix B.2). That is, the blame and external attribution items (resp. regret, internal attribution, and choice between counterfactuals) have positive (resp. negative) loadings. This serves as indirect evidence that blame indeed mitigates regret, as shown already.

**Figure 6:** RBS results: regret and blame in SAR versus STR games

**(a)** SAR1 versus STR1



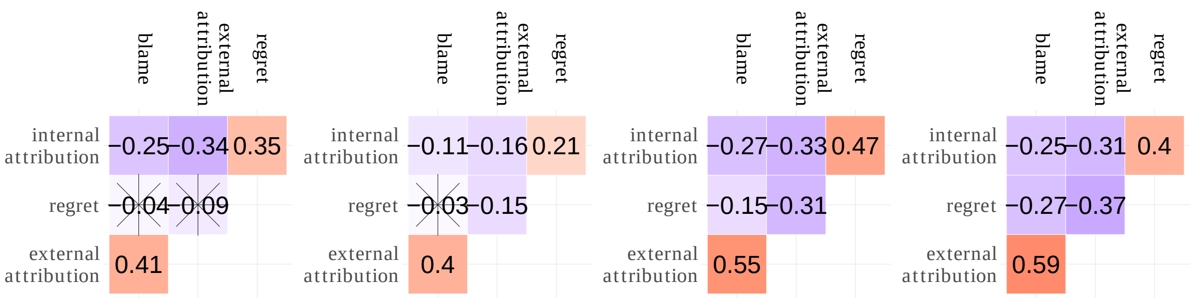

**(b)** SAR2 versus STR2




*Notes:* $N = 202$. Bars of mean responses with standard error intervals. The panels on the right show the percentage of subjects that chose (a) "I had chosen differently" in the choice between counterfactuals item. All differences are statistically significant at the 0.1% level based on (i) Wilcoxon signed-rank one-sided tests (Pratt's (1959) method of dealing with ties is used) for the items in the left panels and (ii) Fay and Lumbard (2021) one-sided tests for the right panels. The latter is a test on the sign of differences in paired responses; with binary responses, the two-sided version of the test is equivalent to McNemar's test.

**Figure 7:** Kendall's $\tau_b$ correlation coefficients between RBS survey responses

**(a)** SAR1 **(b)** SAR2 **(c)** STR1 **(d)** STR2




*Notes:* panels (a) and (b): $N = 202$, panels (c) and (d): $N = 254$. Red (resp. blue) denotes a positive (resp. negative) correlation. Crossed-out coefficients are not significant at the 5% level based on a two-sided test under the asymptotic $t$ approximation (with a continuity correction).

Hypotheses 2 and 3 refer to the predictive power of RBS survey responses over incentivized behavior in games. According to strategic regret, participants with stronger tendency to blame the other player (and thus, regret less) should choose higher numbers in the traveler's dilemma and play stag more frequently.

**Hypothesis 2.** Participants with higher Blame Index choose higher numbers in the traveler's dilemma (see section 3.1).

**Hypothesis 3.** Participants with higher Blame Index are more likely to play stag in the stag hunt game (see section 3.2).

Figure 8a and Table 3a show that indeed participants with higher than median Blame Index choose numbers that are on average larger by around 15 compared to the numbers chosen by participants with low Blame Index.[36] The differences are statistically significant across the whole range of values for the bonus/penalty parameter $b$. Similarly, Figure 8b and Table 3b show that—for intermediate values of the cost $c$ of stag—subjects with high Blame Index play stag more frequently than subjects with low Blame Index.[37] For such values of $c$, the frequency with which participants with high Blame Index play stag is higher by 20 percentage points than the corresponding frequency for participants with low Blame Index. For extreme values of $c$, behavior is concentrated close to the extremes for both groups. We conclude that hypotheses 2 and 3 are supported by the data. Participants' answers to survey questions about anticipated regret and blame have predictive power over their choices in incentivized play, consistent with strategic regret predictions. This result becomes even more striking if one notices that the games used in the survey are very different from the traveler's dilemma and the stag hunt game.

#### 4.2.3 Strategic regret explains correlation in behavior across games

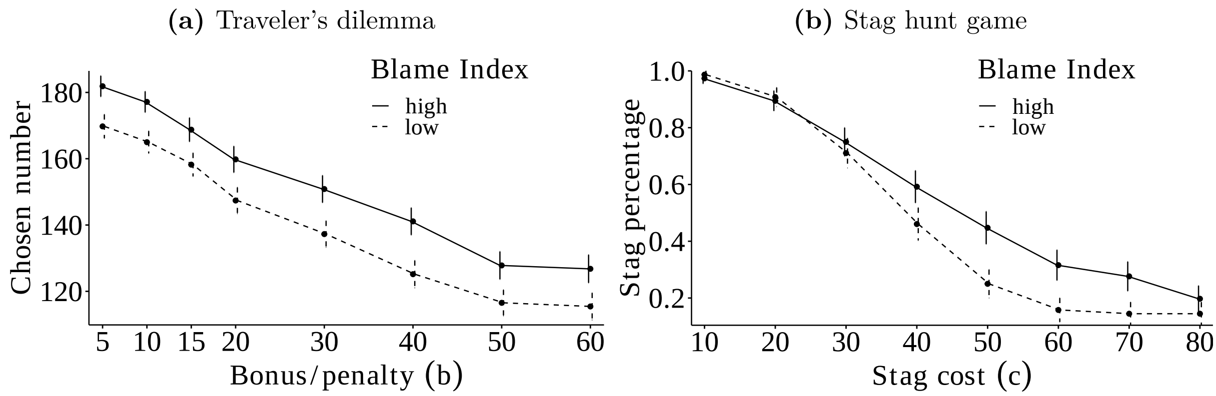
Consistent with strategic regret, I have shown that RBS survey responses predict incentivized play in the traveler's dilemma and the stag hunt game. Even though this should enhance our confidence that the survey responses are meaningful, one may still be skeptical of survey responses and their predictive power as strong evidence in favor of strategic regret. Thus, I also test hypothesis 4, which only uses data on incentivized play, and not survey responses. This hypothesis is an implication of hypotheses 2 and 3 combined.[38]

[36]The median Blame Index was calculated for each game separately to ensure a 50%/50% split. That is, a median Blame Index among the participants who played the traveler's dilemma was calculated for the analysis of that game, and another median was calculated among the participants who played the stag hunt game (which is a subset of those who played the traveler's dilemma).

[37]Boschloo's (exact) test, which is used in Table 3b, is uniformly more powerful than Fisher's exact test and applies to cases where the sample size of each group is fixed (i.e., not random)—as are the sample sizes of the high and low Blame Index groups in our case (due to the 50%/50% split). For completeness, Fisher's exact test $p$-values are reported in Appendix B.3.

[38]Section 4.2.5 presents and tests an additional hypothesis that is derived from strategic regret and does not employ survey responses.

**Figure 8:** Behavior of high versus low Blame Index subjects in incentivized play




*Notes:* panel (a): $N = 254$, panel (b): $N = 152$. The lines represent the mean action for each group of participants with standard error intervals. The group "high" (resp. "low") is the subset of participants whose Blame Index is above (resp. below) the median.

**Table 3:** Behavior of high versus low Blame Index subjects in incentivized play

**(a)** Traveler's dilemma: Wilcoxon-Mann-Whitney one-sided tests ($N = 254$)

| Bonus/penalty ($b$) | 5 | 10 | 15 | 20 | 30 | 40 | 50 | 60 |
|---|---|---|---|---|---|---|---|---|
| $p$-value | 0.004 | 0.001 | 0.005 | 0.009 | 0.011 | 0.004 | 0.038 | 0.031 |

**(b)** Stag hunt game: Boschloo's one-sided tests ($N = 152$)

| Stag cost ($c$) | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 |
|---|---|---|---|---|---|---|---|---|
| $p$-value | 0.854 | 0.662 | 0.309 | 0.058 | 0.006 | 0.014 | 0.027 | 0.233 |

*Notes:* the normal approximation with a continuity correction is used in the Wilcoxon-Mann-Whitney tests.

**Hypothesis 4.** Participants who choose higher numbers in the traveler's dilemma are more likely to play stag in the stag hunt game.

To test hypothesis 4, I estimate a logistic regression of the stag hunt action on a constant and the number chosen in the traveler's dilemma for each combination of stag cost $c$ and bonus/penalty $b$ for a total of $8 \times 8 = 64$ regressions.[39] That is, I estimate $Prob(stag|c) = 1/[1+e^{-(\gamma_{c,b}+\delta_{c,b}\text{TDnum}_b)}]$, where $Prob(stag|c)$ is the probability that stag is chosen when the stag cost is $c$ and $\text{TDnum}_b$ is the number chosen in the traveler's dilemma when the bonus/penalty is $b$. This gives estimates $\widehat{\gamma}_{c,b}$ and $\widehat{\delta}_{c,b}$ for each combination of $c$ and $b$.

In 53 out of the 64 regressions $\widehat{\delta}_{c,b}$ is positive. In 35 (resp. 31) it is positive and significant at the 10% (resp. 5%) level. At the same time, in no regression is $\widehat{\delta}_{c,b}$

[39]Table 11 in Appendix B.4 presents a test of the hypothesis using non-parametric methods. The results are robust.

negative and significant at the 10% level. Particularly, Table 4 shows that the coefficients are negative and/or insignificant mostly for $c$ and/or $b$ low, in which case behavior is concentrated at the extremes of the action space. For $b$ and $c$ not too low, an increase in the number chosen in the traveler's dilemma by 10 implies a 10-20% increase in the odds of stag. We conclude that subjects who choose higher numbers in the traveler's dilemma are more likely to choose stag, consistent with the predictions of strategic regret.

**Table 4:** Logistic regressions of the stag hunt action (stag = 1) on the number chosen in the traveler's dilemma ($N = 152$)

**(a)** $p$-values for $\widehat{\delta}_{c,b}$

| | | Stag cost ($c$) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 |
| Bonus/ penalty ($b$) | 5 | 0.49 | 0.22 | 0.59 | 0.63 | 0.13 | 0.72 | 0.78 | 0.81 |
| | 10 | 0.85 | 0.09 | 0.21 | 0.37 | 0 | 0.2 | 0.14 | 0.17 |
| | 15 | 0.29 | 0.41 | 0.08 | 0.11 | 0 | 0.01 | 0.04 | 0.04 |
| | 20 | 0.39 | 0.61 | 0.07 | 0.19 | 0 | 0.03 | 0.04 | 0.05 |
| | 30 | 0.57 | 0.25 | 0.02 | 0.02 | 0 | 0 | 0 | 0 |
| | 40 | 0.3 | 0.44 | 0.03 | 0.03 | 0 | 0 | 0 | 0 |
| | 50 | 0.22 | 0.51 | 0.03 | 0.02 | 0 | 0.01 | 0 | 0 |
| | 60 | 0.24 | 0.85 | 0.12 | 0.03 | 0 | 0.01 | 0 | 0 |

**(b)** Odds ratios for an increase in $\text{TDnum}_b$ by 10

| | | Stag cost ($c$) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 |
| Bonus/ penalty ($b$) | 5 | 1.09 | 1.08 | 1.02 | 0.98 | 1.08 | 0.98 | 0.99 | 0.99 |
| | 10 | 0.97 | 1.12 | 1.06 | 1.04 | 1.21 | 1.08 | 1.1 | 1.1 |
| | 15 | 0.57 | 1.05 | 1.08 | 1.07 | 1.19 | 1.14 | 1.12 | 1.13 |
| | 20 | 0.87 | 1.03 | 1.07 | 1.05 | 1.17 | 1.1 | 1.1 | 1.11 |
| | 30 | 0.93 | 1.07 | 1.1 | 1.09 | 1.19 | 1.14 | 1.14 | 1.18 |
| | 40 | 0.87 | 1.05 | 1.1 | 1.08 | 1.17 | 1.14 | 1.15 | 1.17 |
| | 50 | 0.86 | 1.04 | 1.09 | 1.08 | 1.16 | 1.11 | 1.13 | 1.17 |
| | 60 | 0.87 | 1.01 | 1.06 | 1.07 | 1.17 | 1.11 | 1.14 | 1.15 |

#### 4.2.4 Accounting for alternative explanations

Nevertheless, the observed relationship between a participant's behavior in the traveler's dilemma and her choices in the stag hunt game could also be due to other-regarding preferences. If, instead of using strategic regret, we let modified payoffs be given by $m_i(s) = u_i(s) + \gamma_i u_j(s)$ for some $\gamma_i \geq 0$, then a higher $\gamma_i$ makes stag more attractive and at the same time induces $i$ to choose a higher number in the traveler's dilemma.

The predictive power of survey responses over incentivized behavior indicates that the mitigating effect of blame on regret is (at least partly) the mechanism behind this relationship. However, since the survey measures the regret-mitigating blame that a participant would assign to another for not playing a *Pareto-improving* best-response—which implies that one takes into account both players' payoffs, survey responses may correlate with other-regarding preferences. Particularly, participants with stronger tendency to blame may also assign a greater weight $\gamma_i$ to another person's payoff. In that case, the evidence in favor of hypotheses 2 and 3 could be partly attributed to other-regarding preferences.

We will test this alternative explanation in the following way. As we have seen in section 3.3, the propensity to blame should not predict behavior in the dictator game, prisoner's dilemma, or public goods game. On the other hand, other-regarding preferences can play a significant role in these games. Particularly, people with higher $\gamma_i$'s should (i) give more in the dictator game, (ii) be more willing to cooperate in the prisoner's dilemma, and (iii) contribute more in the public goods game. Therefore, using these three games we can conduct the following placebo tests.

**Hypothesis 5.** Participants with higher Blame Index do *not* contribute more in the public goods game (see section 3.3).

**Hypothesis 6.** Participants with higher Blame Index are *not* more likely to cooperate in the prisoner's dilemma (see section 3.3).

**Hypothesis 7.** Participants with higher Blame Index do *not* give more in the dictator game (see section 3.3).

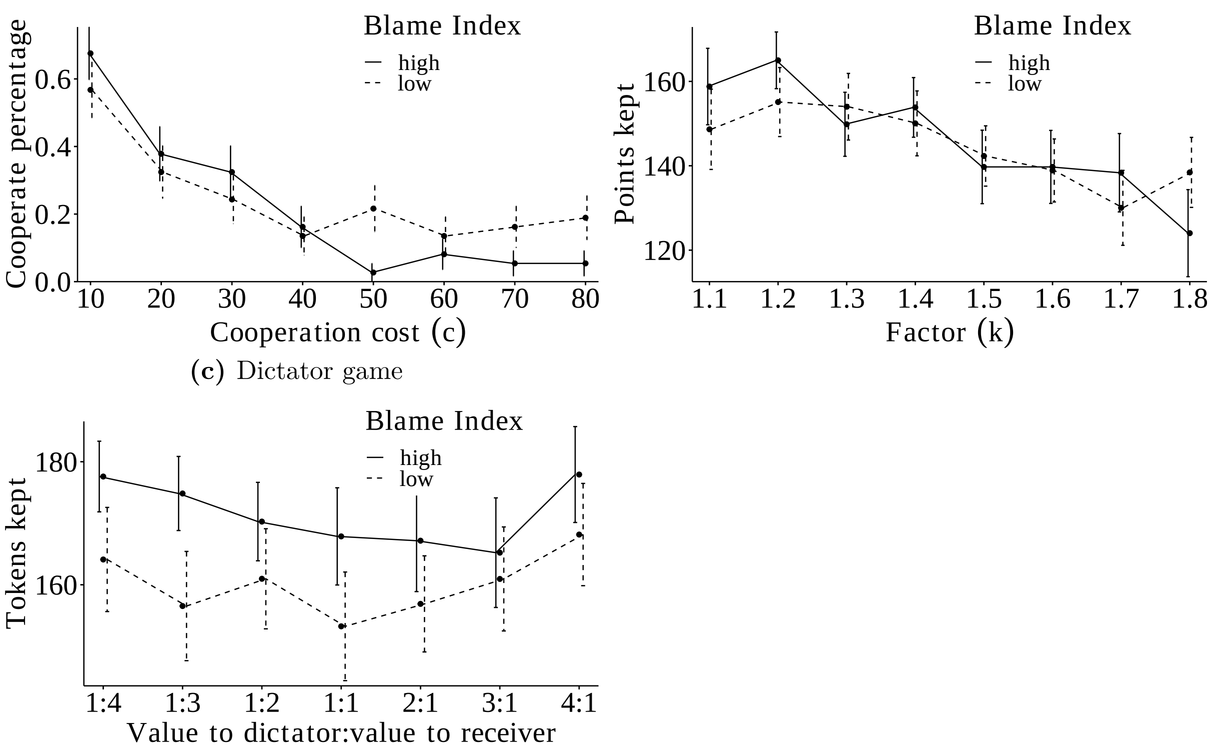
Indeed, Figure 9 and Table 5 show that survey responses have minimal predictive power over behavior in these games. In the prisoner's dilemma, participants with stronger tendency to blame are more likely to cooperate for low levels of the cooperation cost, $c$, which is consistent with the other-regarding preferences explanation. However, the differences are small and statistically insignificant. Also, for higher levels of $c$, the difference is reversed—contrary to the other-regarding preferences explanation—and is somewhat significant. In the public goods game, the propensity to blame has no predictive ability. Last, in the dictator game, participants with stronger tendency to blame keep a larger share for themselves, contrary to the other-regarding preferences explanation. Also, the differences are not statistically significant.[40]

#### 4.2.5 An alternative test based on existing experimental evidence

This section presents additional (existing) experimental results in favor of strategic regret that (i) do not employ survey responses and (ii) cannot be explained by other-regarding preferences.

[40]The evidence on these three games also rules out the alternative explanation that the results are driven by the participants' (heterogeneous) sense of moral obligation to "do the right thing." If the Blame Index measured this sense of moral obligation, then we would expect those with higher Blame Index to (i) give more in the dictator game, (ii) be more willing to cooperate in the prisoner's dilemma, and (iii) contribute more in the public goods game.

**Figure 9:** Behavior of high versus low Blame Index subjects




(a) Prisoner's dilemma

(b) Public goods game

(c) Dictator game

*Notes:* $N = 74$. The lines represent the mean action for each group of participants with standard error intervals. The group "high" (resp. "low") is the subset of participants whose Blame Index is above (resp. below) the median. In the dictator game, 1:4 means, for example, that one token is worth 1 monetary unit to the dictator but 4 points to the receiver.

Our analysis so far suggests that the way people experience regret in games differs from how they experience it in single-agent settings. An alternative test of strategic regret will check exactly that: whether participant behavior differs between a game and a comparable individual decision-making problem, as predicted by strategic regret.[41]

Consider the following "single-agent" (i.e., non-strategic) version of the stag hunt game presented in Figure 2 of section 3.2. Player 1 chooses between stag and hare as in the standard game. However, player 2 is passive; instead of choosing an action himself, nature chooses his action for him (and this is common knowledge). Namely, the computer chooses hare or stag with some exogenous probability. Denote by $\text{BAS}_1^{\text{STR}}$ the size of the basin of attraction of stag for player 1 in the stag hunt game as calculated in Claim 2, and by $\text{BAS}_1^{\text{SA}}$ its corresponding value in the single-agent version (i.e., its value for $\beta_1 = 0$, since player 1 cannot blame nature).[42] The following is an immediate corollary of Claim 2.

**Claim 3.** Let $\Lambda \leq 1$. Then, $\text{BAS}_1^{\text{STR}}$ is higher than (resp. equal to) $\text{BAS}_1^{\text{SA}}$ if $\alpha_1\beta_1 > 0$ (resp. if $\alpha_1\beta_1 = 0$).

[41] I thank Séverine Toussaert for suggesting this test of strategic regret.

[42] STR (resp. SA) stands for "strategic" (resp. "single-agent").

**Table 5:** Behavior of high versus low Blame Index subjects in incentivized play

**(a)** Prisoner's dilemma: Boschloo's two-sided tests ($N = 74$)

| Cooperate cost ($c$) | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 |
|---|---|---|---|---|---|---|---|---|
| $p$-value | 0.372 | 0.688 | 0.477 | 0.792 | 0.016 | 0.561 | 0.201 | 0.099 |

**(b)** Public goods game: Wilcoxon-Mann-Whitney two-sided tests ($N = 74$)

| Factor ($k$) | 1.1 | 1.2 | 1.3 | 1.4 | 1.5 | 1.6 | 1.7 | 1.8 |
|---|---|---|---|---|---|---|---|---|
| $p$-value | 0.422 | 0.506 | 0.551 | 0.776 | 0.887 | 0.849 | 0.505 | 0.381 |

**(c)** Dictator game: Wilcoxon-Mann-Whitney two-sided tests ($N = 74$)

| Value to dictator:value to receiver | 1:4 | 1:3 | 1:2 | 1:1 | 2:1 | 3:1 | 4:1 |
|---|---|---|---|---|---|---|---|
| $p$-value | 0.414 | 0.181 | 0.521 | 0.248 | 0.226 | 0.612 | 0.505 |

*Notes:* the normal approximation with a continuity correction is used in the Wilcoxon-Mann-Whitney tests. In the dictator game, 1:4 means, for example, that one token is worth 1 monetary unit to the dictator but 4 points to the receiver.

Claim 3 shows that under strategic regret—but not under single-agent regret or standard assumptions on preferences, people should be more willing to play stag in the stag hunt game than in its single-agent version. Particularly, $\mathrm{BAS}_i^{\mathrm{STR}} > \mathrm{BAS}_i^{\mathrm{SA}}$. Indeed, Bolton et al. (2016) experimentally elicit the size of the basin of attraction of stag in both versions of a stag hunt game with a safe option (i.e., $\Lambda = 1$; also, $\lambda = 3/2$ in their experiment) to find that $\widehat{\mathrm{BAS}}^{\mathrm{STR}} = 0.36$, while $\widehat{\mathrm{BAS}}^{\mathrm{SA}} = 0.25$ on average (across subjects).[43] That is, the maximum probability with which the other player (resp. the computer) can play hare with the participant still willing to play stag is 0.36 (resp. 0.25) on average in the standard game (resp. single-agent version).[44] In other words, "on average," if the other side plays hare with probability between 0.25 and 0.36, then a

[43]Chierchia et al. (2018) also find evidence pointing towards this direction. Bolton et al. (2016) elicit $\widehat{\mathrm{BAS}}^{\mathrm{STR}}$ as follows. First, some participants choose actions in the stag hunt game. Then, other participants (who do not know what proportion $p$ of the first group of subjects have chosen stag) choose an action *conditional* on $p$ (i.e., they report their best-response function). Then, each participant's action is determined based on the actual proportion $p$, each participant is matched to another participant, and payoffs are realized.

The difference in the distributions of $\mathrm{BAS}_i^{\mathrm{STR}}$ and $\mathrm{BAS}_i^{\mathrm{STR}}$ is statistically significant. The magnitude of the difference can easily be explained by strategic regret. For example, $\alpha_1 = 1$ and $\beta_1 = 1/2$ give $\mathrm{BAS}_1^{\mathrm{STR}} = 8/15$. Also, $\mathrm{BAS}_1^{\mathrm{SA}} = 2/5$, so $\mathrm{BAS}_1^{\mathrm{STR}} - \mathrm{BAS}_1^{\mathrm{SA}} = 2/15 \approx 0.13$. Remember that these numbers are derived with baseline payoffs linear in monetary payoffs. Risk aversion can explain the lower estimates of Bolton et al. (2016) in both versions of the game.

[44]A difference in participant beliefs between the probability with which a human plays stag and the probability with which the computer does *cannot* explain this finding. By eliciting BAS, Bolton et al. (2016) elicit each participant's best-response for every possible belief she may hold over the probability with which the other side (human or computer playing on behalf of a human, depending on the treatment) plays hare.

participant's best-response depends on whether the other side is a human or a computer choosing an action on behalf of a human. Namely, the participant prefers to play stag against a human but prefers to play hare against a computer playing on behalf of a human. Overall, strategic regret explains the finding that stag is more robust to strategic uncertainty than to uncertainty stemming from "nature."[45] To the best of my knowledge, no other model (or concrete mechanism) has been proposed that explains this finding.

## 5 Conclusion

Despite its significant role in decision-making, our understanding of regret in strategic interactions is limited. Research on (anticipated) regret in games has so far followed the *single-agent regret* approach, modeling regret as if in a single-agent context with the other players' actions treated as the state of the world. However, as Sugden (1985) notes, the magnitude of an agent's regret can depend not only on a comparison of 'what is' and 'what might have been' but also on the degree to which the agent blames herself for her original decision. Indeed, in this paper, I have argued that in games, because 'what might have been' depends on what *every* player could have done differently, the intensity of regret is influenced by the extent to which a player blames herself and is, therefore, decreasing in the degree to which someone else is responsible. I call this the *strategic regret* approach. Namely, I have posed that blame assigned to another player for not playing—when available—a Pareto-improving (compared to her actual action) best-response mitigates one's own regret.

Experimental evidence lends direct support to both the assumptions and predictions of strategic regret. Survey questions that elicit participants' feelings in certain hypothetical scenarios show that the subjects' regret is indeed mitigated through blame assigned to others for not playing a Pareto-improving best-response. Notably, participants' anticipated regret and blame elicited in certain games have predictive power—consistent with strategic regret predictions—over their choices in vastly different games. Namely, participants who (according to survey responses) tend to more strongly blame the other player (and regret less) choose higher numbers in the traveler's dilemma and are more likely to play stag in the stag hunt game. This implies that although often negatively valenced, blame and the division of responsibility can actually induce people to take socially desirable actions by mitigating those actions' potential to generate regret. Also, strategic regret can explain Bolton et al.'s (2016) finding that people take more risks in a stag hunt game when they

[45]Yet, strategic regret cannot explain the opposite pattern (termed "betrayal aversion") documented in the trust game (e.g., see Bohnet and Zeckhauser, 2004; Bohnet et al., 2008), where participants are less willing to trust when they play against a human compared to when they play against the computer. In that game, in the second player's decision node, there is complete conflict of interest. Thus, the first player can never blame the second for not playing a Pareto-improving best-response (since such a response never exists).

play against another person rather than when a computer chooses the other player's action. Nevertheless, consistent with theoretical predictions, strategic regret does not seem to play a role in games with extreme conflict of interest—particularly, the public goods game, prisoner's dilemma, and dictator game, where no unilateral change in a player's action can cause a Pareto-improvement. This feature differentiates strategic regret from standard other-regarding preferences and has allowed us to experimentally disentangle the two.

I conclude that, when modified to account for blame and the division of responsibility in games, regret offers novel insights into strategic behavior. More generally, the results emphasize that models of individual decision-making may benefit from modifications when applied in games. (Implicit) assumptions that are plausible (or even hardly qualify as assumptions) in single-agent settings (e.g., that the agent does not blame the random state of the world) should be reconsidered in strategic environments.

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# Appendix

## A Extensions and additional results

This section discusses extensions of the model, equilibrium predictions, as well as the results on the Kreps game and the volunteer's dilemma.

### A.1 Equilibrium concepts

Denote by $s_{-i} \in S_{-i} \coloneqq \times_{j \in N \setminus \{i\}} S_j$ an action profile of all players except $i$. Using the baseline and modified payoffs, respectively, we define the following types of equilibria of a game $G$.

**Definition 3.** A Nash equilibrium (NE) with baseline payoffs of a game $G$ is an action profile $\sigma^* \in \Delta$ such that $\sigma_i^* \in \arg\max_{\sigma_i \in \Delta(S_i)} u_i(\sigma_i, \sigma_{-i})$ for every $i \in N$. If the cardinality $|\text{supp}(\sigma_i)| = 1$ for every player $i \in N$, then it is called a pure Nash equilibrium (PNE).

**Definition 4.** A regret equilibrium (RE) of a game $G$ is a Nash equilibrium with modified payoffs; that is, an action profile $\sigma^* \in \Delta$ such that $\sigma_i^* \in \arg\max_{\sigma_i \in \Delta(S_i)} m_i(\sigma_i, \sigma_{-i})$ for every player $i \in N$. If the cardinality $|\text{supp}(\sigma_i^*)| = 1$ for every $i \in N$, then it is called a pure regret equilibrium (PRE).

With attention restricted to static games without chance moves, the RE concept is the same as the one considered in Battigalli et al. (2022). I will call a NE with baseline payoffs simply a NE. Denote by $NE(G)$ and $RE(G)$ the sets of action profiles satisfying definitions 3 and 4 in a game $G$, respectively. The corresponding subsets of pure equilibria are $PNE(G)$ and $PRE(G)$, which Proposition 2 shows to coincide.

**Proposition 2.** For any game $G$, the set of pure NE and the set of pure RE coincide, $PNE(G) = PRE(G)$.

Thus, regret may alter or augment the set of NE by changing the set of mixed—but not pure—equilibria. This is because given belief consistency, (strategic) uncertainty vanishes in pure equilibria. In more detail, notice that by pure best-responding (in baseline payoff terms) a player both maximizes her baseline payoff and has no regret. Thus, each player pure best-responding (in baseline payoff terms) is a PRE. Conversely, a pure action profile not being a PNE means that a player can deviate (to a best-response) to increase her baseline payoff. But deviating to a best-response also induces no regret. Thus, the deviation also increases her modified payoff. Therefore, a pure action profile that is not a PNE is not a PRE either.

But then, can regret alter the set of mixed equilibria, and, if so, when? Proposition 3 states that under single-agent regret, it cannot; in that case, not only the pure but also the mixed NE and RE sets coincide.[46] On the other hand, with strategic regret, the mixed NE and RE can differ.

**Proposition 3.** The following statements hold:

(i) If $\beta_1 = \beta_2 = 0$, then $NE(G) = RE(G)$ for any game $G$.

(ii) However, there exist $(\beta_1,\beta_2) \neq (0,0)$ and game $G$ such that $NE(G) \neq RE(G)$.

### A.2 Strategic regret reconciles experimental results with equilibrium predictions in the traveler's dilemma

Proposition 3 has shown that—unlike single-agent regret—strategic regret *does* alter the (mixed) equilibrium set of some games. However, this change could in principle be in the "wrong" direction. Therefore, we now study whether strategic regret changes equilibrium predictions in a way that brings them closer to existing experimental results.

In the traveler's dilemma, the unique rationalizable outcome under baseline payoffs (and thus, unique NE) is both players choosing the lowest number. Under single-agent regret, this remains not only the unique RE (as implied by Proposition 3) but also the unique rationalizable outcome. For simplicity in numerical simulations, let the players choose numbers in $\{11,12,\ldots,20\}$.

**Claim 4.** Consider the traveler's dilemma with single-agent regret, $\beta_1 = \beta_2 = 0$. The unique RE and unique rationalizable outcome under modified payoffs is (11,11).

However, experimental results show that players in fact choose higher amounts, which decrease with $b$ (e.g., see Capra et al., 1999; Goeree and Holt, 2001).[47] Table 6 presents the number of RE (including the unique NE) for different values of $b$ and regret parameters. As shown already, the only single-agent RE is (11,11). On the other hand, with strategic regret ($\beta_1 = \beta_2 > 0$) apart from the PNE (which by Proposition 2 is also the unique PRE) there are mixed RE where players choose higher amounts. Particularly, given $\alpha$ and $\beta$, there is a threshold such that if the bonus/penalty parameter $b$ is above that threshold, only the PNE survives. The threshold is relaxed as $\alpha$ and/or $\beta$ increase. Strategic regret thus brings theoretical predictions closer to experimental results, which single-agent regret does not.

### A.3 The Kreps game

**Theoretical predictions.** Goeree and Holt (2001) study the game presented in Figure 10a for $\delta = 330$, a game similar to the one presented in Kreps (1989). The game possesses

[46] This is actually true for $n$-player games (studied in section A.4 of the appendix). Part (i) of the proposition replicates the result of Battigalli et al. (2022) for static games without chance moves.

[47] The players' sophistication seems inadequate in explaining these results, as even game theory experts choose high amounts (Becker et al., 2005).

**Table 6:** Number of RE in the traveler's dilemma for various values of $b$ and regret parameters

| | $\alpha$ | $\beta$ | $b$ 1.5 | 2 | 2.5 | 3 | 3.5 | 4 | 4.5 | 5 |
|---|---|---|---|---|---|---|---|---|---|---|
| # of RE | 1 | 0.5 | 73 | 67 | 51 | 1 | 1 | 1 | 1 | 1 |
| | 0.5 | 0.5 | 374 | 121 | 1 | 1 | 1 | 1 | 1 | 1 |
| | 1 | 1 | 138 | 78 | 93 | 31 | 1 | 1 | 1 | 1 |
| | 0.5 | 1 | 441 | 109 | 1 | 1 | 1 | 1 | 1 | 1 |
| | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | 0.5 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

*Notes:* in every row $\alpha_1 = \alpha_2 = \alpha$ and $\beta_1 = \beta_2 = \beta$. The *lrs* algorithm (Avis et al., 2010) is used for equilibrium computation. All RE are symmetric.

three NE: two pure, (T,L) and (B,R), and one where both players randomize; the column one between L and M. However, both in Kreps' (1989) informal experiments and in Goeree and Holt's (2001) incentivized lab experiments, the majority of column players choose N, an action that is not part of any NE, while M is played with very low probability.[48] Claim 5 studies the equilibria of that game under our canonical specification of regret given in (2).

**Figure 10:** The Kreps game

**(a)** Baseline/monetary payoffs

| | $L$ | $M$ | $N$ | $R$ |
|---|---|---|---|---|
| $T$ | 500,350 | 300,345 | 310,$\delta$ | 320,50 |
| $B$ | 300,50 | 310,200 | 330,$\delta$ | 350,340 |

**(b)** Modified payoffs

| | L | M | N | R |
|---|---|---|---|---|
| $T$ | 500,350 | 300,$345 - 5\alpha_2$ | 310,$\delta - (350 - \delta)\alpha_2$ | 320, $50 - 10\alpha_2 \cdot (30 - 29\beta_2)$ |
| $B$ | $300 - 10\alpha_1 \cdot (20 - 5\beta_1)$, $50 - 10\alpha_2 \cdot (29 - 30\beta_2)$ | 310,$200 - 140\alpha_2$ | 330,$\delta - (340 - \delta)\alpha_2$ | 350,340 |

*Notes:* the modified payoffs are given for $\beta_2 \leq 29/30$ and $\beta_1 \geq 1/6$ so that expressions are not too long.

**Claim 5.** Consider the Kreps game with $\delta \in [200, 330]$, $\beta_2 \leq 29/30$, and $\alpha_2 \leq 1$.

(i) There exist two PNE: $(T,L)$ and $(B,R)$.

[48] While N can be seen as a safe action, risk aversion of the column player cannot explain this finding. This is because L needs to be played with positive probability for the row player to be willing to mix. But for L to be a best-response, T needs to be played with extremely high probability for otherwise M is superior. But if T is played with extremely high probability, risk aversion (of the column player) plays a negligible role.

(ii) If $\beta_2 = 0$, there exists a unique mixed RE; in this RE both players mix, the column one between L and M.

(iii) There exists $\delta^*$ such that for $\beta_2 > 0$, if $\delta >$ (resp. $<$) $\delta^*$, then there exists a unique mixed RE; in this RE both players mix, the column one between L and N (resp. L and M), where $\delta^*$ is decreasing in $\beta_2$.

When $\delta > \delta^*$ in the mixed RE, N is played with high probability, as seen in existing experimental results.[49] For example, for $\alpha_2 = 1$ and $\beta_2 = 9/10$, $\delta^* = 308.75$ and $\sigma_2(N) = 71/75$. Thus, strategic—unlike single-agent—regret can explain the high frequency with which N is played in experiments and the low one with which M is played. At the same time, strategic regret offers an intuitive comparative statics prediction. For $\delta$ high enough the safe option N is played in equilibrium (and M is not), while for $\delta$ low, the risky action M is played in the mixed equilibrium. Particularly, the threshold level $\delta^*$ that $\delta$ needs to surpass for N to be played in equilibrium is decreasing in $\beta_2$.[50]

**Experimental results.** Claim 5 gives rise to hypothesis 8, which is indeed supported by the data.[51]

**Hypothesis 8.** The frequency with which *N* (resp. *M*) is played in the Kreps game increases (resp. decreases) with $\delta$.

Table 7 shows the distribution of outcomes in the Kreps game for various values of the parameter $\delta$. As predicted under strategic regret, the frequency with which $N$ is played is increasing in $\delta$. Namely, for $\delta$ high enough, play is concentrated on actions $L$ and $N$ with $N$ played with high probability. For $\delta$ low, play is concentrated on $L$ and $M$. These results are consistent with mixed strategic RE predictions, but not with predictions under single-agent regret or standard assumptions on preferences.

### A.4 A simple extension to $n$-person games

This section presents a simple extension of the model to $n$-person games using the following definition of the blame payoff. Given an action profile $s$, each player $i$ identifies the player $j$ who by individually best-responding to $s_{-j}$ could have increased player $i$'s baseline payoff the most. Then, player $i$ assigns blame to that player as in two-player games.

[49] $\delta^* \equiv 50 + 300[30(1+\alpha_2) - 59\alpha_2\beta_2]/[31(1+\alpha_2) - 60\alpha_2\beta_2]$ and the probability is given by $\sigma_2(N) = [20 + \alpha_1(20 - 5\beta_1)]/[22 + \alpha_1(20 - 5\beta_1 + \max\{2 - 19\beta_1, 0\})]$.

[50] Here is why this happens. Starting from $\beta_2 = 0$ (in which case M is played in the mixed RE), an increase in $\beta_2$ causes the payoff of the column player at (B,L) to increase. This increases the probability with which B has to be played to make the column player indifferent between L and M. But as the probability of $B$ increases, $N$ becomes more attractive compared to M. When $\delta$ passes the threshold $\delta^*$, $N$ is played instead of $M$ in the mixed RE.

[51] Since the experiment already lasts approximately 90 minutes, participants played one-shot games, although equilibrium predictions would be better tested with experienced subjects.

**Table 7:** Distribution of outcomes in the Kreps game

**(a)** $\delta = 250$

| | $L$ | $M$ | $N$ | $R$ |
|---|---|---|---|---|
| $T$ | 34.7% | 36.6% | 7.9% | 3% |
| $B$ | 9.9% | 6.9% | 1% | 0% |

**(b)** $\delta = 270$

| | $L$ | $M$ | $N$ | $R$ |
|---|---|---|---|---|
| $T$ | 24.8% | 26.7% | 25.7% | 4% |
| $B$ | 5% | 7.9% | 5% | 1% |

**(c)** $\delta = 290$

| | $L$ | $M$ | $N$ | $R$ |
|---|---|---|---|---|
| $T$ | 18.8% | 18.8% | 41.6% | 3% |
| $B$ | 4% | 1% | 10.9% | 2% |

**(d)** $\delta = 310$

| | $L$ | $M$ | $N$ | $R$ |
|---|---|---|---|---|
| $T$ | 9.9% | 5% | 51.5% | 3% |
| $B$ | 5.9% | 3% | 20.8% | 1% |

**(e)** $\delta = 330$

| | $L$ | $M$ | $N$ | $R$ |
|---|---|---|---|---|
| $T$ | 8.9% | 0% | 53.5% | 3% |
| $B$ | 4% | 2% | 28.7% | 0% |

**Definition 5.** The blame payoff for player $i$ is $u_i^b(s_i,s_{-i}) \coloneqq \max\{u_i^{ba}(s_i,s_{-i}), u_i(s_i,s_{-i})\}$, where $u_i^{ba}(s_i,s_{-i}) \coloneqq \max_{j \in N \setminus \{i\}}\{\max_{s'_j \in PBR_j(s_{-j})} u_i(s'_j,s_{-j})\}$ is the payoff $i$ would receive if a player "most to blame" had by best-responding increased $i$'s baseline payoff.

A player is "most to blame" if by best-responding, she could have increased player $i$'s baseline payoff the most (compared to any other player individually best-responding).[52] Modified payoffs are then given by (1) and (2). Notice that a player is assumed to blame another for not playing a mutually beneficial best-response, which—when there are more than two players—may not be Pareto-improving (i.e., a third player could be harmed by that best-response). An alternative formulation could have a player assign blame to another only for not playing a Pareto-improving best-response. In the volunteer's dilemma, any mutually beneficial (for two players) best-response is also Pareto-improving. In any case, a careful analysis of regret and blame in $n$-person games is left for future work.

### A.5 The volunteer's dilemma

**Theoretical predictions.** We now use the extension of section A.4 to derive theoretical predictions for the $n$-player volunteer's dilemma, as described in Diekmann (1985). There are $n$ players simultaneously choosing whether to volunteer. If none of the players volunteers, then each receives a baseline payoff normalized to 0. If at least one player volunteers, then (i) any volunteering player receives baseline payoff $\phi_1 > 0$ and (ii) any non-volunteering player receives baseline payoff $\phi_2 > \phi_1$, as she does not incur the cost $c \coloneqq \phi_2 - \phi_1$ of volunteering.

Claim 6 characterizes a player's best-response correspondence.

[52]Notice that there can be multiple players "most to blame."

**Claim 6.** Consider the volunteer's dilemma with regret given by (2) and let $\xi_i$ be the probability with which player $i$ expects at least one other player to volunteer. Then, there exists $\overline{\xi}_i$ such that volunteering is optimal for $i$ if and only if $\xi_i \leq \overline{\xi}_i$, where $\overline{\xi}_i$ is (a) decreasing in $\beta_i$ for $\beta_i \in [0, \phi_1/\phi_2]$ and constant in $\beta_i$ for $\beta_i \in [\phi_1/\phi_2, 1]$ provided $\alpha_i > 0$, and (b) decreasing in $\alpha_i$ provided $\beta_i > 0$.[53]

Similar to $\text{BAS}_i$ in the stag hunt game, $\overline{\xi}_i$ can be interpreted as a measure of the robustness of volunteering to strategic uncertainty. Claim 6 shows that the more a player $i$ tends to blame (i.e., $\beta_i$ high), the less willing she is to volunteer.[54] This is because the only outcome where there is scope for blame is when no player has volunteered. In this case, a player's regret for not volunteering herself is mitigated through blame put on the other player for not volunteering either.

**Experimental results.** We will now use the volunteer's dilemma to show that there are limits to blame.[55] Claim 6 gives rise to hypothesis 9.

**Hypothesis 9.** Participants with higher Blame Index are less likely to volunteer in the volunteer's dilemma.

Hypothesis 9 is not supported. Figure 11 shows no predictive power of the Blame Index over choices in either the two- or the four-player volunteer's dilemma. A natural explanation is the following. The only case where a player $i$ may blame another player $j$ is (in theory) when nobody has volunteered. But in that case, what $j$ could have done differently is exactly what $i$ herself could have done. It makes sense that people do not blame others for not volunteering when they themselves have not volunteered. Put differently, when nobody volunteers, each player has equal responsibility for the bad outcome, and thus, does not blame the others. This intuition is consistent with Çelen et al.'s (2017) finding that in public goods games, a player $i$ tends to blame (i.e., punish) another player $j$ when $j$'s contribution is lower than $i$'s. Section A.6 formalizes this idea.

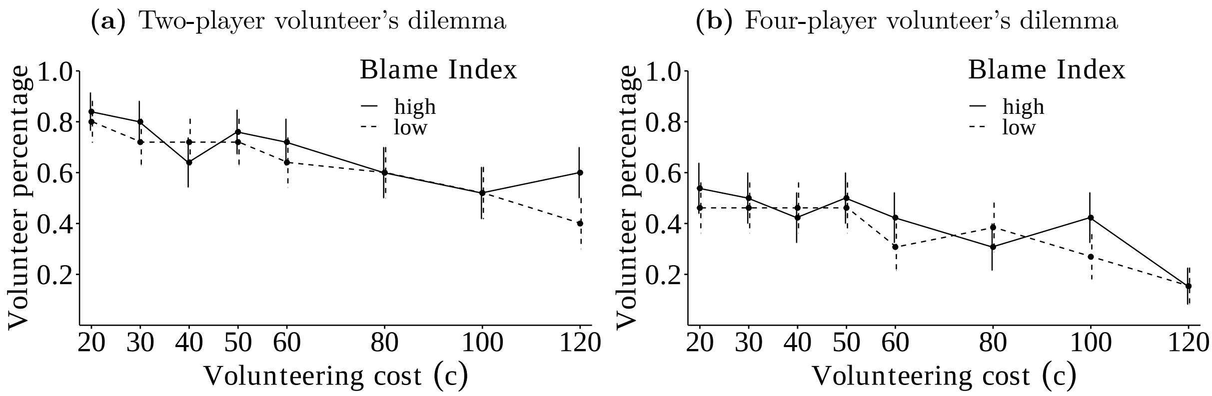
This explanation is also supported by the evidence from the two games where blame *does* have predictive power over incentivized play. In the traveler's dilemma, the cases where player $i$ blames player $j$ is when the former has chosen a number that is higher (by at least 2) compared to the number chosen by $j$. In that case, given $i$'s action, $j$

[53] $\overline{\xi}_i \equiv [1 + (1+\alpha_i)(\phi_2 - \phi_1)/(\phi_1 + \alpha_i \max\{\phi_1 - \beta_i\phi_2, 0\})]^{-1} \in (0,1)$. If $\alpha_i\beta_i = 0$, then $\overline{\xi}_i = \phi_1/\phi_2$.

[54] Also, the attractiveness of volunteering to player $i$ decreases with regret intensity $\alpha_i$. While both volunteering and not volunteering can generate regret (when at least one more player volunteers or no player volunteers, respectively), the former type of regret dominates, which makes $\overline{\xi}_i$ decreasing in $\alpha_i$ (if $\beta_i > 0$). This means that a higher weight $\alpha_i$ on regret tends to induce player $i$ not to volunteer, but only as long as player $i$ has some tendency to blame others. Otherwise, $\alpha_i$ does not play a role.

[55] Participants played the volunteer's dilemma in groups of two or four with $c$ being the cost of volunteering. The payoff if nobody volunteers was 40. The gross payoff if at least one player volunteers was 200.

**Figure 11:** Behavior of high versus low Blame Index subjects in the volunteer's dilemma




*Notes:* panel (a): $N = 50$, panel (b): $N = 52$. The lines represent the percentage of subjects that volunteered in each group of participants with standard error intervals. The group "high" (resp. "low") is the subset of participants whose Blame Index is above (resp. below) the median.

could have acted differently (i.e., best-responded by undercutting $i$ by exactly 1, causing a Pareto improvement) in a way that $i$ could not have, given $j$'s action.

The stag hunt game with a safe option offers even stronger evidence in favor of this explanation, thanks to its similarity to a two-player volunteer's dilemma. Notice that this stag hung game is equivalent to a two-player volunteer's dilemma with only the following difference: *two* volunteers (i.e., players who choose stag)—instead of one—are needed for the benefits of volunteering (i.e., playing stag) to materialize. Then, the only case where player $i$ blames player $j$ is when the former has played stag while the latter has played hare. In that case, given $i$'s action, $j$ could have acted differently (i.e., best-responded by playing stag, causing a Pareto improvement) in a way that $i$ could not have, given $j$'s action.

### A.6 The limits of blame: a simple generalization of strategic regret

This section presents a generalization of strategic regret to reconcile the theory with the evidence on the volunteer's dilemma. Under this generalization, the blame player $i$ assigns to player $j$ (for not playing a Pareto-improving best-response) can be mitigated when $i$ herself could have played a Pareto-improving best-response. For simplicity, restrict attention to two-player games and normalize all baseline payoffs to be positive. The blame payoff for player $i$ is given by

$$u_i^b(s_i,s_j) := u_i(s)\left(1+\max\left\{\frac{u_i^{ba}(s_i)}{u_i(s)}-\max\left\{\gamma_i\frac{u_j^{ba}(s_j)}{u_j(s)},1\right\},0\right\}\right),$$

where for each player $i$, $u_i^{ba}(s_i) \equiv \max_{s'_j\in PBR_j(s_i)} u_i(s_i,s'_j)$ and $\gamma_i \in [0,1]$ measures how strongly blame (assigned by $i$ to $j$) is mitigated when $i$ herself could have played a

Pareto-improving best-response.[56] For $\gamma_i = 0$, this reduces to our standard definition of the blame payoff.

Let $\gamma_i = 1$, assume that action profile $s$ is played and that by best-responding $j$ could have increased $i$'s baseline payoff by percentage $x$. This tends to make $i$ blame $j$. However, if by best-responding $i$ could also have increased $j$'s baseline payoff by percentage $x$ or higher, then $i$ does not blame $j$. This means that for $\gamma_i = 1$, $i$ never blames player $j$ in the volunteer's dilemma, so $i$'s best-response does not depend on $\alpha_i$ or $\beta_i$.

At the same time, theoretical predictions for the traveler's dilemma and the stag hunt game with $\Lambda \leq 1$ remain the same under any parametrization of the generalized model. That is because in these games, in all cases where $i$ can blame $j$ for not playing a Pareto-improving best-response, $i$ does not have a Pareto-improving best-response. Namely, for any action profile $s$ such that $u_i^{ba}(s_i) > u_i(s)$ it holds that $u_j^{ba}(s_j) \leq u_j(s)$. Therefore, blame assigned by $i$ to $j$ is never mitigated regardless of the value of $\gamma_i \in [0,1]$, so the theoretical predictions of section 3 still go through.[57]

# B Additional analyses of experimental data

## B.1 Affective reaction and control item responses

Figure 12 presents the mean responses to the affective reaction and control item of the RBS. These suggest that in all games there is on average a significant (anticipated) emotional reaction to the outcome of the game.

We also verify that responses to the affective reaction item are negatively correlated with those to the control item, as seen in Table 8.

**Table 8:** RBS results: correlation between affective reaction and control item responses

| Correlation coefficient | Game | | | |
|---|---|---|---|---|
| | SAR 1 | SAR2 | STR1 | STR2 |
| Pearson | -0.26 | -0.39 | -0.19 | -0.25 |
| Kendall's $\tau_b$ | -0.25 | -0.28 | -0.24 | -0.18 |

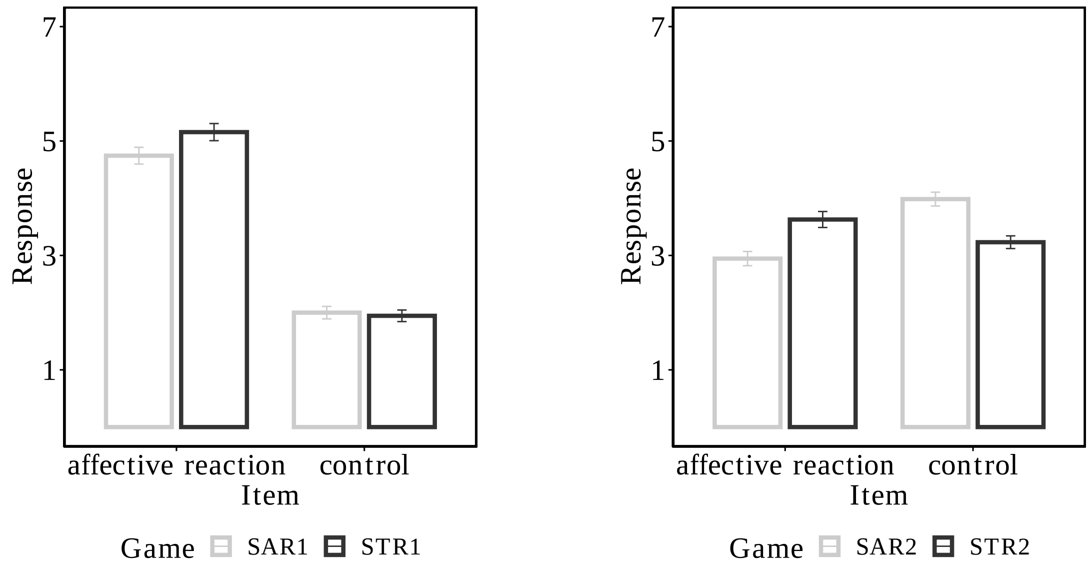
*Notes:* all coefficients are significant at the 1% level based on two-sided tests under the asymptotic $t$ approximation (with a continuity correction).

[56] Notice that because ratios of baseline payoffs are used in the definition of the blame payoff, linear transformations of $j$'s baseline payoffs will not affect $i$'s blame payoff. However, affine transformations will.

[57] This modification of blame has no bite in the hypothetical scenario (described in the survey) for game STR1, but it does play a role in the scenario for game STR2.

**Figure 12:** RBS results: affective reaction and control items

**(a)** SAR1 and STR1 **(b)** SAR2 and STR2




*Notes:* bars of mean responses with standard error intervals.

## B.2 Principal component analysis loadings

Table 9 presents the loadings in the principal component analysis that produced the Blame Index.

**Table 9:** PCA loadings in the Blame Index

| Game | RBS item | | | | |
|---|---|---|---|---|---|
| | regret | blame | internal attribution | external attribution | choice between counterfactuals |
| STR 1 | -0.28 | 0.32 | -0.27 | 0.37 | -0.36 |
| STR 2 | -0.26 | 0.32 | -0.29 | 0.37 | -0.31 |

*Notes:* before the principal component analysis was performed, responses to each of the 20 items were centered and scaled to have zero mean and unit variance.

## B.3 Non-parametric tests on the predictive power of RBS survey responses over behavior in the stag hunt game

Using Fisher's exact test, Table 10 verifies the result of Table 3b that subjects with high Blame Index choose stag more frequently than subjects with low Blame Index.

**Table 10:** Behavior of high versus low Blame Index subjects in the stag hunt game: Fisher's exact one-sided tests

| Stag cost ($c$) | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 |
|---|---|---|---|---|---|---|---|---|
| $p$-value | 0.877 | 0.706 | 0.358 | 0.072 | 0.008 | 0.017 | 0.036 | 0.259 |

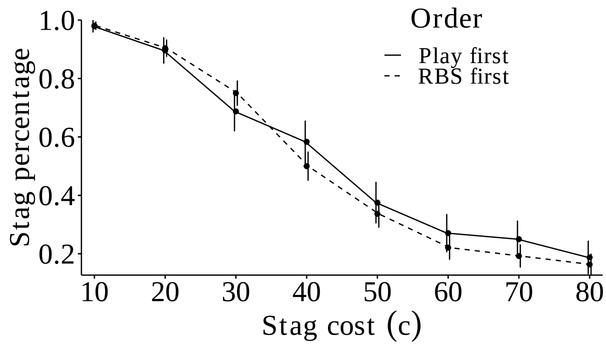
### B.4 Additional tests on the relationship between behavior in the traveler's dilemma and behavior in the stag hunt game

Table 11 shows that the results of Table 4 are robust when we instead use a non-parametric test. Namely, for $b$ and $c$ not too low, participants who played stag in the stag hunt game chose higher numbers in the traveler's dilemma. Table 11 shows that the difference is large: the median number chosen by the former is larger by about 30 to 100 (compared to the median number chosen by the latter) depending on the parameters of the games.

### B.5 Order effects

Table 12 shows that the null hypothesis that no order/priming effects exist for the traveler's dilemma cannot be rejected at the 10% level for any value of $b$. Similarly, Table 13 and Figure 13 show that the null hypothesis that no order/priming effects exist for the stag hunt game cannot be rejected for any value of $c$. Filling in the RBS questionnaire before playing the traveler's dilemma and stag hunt game does not seem to affect behavior.

**Figure 13:** Order effects in the stag hunt game




*Notes:* the percentage of subjects that chose stag with standard error intervals is reported.

**Table 11:** Number chosen in the traveler's dilemma: participants who played stag in the stag hunt game versus participants who played hare

**(a)** Difference in median number chosen (i.e., median number chosen by those who played stag minus the median number chosen by those who played hare)

| | | Stag cost ($c$) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 |
| Bonus/ penalty ($b$) | 5 | 23 | -1 | 0 | -1.5 | 4 | 2 | 1.5 | 0 |
| | 10 | -6 | 24 | 9 | 4.5 | 28 | 9.5 | 11.5 | 10 |
| | 15 | -23 | 20 | 33 | 26.5 | 40 | 30 | 34.5 | 27.5 |
| | 20 | -40 | 1 | 48 | 28.5 | 45 | 30 | 33.5 | 29 |
| | 30 | -42 | 50 | 49 | 49 | 51 | 53 | 55 | 64.5 |
| | 40 | -80 | 30 | 55 | 52.5 | 70 | 61 | 63 | 78.5 |
| | 50 | -105 | 15 | 20 | 39 | 69 | 68.5 | 68.5 | 87 |
| | 60 | -111 | 10 | 20 | 49.5 | 65 | 62.5 | 89.5 | 99.5 |

**(b)** Wilcoxon-Mann-Whitney one-sided $p$-values

| | | Stag cost ($c$) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 |
| Bonus/ penalty ($b$) | 5 | 0.26 | 0.4 | 0.39 | 0.64 | 0.08 | 0.52 | 0.55 | 0.6 |
| | 10 | 0.61 | 0.16 | 0.07 | 0.26 | 0 | 0.04 | 0.03 | 0.04 |
| | 15 | 0.96 | 0.41 | 0.06 | 0.09 | 0 | 0.01 | 0.01 | 0.01 |
| | 20 | 0.89 | 0.24 | 0.03 | 0.09 | 0 | 0.02 | 0.01 | 0.01 |
| | 30 | 0.72 | 0.1 | 0.01 | 0.01 | 0 | 0 | 0 | 0 |
| | 40 | 0.92 | 0.21 | 0.02 | 0.01 | 0 | 0 | 0 | 0 |
| | 50 | 0.87 | 0.18 | 0.01 | 0 | 0 | 0 | 0 | 0 |
| | 60 | 0.89 | 0.32 | 0.05 | 0 | 0 | 0 | 0 | 0 |

*Notes:* $N = 152$. In the Wilcoxon-Mann-Whitney test, the alternative hypothesis is that if we randomly select a participant who played stag and one who played hare, the probability that the former chose a higher number in the traveler's dilemma (than the latter) is higher than the probability that the latter chose a higher number in the traveler's dilemma (than the former).

# C Participant instructions

This section presents the participant instructions. After the instructions were read, the ability of participants to read two-player game matrices was tested before they completed any survey or played any game. Before playing the traveler's dilemma, volunteer's dilemma, stag hunt game, and public goods game, participants answered comprehension questions on how the game works.[58] The instructions for treatment 1 follow:

"Welcome to our experiment!

[58]In all comprehension tests, only after they answered correctly were the subjects allowed to proceed.

**Table 12:** Order effects in the traveler's dilemma: Kolmogorov-Smirnov test $p$-values

| $b$ | | | | | | | |
|---|---|---|---|---|---|---|---|
| 5 | 10 | 15 | 20 | 30 | 40 | 50 | 60 |
| 0.287 | 0.128 | 0.222 | 0.197 | 0.831 | 0.137 | 0.185 | 0.23 |

*Notes:* for each value of $b$, the null hypothesis is that the numbers chosen in the traveler's dilemma in the treatment where participants answered the SAR portion of the RBS first are drawn from the same distribution as the numbers chosen in the treatment where participants first played the traveler's dilemma and stag hunt game, and then completed the SAR portion of the RBS. Since the distributions are discrete, simulated (two-sided) $p$-values are reported with 10,000 replicates used in the Monte Carlo simulation.

**Table 13:** Order effects in the stag hunt game: exact test two-sided $p$-values

| | $c$ | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 |
| Fisher's exact test | 1 | 1 | 0.437 | 0.385 | 0.715 | 0.541 | 0.521 | 0.817 |
| Boschloo's test | 1 | 0.892 | 0.397 | 0.364 | 0.691 | 0.499 | 0.481 | 0.769 |

*Notes:* for each value of $c$, the null hypothesis is that the percentage of participants that play stag in the treatment where participants answered the SAR portion of the RBS first is equal to the corresponding percentage in the treatment where participants first played the traveler's dilemma and stag hunt game, and then completed the SAR portion of the RBS.

### C.1 General guidelines

During this experiment you and other participants will be asked to answer questions and make decisions in various different settings. At the end of the experiment, you will receive a sum of money that will depend both on your decisions and the other participants' decisions during the experiment. Therefore, it is important that you read these instructions carefully so that you can make informed decisions during the experiment.

The experiment will last approximately 90 minutes; even if a participant finishes earlier, they will have to wait until the experiment has concluded to receive their payment. Thus, it is best to spend your time considering carefully the different scenarios presented in the experiment.

No communication with the other participants is allowed during the experiment. Any participant who fails to follow this rule will be excluded from the experiment and will receive no payment. Should you have any questions, please raise your hand.

During the experiment, the currency that is used will not be dollars but points. Your earnings will therefore initially be calculated in points. The total number of points that you accumulate during the experiment will be paid to you in dollars (you will get a receipt which you will then bring to the Office of the Bursar to receive money) at a rate of:

$$1 \text{ point} = 0.04 \text{ dollars } (25 \text{ points} = 1 \text{ dollar}).$$

### C.2 What is a game?

A game is a situation where each of multiple (2 or more) participants makes decisions (independently and privately) and the number of points that each participant earns depends (based on well-defined rules) on the actions of that participant and the actions of the other participants in the game.

When there are two participants that take part in a game, it is sometimes (but not always) useful to present that game in a table. For example, a game with two players where each player has 3 actions to choose from can be represented as follows.

| | $L$ | $M$ | $R$ |
|---|---|---|---|
| $T$ | $a_1$,$a_2$ | $b_1$,$b_2$ | $c_1$,$c_2$ |
| $C$ | $d_1$,$d_2$ | $e_1$,$e_2$ | $f_1$,$f_2$ |
| $B$ | $g_1$,$g_2$ | $h_1$,$h_2$ | $i_1$,$i_2$ |

where $a_1$,$a_2$,$b_1$,$b_2$,...,$i_1$,$i_2$ are some numbers that differ from game to game (in a specific game you will see what these numbers are).

In this game, the *row player* has three actions to choose from: $T$, $C$, and $B$. The *column player* also has three actions to choose from, $L$, $M$, and $R$. Thus, there are $3 \times 3 = 9$ possible outcomes in this game (e.g., a possible outcome is that the row player chooses $C$ and the column player chooses $R$).

Each of the nine cells inside the table then gives the number of points each player will earn in each possible outcome of the game. The first number in the cell is the amount of points earned by the row player and the second number in the cell is the amount of points earned by the column player. For example, if the row player chooses action $C$ and the column player chooses action $R$, then the row player earns $f_1$ points and the column player earns $f_2$ points from this game.

### C.3 Types of settings and questions that you will face during the experiment

There are two types of items in this experiment. You will first complete some items of the first type, then some of the second, and finally again some of the first type. Before completing items you will sometimes be asked to answer questions that will test your understanding of the item. Only after you have answered correctly will you be allowed to complete the items.

In the first item type, a hypothetical scenario is described to you and you are asked to describe your thoughts, feelings, and emotions in that scenario. You will do so by denoting your level of agreement with various statements. For this type of item, you will be required to spend at least 3 minutes on a scenario before you can proceed to the next scenario (but you are free to spend more than 3 minutes). The button "Continue" will only appear on your screen after said amount of time has passed.

In the second item type, you are randomly matched with another participant, and a game is described to both of you. Each of you then is asked to individually and privately choose an action in the game. You will play 3 different games and you will play each game multiple times. For each of the three games, one of these multiple rounds will be randomly selected by the computer to be the pay round. You will be rewarded points only for that pay round (and not for the other times that you played the specific game). Thus, the total number of points that you accumulate in this experiment will be the sum of three numbers (one number for each of the 3 games).

Each time that you play a game you are randomly matched with a participant. Thus, in most cases, the participant that you play a game with will not be the same as the participant(s) that you played that game with before (unless by chance you are again matched with the same participant(s), which happens with low probability). After you have finished playing all the rounds of a game, you will see what the participant you were matched with in each round chose and which round has randomly been chosen to be the pay round.

### C.4 Games that you will play (second item type)

#### C.4.1 Game 1 (8 rounds)

You will be repeatedly and randomly matched with another participant to play the following game. Each of you will privately choose a number (integer) between 80 and 200; that is, any of the following numbers: 80, 81, 82, . . . , 198, 199, 200.

- If you both choose the same number, then each of you earns points equal to that number.
- If you choose different numbers, then each of you earns points equal to the lowest of the two numbers plus a bonus or minus a penalty, which is determined as follows:
  - if you have chosen the lowest number of the two, then you receive a bonus of additional $b$ points, and the other participant's points are reduced by a penalty of $b$ points (the value of $b$ will change from round to round and will be shown on everyone's screen).
  - if you have chosen the higher number of the two, then your points are reduced by a penalty of $b$ points, and the other participant receives a bonus of additional $b$ points.

For example, if you choose the number 135, the other participant chooses the number 145, and $b = 5$, then you receive $135 + 5 = 140$ points, while the other participant receives $135 - 5 = 130$ points.

### C.4.2 Game 2 (8 rounds)

You will be repeatedly and randomly matched with 1 other participant (so that you are a group of 2 people in total) to play the following game.

Both you and the other person in your group will (individually and privately) decide whether to incur a cost to undertake an action (i.e., invest) that can benefit all the people in the group. The full benefit from this action is available to all the people in the group if both people in the group undertake the costly action.

The cost $c$ of taking the action will be the same for all people in each group. In the game, each player in the group decides whether to invest by incurring a cost of $c$ points (the value of $c$ will change from round to round and will be shown on everyone's screen). If a player does not invest, then that player incurs no cost.

If both people in your group decide to invest, both people in the group will receive 200 points. Thus, if both people (in a specific group) invest, then each person (in that specific group) earns $200 - c$ points.

If in a specific group none or only one person invests, then each person in that group earns 100 points (minus investment costs, when applicable).

For example, if $c = 20$ and you invest and the other person in your group does not invest, then you earn $100 - 20 = 80$ points and the other person (who does not incur the cost) earns 100 points.

The game can be presented in a table as follows:

| | invest | not invest |
|---|---|---|
| invest | $200 - c$,$200 - c$ | $100 - c$,100 |
| not invest | 100,$100 - c$ | 100,100 |

### C.4.3 Game 3 (5 rounds)

You will be repeatedly and randomly matched with other participants to play the following game under various values of the parameter $x$ (the value $x$ will change from round to round and will be shown on everyone's screen).

| | $L$ | $M$ | $N$ | $R$ |
|---|---|---|---|---|
| $T$ | 500,350 | 300,345 | 310,$x$ | 320,50 |
| $B$ | 300,50 | 310,200 | 330,$x$ | 350,340 |

One of you will randomly be assigned the role of the row player and the other the role of the column player. All the times that you will play the game you will have the same role, either row or column player, as determined before the first time that you play the game."

**Instructions in other treatments.** The instructions were modified accordingly in the other treatments.

**Four-player volunteer's dilemma.** In the four-player volunteer's dilemma treatment, Game 2 was described as follows:

"You will be repeatedly and randomly matched with 3 other participants (so that you are a group of 4 people in total) to play the following game.

Both you and each of the other 3 people in your group will (individually and privately) decide whether to incur a cost to undertake an action (i.e., invest) that can benefit all the people in the group.

The full benefit from this action is available to all the people in the group if at least one person from the group undertakes the costly action, and no additional benefit is accrued if more than one person incurs this cost.

The cost $c$ of taking the action will be the same for all people in each group.

In the game, each player in the group decides whether to invest by incurring a cost of $c$ points (the value of $c$ will change from round to round and will be shown on everyone's screen). If a player does not invest, then that player incurs no cost.

If at least one person in your group decides to invest, all people in the group will receive 200 points whether or not they invested themselves.

Thus, if at least one person (in a specific group) invests, then any person (in that specific group) who invests earns $200 - c$ points, and any person (in that specific group) who does not invest earns 200 points.

If in a specific group nobody invests, then each person in that group earns 40 points.

For example, if $c = 20$ and you invest and one more person in your group invests, then each of the two of you earns $200 - 20 = 180$ points and each of the two other people in your group (who do not incur the cost) earns 200 points."

**Dictator game survey.** The dictator game survey was described as follows: "In the second item type, a hypothetical scenario is described to you and you are asked to describe how you would act in that scenario. You will be required to spend at least 45 seconds on the first item and 15 seconds for each item after that before you can proceed to the following item (but you are free to spend more time). The button "Continue" will only appear on your screen after said amount of time has passed.

Suppose the participants in the room are randomly (and equally) divided into two groups: group 1 and group 2. Then, imagine that each participant from group 1 is repeatedly and randomly (and anonymously) matched with a participant from group 2 and is asked to make a choice about how to divide a set of tokens (which will then be converted to points) between themself and the participant from group 2. Suppose that only one of these choices will be randomly selected by the computer to be implemented; the other choices will not generate points for either participant. Participants in group 2 never make a choice.

Suppose you are in group 1. As you (hypothetically) divide the tokens, you and the other participant will each earn points (for one randomly selected choice). The choice that you make is similar to the following:

Suppose that there are 200 tokens.

The number of points that you earn per token that you keep is: 1

The number of points that the other participant earns per token that you pass is: 2

How many tokens would you keep? ...

How many tokens would you pass? ...

In this choice, you must divide 200 tokens. You can keep all the tokens, keep some and pass some, or pass all the tokens. In this example, you will receive 1 point for every token you keep, and the other participant will receive 2 points for every token you pass. For example, if you keep 200 and pass 0 tokens, you will receive 200 points, and the other person will receive no points. If you keep 0 tokens and pass 200, you will receive 0 points and the other person will receive 400 points. However, you could choose any number between 0 and 200 to keep. For instance, you could choose to keep 121 tokens and pass 79. In this case, you would earn 121 points, and the other participant would receive 158 points."

**Public goods game.** The public goods game instructions were as follows: "You will be repeatedly and randomly matched with another participant (so that you are a group of 2 people in total) to play the following game. Each of you will receive 200 points and will choose how many of these points to keep; the remaining points will go to the group account. You can keep all the points, keep some and put some in the group account, or put all of them in the group account. The points that you put in your group account will be multiplied by some factor $b > 1$ and will then be shared equally by the two members in the group (the value of $b$ will change from round to round and will be shown on everyone's screen).

For example, if you keep 105 points and the other participant in your group keeps 115 points and $b = 1.5$, then the group account will have $(200-105)+(200-115) = 180$ points, which after being multiplied by 1.5 become 270 points. Thus, you receive $105+270/2 = 240$ points, and the other participant receives $115 + 270/2 = 250$ points.

*Note:* in case you need to use a calculator during this game (or to answer the questions that will test your understanding of the rules of the game), you can click on the calculator button that will be on your screen."

**Prisoner's dilemma.** The prisoner dilemma instructions were as follows: "You will be repeatedly and randomly matched with another participant (so that you are a group of 2 people in total) to play the following game under various values of the parameter $c$ (the value of $c$ will change from round to round and will be shown on everyone's screen):

| | A | B |
|---|---|---|
| A | 200,200 | $100 - c$,$200 + c$ |
| B | $200 + c$,$100 - c$ | 100,100 |

That is, if you both choose A, then each of you receives 200 points. If you both choose B, then each of you receives 100 points. If you choose A and the other participant chooses B, then you receive $100 - c$ points and the other participant receives $200 + c$ points. Last, if you choose B and the other participant chooses A, then you receive $200 + c$ points and the other participant receives $100 - c$ points."

# D Screenshots from experiment interface

In comprehension tests, when a participant had given a wrong answer to one or more questions and clicked *Continue*, she received the following message: "You have answered some question(s) incorrectly. Please, read the instructions carefully and try again."

**Figure 14:** Game matrix comprehension screenshot

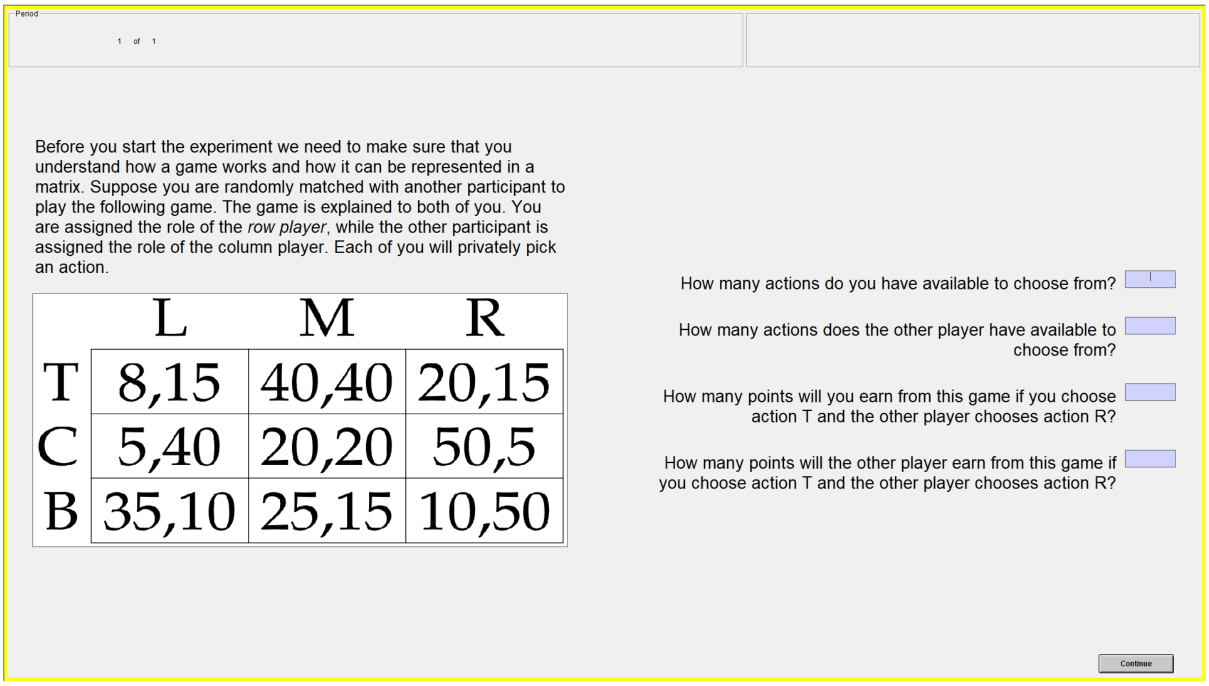
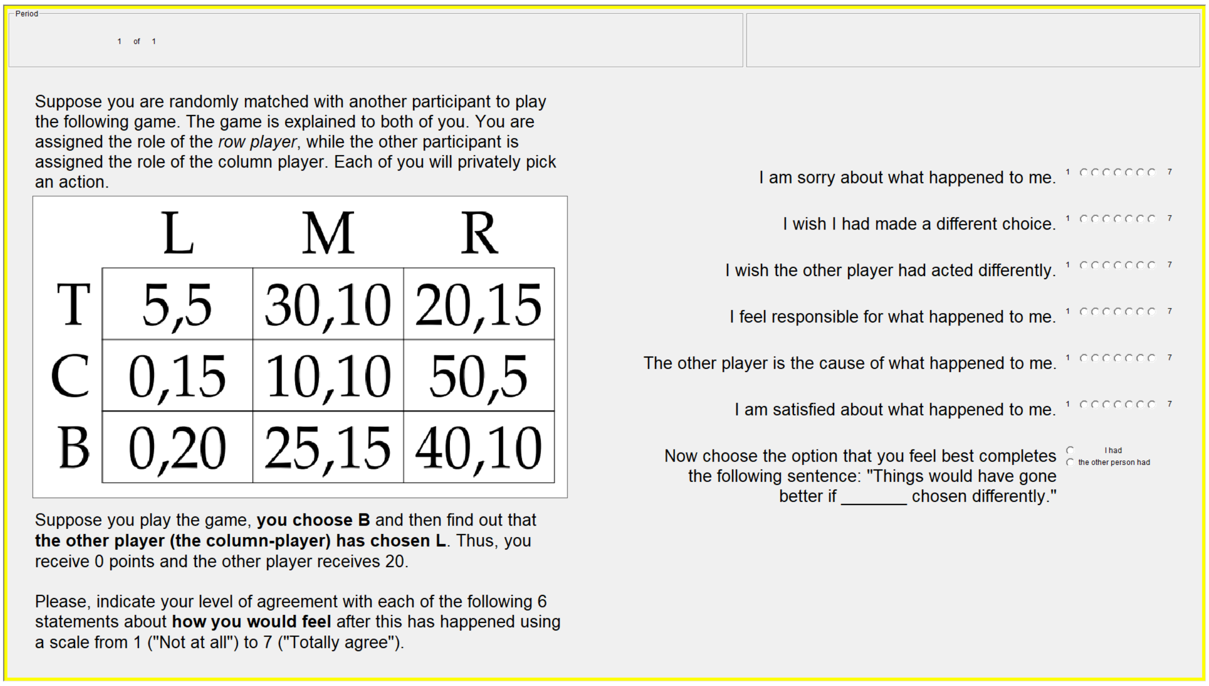



**Figure 15:** RBS survey for game SAR1 screenshot




*Notes:* the button *Continue* appeared in the bottom-right corner of the screen after 3 minutes had passed.

**Figure 16:** Traveler's dilemma comprehension test screenshot

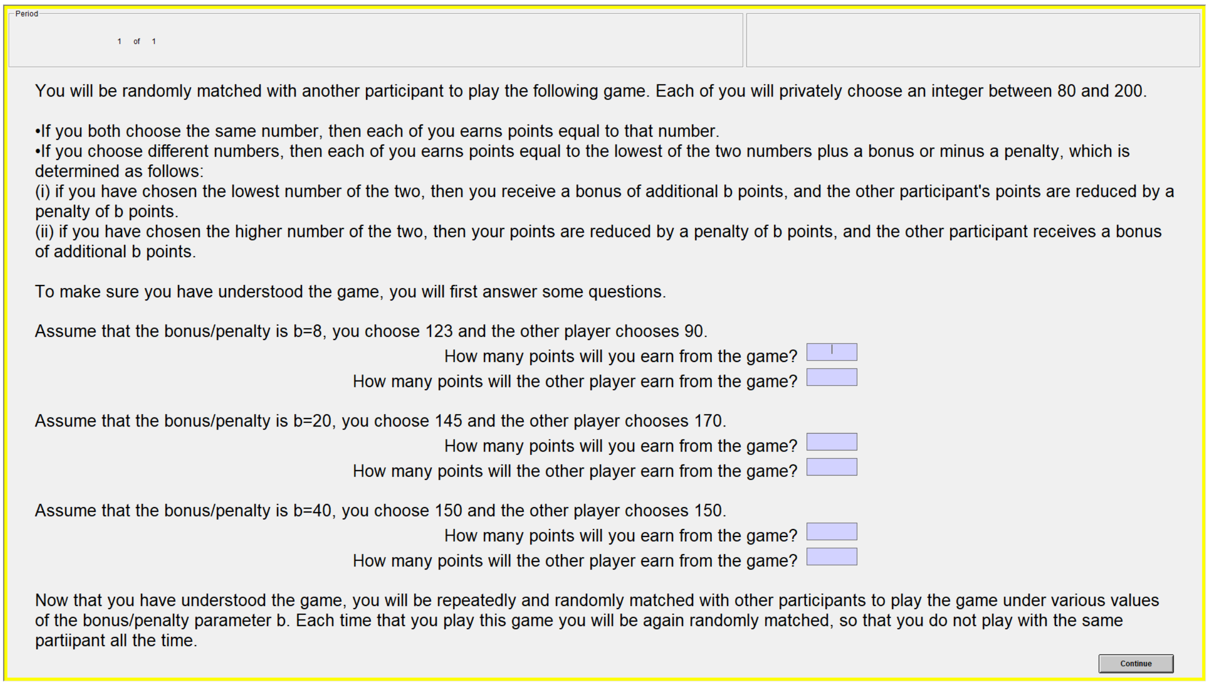



**Figure 17:** Traveler's dilemma choice screenshot

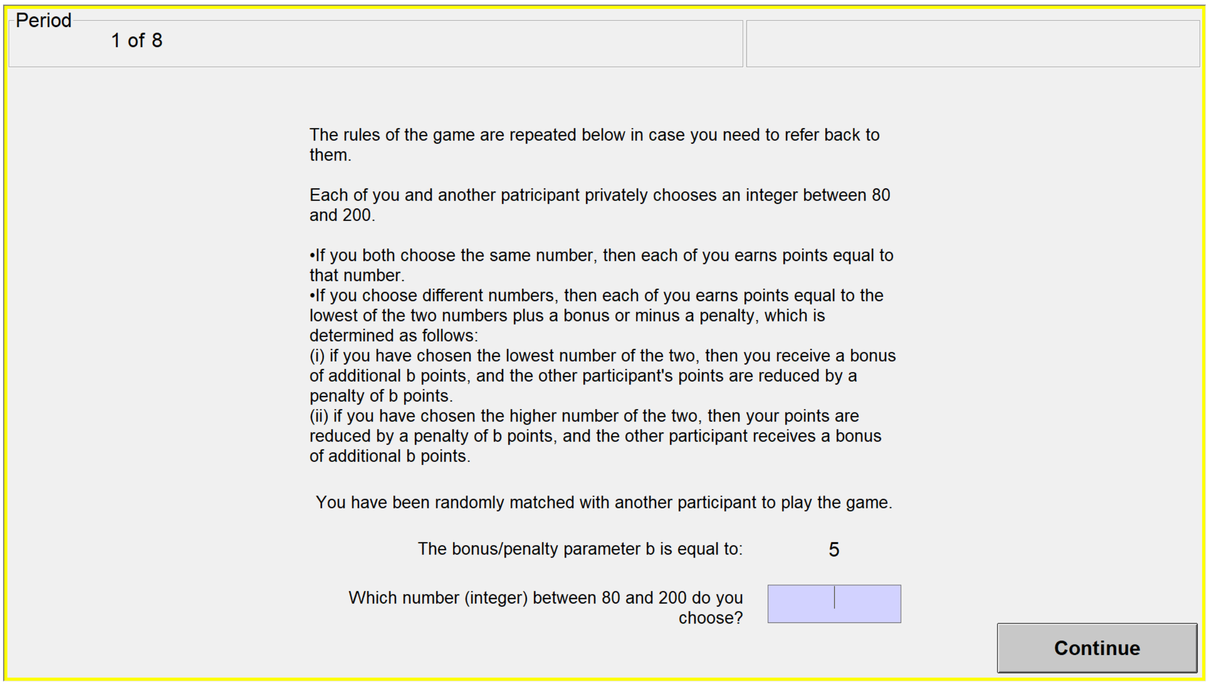
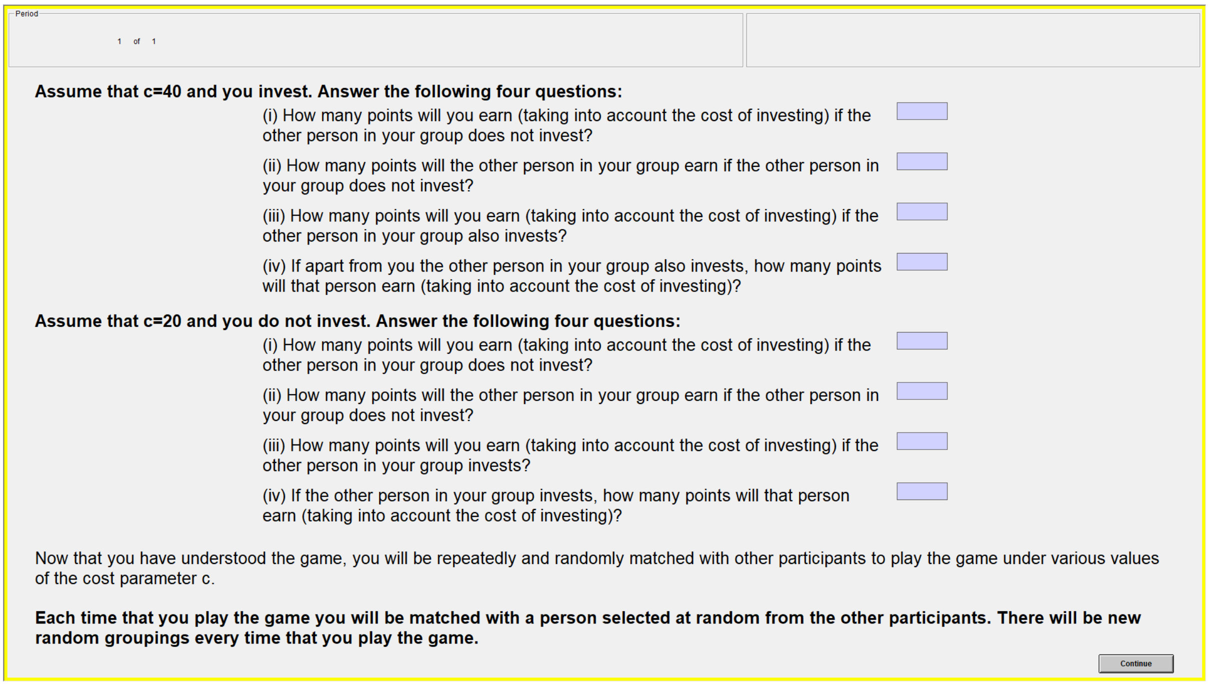


**Figure 18:** Stag hunt game comprehension test screenshot


Period

1 of 1

**Assume that c=40 and you invest. Answer the following four questions:**

(i) How many points will you earn (taking into account the cost of investing) if the other person in your group does not invest?

(ii) How many points will the other person in your group earn if the other person in your group does not invest?

(iii) How many points will you earn (taking into account the cost of investing) if the other person in your group also invests?

(iv) If apart from you the other person in your group also invests, how many points will that person earn (taking into account the cost of investing)?

**Assume that c=20 and you do not invest. Answer the following four questions:**

(i) How many points will you earn (taking into account the cost of investing) if the other person in your group does not invest?

(ii) How many points will the other person in your group earn if the other person in your group does not invest?

(iii) How many points will you earn (taking into account the cost of investing) if the other person in your group invests?

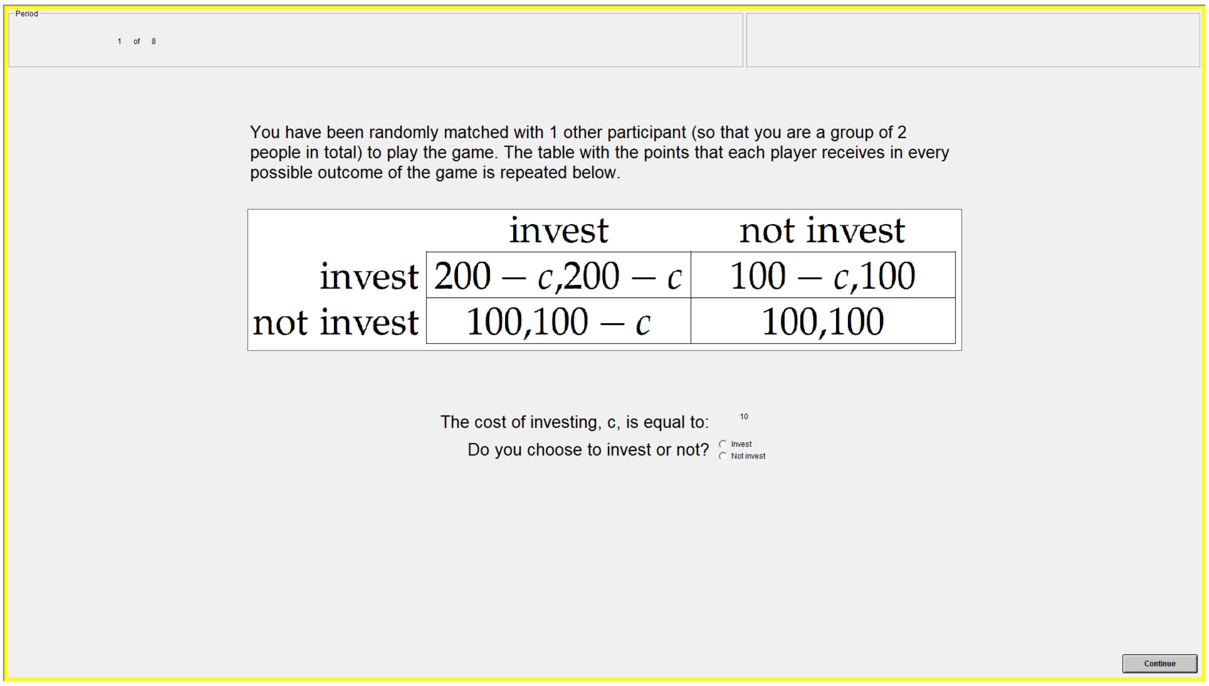
(iv) If the other person in your group invests, how many points will that person earn (taking into account the cost of investing)?

Now that you have understood the game, you will be repeatedly and randomly matched with other participants to play the game under various values of the cost parameter c.

**Each time that you play the game you will be matched with a person selected at random from the other participants. There will be new random groupings every time that you play the game.**

Continue

**Figure 19:** Stag hunt game choice screenshot


Period

1 of 8

You have been randomly matched with 1 other participant (so that you are a group of 2 people in total) to play the game. The table with the points that each player receives in every possible outcome of the game is repeated below.

| | invest | not invest |
|---|---|---|
| invest | $200-c, 200-c$ | $100-c, 100$ |
| not invest | $100, 100-c$ | $100, 100$ |

The cost of investing, c, is equal to: 10

Do you choose to invest or not? Invest / Not invest

Continue

**Figure 20:** Public goods game comprehension test screenshot

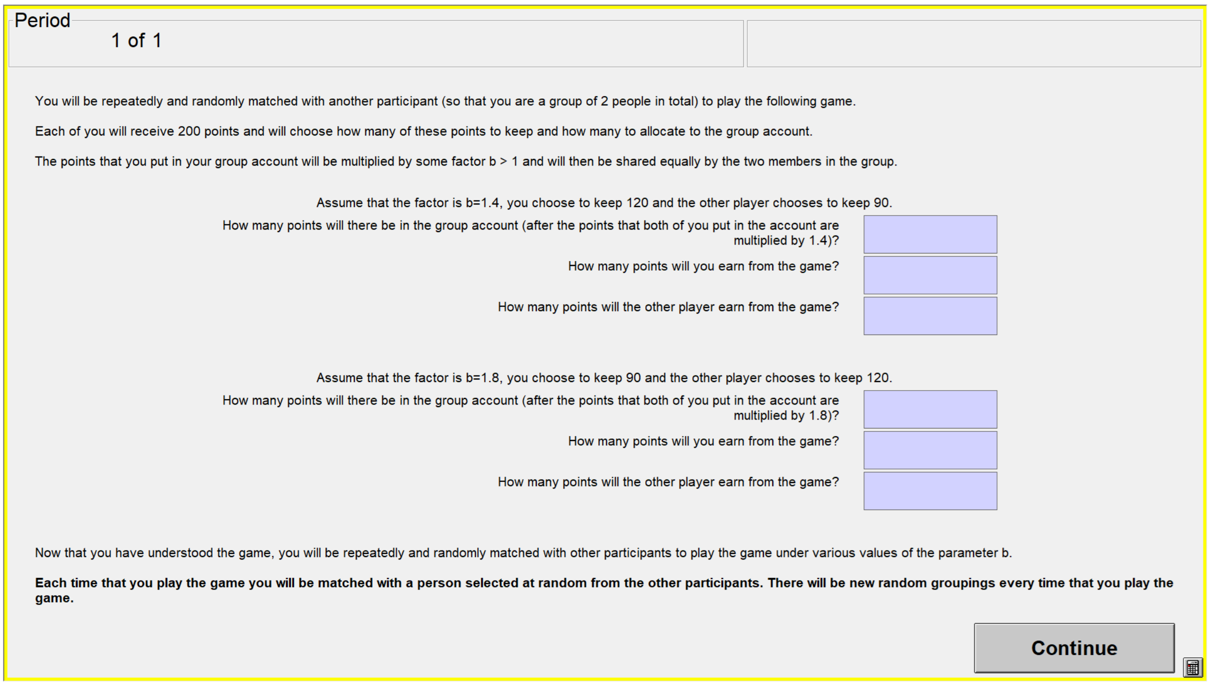



**Figure 21:** Public goods game choice screenshot

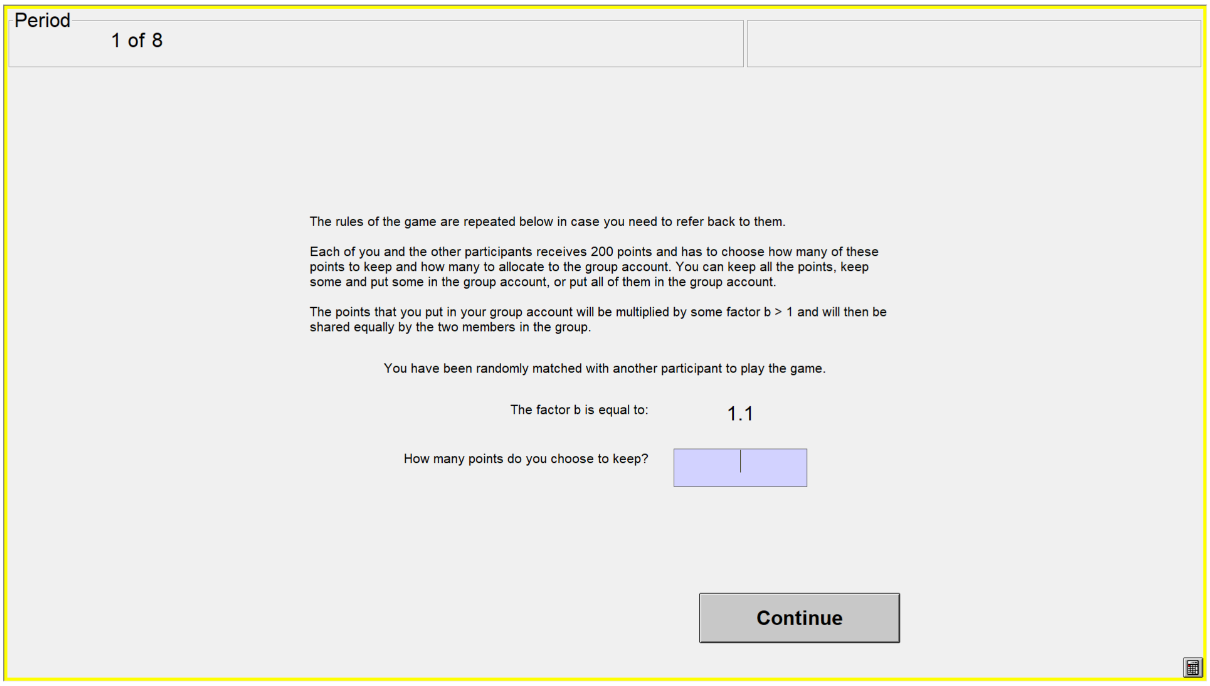


**Figure 22:** Prisoner's dilemma choice screenshot

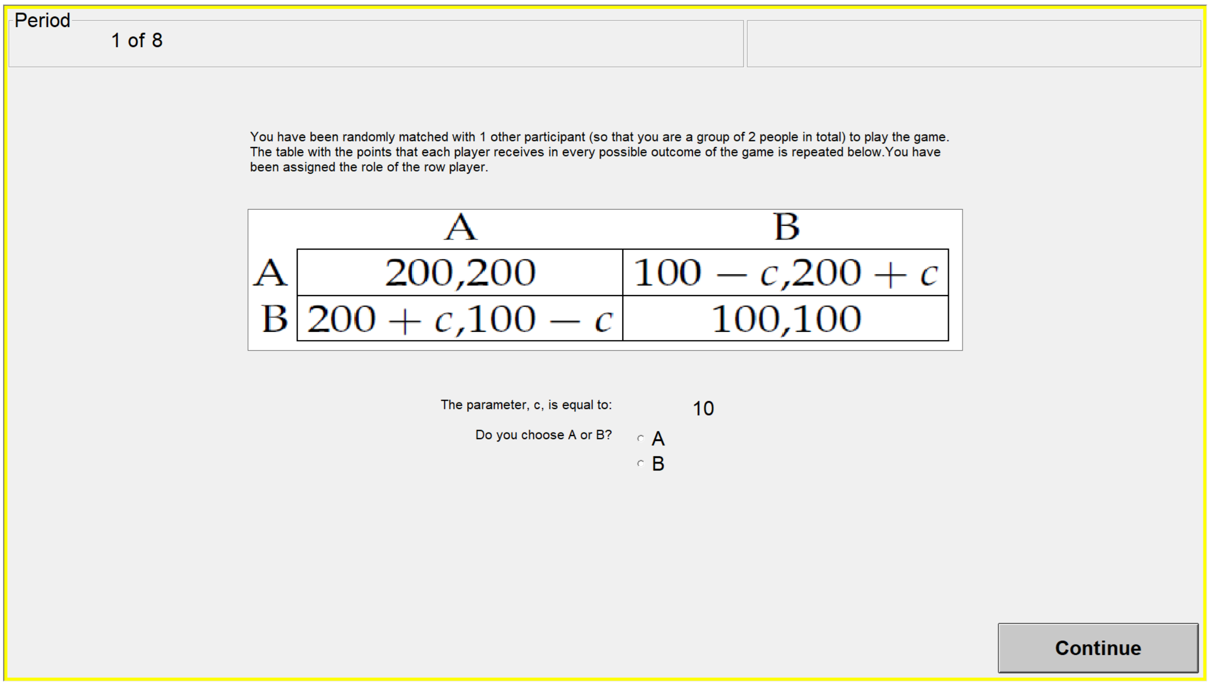



**Figure 23:** Dictator game choice screenshot

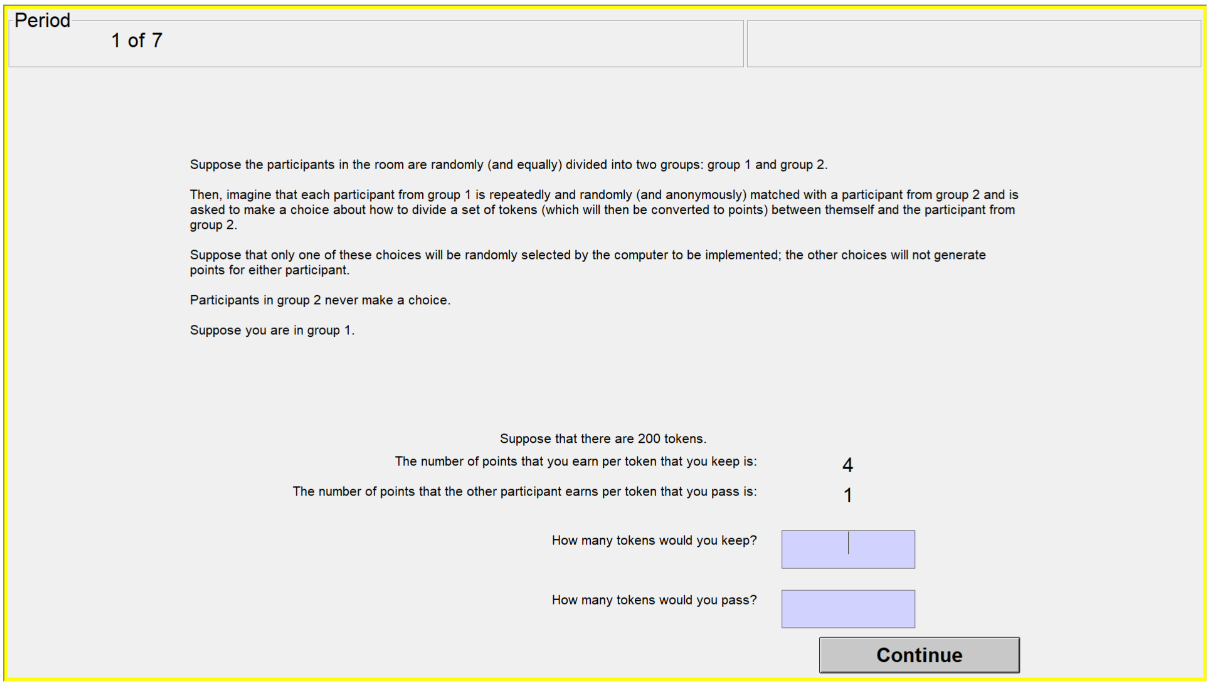


Figure 24: Four-player volunteer's dilemma comprehension test screenshot

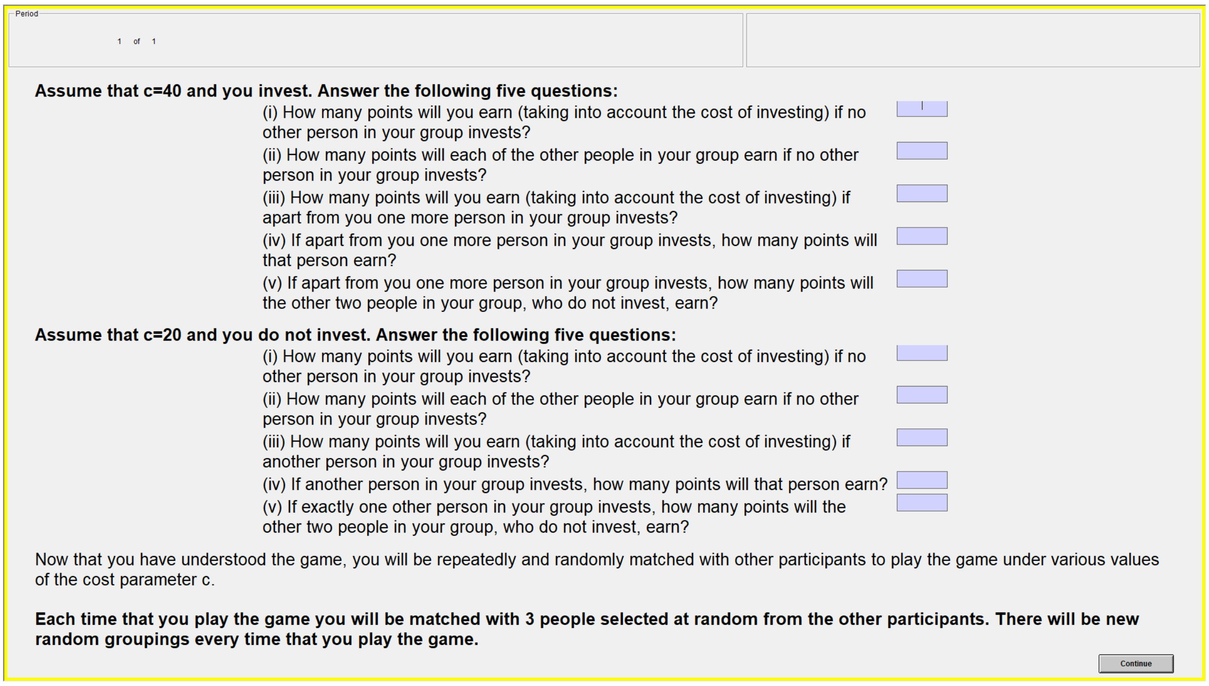



Figure 25: Four-player volunteer's dilemma choice screenshot

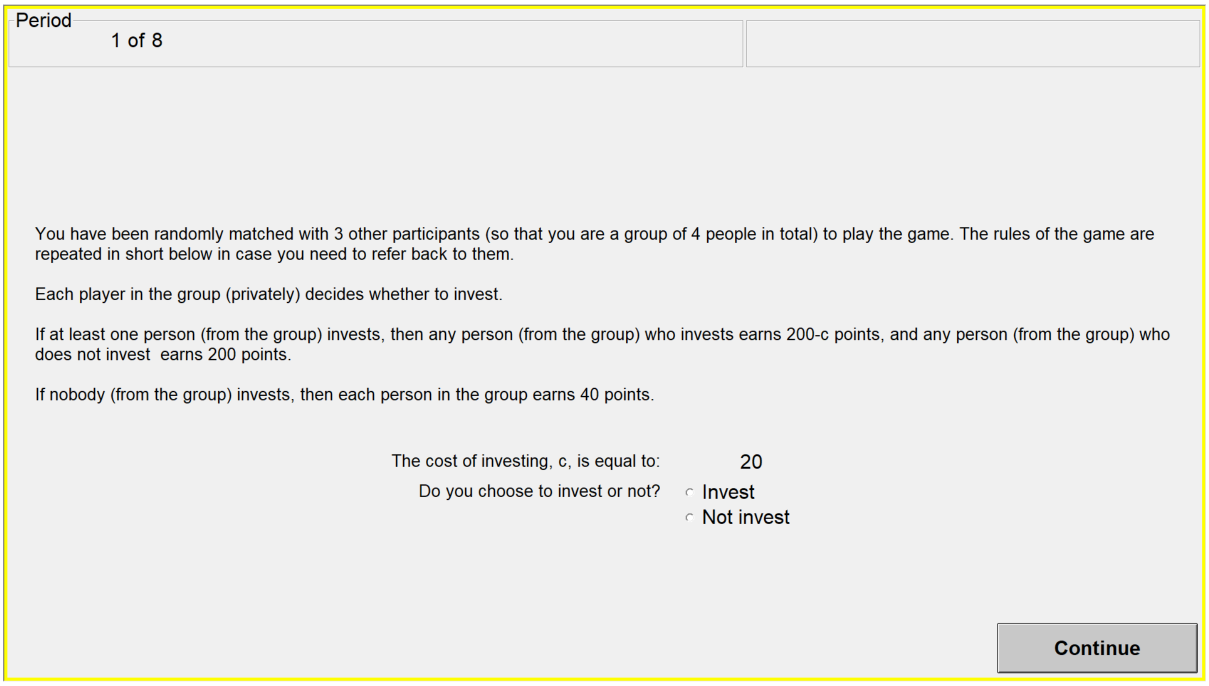
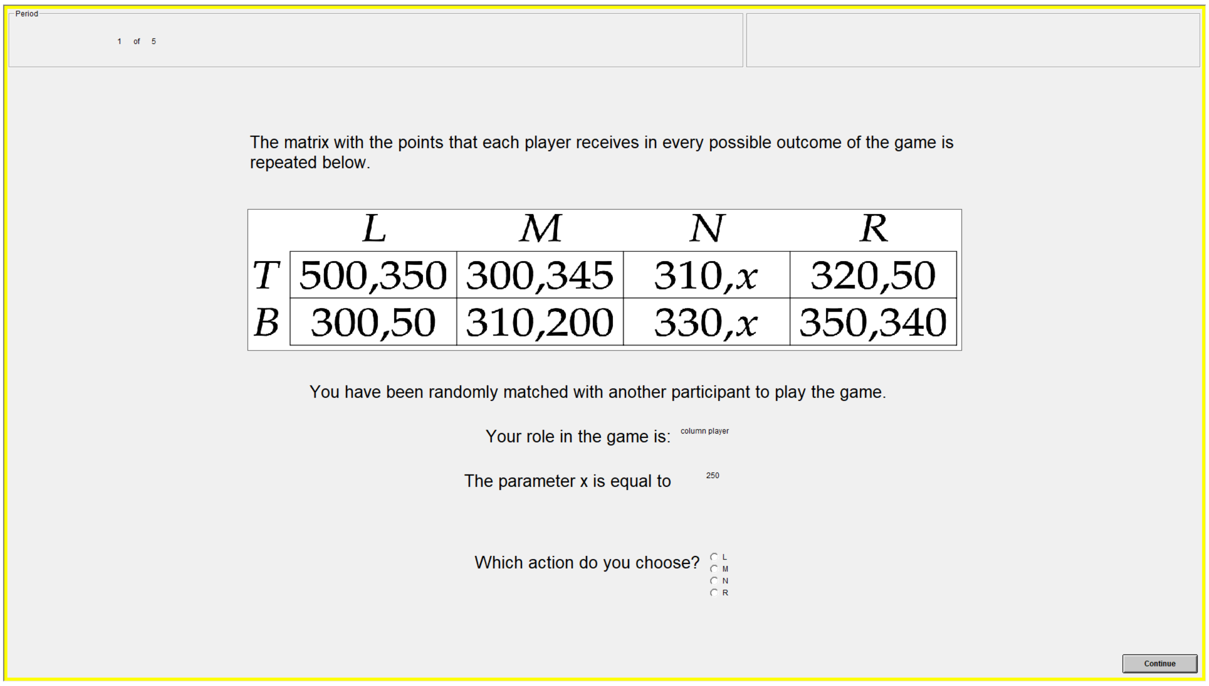


**Figure 26:** Kreps game choice screenshot




# E Theoretical results under weaker assumptions on regret

This section presents additional theoretical results under weaker assumptions on regret. Assumption 1 is the weakest assumption to be used.

**Assumption 1.** For every player $i$, $r_i(u_i, u_i^{br}, u_i^b)$ satisfies the following:

(i) **No rejoicing:** player $i$'s regret is non-negative, that is, $r_i\,(x,y,z) \geq 0$ for every $(x,y,z)$.

(ii) **Regret, realized baseline payoff, and best-response payoff:** player $i$'s regret is non-increasing in the baseline payoff she would receive if she best-responded, non-positive if she best-responds, and non-decreasing in the own realized baseline payoff, that is, (a) $r_i\,(x',y,z) \leq r_i\,(x,y,z)$ for every $(x',y,z),(x,y,z)$ such that $x' \geq x$, (b) $r_i\,(x,x,z) \leq 0$ for every $(x,x,z)$, and (c) $r_i\,(x,y',z) \geq r_i\,(x,y,z)$ for every $(x,y',z),(x,y,z)$ such that $y' \geq y$.

(iii) **Regret and blame:** player $i$'s regret is non-increasing in the blame payoff, that is, $r_i\,(x,y,z') \leq r_i\,(x,y,z)$ for every $(x,y,z'),(x,y,z)$ such that $z' \geq z$.

Assumptions 1(i) and 1(iib) together imply that blame put on the opponent cannot more than compensate for the regret a non-best-response (i.e., $x < y$) tends to generate. To see this, notice that $r_i\,(x,y,z') \geq r_i\,(x,x,z) = 0$ always, which means that even if $z' \gg z$, the most a high blame payoff $z'$ can do is reduce regret down to the level it would have if $i$ best-responded.

Assumption 1 leaves a lot of modeling freedom, since it describes the effects of realized, best-response, and blame payoffs on regret *all else constant.* For example, it can allow for $r(1{,}20{,}2) < r(1{,}1{,}1)$, which seems unreasonable. However, we will see that in the case of single-agent regret (i.e., when assumption 1(iii) holds with regret constant in $u_i^b$), these assumptions are sufficient for showing the inability of single-agent regret to move theoretical predictions away from predictions derived under standard assumptions on preferences. On the other hand, we will see that strategic regret can give rise to novel predictions under the stronger assumption 2, which significantly restricts modeling freedom.

**Assumption 2.** There exists a function $\widetilde{r}_i : \mathbb{R} \to \mathbb{R}_+$ and $\beta_i \in [0{,}1]$ such that

(i) $r_i\left(u_i{,}u_i^{br}{,}u_i^b\right) = \widetilde{r}_i\left(u_i^{br} - \left(\beta_i u_i^b + (1-\beta_i)u_i\right)\right)$ for every $(x{,}y{,}x)$,

(ii) $\widetilde{r}_i\left(t\right) = 0$ for $t \leq 0$, and

(iii) $\widetilde{r}_i(t') > \widetilde{r}_i(t)$ for every $t{,}t'$ such that $t' > \max\{t{,}0\}$.

Assumption 2 restricts modeling freedom requiring regret to be non-decreasing in the difference between the best-response payoff and a weighted average of the realized and the blame payoff. For instance, it requires that $r(1{,}20{,}2) = \widetilde{r}_i(19 - \beta_i) > \widetilde{r}_i(0) = r(1{,}1{,}1)$. The canonical specification of regret satisfies the general assumptions above.

**Lemma 1.** If regret is given by (2) with $\alpha_i \geq 0$, $\beta_i \in [0{,}1]$, then it satisfies assumption 2. Also, if regret satisfies assumption 2, then it also satisfies assumption 1.

### E.1 Standard assumptions on preferences versus single-agent regret versus strategic regret: additional comparative results

This section presents more general results on the comparison of NE, single-agent RE, and strategic RE.

**Equilibrium outcomes.** Proposition 4 shows that the result of Proposition 2 (i.e., that regret does not alter the set of pure equilibria) generalizes to $n$-player games with weaker assumptions on regret.

**Proposition 4.** Under assumption 1(i-ii) and for any game $G$, the set of pure NE and the set of pure RE coincide, $PNE(G) = PRE(G)$.

**Rationalizable outcomes.** *Conventions:* throughout $\subset$ ($\supset$) denotes weak subset (superset); convex (concave), means weakly convex (concave).

Before proceeding, we need to define some standard concepts. Let $\mathcal{A}$ denote the collection of all Cartesian subsets of $S$, that is $\mathcal{A} \coloneqq \{A \subset S : \exists A_1 \subset S_1, A_2 \subset$

$S_2$ such that $A = A_1 \times A_2\}$. For $A \in \mathcal{A}$, $i \in N$, $w \in \{u,m\}$ denote by $ND_{w;i}(A) \subset A_i$ the set of actions in $A_i$ that are not (strictly) dominated when only actions in $A_i$ and conjectures over $A_j$ are considered, under baseline ($w = u$) or modified ($w = m$) payoffs, respectively, and let $ND_w(A) = ND_{w;1}(A) \times ND_{w;2}(A)$. Also, define recursively $ND_w^k(A) = ND_w\left(ND_w^{k-1}(A)\right)$ with $ND_w^0(A) = A$. Similarly, define $PND_w(A) \subset A$ to be the subset of action profiles such that no action of the profile is dominated when only pure dominance is used (i.e., when a pure action is said to be dominated only if it is so by another pure action). Then, define the sets of $u$ and $m$-rationalizable action profiles, as well as dominance solvable games as follows.

**Definition 6.** Given a two-player game $G \coloneqq \langle N, (S_i)_{i\in N}, (u_i)_{i\in N}, (m_i)_{i\in N}\rangle$, for $w \in \{u, m\}$, $ND_w^\infty(S) \coloneqq \cap_{k\geq 1} ND_w^k(S)$ is the set of $w$-rationalizable action profiles. Similarly, define $PND_w^\infty(S) \coloneqq \cap_{k\geq 1} PND_w^k(S)$ to be the set of $w$-pure rationalizable action profiles.

**Definition 7.** A two-player game $G$ is $w$-dominance solvable if the set $ND_w^\infty(S)$ is a singleton. Similarly, it is $w$-pure dominance solvable if $PND_w^\infty(S)$ is a singleton.

Given a game $G$, denote by $\mathbb{DR}(G) \subset \mathbb{R}^3$ the domain of $r_1$ and $r_2$ in game $G$, that is,

$$\mathbb{DR}(G) \coloneqq \left\{ \begin{aligned} &(x,y,z) \in \mathbb{R}^3 | \exists (s_1,s_2) \in S, i,j \in \{1,2\}, j \neq i \text{ such that} \\ &\qquad\qquad x = u_i(s_i,s_j), y = u_i^{br}(s_j), z = u_i^b(s_i,s_j) \end{aligned} \right\}.$$

Proposition 5 then draws connections between the set of rationalizable action profiles (and more generally $k$ rounds of iterated deletion of strictly dominated actions) under baseline payoffs and the rationalizable action profiles when modified payoffs are used instead.

**Proposition 5.** Consider a two-player game $G \coloneqq \langle N, (S_i)_{i\in N}, (u_i)_{i\in N}, (m_i)_{i\in N}\rangle$ and let regret satisfy assumption 1. Then, for every $k \in \mathbb{N} \cup \{\infty\}$,$A \in \mathcal{A}$ the following statements hold:

(i) If 1(ii) is satisfied with the regret of each player $i$ constant in $u_i^b$ (single-agent regret), then $PND_u^k(A) = PND_m^k(A)$.

(ii) If for some player $i$ assumption 2 is satisfied for $\beta_i > 0$ so that 1(ii) is satisfied with regret decreasing in $u_i^b$ (strategic regret) in a subset of the domain $\mathbb{DR}$, then it can be that $PND_u^k(A) \neq PND_m^k(A)$.

(iii) Assume that for each player $i$, $r_i\left(u_i,u_i^{br},u_i^b\right)$ is concave (resp. convex) in $u_i$. If assumption 1(ii) is satisfied with the regret of player $i$ constant in $u_i^b$ (single-agent regret), then $ND_u^k(A) \supset ND_m^k(A)$ (resp. $ND_u^k(A) \subset ND_m^k(A)$).

(iv) If assumption 2 is satisfied for $\beta_i > 0$ so that 1(ii) is satisfied with regret decreasing in $u_i^b$ (strategic regret) in a subset of the domain $\mathbb{DR}$, then the conclusions of point (iii) need not follow.

**Remark.** If regret is given by (2), for $\beta_i = 0$, $r_i\left(u_i, u_i^{br}, u_i^b\right)$ is linear in $u_i$, so $ND_u^k(A) = ND_m^k(A)$.

Single-agent regret makes little to no difference compared to baseline preferences. Parts (i) and (iii) show that in every game, the rationalizable outcomes under single-agent regret are closely connected to those under standard assumptions on preferences. Particularly, part (iii) says that under the concavity assumption, rationalizability under single-agent regret rules out all outcomes that rationalizability under baseline preferences does. Thus for dominance solvable (under baseline payoffs) games the NE and the single-agent RE coincide. Conversely, under the convexity assumption, if a game is dominance solvable under single-agent regret, then the unique RE is also the unique NE. Under our canonical specification of regret given in (2), rationalizability delivers the same result regardless of whether baseline or single-agent regret payoffs are used. Thus, the result in section 3 that the traveler's dilemma is dominance-solvable under single-agent regret—just like under baseline payoffs—is not a coincidence. Last, part (i) says that rationalizability has the same implications under single-agent regret as it does under baseline payoffs regardless of the curvature of $r_i\left(u_i, u_i^{br}, u_i^b\right)$ in $u_i$ when only pure dominance is used.

On the other hand, strategic regret can alter the set of rationalizable outcomes. Particularly, it can lead to equilibria different from the NE even when a game is dominance solvable (in baseline payoff terms). The traveler's dilemma presented in section 3 is an example of a dominance solvable (under baseline payoffs) game where strategic regret gives rise to new RE.

### E.2 Invariance to positive affine transformations of baseline payoffs

I conclude this section by examining the invariance of RE to positive affine transformations of the baseline payoffs.

**Definition 8.** Games $G^1 := \langle N, (S_i)_{i\in N}, (u_i^1)_{i\in N}, (m_i^1)_{i\in N}\rangle$ and $G^2 := \langle N, (S_i)_{i\in N}, (u_i^2)_{i\in N},$ $(m_i^2)_{i\in N}\rangle$ are $u$ (resp. $m$)-strategically equivalent if for each player $i \in N$ the baseline (resp. modified) payoff function $u_i^2$ (resp. $m_i^2$) is a positive affine transformation of the baseline (resp. modified) payoff function $u_i^1$ (resp. $m_i^1$).

**Proposition 6.** Consider two games $G^1 := \langle N, (S_i)_{i\in N}, (u_i^1)_{i\in N}, (m_i^1)_{i\in N}\rangle$ and $G^2 := \langle N, (S_i)_{i\in N}, (u_i^2)_{i\in N}, (m_i^2)_{i\in N}\rangle$ and let each player $i$'s regret be given by (2) (where $\alpha_i$'s and $\beta_i$'s do not depend on the game). If $G^1$ and $G^2$ are $u$-strategically equivalent, then they are also $m$-strategically equivalent.

Proposition 6 asserts that under our canonical specification of regret, theoretical predictions (including best-response correspondences, rationalizable outcomes, and RE) are invariant to affine transformations of baseline payoffs. Given that theoretical predictions under baseline payoffs are also invariant to affine transformations of baseline payoffs, it follows that an affine transformation of baseline payoffs will not affect the analysis of section 3.

# F Proofs

**Proof of Claim 1.** I prove the claim for $i = 1$ and under weaker assumptions, namely, with $v_1(x)$ being the baseline payoff of player 1 from $x$ monetary units where $v_1$ is (strictly) increasing. For $s_1,s_2 \geq 81$ we have that $m_1(s_1+1,s_2) - m_1(s_1,s_2)$ is equal to

$$= \begin{cases} \begin{array}{r} -\widetilde{r}_1\left(v_1(s_2-1+b) - (\beta_1 v_1(s_1-b) + (1-\beta_1)v_1(s_2-b))\right) \\ +\widetilde{r}_1\left(v_1(s_2-1+b) - (\beta_1 v_1(s_1-1-b) + (1-\beta_1)v_1(s_2-b))\right) \end{array} & \text{if } s_1 \geq s_2+1 \\ \begin{array}{r} v_1(s_2-b) - \widetilde{r}_1\left(v_1(s_2-1+b) - v_1(s_2-b)\right) \\ -v_1(s_2) + \widetilde{r}_1\left(v_1(s_2-1+b) - v_1(s_2)\right) \end{array} & \text{if } s_1 = s_2 \\ \begin{array}{r} v_1(s_2) - \widetilde{r}_1\left(v_1(s_1+b) - v_1(s_2)\right) \\ -v_1(s_1+b) + \widetilde{r}_1\left(v_1(s_1+b) - v_1(s_1+b)\right) \end{array} & \text{if } s_1 = s_2-1 \\ \begin{array}{r} v_1(s_1+1+b) - \widetilde{r}_1\left(v_1(s_2-1+b) - v_1(s_1+1+b)\right) \\ -v_1(s_1+b) + \widetilde{r}_1\left(v_1(s_2-1+b) - v_1(s_1+b)\right) \end{array} & \text{if } s_1 \leq s_2-2. \end{cases}$$

The part that depends on $\beta_1$ is equal to

$$= \begin{cases} -\widetilde{r}_1(t_1) + \widetilde{r}_1(t_2) & \text{if } s_1 \geq s_2+2 \\ -\widetilde{r}_1(t_1) & \text{if } s_1 = s_2+1 \\ 0 & \text{if } s_1 \leq s_2. \end{cases}$$

where $t_1 \coloneqq v_1(s_2-1+b) - (\beta_1 v_1(s_1-b) + (1-\beta_1)v_1(s_2-b))$ and $t_2 \coloneqq v_1(s_2-1+b) - (\beta_1 v_1(s_1-1-b) + (1-\beta_1)v_1(s_2-b))$. Notice that $t_2 \geq t_1$. Then, the derivative of the expression in the first case (i.e., $s_1 \geq s_2+2$) with respect to $\beta_1$ is equal to

$$\begin{aligned} &\left(v_1(s_1-b) - v_1(s_2-b)\right)\widetilde{r}_1'(t_1) - \left(v_1(s_1-1-b) - v_1(s_2-b)\right)\widetilde{r}_1'(t_2) \\ &\geq \left(v_1(s_1-b) - v_1(s_2-b)\right)\left(\widetilde{r}_1'(t_1) - \widetilde{r}_1'(t_2)\right) \\ &\geq \left(v_1(s_1-b) - v_1(s_2-b)\right)\left(\widetilde{r}_1'(t_1) - \widetilde{r}_1'(t_1)\right) = 0, \end{aligned}$$

where the first equality follows from $\widetilde{r}_1' \geq 0$ and $v_1$ being an increasing function and the second from $\widetilde{r}_1(x)$ being a concave function for $x \geq 0$, $v_1$ being an increasing function, $t_2 \geq t_1$ and $s_1 > s_2$. It is trivial that in the second case (i.e., $s_1 = s_2+1$), the expression is increasing in $\beta_1$. In the last case (i.e., $s_1 \leq s_2$), there is no room for blame (whether player 1 plays $s_1$ or $s_1+1$), and thus, the expression is constant in $\beta_1$.

Last, for $s_2 = 80$, everything follows as above with the only difference that $u_1^{br}(s_2) = v_1(s_2)$, instead of $u_1^{br}(s_2) = v_1(s_2 - 1 + b)$. For $s_1 = 80$, $m_1(s_1+1,s_2) - m_1(s_1,s_2)$ is constant in $\beta_1$. We have shown that $m_1(s_1+1,s_2) - m_1(s_1,s_2)$ is non-decreasing in $\beta_1$ for every $s_2$, and the claim follows. **Q.E.D.**

*Note:* I expect the result to hold also under the canonical $\tilde{r}_i(x) := \alpha_i \max\{x,0\}$ but the fact that $\tilde{r}_i(x)$ is constant in $x$ for $x \leq 0$ in that case creates the following complication. When $t_2 > 0 \geq t_1$, the expression in the first case (i.e., $s_1 \geq s_2 + 2$) is equal to $-\tilde{r}_1(t_1) + \tilde{r}_1(t_2) = \tilde{r}_1(t_2)$, which is—locally—decreasing in $\beta_1$ (until the increase in $\beta_1$ makes $t_2 \leq 0$). In the case $t_1 \geq 0$ we still get that $-\tilde{r}_1(t_1) + \tilde{r}_1(t_2)$ is increasing in $\beta_1$. For $t_2 \leq 0$, $-\tilde{r}_1(t_1) + \tilde{r}_1(t_2)$ is constant in $\beta_1$.

Given a conjecture $\sigma_2$, whether the best-response $PBR_1(\sigma_2)$ of player 1 moves in the same direction as $\beta_1$ depends on the sign of $m_1(PBR_1(\sigma_2)+1,\sigma_2) - m_1(PBR_1(\sigma_2),\sigma_2)$. Thus, given that the complication arises only in small intervals of the domain of $\tilde{r}_1$ and also that $PBR_1(\sigma_2) \geq s_2 + 2$ with low probability (the probability taken over $\sigma_2$), we can expect the claim to still hold despite the complication.

**Proof of Proposition 1.** Fix an arbitrary $s \in S$ and $i \in N$. Any best-response $s'_j \in PBR_j(s_i)$ of player $j$ to player $i$'s action satisfies $u_j(s_i,s'_j) \geq u_j(s_i,s_j)$. This combined with the fact that the game is WUC implies that $u_i(s_i,s'_j) \leq u_i(s_i,s_j)$ for any $s'_j \in PBR_j(s_i)$. Thus, $u_i^{ba}(s) \leq u_i(s)$, so $u_i^b(s) = u_i(s)$. **Q.E.D.**

**Proof of Claim 2.** Mixing is optimal for player $i$ if and only if

$$\begin{aligned} 1 - \sigma_j^*(\text{hare}) - \sigma_j^*(\text{hare})\left(\lambda + \alpha_i \max\{\lambda - \beta_i(1+\lambda), 0\}\right) = \\ \left(1 - \sigma_j^*(\text{hare})\right)\left[1 - (1+\alpha_i)\Lambda + \alpha_i\beta_i \max\{\Lambda - 1, 0\}\right], \end{aligned}$$

which gives

$$\begin{aligned} \text{BAS}_i &= \frac{(1+\alpha_i)\Lambda - \alpha_i\beta_i \max\{\Lambda - 1, 0\}}{\lambda + \alpha_i \max\{\lambda - \beta_i(1+\lambda), 0\} + (1+\alpha_i)\Lambda - \alpha_i\beta_i \max\{\Lambda - 1, 0\}} \\ &= \left(1 + \frac{\lambda + \alpha_i \max\{\lambda - \beta_i(1+\lambda), 0\}}{(1+\alpha_i)\Lambda - \alpha_i\beta_i \max\{\Lambda - 1, 0\}}\right)^{-1} \in (0,1). \end{aligned}$$

Then, part (i) follows since given $\alpha_i \geq 0$ and $\beta_i \in [0,1]$, $\lambda + \alpha_i \max\{\lambda - \beta_i(1+\lambda), 0\}$ is increasing in $\lambda$ and $(1+\alpha_i)\Lambda - \alpha_i\beta_i \max\{\Lambda - 1, 0\}$ is increasing in $\Lambda$.

For part (ii), notice that under $\Lambda > 1$ and $\beta_i \leq \lambda/(1+\lambda)$,

$$\frac{d\left(\frac{\lambda + \alpha_i[\lambda - \beta_i(1+\lambda)]}{(1+\alpha_i)\Lambda - \alpha_i\beta_i(\Lambda - 1)}\right)}{d\alpha_i} \propto [\lambda - \beta_i(1+\lambda)]\left[(1+\alpha_i)\Lambda - \alpha_i\beta_i(\Lambda - 1)\right]$$

$$
\begin{aligned}
&- [\Lambda - (\Lambda - 1)\beta_i] \left[\lambda + \alpha_i[\lambda - \beta_i(1 + \lambda)]\right] \\
&- \Lambda\alpha_i[\lambda - \beta_i(1 + \lambda)] \\
=& - \beta_i(\lambda + \Lambda) < 0,
\end{aligned}
$$

so $\text{BAS}_i$ is increasing in $\alpha_i$ in this case. Notice that $\Lambda > 1$ and $\beta_i \leq \lambda/(1+\lambda)$ make $[\lambda+\alpha_i[\lambda-\beta_i(1+\lambda)]]/[(1+\alpha_i)\Lambda-\alpha_i\beta_i(\Lambda-1)]$ "least" decreasing in $\alpha_i$. Given that it still is decreasing under these assumptions, it is still decreasing under $\Lambda \leq 1$ and $\beta_i \leq \lambda/(1+\lambda)$, or $\Lambda > 1$ and $\beta_i > \lambda/(1+\lambda)$ or $\Lambda \leq 1$ and $\beta_i > \lambda/(1+\lambda)$.[59]

For part (iii) notice that under $\Lambda > 1$ and $\beta_i \leq \lambda/(1+\lambda)$,

$$
\begin{aligned}
\frac{d\left(\frac{\lambda+\alpha_i[\lambda-\beta_i(1+\lambda)]}{(1+\alpha_i)\Lambda-\alpha_i\beta_i(\Lambda-1)}\right)}{d\beta_i} \propto& - \alpha_i(1+\lambda)\left[(1+\alpha_i)\Lambda - \alpha_i\beta_i(\Lambda-1)\right] \\
&+ \alpha_i(\Lambda-1)\left[\lambda + \alpha_i[\lambda - \beta_i(1+\lambda)]\right] \\
=& - \alpha_i(1+\lambda)(1+\alpha_i)\Lambda + \alpha_i(\Lambda-1)\lambda\,(1+\alpha_i) \\
\propto& - (1+\lambda)\Lambda + (\Lambda-1)\lambda = -(\lambda+\Lambda) < 0,
\end{aligned}
$$

so $\text{BAS}_i$ is increasing in $\beta_i$ in this case. Similarly, it can be checked that under $\Lambda > 1$ and $\beta_i > \lambda/(1+\lambda)$, $\text{BAS}_i$ is decreasing in $\beta_i$. The result under $\Lambda \leq 1$ follows easily. **Q.E.D.**

**Proof of Propositions 2 and 4.** Given Lemma 1, it suffices to prove Proposition 4. Assumption 1 implies that for any action profile $s \in S$ the modified payoff of a player is not higher than the baseline one: $\forall s \in S, i \in N\ m_i(s_i,s_{-i}) \leq u_i(s_i,s_{-i})$. Also, if player $i$ (pure) best-responds, she experiences no regret, and thus, the relation holds with equality: $s_i \in PBR_i(s_{-i}) \implies m_i(s_i,s_{-i}) = u_i(s_i,s_{-i})$.

First I show that $PNE(G) \subset PRE(G)$. If there is no pure Nash equilibrium, then it follows trivially that $PNE(G) \subset PRE(G)$. Now consider the case where $PNE(G) \neq \emptyset$; take an arbitrary equilibrium $s^* \in PNE(G)$. Then for every player $i \in N$, $u_i(s_i^*,s_{-i}^*) \geq u_i(s_i,s_{-i}^*)\ \forall s_i \in S_i$, and given what we saw above

$$
m_i(s_i^*,s_{-i}^*) = u_i(s_i^*,s_{-i}^*) \geq u_i(s_i,\sigma_{-i}^*) \geq m_i(s_i,\sigma_{-i}^*)\ \forall s_i \in S_i,
$$

so $s^* \in RE(G)$. Thus, $PNE(G) \subset PRE(G)$.

Now, to see that also $PRE(G) \subset PNE(G)$, suppose by contradiction that $\exists s^* \in PRE(G) \setminus PNE(G)$. Since $s^* \notin PNE(G)$, there exists player $j \in N$ such that $s_j^* \notin PBR_j(\sigma_{-j}^*)$. It follows that there exists $s_j' \in S_j \setminus \{s_j^*\}$ such that $u_j(s_j',s_{-j}^*) = \max_{s_j \in S_j} u_j(s_j,s_{-j}^*) > u_j(s_j^*,s_{-j}^*)$. But given assumption 1, we have then that $m_j(s_j',s_{-j}^*) = u_j(s_j',s_{-j}^*) > u_j(s_j^*,s_{-j}^*) \geq m_j(s_j^*,s_{-j}^*)$, which contradicts $s^* \in PRE(G)$. Thus, $PNE(G) \supset PRE(G)$. **Q.E.D.**

[59]This can also be checked directly.

**Proof of Proposition 3.** Instead of part (i), I prove the more general result that if $r_i\left(u_i,u_i^{br},u_i^b\right)$ is additively separable, linear (and non-decreasing) in $u_i$ and constant in $u_i^b$, then $NE(G) = RE(G)$.[60]

*First step for part (i):* Consider a two-player game $G$ and take a NE $\sigma^* \in NE(G)$. By definition of a NE, we have that for every player $i \in N$ and every $s_i \in S_i$, $s_i^* \in \text{supp}(\sigma_i^*)$, $u_i(s_i^*,\sigma_j^*) \geq u_i(s_i,\sigma_j^*)$, which implies that for every $s_i \in S_i$, $s_i^* \in \text{supp}(\sigma_i^*)$

$$m_i(s_i^*,\sigma_j^*) + \prod_{s_j \in S_j} r_i\left(u_i(s_i^*,s_j),u_i^{br}(s_j),0\right)\sigma_j^*(s_j)$$
$$\geq m_i(s_i,\sigma_j^*) + \prod_{s_j \in S_j} r_i\left(u_i(s_i,s_j),u_i^{br}(s_j),0\right)\sigma_j^*(s_j).$$

where the terms $u_i^b(s_i^*,s_j)$ and $u_i^b(s_i,s_j)$ have been replaced with zeros, since $r_i$ is constant in $u_i^b$. By additive separability, the terms of $r_i$ depending on $u_i^{br}$ cancel (in the LHS and RHS). Thus, by separability and linearity of $r_i$ in $u_i$, the inequality above can be written as

$$m_i(s_i^*,\sigma_j^*) + \prod_{s_j \in S_j}\left[\kappa u_i(s_i^*,s_j) - \kappa u_i(s_i,s_j)\right]\sigma_j^*(s_j) \geq m_i(s_i,\sigma_j^*) \implies$$
$$m_i(s_i^*,\sigma_j^*) + \kappa\left(u_i(s_i^*,\sigma_j^*) - u_i(s_i,\sigma_j^*)\right) \geq m_i(s_i,\sigma_j^*)$$

for some $\kappa \leq 0$, which given that $u_i(s_i^*,\sigma_j^*) \geq u_i(s_i,\sigma_j^*)$ implies that $m_i(s_i^*,\sigma_j^*) \geq m_i(s_i,\sigma_j^*)$ for every player $i$ and every $s_i \in S_i$, $s_i^* \in \text{supp}(\sigma_i^*)$, so $\sigma^* \in RE(G)$. Thus, $NE(G) \subset RE(G)$.

*Second step for part (i):* Now take an action profile $\sigma^* \notin NE(G)$. Then, there exists $i \in N, s_i \in S_i$ such that $u_i(\sigma_i^*,\sigma_j^*) < u_i(s_i,\sigma_j^*)$, which means that there exists $s_i \in S_i$, $s_i^* \in \text{supp}(\sigma_i^*)$ such that $u_i(s_i^*,\sigma_j^*) < u_i(s_i,\sigma_j^*)$ so that by the same arguments as in the first step, $m_i(s_i^*,\sigma_j^*) + \kappa\left(u_i(s_i^*,\sigma_j^*) - u_i(s_i,\sigma_j^*)\right) < m_i(s_i,\sigma_j^*)$ for some $\kappa \leq 0$, which given that $u_i(s_i^*,\sigma_j^*) < u_i(s_i,\sigma_j^*)$ implies that $m_i(s_i^*,\sigma_j^*) < m_i(s_i,\sigma_j^*)$. Therefore, $s_i^* \in \text{supp}(\sigma_i^*)$ is not a best-response to $\sigma_j^*$ under modified payoffs, so $\sigma^* \notin RE(G)$. Thus, $NE(G) \supset RE(G)$.

To see why point (ii) holds look at the examples of section 3. **Q.E.D.**

**Proof of Claim 4.** I prove the claim under weaker assumptions; namely, that each player's baseline payoff is strictly increasing in (and only dependent on) own monetary units and regret satisfies assumption 1, with 1(iii) satisfied with the regret of each player $i$ constant in $u_i^b$ (single-agent regret).

Also, for ease of notation, I prove the proposition for the specific example of the traveler's dilemma described in the text but the proof works the same way for any finite

[60] Notice that for $\beta_1 = \beta_2 = 0$, $r_i\left(u_i,u_i^{br},u_i^b\right) = \alpha_i\left(u_i^{br} - u_i\right)$, which satisfies these assumptions.

set of the form $\{a,a+1,\ldots,a+m\}$, $m \in \mathbb{N}$. Denote by $k_i$ the number chosen by player $i$.

Conjectures with 199 or 200 being the maximum of the support: consider any conjecture of $i$ that assigns positive probability to $j$ choosing 199 or 200. Notice that $m_i(200,k_j) = m_i(199,k_j)$ for any $k_j \in \{80,\ldots,198\}$, since (i) $u_i(200,k_j) = u_i(199,k_j)$ for such $k_j$ by the rules of the game, (ii) $u_i^{br}(k_j)$ by definition only depends on $k_j$, and (iii) assumption 1(iii) holds with $r_i$ constant in $u_i^b$. Also, $m_i(200,k_j) < m_i(199,k_j)$ for $k_j \in \{199,200\}$, since (i) $u_i(200,k_j) < u_i(199,k_j)$ for such $k_j$, (ii) $u_i^{br}(k_j)$ only depends on $k_j$, and (iii) assumption 1(iii) holds with $r_i$ constant in $u_i^b$. Thus, 200 is not a best-response to any such conjecture, since 199 delivers a higher (modified) expected payoff given any such conjecture.

Conjectures with 197 or 198 being the maximum of the support: now consider any conjecture of $i$ that assigns zero probability to $j$ choosing 199 or 200 but positive to choosing 197 or 198. Notice that $m_i(200,k_j) = m_i(198,k_j)$ for any $k_j \in \{80,\ldots,196\}$, since (i) $u_i(200,k_j) = u_i(198,k_j)$ for such $k_j$ by the rules of the game, (ii) $u_i^{br}(k_j)$ by definition only depends on $k_j$, and (iii) assumption 1(iii) holds with $r_i$ constant in $u_i^b$. Also, $m_i(200,k_j) < m_i(197,k_j)$ for $k_j \in \{197,198\}$, since (i) $u_i(200,k_j) < u_i(197,k_j)$ for such $k_j$, (ii) $u_i^{br}(k_j)$ only depends on $k_j$, and (iii) assumption 1(iii) holds with $r_i$ constant in $u_i^b$. Thus, 200 is not a best-response to any such conjecture, since 197 delivers a higher (modified) expected payoff given any such conjecture.

Continuing in the same fashion, we see that 200 is a never-best-response (for either player). With 200 deleted in the first iteration, 199 is a never-best-response in the second iteration (where conjectures are constrained to assign probability 0 to 200 being chosen), and so on. The only rationalizable outcome is the pure NE (80,80). **Q.E.D.**

**Proof of Claim 5.** The modified payoffs are given in Figure 27.

**Figure 27:** The Kreps game: modified payoffs

**(a)** Row player payoffs

| | L | M | N | R |
|---|---|---|---|---|
| $T$ | 500 | $300 - 10\alpha_1 \cdot \max\{1-20\beta_1, 0\}$ | $310 - 10\alpha_1 \cdot \max\{2-19\beta_1, 0\}$ | $320 - 10\alpha_1 \cdot \max\{3-18\beta_1, 0\}$ |
| $B$ | $300-10\alpha_1 \cdot (20 - 5\beta_1)$ | 310 | 330 | 350 |

**(b)** Column player payoffs

| | L | M | N | R |
|---|---|---|---|---|
| $T$ | 350 | $345 - 5\alpha_2$ | $\delta - (350 - \delta)\alpha_2$ | $50 - 10\alpha_2(30 - 29\beta_2)$ |
| $B$ | $50 - 10\alpha_2(29 - 30\beta_2)$ | $200 - 140\alpha_2$ | $\delta - (340 - \delta)\alpha_2$ | 340 |

Clearly, in any mixed RE the row player should be mixing for otherwise the column player has a unique pure best-response. For mixing by the row player to be optimal, it must be that $\sigma_2(L) > 0$, since B dominates T when the column player chooses $\sigma_2(L) = 0$. Particularly, if a totally mixed action $\sigma_1 : \{T,B\} \to \Delta^2$ of the row player makes L and at least one of M, N, or R a best-response, then a mixed RE where the row player plays $\sigma_1$ and the column player mixes between L and some of the other actions exists.

The column player is indifferent between L and M if and only if

$$0 = 5(1+\alpha_2)\sigma_1(T) + [-150 + 10\alpha_2\,(14 - (29 - 30\beta_2))]\,(1 - \sigma_1(T)) \iff$$
$$\sigma_1(T) = \frac{30 - \alpha_2\,(28 - 2(29 - 30\beta_2))}{31 - \alpha_2\,(27 - 2(29 - 30\beta_2))} = \frac{1 + \alpha_2 - 2\alpha_2\beta_2}{(1+\alpha_2)31/30 - 2\alpha_2\beta_2}.$$

The column player is indifferent between L and N if and only if

$$\sigma_1(T) = \frac{(1+\alpha_2)(\delta - 50)/300 - \alpha_2\beta_2}{1 + \alpha_2 - \alpha_2\beta_2}.$$

The column player is indifferent between L and R if and only if

$$\sigma_1(T) = \frac{(1+\alpha_2)29 - 30\alpha_2\beta_2}{(1 + \alpha_2 - \alpha_2\beta_2)59}.$$

Thus, L is a best-response if and only if

$$\sigma_1(T) \geq \max\left\{\begin{matrix} \dfrac{1 + \alpha_2 - 2\alpha_2\beta_2}{(1+\alpha_2)31/30 - 2\alpha_2\beta_2}, & \dfrac{(1+\alpha_2)(\delta - 50)/300 - \alpha_2\beta_2}{1 + \alpha_2 - \alpha_2\beta_2}, \\ & \dfrac{(1+\alpha_2)29 - 30\alpha_2\beta_2}{(1 + \alpha_2 - \alpha_2\beta_2)59} \end{matrix}\right\}.$$

First I show that R is never part of a mixed equilibrium. For this, it is sufficient to show that the first term in the brackets above is higher than the last one. This is true if and only if

$$\begin{gathered} \frac{1 + \alpha_2 - 2\alpha_2\beta_2}{(1+\alpha_2)31/30 - 2\alpha_2\beta_2} > \frac{(1+\alpha_2)29 - 30\alpha_2\beta_2}{(1 + \alpha_2 - \alpha_2\beta_2)59} \iff \\ 59(1 + \alpha_2 - 2\alpha_2\beta_2)(1 + \alpha_2 - \alpha_2\beta_2) \\ -[(1+\alpha_2)31/30 - 2\alpha_2\beta_2][(1+\alpha_2)29 - 30\alpha_2\beta_2] > 0 \end{gathered} \tag{3}$$

The partial derivative of the expression in the LHS with respect to $\beta_2$ is

$$\begin{aligned} &59[-2\alpha_2(1 + \alpha_2 - \alpha_2\beta_2) - \alpha_2(1 + \alpha_2 - 2\alpha_2\beta_2)] + 2\alpha_2[(1+\alpha_2)29 - 30\alpha_2\beta_2] \\ &\quad + 30\alpha_2[(1+\alpha_2)31/30 - 2\alpha_2\beta_2] \\ =&59\alpha_2(-3 - 3\alpha_2 + 4\alpha_2\beta_2) + \alpha_2[(1+\alpha_2)89 - 120\alpha_2\beta_2] \\ =&\alpha_2\,[116\alpha_2\beta_2 - (1+\alpha_2)89] \leq \alpha_2\,(347\alpha_2/15 - 89) \leq 0 \end{aligned}$$

where the first inequality follows from $\beta_2 \leq 29/30$ and the second from $\alpha_2 \leq 1$.

Inequality (3) indeed holds for $\beta_2 = 29/30$ and $\alpha_2 \leq 1$, and thus, for every $\beta_2 \in [0{,}29/30]$.

Now it remains to see when both M and N are best-responses along with L. This is true if and only if

$$\frac{1+\alpha_2-2\alpha_2\beta_2}{(1+\alpha_2)31/30-2\alpha_2\beta_2} = \frac{(1+\alpha_2)(\delta-50)/300-\alpha_2\beta_2}{1+\alpha_2-\alpha_2\beta_2} \iff$$
$$\delta = \delta^* := 50 + 300\frac{1+\alpha_2-59\alpha_2\beta_2/30}{(1+\alpha_2)31/30-2\alpha_2\beta_2}.$$

Last, when the column player mixes between L and N, the row player is indifferent between T and B if and only if

$$0 = 10\left(20+\alpha_1(20-5\beta_1)\right)\sigma_2(L) - 10\left(2+\alpha_1\max\{2-19\beta_1,0\}\right)\left(1-\sigma_2(L)\right),$$

and the result follows. **Q.E.D.**

**Proofs of Claim 6** Volunteering is optimal for $i$ if and only if

$$\phi_1(1-\xi_i) + \left[\phi_1 - \alpha_i(\phi_2-\phi_1)\right]\xi_i \geq \phi_2\xi_i + \left[0-\alpha_i\max\{\phi_1-\beta_i\phi_2{,}0\}\right](1-\xi_i),$$

or equivalently,

$$\xi_i \leq \overline{\xi}_i := \frac{\phi_1+\alpha_i\max\{\phi_1-\beta_i\phi_2{,}0\}}{(1+\alpha_i)(\phi_2-\phi_1)+\phi_1+\alpha_i\max\{\phi_1-\beta_i\phi_2{,}0\}}.$$

**Q.E.D.**

**Proof of Lemma 1.** It is trivial, and thus, omitted.

**Proof of Proposition 5.** In proving Proposition 5, we will use the following Lemma, which studies the relation between dominance under baseline and dominance under modified payoffs. Dominance relations between actions are for the most part preserved when we move from baseline to single-agent regret preferences, which is however not true with strategic regret.

**Lemma 2.** Consider a two-player game $G := \langle N, (S_i)_{i\in N}, (u_i)_{i\in N}, (m_i)_{i\in N}\rangle$ and let regret satisfy assumption 1.

(i) If 1(ii) is satisfied with the regret of player $i$ constant in $u_i^b$ (single-agent regret), then $\forall s_i{,}s_i' \in S_i$ and $\forall A_j \subset S_j$

$$u_i(s_i{,}s_j) > u_i(s_i'{,}s_j)\ \forall s_j \in A_j \iff m_i(s_i{,}s_j) > m_i(s_i'{,}s_j)\ \forall s_j \in A_j,$$

(ii) If assumption 2 is satisfied for $\beta_i > 0$ so that 1(ii) is satisfied with regret decreasing in $u_i^b$ (strategic regret) in a subset of the domain $\mathbb{DR}$, then the above does not follow.

(iii) Assume that $r_i\left(u_i,u_i^{br},u_i^b\right)$ is concave (resp. convex) in $u_i$. If 1(ii) is satisfied with the regret of player $i$ constant in $u_i^b$ (single-agent regret), then $\forall(\sigma_i,s_i') \in \Delta(S_i) \times S_i$ and $\forall A_j \subset S_j$

$$u_i(\sigma_i,s_j) > u_i(s_i',s_j)\ \forall s_j \in A_j \overset{\text{(resp. }\Longleftarrow\text{)}}{\Longrightarrow} m_i(\sigma_i,s_j) > m_i(s_i',s_j)\ \forall s_j \in A_j.$$

(iv) If assumption 2 is satisfied for $\beta_i > 0$ so that 1(ii) is satisfied with regret decreasing in $u_i^b$ (strategic regret) in a subset of the domain $\mathbb{DR}$, then the above does not follow.

**Proof of Lemma 2.**

(i) $\Longrightarrow$ : For any $s_i,s_i' \in S_i$ and $\forall A_j \subset S_j$ we have that if $u_i(s_i,s_j) > u_i(s_i',s_j)\ \forall s_j \in A_j$, then by definition of modified utility $\forall s_j \in A_j$

$$\begin{aligned} m_i(s_i,s_j) + r_i\left(u_i(s_i,s_j),u_i^{br}(s_j),u_i^b(s_i,s_j)\right) > \\ m_i(s_i',s_j) + r_i\left(u_i(s_i',s_j),u_i^{br}(s_j),u_i^b(s_i',s_j)\right), \end{aligned}$$

Given (a) assumption 1(ii), (b) that regret is constant in its third argument, and (c) $u_i(s_i,s_j) > u_i(s_i',s_j)\ \forall s_j \in A_j$, we get that $\forall s_j \in A_j$

$$r_i\left(u_i(s_i,s_j),u_i^{br}(s_j),u_i^b(s_i,s_j)\right) \leq r_i\left(u_i(s_i',s_j),u_i^{br}(s_j),u_i^b(s_i',s_j)\right),$$

which combined with the first inequality implies that $\forall s_j \in A_j$, $m_i(s_i,s_j) > m_i(s_i',s_j)$.

$\Longleftarrow$ : I prove the contrapositive. For any $s_i,s_i' \in S_i$ and $\forall A_j \subset S_j$ if $\exists s_j \in A_j$ such that $u_i(s_i,s_j) \leq u_i(s_i',s_j)$, then for such $s_j$

$$\begin{aligned} m_i(s_i,s_j) + r_i\left(u_i(s_i,s_j),u_i^{br}(s_j),u_i^b(s_i,s_j)\right) \leq \\ m_i(s_i',s_j) + r_i\left(u_i(s_i',s_j),u_i^{br}(s_j),u_i^b(s_i',s_j)\right), \end{aligned}$$

which given (a) assumption 1(ii), (b) that regret is constant in its third argument, and (c) $u_i(s_i,s_j) \leq u_i(s_i',s_j)$, implies that $m_i(s_i,s_j) \leq m_i(s_i',s_j)$ for such $s_j$.

(ii) Consider the game depicted in Figure 28. With baseline payoffs $B$ dominates $T$, but with modified ones it does not.

(iii) With $r_i(u_i,u_i^{br},u_i^b)$ concave in $u_i$, as in (i) we get that $\forall(\sigma_i,s_i') \in \Delta(S_i) \times S_i$ and $\forall A_j \subset S_j$, if $u_i(\sigma_i,s_j) > u_i(s_i',s_j)\ \forall s_j \in A_j$ then

**Figure 28:** Game with baseline payoffs (on the left) and with modified payoffs with strategic regret (on the right)

| | $L$ | $M$ | $R$ |
|---|---|---|---|
| $T$ | 1,1 | 1,1 | 4,2 |
| $C$ | 4,3 | 4,2 | -2,1 |
| $B$ | 2,1 | 2,3 | 5,2 |

| | $L$ | $M$ | $R$ |
|---|---|---|---|
| $T$ | 1,1 | 1,1 | 3,2 |
| $C$ | 4,3 | 4,1 | -3,0 |
| $B$ | 0,1 | 0,3 | 5,1 |

*Notes:* the modified payoffs are given by functions (1) and (2) for $\alpha_1 = \alpha_2 = 1$ and $\beta_1 = \beta_2 = 1$.

$$m_i(\sigma_i,s_j) + \prod_{s_i \in S_i} r_i\left(u_i(s_i,s_j),u_i^{br}(s_j),u_i^b(s_i,s_j)\right)\sigma_i(s_i) \\ > m_i(s_i',s_j) + r_i\left(u_i(s_i',s_j),u_i^{br}(s_j),u_i^b(s_i',s_j)\right) \quad \forall s_j \in A_j.$$

Then, to show that $m_i(\sigma_i,s_j) > m_i(s_i',s_j)$ $\forall s_j \in A_j$, it is sufficient to show that $\forall s_j \in A_j$

$$\prod_{s_i \in S_i} r_i\left(u_i(s_i,s_j),u_i^{br}(s_j),u_i^b(s_i,s_j)\right)\sigma_i(s_i) \leq r_i\left(u_i(s_i',s_j),u_i^{br}(s_j),u_i^b(s_i',s_j)\right).$$

By concavity of $r_i$ in its first argument (and since $r_i$ is constant in its third argument) and using Jensen's inequality we get that $\forall s_j \in A_j$

$$\prod_{s_i \in S_i} r_i\left(u_i(s_i,s_j),u_i^{br}(s_j),u_i^b(s_i,s_j)\right)\sigma_i(s_i) \leq r_i\left(u_i(\sigma_i,s_j),u_i^{br}(s_j),u_i^b(s_i',s_j)\right).$$

Also, by assumption 1(ii) and the fact that $u_i(\sigma_i,s_j) > u_i(s_i',s_j)$ $\forall s_j \in A_j$, it follows that for every $s_j \in A_j$, $r_i(u_i(\sigma_i,s_j),u_i^{br}(s_j),u_i^b(s_i',s_j)) \leq r_i(u_i(s_i',s_j),u_i^{br}(s_j),u_i^b(s_i',s_j))$, which combined with the inequality above gives the desired sufficient condition.

With $r_i(u_i,u_i^{br},u_i^b)$ convex in $u_i$ I show the contrapositive. Assume $u_i(\sigma_i,s_j) \leq u_i(s_i',s_j)$, $\exists s_j \in A_j$. Then, for such $s_j$

$$m_i(\sigma_i,s_j) + \prod_{s_i \in S_i} r_i\left(u_i(s_i,s_j),u_i^{br}(s_j),u_i^b(s_i,s_j)\right)\sigma_i(s_i) \\ \leq m_i(s_i',s_j) + r_i\left(u_i(s_i',s_j),u_i^{br}(s_j),u_i^b(s_i',s_j)\right).$$

Thus, to show that $m_i(\sigma_i,s_j) \leq m_i(s_i',s_j)$, it is sufficient to show that for such $s_j$

$$\prod_{s_i \in S_i} r_i\left(u_i(s_i,s_j),u_i^{br}(s_j),u_i^b(s_i,s_j)\right)\sigma_i(s_i) \geq r_i\left(u_i(s_i',s_j),u_i^{br}(s_j),u_i^b(s_i',s_j)\right),$$

which follows (similarly as above) by convexity of $r_i$ combined with Jensen's inequality, the fact that $r_i$ is constant in its third argument, and assumption 1(ii) combined with the fact that $u_i(\sigma_i,s_j) \leq u_i(s_i',s_j)$.

(iv) For a counterexample see point (ii) above, where it can be checked that the regret of the row player is constant (and thus, linear) in her realized payoff over $\mathbb{DR}$. $\square$

We now proceed with the proof of Proposition 5.

(i) Given point (i) from Lemma 2 the exact same procedure of iterated deletion of strictly dominated strategies is used under baseline and modified payoffs.

(ii) Consider the game depicted in Figure 28. With baseline payoffs $B$ dominates $T$, then $M$ dominates $R$, then $C$ dominates $B$, and finally $L$ dominates $M$. However, with modified payoffs, no action is dominated.

(iii) If $r_i\left(u_i,u_i^{br},u_i^b\right)$ is concave (resp. convex) in $u_i$, then by point (iii) of Lemma 2 the exact same procedure of iterated deletion of strictly dominated strategies that is used under baseline (resp. modified) payoffs can be used under modified (resp. baseline) payoffs—and after the procedure is finished, additional actions may be deleted, thus the inclusion relation.

(iv) For counterexamples see point (ii) above. **Q.E.D.**

**Proof of Proposition 6.** For any action profile $s \in S$ the best-responses and the actions that give the blame payoffs are the same in the two $u$-strategically equivalent games. Then, for modified payoffs $\forall s \in S, i \in N$ (suppressing functional notation) we have:

$$
\begin{aligned}
m_i^2(s_i,s_j) &= u_i^2 - \alpha_i \max\left\{u_i^{2;pbr} - \left[\beta_i u_i^{2;b} + (1-\beta_i)u_i^2\right],0\right\} \\
&= \kappa_i u_i^1 + \lambda_i - \alpha_i \max\left\{\begin{matrix} \kappa_i u_i^{1;pbr} + \lambda_i - \left[\beta_i\left(\kappa_i u_i^{1;b} + \lambda_i\right)\right. \\ \left. + (1-\beta_i)\left(\kappa_i u_i^1 + \lambda_i\right)\right], 0 \end{matrix}\right\} \\
&= \kappa_i u_i^1 + \lambda_i - \alpha_i \kappa_i \max\left\{u_i^{1;pbr} - \left[\beta_i u_i^{1;b} + (1-\beta_i)u_i^1\right], 0\right\} \\
&= \kappa_i\left(u_i^1 - \alpha_i \max\left\{u_i^{1;pbr} - \left[\beta_i u_i^{1;b} + (1-\beta_i)u_i^1\right], 0\right\}\right) + \lambda_i \\
&= \kappa_i m_i^1(s_i,s_j) + \lambda_i,
\end{aligned}
$$

so an affine transformation of baseline payoffs implies an affine transformation (the same one) of modified payoffs. **Q.E.D.**

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