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The logic of relative frustration revisited: theoretical revision of Boudon's competition model and experimental evidence

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It is commonly believed that improvements in social opportunities can paradoxically lead to a larger share of frustrated individuals. This paradox has been studied in the field of analytical sociology through a competition model proposed by Raymond Boudon. So far, analyses of the model suggest that the paradox indeed occurs, especially when opportunities improve from a low to medium level and acting on these opportunities carries relatively low costs. However, these analyses are based on the premise that actors care about their absolute payoffs and not their relative payoffs. We extend this premise such that actors care both about their absolute and relative payoffs, by incorporating a form of inequity aversion that we call relative deprivation aversion (RDA). Through game-theoretic analyses, we show that the paradoxical relationship is strongly attenuated when incorporating RDA. Using data from several experiments, we show also empirically that there is no significant increase in relative deprivation under improving opportunities. We conclude that the paradox is theoretically and empirically not likely in the situations captured in Boudon's competition model. We discuss the implications this has for the paradox in general and provide suggestions for situations under which the paradox may be more likely.

Introduction

The satisfaction that people derive from their status, job, wealth and many other goods often depends not only on what they absolutely have, but also on what they have relative to others. This is a well-known psychological phenomenon (Frank, 1989; Smith et al., 2012), but also has important sociological implications. If satisfaction does not solely depend on absolute social conditions, an improvement of social conditions may not coincide with an improvement in satisfaction. If the improvement of social conditions predominantly benefits a minority, the relative condition of the majority will have worsened, potentially leading to less satisfaction overall. Indeed, several scholars have argued that paradoxical relationships exist whereby improvements in absolute social conditions lead to more collective dissatisfaction expressed through protests and revolutions (De Tocqueville, 1955 [1856]; Brinton, 1965) or even increased suicide rates (Durkheim, 1952 [1897]).

A classic example of the paradox is the finding by Stouffer et al. (1965 [1949]) that American soldiers were less satisfied with their promotion opportunities in branches of the army with higher objective promotion opportunities. Stouffer et al. reasoned that not absolute promotion opportunities mattered, but rather the relative promotion opportunities within one's group. They coined the term relative deprivation to describe people's dissatisfaction with their social conditions relative to others (Stouffer et al., 1965 [1949]). Also, more recently, paradoxical relationships between improving opportunities and increased dissatisfaction have been found and linked to relative deprivation. For example, dissatisfaction in China has increased during periods of rapid economic growth, with relative deprivation being suggested as a driving cause (Ishida, Kosaka and Hamada, 2014). In this study, we theoretically analyze and experimentally test a game-theoretic model of relative deprivation that aims to explain when improvements in social conditions lead to higher rates of the relative deprivation.

The observation that satisfaction with one's status, job or wealth depends on one's position relative to others reveals an underlying competition process. Sometimes, this competition is explicit, such as

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employees competing for a promotion in work organizations or job candidates competing for positions in the labour market. In other situations, the competition is implicit. For example, the famous idiom of "keeping up with the Joneses" refers to a form of conspicuous consumption whereby people compete indirectly by buying clothes, cars, houses and other goods to increase or maintain one's social status (Veblen, 1965 [1899]; Nelissen and Meijers, 2011; Berger, 2017). Because status competition over consumption is a zero-sum game, increasing income levels may shift the social standards for consumption without producing greater happiness. Indeed, studies suggest that long-term happiness does not increase when a country's income increases (Easterlin et al., 2010), a finding which has been labelled the happiness-income paradox or Easterlin paradox. Although evidence for this paradox is debated, research suggests that relative income is a stronger predictor of happiness than absolute income (Alderson and Katz-Gerro, 2016).

Regardless of whether the competition is explicit or implicit, or whether the intended outcome is a job, promotion, status or any other scarce good, the competition will result in both winners and losers. The winners obtain the desired good and hence see their condition improve, the losers do not obtain the good and remain left behind or become even worse off if participation in the competition required some form of investment. The losers of the competition are thus relatively deprived. Regardless of their change in absolute condition, their relative position has declined compared to the winners, often resulting in feelings of frustration, anger, and dissatisfaction (Smith et al., 2012).

Although relative deprivation has become a major social science concept, it is mostly invoked post-hoc to explain surprising findings (Manzo, 2011). Formal modelling to beforehand predict how changes in absolute conditions influence the rate of relative deprivation is rare. A notable exception is Boudon's competition model, which explains how levels of relative deprivation result from rational individual-level decisions in competition situations (Boudon, 1982 [1977]). In the model, actors can choose whether to join a costly competition for a limited number of rewards. Actors that do not enter the competition receive a 'sustainer' payoff. Actors that enter the competition and win one of the rewards receive a 'winner' payoff, which is higher than the 'sustainer' payoff. Actors that enter the competition and fail to win one of the rewards receive a 'loser' payoff, which is lower than the 'winner' and 'sustainer' payoff.

Entering the competition is thus risky; it can increase or decrease your payoff. The chance of winning a reward when entering the competition depends on the number of rewards and how many others enter the competition (keeping group size fixed). If the number of competitors does not exceed the number of rewards, all the competitors win a reward. If there are more competitors than rewards, the rewards will be randomly allocated among the competitors and some will lose the competition. Thus, the higher the number of rewards, the better the opportunities to become a winner. The model assumes rational payoff-maximizing actors. That is, actors calculate the absolute payoff they are expected to get when entering the competition and when not entering the competition and choose the action that gives them the highest absolute expected payoff. The resulting level of relative deprivation is measured by the proportion of losers of the competition. The losers are considered to be relatively deprived because they entered the competition under the same circumstances as the winners, yet they end up with the lowest payoff of all. Actors thus aim for high absolute payoffs, which can lead to an unanticipated and unintended low relative payoff when losing the competition.

Using this model, Boudon showed that improvements in opportunities can lead to heightened levels of relative deprivation. This occurs when an increase in the number of rewards will convince a disproportionate number of actors to enter the competition, thereby increasing the proportion of actors that will end up a loser, and hence, relatively deprived. Despite Boudon's model being one of the only formal and mechanism-oriented models of relative deprivation, it has received relatively little attention, especially when compared with the large body of research that studies relative deprivation without formal analyses (Smith et al., 2012). However, a few scholars did analyze the model in detail (Raub, 1984; Kosaka, 1986; Yamaguchi, 1998; Manzo, 2009, 2011; Ishida, 2012; Otten, 2020). These analyses revise and extend Boudon's model in several aspects, but they all find that relative deprivation is indeed predicted to paradoxically increase when opportunities improve under certain conditions. In particular, the paradox appears when opportunities improve from a low to a medium level and the costs of entering the competition are low. However, the dependence of this result on the assumption that actors care only about their absolute payoffs has not yet been examined.

In this article, we replace the premise that actors care only about their absolute payoffs with the premise that actors care about both their absolute and relative payoffs when making their decisions. From a theoretical point of view, incorporating a concern for relative payoffs makes sense if we consider rational decision-making. So far, relative payoffs matter for the actors' outcome in terms of relative deprivation but are not incorporated into actors' decision-making. Indeed, a concern for relative payoffs has been explicitly incorporated in Boudon's model (Manzo, 2011), but only in the terms of how actors evaluate their outcome after their competition decision. We extend this theoretically by suggesting that what rational actors care about in terms of outcomes should also be what they factor into their decision-making. From an empirical point of view, changing the behavioural assumptions of the model might improve predictions, as previous experimental research on Boudon's model has found mixed results so far (Berger and Diekmann, 2015).

To incorporate the premise that actors care about both their absolute and relative payoffs when making their decisions, we game-theoretically incorporate a form of inequity aversion which we will call relative deprivation aversion (RDA). The conventional inequality aversion model assumes that actors receive positive utility from higher absolute payoffs and negative utility from low and high relative payoffs (Fehr and Schmidt, 1999). The negative utility from low relative payoffs is typically regarded as modelling envy, whereas the negative utility from high relative payoffs is regarded as modelling guilt. To incorporate RDA, we model actors that receive positive utility from higher absolute payoffs and negative utility from low relative payoffs (losers feel envy compared to winners).

Actors with RDA will generally compete more cautiously than absolute payoff maximizing actors because competing carries the risk of becoming a loser and hence relatively deprived. Through game-theoretic analyses, we show that the paradoxical relationship between improving social conditions and heightened relative deprivation levels is strongly attenuated when actors have RDA. Empirically, we show that our revised model more accurately reflects behaviour than the original model and correctly predicts the absence of a paradoxical relationship between improving opportunities and increased relative deprivation as measured by the proportion of losers. To do so, we make use of data by Berger and Diekmann (2015), who rigorously tested Boudon's competition model with several lab experiments, and newly collected experimental data. We conclude that the paradoxical relationship between improving social conditions and heightened levels of relative deprivation is theoretically and empirically not very likely in the situations captured by Boudon's competition model. We end with a discussion of the implications this has for the paradox in general and provide suggestions for alterations to the model to capture situations under which the paradox may be more likely to appear.

Theory

In Boudon's model, an actor's level of relative deprivation is both an unintended and unanticipated consequence of competition behaviour. It is unintended because actors are assumed to not want to become a loser. It is unanticipated because actors are assumed to *not* incorporate the potential consequences of relative deprivation into their decision-making. Instead, actors decide whether to compete solely based on the absolute payoff consequences, i.e. actors are payoff maximizers. We revise Boudon's model by assuming that actors do incorporate the potential consequences of relative deprivation into their decision of whether to compete. To do so, we game-theoretically incorporate RDA as a social preference. In our revision, an actor's relative deprivation level is thus still unintended but no longer unanticipated. Incorporating concern for relative deprivation is arguably more in line with a rational decision-making perspective; what actors care about in terms of outcomes should also be what they factor into their decision-making. Of course, that people are motivated to prevent low relative positions for themselves is already well-established in prevailing theories and evidence on human motivation (Frank, 2012). What remains to be shown is the consequences this has for the relationship between improving opportunities and rates of relative deprivation. In what follows, we will first describe Boudon's original model and then show how its results change when incorporating relative deprivation aversion.

In Boudon's competition model (1982 [1977]), there is a group of N actors and each actor has to choose whether to enter a competition to get a chance of obtaining a reward. The number of competitors is denoted by n and the number of rewards by k. The rewards are limited, so $k < N$. Actors that enter the competition and obtain a reward receive a winner's payoff α. Actors that do not enter the competition receive a sustainer's payoff β. Actors that enter the competition and do not obtain a reward receive a loser's payoff γ. Winning is better than sustaining, and sustaining is better than losing, so $\alpha > \beta > \gamma$. In the original model, these payoffs are equated with utility, i.e. actors want to maximize their payoffs. The influence of these three payoffs can be summarised into a cost-benefit ratio $Q = (\beta - \gamma) / (\alpha - \gamma)$. This ratio expresses how risky it is to enter the competition considering all three potential outcomes, with values close to 0 indicating very low risks and values close to 1 indicating very high risks. Actors choose simultaneously whether to compete and have all information on the game, but they do not know how many other actors will choose to compete. If the number of competitors does not exceed the number of rewards ($n \leq k$), all the competitors will receive the winner's payoff and all non-competitors the sustainer's payoff. If the number of competitors exceeds the number of rewards ($n > k$), the rewards are randomly allocated over the competitors, giving a chance of winning of k/n and a chance of losing of $(n - k)/n$. For each potential number of competitors, the expected utility of competing is the sum of the winner's and loser's payoff multiplied by their respective probabilities.

In Table 1a, we give an example of an actor's expected utility under all possible numbers of other competitors $(n - 1)$, in a group of six actors $(N = 6)$, with 1 reward $(k = 1)$, with the winner's payoff $\alpha = 80$, the sustainer's payoff $\beta = 20$, and the loser's payoff $\gamma = 0$. We see that the expected utility of competing indeed depends on the number of other competitors. If there are no other competitors, the actor can be sure of a reward when competing, and therefore obtains an expected utility of $\alpha = 80$. If there is one other competitor, there is a one-half probability of coming out a winner and a one-half probability of coming out a loser when competing, giving an expected utility of ½ × 80 + ½ × 0 = 40, which is higher than the expected utility of not competing $(\beta = 20)$. If there are 2 other competitors, there is a one-third probability of coming out a winner and a two-thirds probability of coming out a loser, giving an expected utility of 1/3 × 80 + 2/3 × 0 = 26.7, and so on. We see that, in this example, competing gives a higher expected utility than not competing only if the number of other competitors does not reach three. This means that there is no dominant strategy in the current example; there is no action that gives the highest expected utility regardless of what other actors choose. If there are fewer than three other competitors, a payoff-maximizing actor would want to compete, whereas the actor would not want to compete if there are more than three other competitors (the actor happens to be indifferent in this example when the number of other competitors is exactly three). To predict how actors will behave, we can find the solution in mixed strategies, i.e. find the actor's probability of competition that would maximize one's payoffs. Before doing so, we first show how utility would be affected if actors have relative deprivation aversion.

As mentioned, the losers are commonly considered to be relatively deprived compared to winners. The losers and winners both enter the competition under the same conditions, creating a natural reference group. To incorporate relative deprivation aversion, we can subtract from the loser's payoff γ the payoff difference with the winners $(\alpha - \gamma)$ and multiply it by a parameter indicating the strength of the actor's aversion to relative deprivation. We use parameter θ_i to capture the actor's intensity of relative deprivation aversion. In a two-player scenario with one winner and one loser, this would mean that a loser's utility becomes $\gamma - \theta_i(\alpha - \gamma)$. To incorporate situations with more than one loser and winner, we can multiply the payoff difference between losers and winners by the proportion of winners out of one's group members $(k/(N - 1))$. This means that the disutility of being a loser is stronger when there are more winners, as also suggested by prior theoretical work on Boudon's model (Manzo, 2011). The resulting utility function for losers is presented in Equation 1. We model relative deprivation aversion by using Equation 1 for the loser's utility rather than the loser's payoff.

$$u\,(loser) = \gamma - \theta_i \frac{k}{N-1}\,(\alpha - \gamma) \tag{1}$$

Note that our introduction of relative deprivation aversion is similar to the introduction of the 'envy' parameter in the inequity aversion model (Fehr and Schmidt, 1999). The original inequity aversion model also includes a 'guilt' parameter that lowers payoffs when being advantaged to others instead of disadvantaged. In our model, such a 'guilt' parameter would reduce the payoffs of the winners. While advantageous inequity may bring guilt in some situations, we suggest that it is unlikely to occur among people entering a competition, as there can be no competition without winners and losers. Indeed, altruistic concerns for others' welfare are often argued to be less present in competitive situations (Kagel and Roth, 2015). Moreover, winners and losers took exactly the same action in Boudon's game, making feelings of guilt unlikely. This is different from social dilemma situations, where advantageous positions over others are typically

Table 1. Example game-matrices for actors with and without relative deprivation aversion

	Number of other competitors $(n - 1)$					
	0	1	2	3	4	5
(a) payoff maximization						
Compete	80	40	26.7	20	16	13.3
Do not compete	20	20	20	20	20	20
(b) relative deprivation aversion in loser-winner comparisons						
Compete	80	36	21.3	14	9.6	6.7
Do not compete	20	20	20	20	20	20

obtained through free-riding on others' prosocial behaviour (Van Dijk and De Dreu, 2021). We therefore assume no guilt of coming out as a winner in our model, although it could easily be incorporated if desired. Note that relative deprivation aversion does not replace payoff maximization. Instead, it is added to payoff maximization; actors thus balance payoff maximization and relative deprivation aversion, with the balance depending on the intensity of relative deprivation aversion θ_i. When $\theta_i = 0$, we obtain the payoff maximization model (we impose no upper bound on θ_i).

Recall that we provided an example in Table 1a of a payoff maximizing actor's expected utility in a group of six actors ($N = 6$), with one reward ($k = 1$), with the winner's payoff $\alpha = 80$, the sustainer's payoff $\beta = 20$, and the loser's payoff $\gamma = 0$. We can now see what happens to these utilities if we incorporate relative deprivation aversion in loser–winner comparisons. For this example, we will assume that all actors have the same intensity of relative deprivation aversion of $\theta = 0.5$ and that this is common knowledge, but we will relax both of these assumptions later. Once again, the expected utility of competing is the sum of the winner's and loser's payoff multiplied by their respective probabilities, only now the loser's payoff is subtracted by the winner's payoff according to Equation 1. The resulting utility of actors with relative deprivation aversion is presented in Table 1b. We see that the expected utility of competing again depends on the number of other competitors. If there are no other competitors, the actor can be sure of a reward when competing, and therefore obtains an expected utility of $\alpha = 80$. If there is one other competitor, there is a one-half probability of coming out a winner and a one-half probability of coming out a loser, giving an expected utility of ½ × 80 + ½ × (0 – 0.5 × 1/5 × (80 – 0)) = 36, which is lower than the expected utility without relative deprivation aversion (40). When comparing Table 1a and 1b, we see that the expected utility of competing is decreased when incorporating relative deprivation aversion. Competing thus becomes less attractive, which will generally decrease the probability that an actor chooses to compete (see the calculation of the probability of competing later).

Like relative deprivation aversion in loser–winner comparisons, we can also model relative deprivation aversion in loser–sustainer comparisons. In this case, the utility of losing is the loser's payoff subtracted by the payoff difference between sustainers and losers (multiplied by the proportion of sustainers and the intensity of relative deprivation aversion). Likewise, we can model relative deprivation aversion in sustainer–winner comparisons, and combinations of loser–winner, loser–sustainer, and sustainer–winner comparisons. We include such models and their consequences for competition behaviour in supplementary material S1, but here focus on relative deprivation in loser–winner comparisons as these are the comparisons originally suggested to lead to relative deprivation (Boudon, 1982 [1977]).

To predict the competition decision that actors will make, we need a game-theoretic solution concept. We predict the actor's behaviour by finding the solution in the mixed-strategy Nash equilibrium, i.e. by finding the actor's probability of competition that would lead to the largest expected utility. Raub (1984) showed there is a unique competition probability under the mixed-strategy solution that maximizes the actor's utility in Boudon's model. The optimal competition probability p^* in the mixed-strategy equilibrium can be found by equating the expected utility of competing with the expected utility of not competing. Because the expected utility of competing is different under different numbers of competitors, we have to equate the overall expected utility of competing for all possible permutations of competitors, $C(k, \bullet)$, with the overall expected utility of not competing for all possible permutations of competitors, $D(k, \bullet)$ (Raub, 1984; Berger and Diekmann, 2015):

$$C(k,\bullet) = \sum_{n-1}^{N} \binom{N-1}{n-1} p^{n-1}(1-p)^{N-n} \cdot C(k,n) =$$
$$D(k,\bullet) = \sum_{n-1}^{N} \binom{N-1}{n-1} p^{n-1}(1-p)^{N-n} \cdot D(k,n) \tag{2}$$

Solving Equation 2 gives the optimal competition probability. We can use the values in Table 1a to show an example calculation for payoff maximizing actors:

$$(1-p)^5 \cdot 80 + \binom{5}{1} p(1-p)^4 \cdot 40 + \binom{5}{2} p^2(1-p)^3 \cdot 26.7 + \binom{5}{3} p^3(1-p)^2 \cdot 20 + \binom{5}{4} p^4(1-p) \cdot 16 + p^5 \cdot 13.3 = 20 \tag{3}$$

Solving Equation 3 gives the optimal probability to compete of $p^* = 0.67$. So, we expect that out of the six actors, about four (.67 × 6) will compete if they maximize their payoffs. Because there is only one reward for these four competitors, there will be three losers, giving an overall relative deprivation rate of 3/6 (i.e. the proportion of losers out of the total population). We can also calculate the optimal probability of competing when including relative deprivation aversion in loser–winner comparisons. To calculate the optimal probability of competing with relative deprivation aversion in loser–winner comparisons, we use the values reported in Table 1b to fill in Equation 2, obtaining:

$$(1-p)^5 \cdot 80 + \binom{5}{1} p(1-p)^4 \cdot 36 + \binom{5}{2} p^2(1-p)^3 \cdot 21.3 + \binom{5}{3} p^3(1-p)^2 \cdot 14 + \binom{5}{4} p^4(1-p) \cdot 9.6 + p^5 \cdot 6.7 = 20 \tag{4}$$

Solving Equation 4 gives an optimal probability to compete of $p^* = .52$. Thus, with relative deprivation aversion in loser–winner comparisons, we would expect about 3/6 actors to compete. Because there is only one reward, there will be two losers, giving an overall relative deprivation rate of 2/6. Comparing this to the relative deprivation rate of 3/6 under the payoff maximization model, we see that we obtain a lower deprivation rate with relative deprivation aversion. These calculations are based on the assumption that all actors have the same intensity of relative deprivation aversion and that this is common knowledge. In supplementary material S10, we provide theoretical analyses of such a model with homogeneous relative deprivation aversion and show that it indeed predicts somewhat lower rates of relative deprivation than the payoff maximization model.

It is arguably more realistic if we allow for heterogeneity in the actor's intensity of relative deprivation aversion. To do so, we can move to the Bayesian Nash equilibrium concept (Harsanyi, 1968). Instead of assigning all actors the same value for the intensity of relative deprivation θ_i, we can draw θ_i for each actor from a normal distribution with mean m and standard deviation s. We assume that actors only know their own value for θ_i and the normal distribution that their group members' value of θ_i is drawn from. This means that there is heterogeneity in relative deprivation aversion intensity and actors have incomplete information on the actual intensity of their group members' relative deprivation aversion. If we know the mean m and standard deviation s of the normal distribution of θ_i, we can calculate the threshold value θ^*; participants that surpass the threshold will not compete (their relative deprivation aversion is too intense) and those that fall below it will compete. By seeing where this threshold value falls in the cumulative distribution of θ_i, we can find the average competition probability at the population level and the associated proportion of losers (we provide the exact calculations and scripts at https://osf.io/z6jdm/). We use prior experimental data (Johansson-Stenman, Carlsson and Daruvala, 2002) to set the mean and standard deviation of the normal distribution of θ_i at 0.63 and 0.75, respectively, see supplementary material S2. In supplementary material S4, we use several other experiments to derive other distributions of relative deprivation aversion and show that the theoretical results are similar using these other distributions.

To examine the impact of incorporating relative deprivation aversion, we calculate the competition probability and the loser probability under a broad range of conditions for both the payoff maximization model (using the mixed-strategy Nash equilibrium solution) and the relative deprivation aversion model (using the Bayesian–Nash equilibrium solution). In particular, we show for both models how the competition and loser probability depend on the proportion of rewards and the cost-benefit ratio of competing. We fix the group size because it does not influence the outcomes over and above the proportion of rewards and the cost-benefit ratio of competing (supplementary material S5). We choose a group size of six as this is also the group size that will be used in the experiments. The number of rewards varies from one to five, which means that the proportion of rewards varies from 1/6 to 5/6 because the group size is six. The results are shown in Figure 1.

We first focus on the competition probability, presented in Figure 1a-b. We see that a higher number of rewards and lower cost-benefit ratio are associated with a higher competition probability in both models, which is in line with earlier research on Boudon's model (Raub, 1984; Kosaka, 1986; Yamaguchi, 1998; Manzo, 2009, 2011; Ishida, 2012; Otten, 2020). However, the competition probability is lower in the relative deprivation aversion model than in the payoff maximization model. An increase in the number of rewards leads to a disproportionate increase in the competition probability under payoff maximization, whereas the increase is much more gradual under relative deprivation aversion. If actors maximize payoffs, the competition probability already reaches one when the number of rewards is half of the total population ($k = 3$) and the cost-benefit ratio is not high ($Q \leq .5$). In contrast, if actors are averse to relative deprivation, the competition probability only approaches one if almost all the actors can get a reward ($k = 5$) and the cost-benefit ratio is not high.

In Figure 1c-d, we see that the difference in the competition behaviour between the models has large consequences for relative deprivation as measured by the loser probability. Because increasing the number of rewards leads to disproportionate increases of the competition probability in the payoff maximization model, the proportion of losers will increase until the competition probability has reached one (all the actors compete). After the competition probability has reached one, further increasing the proportion of rewards decreases the gap between the competition probability and the proportion of rewards, thereby decreasing the proportion of losers. Hence, in the payoff maximization model, relative deprivation first increases when social conditions improve (the number of rewards) and then decreases again, which is in line with the pattern found in earlier research on Boudon's model.

The pattern is strikingly different for the relative deprivation aversion model. Because the competition probability does not increase disproportionally when the number of rewards increases, the proportion of losers hardly increases when social conditions improve.

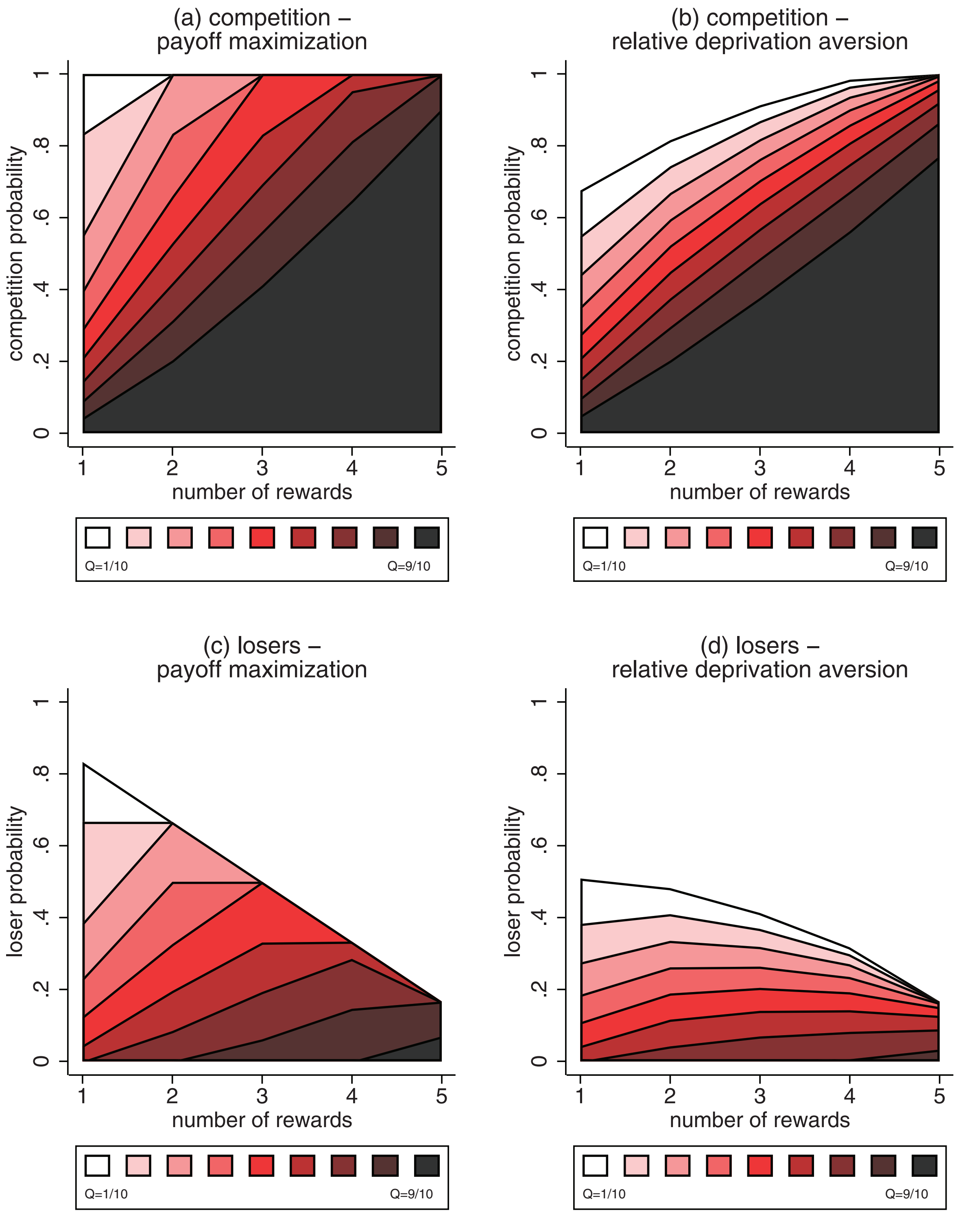

Figure 1 Competition and relative deprivation under payoff maximization and relative deprivation aversion. *Note*: we show the theoretical relationship between the number of rewards and the competition/loser probability for different cost-benefit ratios in a group of six actors. The relationships are shown for two theoretical models: payoff maximization and relative deprivation aversion. Cost-benefit ratios (Q) are indicated by colour, with darker colours indicating higher cost-benefit ratios.

If the cost-benefit ratio is high, the loser probability remains largely constant as social conditions improve. If the cost-benefit ratio is low, the loser probability decreases when social conditions improve. This means that the paradoxical relationship between improving social conditions and heightened levels of relative deprivation is strongly attenuated in the model with relative deprivation aversion. In supplementary material S3, we show that we arrive at the same conclusion when varying the mean level and standard deviation of relative deprivation aversion and we discuss the assumption of normality. In supplementary material S1, we show that the attenuation of the paradox also holds when modelling relative deprivation aversion simultaneously in loser–winner and loser–sustainer comparisons, but argue that it does not hold when incorporating only loss or risk aversion.

The Gini coefficient has been suggested as an alternative measure of a population's level of relative deprivation (Yitzhaki, 1979; Berger and Diekmann, 2015). The Gini coefficient is defined as one-half of the mean payoff difference between all actors, relative to the mean payoff. In contrast to the proportion of losers as a measure of relative deprivation, the Gini coefficient thus incorporates payoff differences among all actor types: losers, sustainers and winners. In supplementary material, Figure S2, we show that replacing the proportion of losers with the Gini coefficient as the measure of relative deprivation leads to a similar conclusion: the paradoxical relationship between improving social conditions and increased relative deprivation levels is attenuated when incorporating relative deprivation aversion. Next, we will test to what extent the paradoxical relationship is present empirically with lab experiments.

Experimental methods

We predict the competition probability and the associated loser probability under the experimental settings of Berger and Diekmann (2015) and newly collected experimental data. This allows us to test the theoretical predictions using both the previous experiments that generated mixed support for the original model and new experimental data. We compare the theoretical predictions based on payoff maximization and on aversion to loser–winner comparisons (predictions that include loser-sustainer comparisons or both comparison types are given in supplementary material S7). Recall that we estimated the relative deprivation aversion parameter θ_i from different data than the experiments of Berger and Diekmann (2015) and ourselves. This means that the relative deprivation aversion model and the payoff maximization model are equally falsifiable. That is, both models give a single predicted competition and loser probability for each experimental setting that can be compared with the observed competition and loser probability found under that experimental setting. We now describe the experiments before turning to the results.

Berger and Diekmann (2015) conducted three experiments on Boudon's competition model. Participants were told that they would have to decide whether to take part in a competition. If they did not enter the competition, they would obtain a medium-level payoff. If they did enter the competition, they would either get a high payoff with some probability or a low payoff. The competition rules followed Boudon's model exactly, and were explained through written instructions that used neutral framing (based on payoffs rather than using labels such as 'winner' or 'loser'). Participants were recruited among Swiss university students and made their competition decisions anonymously via computers in the laboratory. The experiment was coded using z-tree (Fischbacher, 2007) and decisions were incentivized with monetary stakes.

The first experiment used a within-subject design with 72 participants who played the competition game in groups of six. There were three conditions. In the first condition, there was one reward per group, in the second condition there were two rewards, and in the third condition there were five rewards. Each person participated twice per condition, once with low monetary stakes and once with high monetary stakes. In the second and third experiments, a between-subject design was used with 60 participants in each experiment. Both experiments had two conditions: the first with one reward per group, the second with two rewards per group. The cost-benefit ratio of competing varied between the three experiments, but not within the experiments. Because there are three conditions in experiment 1 and two conditions each in experiments 2 and 3, there are a total of seven conditions. In each condition we observe the average competition probability and the associated loser probability, which we can compare with the predicted probabilities under our two different theoretical models: payoff maximization and relative deprivation aversion.

In our own experiment on Boudon's competition model, participants were also told that they have to decide whether to take part in a competition, similar to Berger and Diekmann (2015). We explained that participants would obtain a secure payoff if they did not enter the competition, and that entering the competition can lead to either a higher or lower payoff depending on the number of rewards and competitors. The rules of the competition followed Boudon's model precisely, and were explained in detail through written instructions (provided in supplementary material S6). We used neutral framing (based on payoffs rather than using labels such as 'winner' or 'loser'). We recruited participants with ORSEE (Greiner, 2015) among students at Utrecht University. Participants were randomly placed behind a computer in an individual cubicle and made their competition decisions anonymously. The experiment was coded using z-tree (Fischbacher, 2007). Decisions were incentivized with monetary stakes, with participants earning on average 9 euros for a participation of 40 minutes (in line with the hourly wage for students). The data and analysis scripts are openly available at https://osf.io/z6jdm/.

We used a within-subject design with 60 participants who also played the competition game in groups of six. We varied both the number of rewards and the cost-benefit ratio of competing in a full-factorial design. We varied the number of rewards between one, three, and five, and we varied the cost-benefit ratio between a low and high value, giving a total of six conditions (3 × 2). All 60 participants made competition decisions in each of the six conditions. This gives us sufficient power to find effect sizes similar to those obtained by Berger and Diekmann. For example, in their within-subject experiment, the increase in the competition probability had an effect size of .38 when moving from one to two rewards and an effect size of .78 when moving from two to five rewards; we have ~82 percent power to detect an effect size of .38 and >90 percent power to detect an effect size of .78 with two-sided *t*-tests. We will refer to our three conditions under the low cost-benefit ratio as part 1 of the experiment and our three conditions under the high cost-benefit ratio as part 2 of the experiment.

Like in the experiments of Berger and Diekmann, we observe the average probability of competition and the associated loser probability in each of our six conditions, which we can compare with the predicted probabilities under our different theoretical models. In all experiments, the number of rewards indicates the opportunities to improve one's position by becoming a winner. In line with prior experimental research on Boudon's model (Berger and Diekmann, 2015; Otten, 2020), we will refer to conditions with one reward as low-mobility conditions, conditions with two–three rewards as medium-mobility conditions, and conditions with five rewards as high-mobility conditions. The precise parameter values used in all experiments can be found in supplementary material S6.

Results

In Figure 2, we present the observed and the predicted proportion of competitors and losers for the three experiments of Berger and Diekmann (2015). The proportion of competitors shows the behaviour of the participants and the proportion of losers shows the outcome in terms of relative deprivation. We first descriptively compare the match of the predictions by the payoff maximization model and the relative deprivation aversion model with the observed outcomes, and later turn to statistical tests. In Figure 2a, we see that the payoff maximizing model predicts for experiment 1 that the proportion of competitors increases strongly when moving from the low-mobility condition (k=1) to the medium-mobility condition (k=2), namely from .40 to .83, and then increases further to one when moving to the high-mobility condition (k=5). Because the predicted increase in the proportion of competitors when moving from the low-mobility condition to the medium-mobility condition is disproportionately strong to the increase in the number of rewards, the proportion of losers is predicted to increase as well (Figure 2d). Thus, the payoff maximization model here predicts that relative deprivation increases (as measured by the loser rate) when the social opportunities improve (as measured by the number of rewards) from a low to medium level. This counterintuitive prediction is of central importance, as it is precisely such counterintuitive situations that Boudon set out to explain with his model.

However, we see that the observed proportion of competitors does not match the predictions by the payoff maximization model very well. Contrary to the prediction, the observed increase in the competition probability is mostly proportionate to the increase in the number of rewards; it increases from .35 to .55 to .90 when moving from the low-mobility to medium-mobility to high-mobility condition (from k=1 to k=2 to k=5). Because the proportion of losers only increases if the proportion of competitors increases disproportionally, we observe no increase in the proportion of losers. Hence, the improvement of social opportunities does not lead to more relative deprivation in experiment 1. We see that the relative deprivation aversion model does predict the more gradual increase in the proportion of competitors when increasing the number of rewards. It predicts that the competition proportion moves from .35 to .60 to 1 when moving from the low-mobility to medium-mobility to high-mobility condition, which comes quite close to the observed values (.35 to .55 to .90). Consequently, the relative deprivation aversion model predicts no increase in the proportion of losers and therefore fits well with the observed values in experiment 1.

Also in experiments 2 and 3 (Figure 2e-f), the payoff maximization model predicts an increase in the proportion of losers when moving from a low-mobility condition to a medium-mobility condition (k=1 to k=2) while the relative deprivation aversion model predicts a relatively stable proportion of losers.

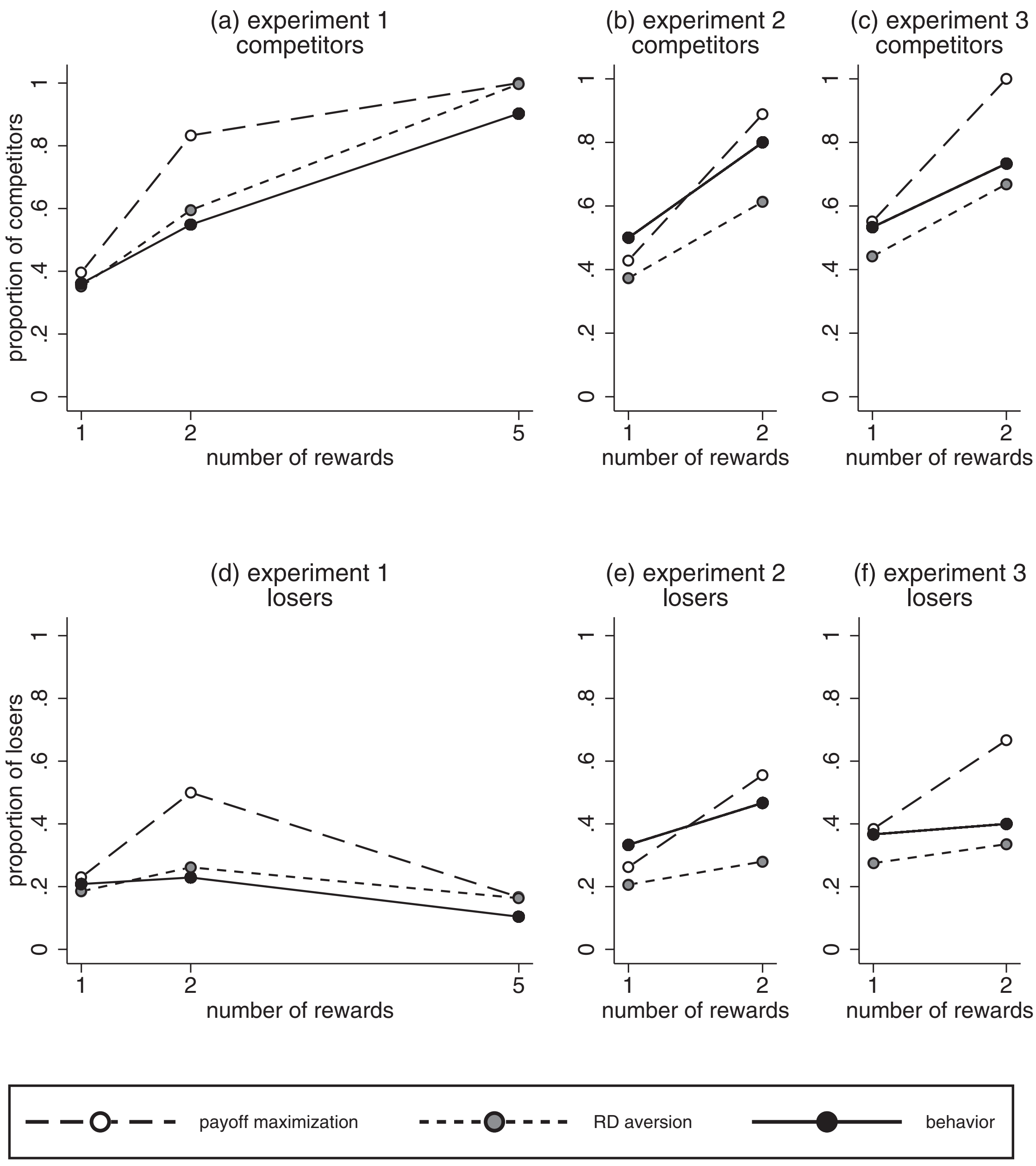

Figure 2 Predictions and behaviour for the competition and loser rate in the Berger and Diekmann (2015) experiments.

It is the latter prediction that appears to come close to the observed pattern. Note, however, that for point predictions instead of directional predictions, the relative deprivation aversion model only comes closer to the observed values in experiments 1 and 3. In supplementary material Figure S11-12, we present extended comparisons that also include alternative relative deprivation aversion models. These supplementary figures suggest that a relatively stable proportion of losers is predicted as long as models incorporate aversion to loser–winner comparisons (models with only aversion to loser–sustainer comparisons still predict an increase in the proportion of losers).

In Figure 3, we present the observed and predicted proportion of competitors and losers for our own experiment. A first thing to note is that the predicted

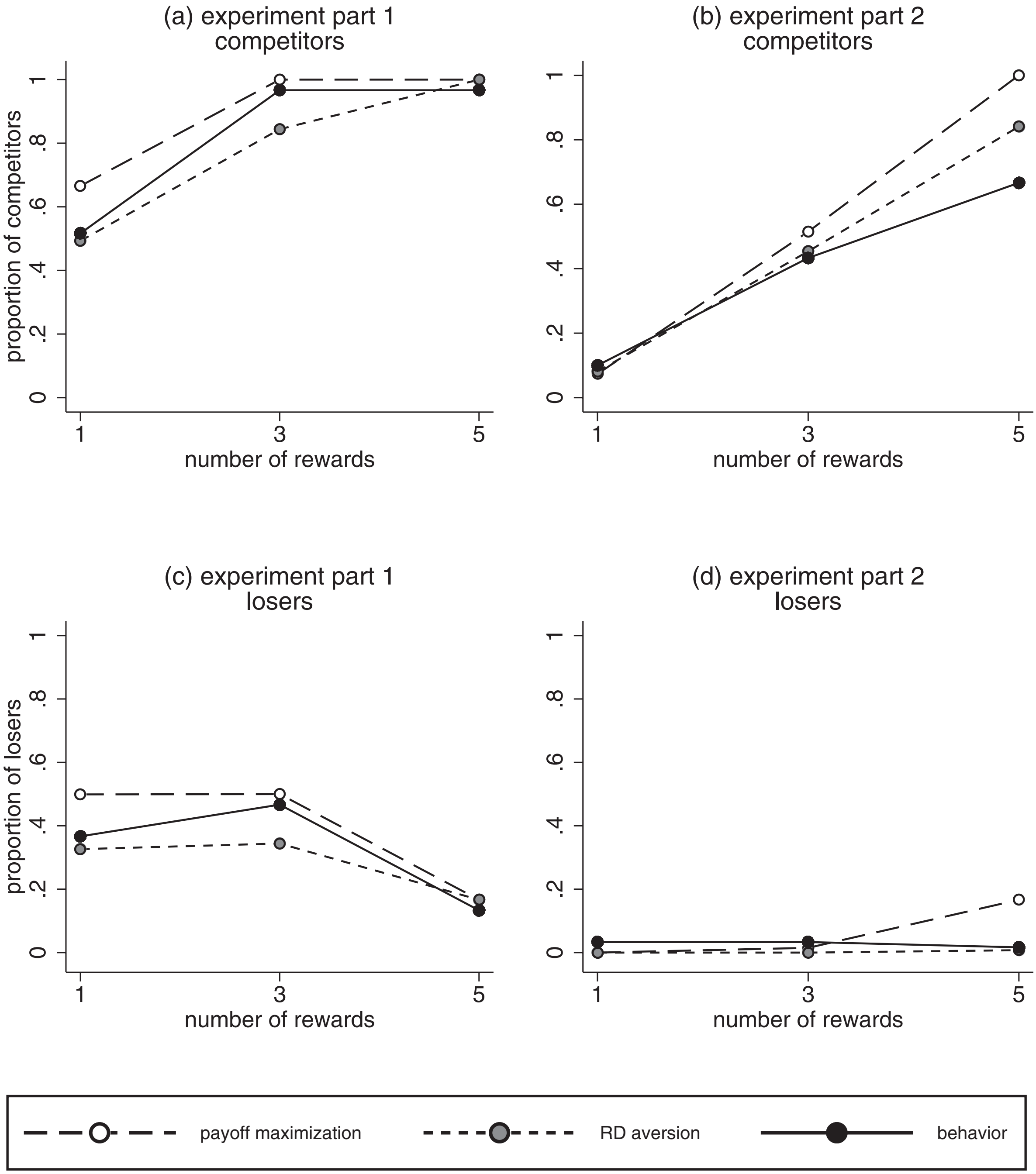

Figure 3 Predictions and behaviour for the competition and loser rate in our own experiment.

and observed competition and loser probability are somewhat different than under the experiments of Berger and Diekmann. This can be explained by the variation between the experiments in the cost-benefit ratio of competing; experiments with lower cost-benefit ratios have a higher competition and loser probability (see supplementary material S6 for the cost-benefit ratio of each experiment). This has no implications for the support of the relative deprivation aversion model versus the payoff maximization model because both predict a higher competition and loser probability with lower cost-benefit ratios (see also Figure 1).

We see in Figure 3 again that moving from lower mobility conditions to higher mobility conditions is associated with larger observed proportions of competitors and that this does not translate to larger proportions of losers. We generally do not see large differences between the predictions by the payoff maximization model and the relative deprivation aversion model in part 1 of the experiment. However, in part 2 of the experiment, the relative deprivation aversion model seems to do somewhat better when moving from the medium-mobility condition to the high-mobility condition. The payoff maximization model here once again predicts a disproportionate increase in the proportion of competitors, leading to an increase in the proportion of losers. In contrast, the relative deprivation aversion model predicts a proportionate increase in the proportion of competitors when moving from the medium-mobility condition to the high-mobility condition and hence a relatively constant proportion of losers. This latter prediction comes closer to the observed pattern and values.

We next examine whether the differences between the payoff maximization model and the relative deprivation aversion model in terms of how accurately they predict the absolute levels of competition and relative deprivation are statistically significant. To do so, we first observe per experimental group the proportion of competitors. We then calculate per experimental group the difference between this observed proportion and the predicted proportion by the payoff maximization model. We also calculate the difference between the observed proportion and the predicted proportion by the relative deprivation aversion model. By comparing these two differences, we can examine per experimental group how much closer either of the two theoretical models (payoff maximization or relative deprivation aversion) is to the observed proportion. Combining all conditions in all experiments, we can compare the difference between the predicted competition proportion and the observed competition proportion for 152 experimental groups. We find that this difference is significantly smaller for the relative deprivation aversion model than for the payoff maximization model (15.7 percent versus 18.1 percent, $t(151) = 2.32$, $p = .02$).

Using the same procedure, we also find that the difference between the predicted and observed proportion of losers is significantly smaller in the relative deprivation aversion model than in the payoff maximization model (12.1 percent versus 14.6 percent, $t(151) = 2.40$, $p = .02$). This suggests that the relative deprivation aversion model more accurately predicts the absolute levels of competition and relative deprivation than the payoff maximization model. Note that these two tests are not independent of each other, as the loser proportion results from the combination of the proportion of competitors and the proportion of rewards. In supplementary material (sections S7–S10), we show that predictions of alternative relative deprivation aversion models also perform somewhat better than payoff maximization, and that this also holds when using the Gini coefficient as the measure of relative deprivation.

Next, we move from tests of absolute predictions to tests of directional predictions. In particular, we statistically examine the situation of moving from a low-mobility condition to a medium-mobility condition, i.e. the situation in which the paradoxical increase in relative deprivation is thought to occur if we assume payoff maximization. There are five experimental settings for which we have a low-mobility condition and a medium-mobility condition (each of the three experiments by Berger and Diekmann and each of the two parts of our own experiment). We can compare the change in the loser proportion when moving from the low-mobility to medium-mobility condition in each of these five settings and sum these changes to get at an estimate of the average change in relative deprivation when moving from a low-mobility condition to a medium-mobility condition. In total, there are 648 observations in the low-mobility and medium-mobility conditions in these five settings (Berger and Diekmann, Exp 1: 288, Exp 2: 60, Exp 3: 60; own experiment: 120 in part 1 and 120 in part 2). The average predicted increase of the loser proportion when moving from the low-mobility to medium-mobility condition in these five settings is 17.2 percent according to the payoff maximization model and 4.6 percent according to the relative deprivation aversion model. The observed average increase is 4.3 percent, which is not significantly different from zero (p =.19, OLS regression controlling for the experimental setting). When using equivalence testing, we find that the observed increase is statistically equivalent to the predicted increase by the relative deprivation aversion model, and not the payoff maximization model (see supplementary material S9).

Finally, we briefly turn to self-reported satisfaction with the competition outcome among participants. After each competition round, participants were asked to report their satisfaction with their outcome. In the Berger and Diekmann experiments, general satisfaction with the outcome was measured. In our own experiment, we measured both the general satisfaction with the outcome and the satisfaction towards specific reference groups (winners, sustainers and losers). We use these measures to examine if average satisfaction decreases when moving from the low-mobility to medium-mobility condition, as would be expected when there is a paradoxical relationship between improving conditions and relative deprivation. The full results are provided in supplementary material S11, here, we report the main results. We find that in none of the experimental settings does the average satisfaction decrease when moving from the low-mobility to medium-condition. This holds both when examining general satisfaction and when examining satisfaction towards specific reference groups. Instead, average satisfaction is largely stable or increases somewhat when the number of rewards increases. Hence, also when examining subjective experiences, we find no evidence for a paradoxical relationship between improving opportunities and heightened levels of relative deprivation.

Discussion

It is often argued in the social sciences that improvements in social opportunities can paradoxically lead to a larger share of frustrated individuals (Durkheim, 1952 [1897]; Tocqueville, 1955 [1856]; Brinton, 1965; Stouffer et al., 1965 [1949]; Coleman, 1990). Whereas these arguments are usually formulated informally, Boudon (1982 [1977]) proposed a competition model of relative deprivation that leads to precise and falsifiable predictions on the situations in which this paradox occurs. Theoretical analyses of this model by Boudon and other scholars suggest that the paradox commonly occurs when opportunities rise from a low to medium level and acting on these opportunities carries relatively low costs (Boudon, 1982 [1977]; Raub, 1984; Kosaka, 1986; Manzo, 2009, 2011; Ishida, 2012). However, empirical evidence for the model has been mixed so far (Berger and Diekmann, 2015), which suggests that revision of its behavioural premises may be needed. Because the model deals with relative payoffs as a central outcome, we suggested to also incorporate a concern for relative payoffs in the actors' decision-making.

We therefore replaced the model's premise that actors care only about their absolute payoffs with a premise where actors care about both their absolute and relative payoffs and called this relative deprivation aversion. Although a concern for relative payoffs had previously been incorporated in actors' evaluation of their outcome (Manzo, 2011), we incorporate it into their decision-making. To do so, we used game-theoretic analyses that incorporate heterogeneity and incomplete information in relative deprivation aversion. The analyses showed that the paradoxical relationship is strongly attenuated when incorporating relative deprivation aversion. The attenuation holds when using the loser proportion as a measure of relative deprivation, as originally suggested by Boudon (1982 [1977]), and also when using the Gini coefficient as suggested by other authors (Yitzhaki, 1979; Berger and Diekmann, 2015). Our model predicts that relative deprivation remains rather stable with improving opportunities.

Using previously and newly collected experimental data, we empirically showed that there is indeed no significant increase in relative deprivation under improving opportunities in Boudon's model. This holds when examining objective measures such as the loser proportion but also when examining subjective measures such as self-reported satisfaction. We furthermore showed that incorporating relative deprivation aversion leads to a modest but significant improvement in predicting the absolute rates of relative deprivation, and a stronger improvement in predicting the change of relative deprivation when opportunities improve from a low to medium level. Although there are different ways to incorporate relative deprivation aversion, we found that a relatively simple model in which only aversion to loser–winner comparisons is incorporated does not perform worse than more complex models including additional interpersonal comparisons.

Although our theoretical model and the empirically observed pattern do not suggest that improving opportunities lead to less satisfaction in the competition structures modelled by Boudon, they also do not suggest that improving opportunities lead to more satisfaction. In this sense, the result still runs counter to common-sense intuition that improving opportunities lead to more overall satisfaction. Interestingly, this result is in line with another common paradox, namely the Easterlin paradox stating that rising income levels do not produce more happiness. Although well-known, the paradox has been criticized, in part due to problems in linking micro-level satisfaction with macro-level opportunity structures (Kaiser and Vendrik, 2019). Boudon's competition model explicitly makes such micro–macro links and may therefore prove to be a useful tool in this debate. Indeed, as far as we are aware, there are no game-theoretic analyses of the Easterlin paradox yet. More generally, Boudon's model provides a theoretical framework for investigating the interplay between macro-level structures of competition and social mobility and micro-level outcomes in terms of individual behaviour and status (Berger and Diekmann, 2015). Seen this way, it can bring a mechanism-based understanding of many sociological phenomena that are typically studied with parametric models instead of formal models.

Our theoretical and empirical analysis of Boudon's model did not produce much evidence for the paradoxical relationship whereby improving opportunities lead to a larger share of frustrated individuals, but this does not mean that the paradox is absent in real-world situations. Rather, it suggests that this paradox is unlikely in the types of competition structures modelled by Boudon and when individuals are averse to relative deprivation. It is possible that the paradox does arise in situations that attract individuals who are not susceptible to the risks of relative deprivation. For example, men are often found to be less averse to competition than women (Niederle and Vesterlund, 2007; Berger, Osterloh and Rost, 2020). This suggests that the paradox may be more likely to occur in contexts populated predominantly by men. Indeed, the classic finding of Stouffer et al. (1965 [1949])—that US soldiers in branches with higher promotion opportunities were less satisfied with their promotion opportunities—involves a setting populated almost exclusively by men.

It is also possible that the paradox does arise under alternative competition structures. This may be investigated by extending Boudon's model in terms of the competition and network structures, and some steps in this direction have already been taken. For example, Manzo (2011) has extended Boudon's model to incorporate different network topologies and Otten (2020) has extended Boudon's model to incorporate situations in which not only excess competition but also a lack of competition can lead to relative deprivation. While these models were not introduced to examine if the paradox would remain under relative deprivation aversion, they could be used for this purpose. Altering the model's method of winner selection is also a worthwhile direction. In the current model, rewards are randomly allocated among the competitors, while in meritocratic societies rewards are often allocated through performance. This could be incorporated in Boudon's model, for example by letting actors choose their competition level within a continuous range and allocating the rewards to those who selected the highest competition levels. Research suggests that individuals who are more competitive are more likely to enter performance-based competitions (Berger et al., 2020), meaning that competition levels and resulting rates of relative deprivation could be higher with performance-based winner selections. We have extended Boudon's model by introducing arguably more realistic behavioural assumptions and shown that the paradox then becomes less likely. We believe a logical next step is to examine to what extent the paradox occurs if we additionally introduce more realistic competition structures.

The inclusion of social preferences into game-theoretic models has been a major research area in the social sciences. Social preferences have been incorporated in models of public good provision, trust, altruism, bargaining and many others, which has generally led to predictions that better match actual behaviour (Fehr and Schmidt, 1999; Henrich et al., 2001; Fehr and Gintis, 2007). Similarly, we show that improvements in predicting relative deprivation are possible when incorporating social preferences that are relevant in competition processes. We focused on one type of social preference, so other social preference specifications remain to be investigated. Indeed, we have seen that the relative deprivation aversion model is also not fully in accordance with the observations in the experiments, so further improvement is certainly possible.

One potential extension that could improve predictions is to incorporate a preference for relative gratification on top of an aversion to relative deprivation. In such a model, actors not only aim to avoid low relative payoffs (relative deprivation), but additionally strive for high relative payoffs (relative gratification). This model may explain a pattern observed in some of the experimental settings with over-entry in competition at lower numbers of rewards and under-entry at higher numbers of rewards. With low numbers of rewards, losers do not have many winners to whom they are relatively deprived but winners have many losers/sustainers to whom they are relatively gratified, leading to potential over-entry into competition. This turns around with high numbers of rewards; losers have many winners to whom they are relatively deprived and winners have few losers to whom they are relatively gratified, leading to potential under-entry in competition compared with the payoff maximization model.

Another opportunity for improvement concerns the generalizability of the empirical evidence on Boudon's model, as studies so far use lab experiments with mostly university students. However, a prior study on a large representative sample of Dutch participants suggests that envy does not depend on age, education, or income (Bellemare, Kröger and Van Soest, 2008). Because envy forms a central element of relative deprivation aversion in Boudon's model, this might provide some assurance. Still, more variation in populations for future research on Boudon's model would be welcome to assess the generalizability of the results.

We believe that game-theoretic modelling has a large untapped potential to bring analytic clarity to research on relative deprivation. Game theory is uniquely suited to shed light on situations in which the happiness of actors depends not just on their own decisions but also on the decisions of others. Situations that lead to relative deprivation fall precisely within this category. A common criticism of the game-theoretic method is that it relies on unrealistic assumptions, for example about individuals' preferences for payoff maximization. We have seen that this need not be the case. Boudon's competition model can be extended to incorporate several types of preferences, one of which is relative deprivation aversion.

Supplementary Data

Supplementary data are available at *ESR* online.

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Data Availability Statement

Our data and analysis scripts are openly available at the Open Science Framework via https://osf.io/z6jdm/.

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