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Social Centipedes: the Impact of Group Identity on Preferences and Reasoning*

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Abstract

Using a group identity manipulation we examine the role of social preferences in an experimental one-shot centipede game. Contrary to what social preference theory would predict, we find that players continue longer when playing with outgroup members. Our explanation rests on two observations: (*i*) players should only stop if they are sufficiently confident that their partner will stop at the next node, given the exponentially-increasing payoffs in the game, and (*ii*) players are more likely to have this degree of certainty if they are matched with someone from the same group, whom they view as similar to themselves and thus predictable. We find strong statistical support for this argument. We conclude that group identity not only impacts a player's utility function, as identified in earlier research, but also affects her reasoning about the partner's behavior.

Keywords: Group identity, centipede game, prospective reference theory
JEL-Classification: C72, C91, C92, D83

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1 Introduction

The centipede game, first introduced by Rosenthal (1981), has attracted much attention both in the theoretical and experimental game theory literature. Many variations of this game have been explored, but all share the same basic structure. Two players alternate in their decision to continue or terminate the game. Payoffs are such that if a player chooses to continue while her partner stops at the subsequent node, she receives less than if she decides to stop immediately. Under common knowledge of rationality (Aumann, 1995, 1998), backward induction leads to the unique subgame-perfect Nash equilibrium where players choose to stop at each of their decision nodes, the game thus ending at the first node.

It has been repeatedly demonstrated in experimental studies, however, that the game is rarely terminated at the first node. Most of the literature has argued that the systematic deviations from the subgame-perfect equilibrium outcome result from some form of bounded rationality.[1] With the exception of McKelvey and Palfrey (1992) and Fey et al. (1996), who allow for altruistic behavior, none of the papers has explicitly tested for the possible import of social preferences in the centipede game.

Our experiment was designed to examine the impact of social preferences on behavior in the centipede game. As in Chen and Li (2009), participants are assigned to near "minimal" groups according to their preferences over paintings and interact with ingroup or outgroup members. It is well established that group identity manipulations increase altruism, positive reciprocity and the desire for maximizing social welfare among ingroup partners (for an overview, see Chen and Li, 2009; Chen and Chen, 2011; Goette et al., 2012a,b). To rigorously test for an effect of social preferences it was essential to elicit subjects' beliefs about their partner's behavior (Manski, 2004).

If group identity increases reciprocity, a natural hypothesis is that subjects playing with an ingroup member are more likely to continue at any given decision node compared to subjects interacting with an outgroup member. Theoretically, increased altruism and concerns for social-welfare maximization would make players continue longer by making later nodes relatively more attractive; positive reciprocity would also lead to continue longer as players repay the favor of continuing by doing likewise.[2] Our experimental data, however, do not support the social-preference-based hypothesis: aggregate strategies across

[1] Boundedly rational explanations of behavior in the experimental literature on the centipede game include quantal response equilibria (Fey et al., 1996; McKelvey and Palfrey, 1998), learning (Nagel and Tang, 1998; Rapoport et al., 2003), varying abilities to perform backward induction or limited depths of reasoning (Palacios-Huerta and Volij, 2009; Levitt et al., 2011; Gerber and Wichardt, 2010; Kawagoe and Takizawa, 2012; Ho and Su, 2013).

[2] McKelvey and Palfrey (1992) and Fey et al. (1996) provide formal theoretical models for the case of altruism. In both the imperfect information model in the former paper, and the AQRE model in the latter, a higher proportion of altruists increases the probability of the game ending at later nodes.

treatments show that participants interacting with outgroup players tend to continue longer and earn considerably higher payoffs in the game than ingroup players.

To explain this result, we take the reasoning processes of subjects into account since group affiliation is also known to impact subjects' mental reasoning about the behavior, and hence the perceived predictability, of others through social projection. Robbins and Krueger (2005, p.32) define social projection as a "tendency to expect similarities between oneself and others" regarding attitudes, intentions, or actions.[3] According to this literature, group identity induces a stronger sense of similarity with a player from the same group. It is this asymmetry between ingroup and outgroup projection which accounts for prosocial ingroup behavior that has been observed in a variety of strategic interactions.[4]

Since the optimal action at a node can only be determined by some form of introspection in one-shot games (e.g. Goeree and Holt, 2004), we hypothesize that beliefs formed about the partner's behavior in the game should be regarded as more relevant when the partner is an ingroup member. We look for support of this hypothesis by estimating a prospective reference theory model (Viscusi, 1989; Viscusi and Evans, 2006). According to this model, subjects do not necessarily take new information at face value but use it to update prior beliefs, where the relative weight assigned to prior beliefs in the updating process depends on the individually perceived content of new information. In our context, the new information are beliefs derived from introspection which will be given greater weight if the partner is an ingroup member. Estimating such a model we indeed find a striking difference: while subjects in the ingroup treatment behave as if their stated beliefs are fully informative, the weight placed on these beliefs by subjects in the outgroup treatment is only around one third. We interpret this finding as evidence that players' behavior relies much more on social projection in ingroup than in outgroup interactions.

The findings of the prospective reference model intuitively explain why outgroups continue longer than ingroups in our setup. With the exponentially-increasing payoffs in the centipede game, players should only stop if they believe that their partner will stop at the next node with high probability. Players are more likely to have this degree of certainty if they are playing with someone who they view as similar to themselves, and thus predictable. More generally, our results provide evidence that attention should be given to the possibility that discriminatory behavior can, in addition to the well-established ingroup favoritism caused by strengthened social preferences, also be driven by uncertainty in be-

[3]There is substantial evidence that social projection in ingroups is stronger than in outgroups, see the meta-analysis of Robbins and Krueger (2005). For a particular form of social projection, known as the (false-) consensus effect, Engelmann and Strobel (2012) demonstrate that the strength of the bias depends on the availability of representative information. Blanco et al. (2012) invoke the consensus effect as a reasonable explanation regarding observed behavior and stated beliefs in a sequential prisoner's dilemma.

[4]Prosocial, cooperative or welfare-maximizing outcomes in simple games have been found in psychological studies explicitly testing the level of social projection in group settings (e.g. Acevedo and Krueger, 2005; Krueger, 2007; Ames et al., 2011; Krueger et al., 2012).

liefs about outgroups. Our results on agent quantal response and level-k models show that the measured level of strategic sophistication of players varies in group affiliation which supports the above interpretation.

The uncertainty-in-beliefs interpretation is also consistent with some puzzling empirical and experimental observations in bargaining and market environments. For example, Graddy (1995) shows that white fishmongers charge less to Asian customers (in take it or leave it offers) and Ayres (1991) finds that test buyers got worse deals from car salespeople of same gender or race. A recent experimental study closely related to our work is Li et al. (2011) who also use group identity manipulations to study seller-buyer relationships in oligopolistic markets. Their results show that sellers charge lower prices to buyers of the other group than of the same group and is in line with our results of an uncertainty driven discrimination if salespeople are less certain about the relevant outgroups' bargaining strategy than that of ingroups.

The remainder of the paper is organized as follows. Section 2 describes the experimental design and Section 3 reports the main results. Section 4 discusses the robustness of our results, including agent quantal response and level-k models, before Section 5 concludes.

2 Design and procedures

The study was designed to investigate the impact of social preferences of the participants on behavior and stated first-order beliefs in the centipede game. The experiment was divided into four parts: a group identity task, participation in a centipede game, elicitation of beliefs regarding the partner's behavior, and a post-experiment questionnaire.

Part 1. Following the procedure in Chen and Li (2009), we used a modified version of the well-known minimal group paradigm of Tajfel and Turner (1979) to induce group identity among participants. In this paradigm, group membership is constructed from artificial contexts to prevent any reasonable association of particular group membership with ability, social preferences, or the like. Participants stated their preferences over five pairs of paintings in this task, with each pair consisting of one painting by Paul Klee and one by Wassily Kandinsky. The identities of the painters were not revealed to participants at this stage. Based on their relative preferences, half of the participants (12 out of 24 per session) were assigned to the "Klee group" and the other half to the "Kandinsky group". The group assignment remained fixed for the course of the experiment. After the group assignment, participants had to guess who of the two painters created two additional paintings. To enhance the effect of group identity, participants were given the possibility of communicating within their own group via a chat program. Participants were incentivized with 10 points for each correct guess. Participants received no feedback on performance until all decision-making parts of the experiment were completed.

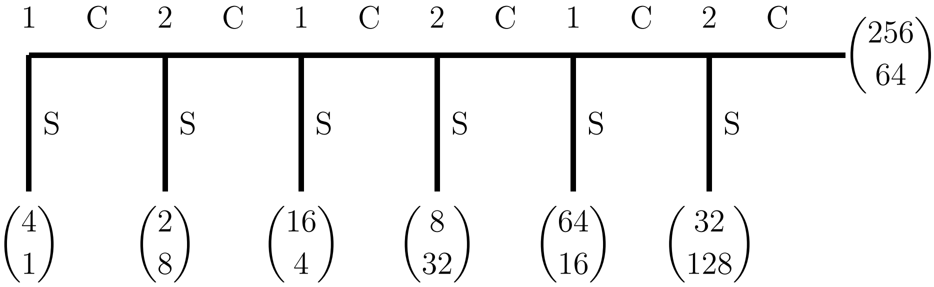


Figure 1: Centipede game with exponentially-increasing payoffs.

Part 2. Participants were matched pairwise to play a six-node centipede game with exponentially-increasing payoffs, depicted in Figure 1. In this game, two players (labelled neutrally as player type 1 and 2 respectively) alternately faced the decision to continue or stop, $a \in \{C, S\}$, until one of them chooses stop, which ends the game, or player 2 chooses C at the final node. Before the start of the game, participants were informed about their player type which was drawn randomly. Treatment allocation for each session was random, with half of the participants matched with a member of the same group (*ingroup* treatment) and the other half with a member of the other group (*outgroup* treatment). Participants were informed of the group membership of their matching partner immediately before and throughout the decision task. We used the strategy method (Selten, 1967) to elicit participants' strategies as we were interested in the full strategy vector and not only the outcome.[5] The decision nodes in the game were shown sequentially to participants. Participants were informed that they would not learn the decisions of their respective matching partner until all decisions were made in all parts. Note that participants played a second identical centipede game, but with a subject drawn from the opposite group as in the first game. We decided against using the observations of the second game in the analysis because of significant order effects.[6]

Part 3. We elicited participants' beliefs about the population behavior of their matched partner types. More specifically, participants guessed how many out of 12 players (all of whom are playing in the role of their respective matching partner in the game) chose "stop" at each of their three decision nodes. Similar to the presentation of decision nodes in part 2, the elicitation method was implemented sequentially for each node (see Appendix C). A

[5]Kawagoe and Takizawa (2012) find no difference in behavior between the direct-response and strategy method implementation of the game. See Brandts and Charness (2011) for a comparison of these two methods over many studies.

[6]A two-sample Wilcoxon Mann-Whitney test for the outgroup data rejects the hypothesis that strategies when playing an outgroup member in the first game are drawn from the same distribution as when playing an outgroup member in the second game (p-value $= 0.058$). The same test for ingroup data was insignificant (p-value $= 0.160$). We speculate that the order effect is due to subjects "anchoring" on their initial choice (54 out of 96 subjects chose an identical strategy in both game).

prize of 100 points was paid for a correct guess.[7] Participants learned about the task only after making their own decisions so as not to influence behavior in the actual games. After all decisions in part 3 were made, a matching partner for the game was randomly drawn to determine the game's outcome and participants were informed about their performance in the all parts of the experiment.

Part 4. Participants completed a short post-experiment questionnaire.

Procedures. The experiment was programmed and conducted using z-Tree (Fischbacher, 2007). Sessions took place in Lakelab, the experimental economics laboratory at the University of Konstanz. Participants were student volunteers recruited from the subject pool of the University; economics and psychology students were excluded from participation. Each subject participated in only one session. We conducted 4 sessions, each comprised of 24 participants (96 participants in total). After the experimenter read out the rules for participation, subjects received a set of written instructions about the general procedure of the experiment (see Appendix B for the instructions). Participants were presented with detailed instructions of each experimental part only prior to its start. At the end of a session, points earned across all experimental parts were added up and converted into Euros at an exchange rate of 20 Points = 1 Euro. In addition, each participant was given a 3 Euro show-up fee. Sessions lasted 45 minutes (including time for payment) and participants earned between 4.25 and 20 Euros (8.60 on average), paid out privately at the end of the experiment.

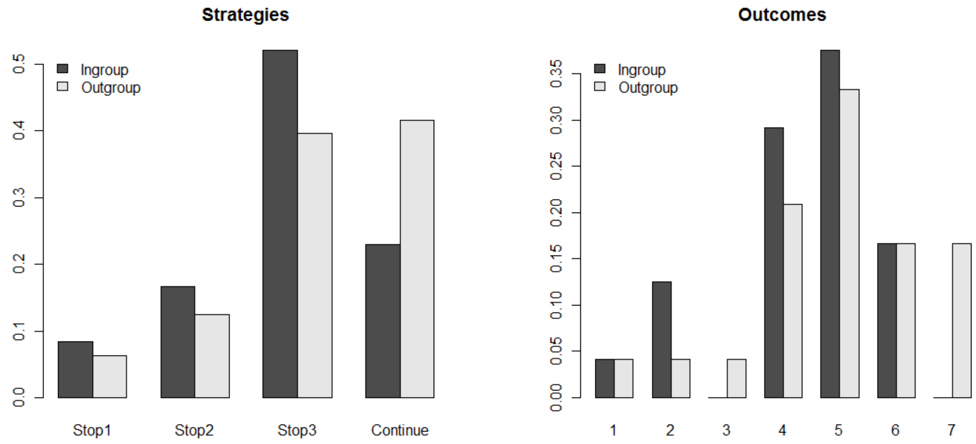
3 Results

This section presents our main results. We begin with a general description of behavior and participants' stated beliefs about partner's behavior and then study the relationship between behavior and stated beliefs using a prospective reference theory framework.

3.1 Behavior and stated beliefs

Figure 2 depicts players' strategies, pooled across player roles, and realized outcomes in the centipede game. The distribution of strategies in Figure 2(a) does appear to be different between treatments. The modal decision for players is to stop at the third decision node in the ingroup treatment and to always continue in the outgroup treatment. There is weak

[7]It is well known that this method elicits beliefs about the modal action. Hurley and Shogren (2005) show that it also elicits an interval for the mean probability, in our case of width 1/13. As a test of the robustness of our results we use a variety of probabilities from the elicited intervals. We chose this method because it is easily understood by subjects. It also has the advantage over scoring rules of being robust to risk aversion.



(a) Strategies

(b) Outcomes

Figure 2: Aggregated strategies and outcomes in the game.

statistical evidence that the distribution of stopping nodes differs between treatments (two-sample Wilcoxon rank-sum, p-value $= 0.087$).[8] The outcome distribution in Figure 2(b) shows that the treatment differences, that do exist in behavior between treatments, lead to substantial differences in realized payoffs. In fact, subjects playing outgroup members earn 58 points on average compared to 35 points for those playing ingroup members. The hypothesis that strengthening of positive social preferences would push the distribution of stopping nodes in the ingroup treatment to the right of the outgroup treatment is thus clearly not supported by the data. On the contrary, it appears that any treatment effect is in the opposite direction.

Even though we fail to find evidence for our social preference hypothesis by considering only strategies, it is still possible that social preferences play a role. If subjects believe for some reason that ingroup players are more likely to stop earlier than outgroup player, this could counteract any effect of strengthened social preferences. This possibility is however not supported by the elicited beliefs summarized in Table 1. Stated beliefs about behavior of the partner's population are very similar across treatments, with the distributions being significantly different only in the case of the player 1s' stated beliefs at the last decision node (two-sided Wilcoxon rank-sum test, p-value $= 0.084$). Furthermore, we also observe similar variance in elicited beliefs between treatments, implying that subjects do not estimate or report their belief with more noise in the outgroup treatment. Overall, the induced group identity does not seem to modify stated beliefs towards behavior of the matched partner.

[8]Similar conclusions can be drawn when considering strategies for player 1 and 2 separately (see Figure 4 in Appendix A.2).

Player type	Node	Elicited belief	
		Ingroup	Outgroup
1	2	1.33 (2.76)	1.54 (3.59)
	4	3.54 (3.68)	3.42 (3.74)
	6	7.29 (3.94)	9.13 (3.50)
2	1	1.96 (4.18)	1.33 (3.07)
	3	3.42 (4.09)	3.13 (3.30)
	5	9.00 (3.15)	8.33 (3.25)

Notes: Average number of subjects, out of 12, guessed to stop at each node (by player type and treatment). Standard deviation in parentheses.

Table 1: Elicited beliefs.

To summarize, group identity manipulations have previously been shown to strengthen social preferences (i.e. increase altruism, propensity to positively reciprocate, and desire for social-welfare maximization), but we find no evidence of this in our study: actions differ in the opposite way to that implied by a long line of research into the effect of group identity on social preferences, while reported beliefs do not differ systematically between treatments.

3.2 Reactiveness to stated beliefs

This section investigates the underlying decision-making process (captured by first-order beliefs and the resulting action-belief correspondence) of players based on their group affiliation. The OLS regressions in Table 2 provide initial evidence that subjects in the ingroup treatment act much more upon their reported beliefs than subjects in the outgroup treatment.[9]

[9]The purpose of this section is primarily to demonstrate a clear pattern in the data in a simple way to justify the more complex approach in the following subsection. Because these regressions are only for illustrative purposes, and properly reporting non-linear models with interaction effects is more elaborate,

	Model 1	Model 2	Model 3
Belief	0.041***	0.041***	0.028**
	(0.006)	(0.006)	(0.008)
Ingroup		–0.091**	–0.288***
		(0.045)	(0.110)
Inbelief			0.028***
			(0.011)
Constant	0.504***	0.549***	0.643***
	(0.060)	(0.063)	(0.079)
R^2	0.209	0.222	0.246

Notes: Standard errors in parentheses are clustered by subject. All estimations with 240 observations. *** significant at the 1% level, ** significant at the 5% level, * significant at the 10% level.

Table 2: Probability of continuing estimated by linear probability model.

Model 1 controls for the beliefs about the number of players that will continue at the *subsequent* decision node. Including this variable as a regressor, we lose the observations of player 2s' final decision node, as there are no subsequent decisions. Results show that the subjects' beliefs have a positive impact on their own decision to continue, significant at the 1% level. Subjects respond in a rational direction to their stated beliefs, that is the more likely they believe it is that their partner will continue at the next node, the less likely they are to stop.

An alternative approach to looking for a social preference effect is to test for a treatment difference in the probability of stopping after controlling for beliefs. Model 2 therefore includes a dummy for the ingroup treatment. The coefficients imply that subjects with the same beliefs about the probability of their partner stopping at the next node are almost 10% less likely to continue if matched with an ingroup member. This result goes against the social preferences hypothesis, and is significant at the 5% level.

Model 3 adds an interaction term between the elicited belief and the ingroup treatment dummy to allow for the possibility that the relationship between reported beliefs and actions differs between treatments. The estimated coefficients are all significant and imply that the relationship between beliefs and actions is twice as strong in the ingroup treatment. Using the estimated coefficients of this model, Figure 3 nicely illustrates the large differences in the reactiveness to beliefs between treatments: behavior of subjects

we report here linear regressions only. Probit and logit regressions however yield similar results and are available upon request.

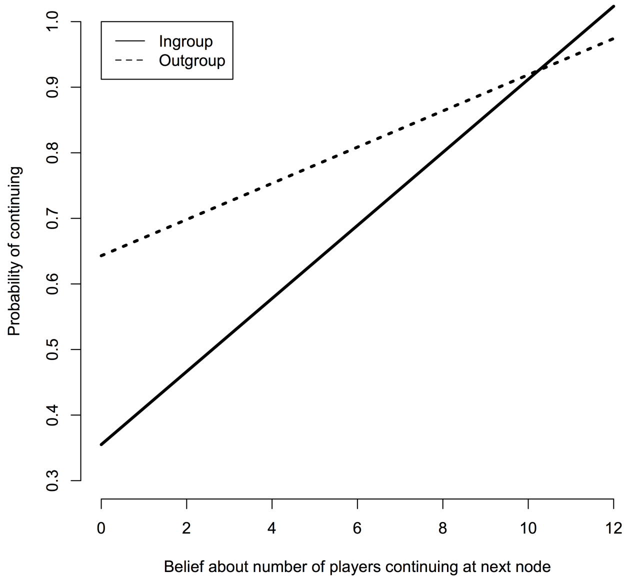


Figure 3: Reactiveness to stated beliefs.

who interact with outgroup members is much less sensitive to their stated beliefs.

A possible explanation for the difference in responsiveness between ingroup and outgroup treatments could be in the *informativeness* subjects place on their reported beliefs. In line with social projection, it may be the case that group affiliation, our main treatment variable, acts as a signal in the decision process which ultimately guides behavior, determining how reliable subjects regard their predictions about their partner's strategy. We examine this idea theoretically and empirically in the next section, using a prospective reference theory framework.

3.3 Prospective reference theory

According to prospective reference theory (Viscusi, 1989), the probabilities that are used to select an action are a weighted average of objective probabilities available to the decision-maker and subjective prior probabilities (often assumed to be based on uniform randomization over outcomes). Essentially, new information is not taken at face value but is used to update prior beliefs. In our experiment subjects must themselves infer the probability with which their matching partner is expected to continue at each node. These inferred probabilities represent the new information which is used to update their prior. We assume that it is these probabilities which are stated in the belief elicitation process. This assumption is supported by Viscusi and Evans (2006) who show, using a PRT framework in a classical situation of decision-making under uncertainty, that reported probabilities are indeed only partially informative about "behavioral" probabilities (defined as the probabilistic belief consistent with observed choices). The inferred probabilities, as proxied by the elicited beliefs, will be viewed as more informative when the partner is considered to be more like oneself, i.e. an ingroup rather than outgroup member.[10]

We will now consider a model based on prospective reference theory that can capture the differences in the reliability of a player's beliefs of the partner's behavior that we observe in our experimental data. Assume that the utility function exhibits constant relative risk aversion (CRRA), $u(x) = \frac{x^{1-r}}{1-r}$, where x denotes the realized payoff in the game and r the degree of risk aversion.[11] Each subject has the choice to stop (S) or continue (C) at each of her three decision nodes (1,3,5 for player type 1 and 2,4,6 for player type 2). A strategy is a vector specifying a choice for each move of player $i = 1, 2$, e.g. $s_i = (C, S, S)$. Since we are only interested in a subject's first stopping decision for the estimation of the model, we consider by a slight abuse of notation only the truncated strategy vector, e.g. $s_i = (C, S, \cdot)$.[12] According to this truncation, each subject has 4 (pure) strategies which are to stop at any of her three decision nodes or to always continue. This yields a total of seven possible outcomes m_j, with $j \in \{1, 2, \ldots, 7\}$, and each outcome m_j being associated with a payoff of $x_{i,j}$ to subject i. For the estimation, we assume that subjects choose a strategy according to a logistic choice function, as specified below.

Define $q_{i,j}$ as the probability of a subject receiving payoff $x_{i,j}$, given that she plays strategy s_i and the other player chooses each of the four strategies with equal probability (the assumed prior belief). The prior belief is supposed to capture beliefs about the partner's actions *before* any reasoning process has begun. The priors we consider are both applications of the "principle of insufficient reason": uniform randomization over truncated strategies and uniform randomization at each node. We assume the former for the estimations in this section, but all results are robust to using the latter. For example, if player 1 chooses to stop at her first node then the only possible outcome of the game is to end there, that is $q_{1,1} = 1$ and $q_{1,j} = 0$ for $j \in \{2, \ldots, 7\}$.[13] Denote by $p_{i,j}$ the probability of the outcome associated with payoff $x_{i,j}$ given the subject's inferred probabilities and the choice s_i. Let the weight the subject places on the assumed prior be $0 \leq \alpha \leq 1$. The term

[10] Rutström and Wilcox (2009) also find that stated beliefs do not predict future actions as well as behavioral probabilities. Note that what they define as "inferred probabilities" are not related to what we define as such, but are conceptually equivalent to our behavioral probabilities.

[11] All results are robust to using a CARA utility function $u(x) = -\exp(a\,x)$, where a is the degree of absolute risk aversion.

[12] Only 3 (out of 96) subjects chose a strategy involving a choice to continue after a choice to stop, so this truncation is of little practical consequence.

[13] As another example, suppose that player 1 chooses to stop at the third node. Then the game terminates at node 2 if player 2 chooses to stop there, or at node 3 if player 2 chooses a strategy that plays continue at node 2, so $q_{1,2} = \frac{1}{4}$, $q_{1,3} = \frac{3}{4}$, and $q_{2,j} = 0$ for $j \in \{1, 4, 5, 6, 7\}$.

$1-\alpha$ captures the "subjective informational content" of the inferred beliefs, with $\alpha = 0$ implying that their reported belief is regarded as fully informative by the subject. We allow this weight to differ between treatments, by replacing α for the ingroup treatment by $\alpha + \alpha_{OUT}$ for the outgroup treatment.

The utility function subject i maximizes when choosing her strategy s_i can then be written as,

$$PRT\left(s_i\right) = \sum_{j=1}^{7} \left(\left(\alpha + \alpha_{OUT}\right) q_{i,j} + \left(1 - \alpha - \alpha_{OUT}\right) p_{i,j}\right) u\left(x_{i,j}\right). \tag{1}$$

As has become standard in the literature, we assume the probability a player chooses strategy s_i is given by the following logistic choice function,

$$Pr\left(s_i\right) = \frac{e^{\lambda PRT(s_i)}}{\sum_{k=1}^{4} e^{\lambda PRT(s_k)}} \tag{2}$$

where $\lambda \geq 0$ represents the degree of rationality (or sensitivity to payoff differences) of the player. Note that this model encompasses expected value (for $r = 0$ and $\alpha = \alpha_{OUT} = 0$) and expected utility (for $\alpha = \alpha_{OUT} = 0$) as special cases. The parameters of interest are estimated using a maximum likelihood estimation, with the log likelihood, given by

$$ln\, L\left(\lambda, r, \alpha, \alpha_{OUT}\right) = \sum_{i=1}^{N} ln\, Pr\left(s_i\right). \tag{3}$$

Table 3 summarizes results for expected value (EV), expected utility (EU), and various PRT specifications.[14] The coefficient on λ in the EV model is significantly different from zero at the 1% level which confirms that subjects are not acting randomly.[15]

The standard subjective expected utility model (EU) allows for risk aversion and yields a much better overall fit than the EV model. Estimates of the coefficient of relative risk aversion r range between 0.830 in the EU and 0.691 in the PRT models; the relatively high estimates (cf. Holt and Laury, 2002) might be due to the exponentially-increasing payoffs in the game and the salience of possibly large monetary earnings that come with them.

[14] As an estimate for the subjective probability of the partner choosing to stop at a given node we use the proportion of subjects guessed to stop at that node. Theoretically, this is always within an interval of size 1/13 of the true subjective probability (see Hurley and Shogren, 2005). Our results are robust to using the minimum, maximum, and mid-point of the elicited interval.

[15] Estimates of λ are much higher in all other models of Table 3, i.e. indicative of a greater level of rationality, but with much greater standard errors and thus are not significant. We are however confident that λ is greater than zero because $\lambda = 0$ implies the model collapses to the random model regardless of the other parameter values, and likelihood ratio tests (in Table 4) show that all the models in Table 3 perform significantly better than the random model at the 1% level.

Model	EV	EU	PRT1	PRT2	PRT3
λ	0.028***	1.163	1.196	0.862	0.906
	(0.005)	(0.962)	(0.983)	(0.699)	(1.070)
λ_{OUT}					-0.049
					(1.465)
r		0.830***	0.784***	0.691***	0.696***
		(0.205)	(0.205)	(0.194)	(0.271)
r_{OUT}					0.000
					(0.397)
α			0.389***	0.017	0.032
			(0.142)	(0.242)	(0.278)
α_{OUT}				0.655**	0.640**
				(0.292)	(0.331)
Log L	–115.78	–110.03	–100.07	–97.21	–97.20
AIC	223.56	224.06	206.14	202.42	206.40

Notes: Standard errors in parentheses. All estimations with 96 observations. *** significant at the 1% level, ** significant at the 5% level, * significant at the 10% level.

Table 3: Likelihood estimations of the prospective reference theory model.

Estimating the prospective reference theory model (PRT1) finds that $\alpha = 0.389$, which is greater than zero and significant at the 1% level. This implies that subjects are on average placing non-zero weight on a uniform prior. Adding a dummy for the outgroup treatment, PRT2 shows that subjects do not place any significant weight on the uniform prior ($\alpha = 0.017$) in the ingroup treatment. This indicates that ingroup players view their beliefs as fully informative. In contrast, subjects in the outgroup treatment assign the prior almost two-thirds of the weight in their behavioral probability ($\alpha_{OUT} = 0.655$, significant at the 5% level). While subjects who interact with players from the outgroup are still responding to some degree to their stated beliefs, the results clearly show that stated beliefs are only treated as partially informative for behavior in the game.

To exclude the possibility that our results are in fact driven by varying sensitivity to payoff differences or risk aversion, PRT3 allows λ and r to differ between ingroup and outgroup treatments. As can be seen in Table 3, all parameters included in PRT2 change only marginally and remain significant at their original levels. The differences in the degree of rationality λ_{OUT} and risk aversion r_{OUT} between treatments are close to zero and not significant. Moreover, likelihood ratio tests find that the additional parameters do

	EV	EU	PRT1	PRT2	PRT3
EV	·	0.00	0.00	0.00	0.00
EU		·	0.00	0.00	0.00
PRT1			·	0.02	0.12
PRT2				·	0.99
PRT3					·

Notes: p-values.

Table 4: Likelihood ratio tests for nested models.

not significantly improve the fit, but that PRT2, with an outgroup dummy on the weight assigned to the prior belief α_{OUT}, performs significantly better than all other nested models (cf. Table 4).

In summary, the estimation results of the PRT model reveal that participants perceive own stated beliefs as much less relevant for behavior when facing an outgroup member. Conversely, subjects behave as though their stated beliefs are fully informative when the partner is considered to be similar to oneself, i.e. an ingroup member. We interpret the large differences in the informativeness of own stated beliefs that do exist between treatments as evidence that subjects face a much higher degree of uncertainty when predicting strategic behavior of an unknown, outgroup player relative to an ingroup player. This finding is consistent with evidence in psychology that social projection, in the sense of perceived similarity and hence predictability of others, is stronger in ingroup than in outgroup interactions (Acevedo and Krueger, 2005; Ames et al., 2011).

4 Discussion

In our experiment, subjects continue slightly longer with outgroups and they are more likely to choose to continue with outgroups even if their stated beliefs indicate a high probability that their partner will stop at the next node. We have argued that uncertainty about outgroup behavior together with the exponentially-increasing payoff structure in the game, explain our main findings. In this section, we briefly explore alternative explanations, including more complex social preferences and limited cognition, that may have contributed to subjects continuing longer in the outgroup treatment.

Theoretically, fairness between ingroup members could be a concern in the game as the absolute (but not relative) difference between payoffs increases at each node. Given the large potential welfare gains, we believe nevertheless that altruism and social-welfare maximization effects would substantially outweigh any fairness-related concerns, as was found to be the case in the games investigated by Charness and Rabin (2002). Moreover, the combination of theoretical results from Ho and Su (2013) and empirical estimations in Kranton et al. (2012) support our intuition. Using the utility function of the inequity aversion model of Fehr and Schmidt (1999), $U_i(x_i, x_j) = x_i - \alpha\,[x_i - x_j]^+ - \beta\,[x_j - x_i]^+$ where x_i and x_j is the monetary payoff of player i and j respectively, Ho and Su (2013) show that if players are sufficiently averse to having a lower payoff than the other player (high β) they will stop, whereas if they are sufficiently averse to having a higher payoff (high α) they will continue all the way. Employing a Klee-Kandinsky manipulation similar to ours, Kranton et al. (2012) estimate that α is substantially higher and β substantially lower for subjects interacting with ingroups. Thus, the impact of group identity on fairness concerns should, if anything, cause players to continue longer with ingroups.

Alternatively, one may also argue that players may feel more disappointed at being "betrayed" by members of the same group and stop earlier to avoid this potential disappointment, or outgroup members are rewarded more (in anticipation) because nice behavior from them is more unexpected. This reasoning however is not in line with previous laboratory evidence finding stronger positive reciprocity with ingroups and negative reciprocity stronger with outgroups (Chen and Li, 2009). In short, we do not think that more complex social preferences explain our results.

In contrast to social-preference based arguments, the experimental literature has focussed on limited cognition as an explanation for the systematic deviations from the backward-induction solution.[16] We discuss two alternative models of boundedly rational behavior, the agent quantal response equilibrium model (AQRE) and the level-k model and compare their performance to the PRT model presented in Section 3.

In an AQRE model, players are expected to commit mistakes in their decisions. More specifically, the probability of a particular strategy being chosen is increasing in the expected payoff to that strategy. The parameter λ in the logistic choice function can be interpreted as the propensity of a player committing errors, with a value of zero indicating no relationship between beliefs and actions, and a value of infinity implying that the agent best-responds perfectly. Errors, committed by the player at different decision nodes, are assumed to be independent and realized only when the respective node is reached (see Appendix A.1 for details on the specifications). Table 5 reports the estimates for the AQRE.

[16] Palacios-Huerta and Volij (2009) find that subjects stop sooner when playing chess players than when playing students, and Bornstein et al. (2004) show that games tend to stop earlier when decisions are made by groups than by individuals. These results are explained in the respective papers by chess-players being better at backward induction than students, and groups behaving more rationally than individuals. Note that Levitt et al. (2011) however find no such clear relation between the ability to perform backward induction (measured in a "race to 100" game) and behavior of chess players in the centipede game. Gerber and Wichardt (2010) use an "enriched" centipede game (which includes insurance options against termination of the game by the partner or reward options for not terminating the game) and explain their results by a process of limited iterated reasoning of players.

Model	Data	λ	ϕ	Log L	AIC
AQRE	Ingroup	0.044		–66.68	282.24
	Outgroup	0.030		–73.44	
AQRE+ALT	Ingroup	0.076	0.057	–60.50	251.52
	Outgroup	0.048	0.103	–63.26	

Table 5: Agent quantal response estimations in the standard model (AQRE) and in the model allowing for a proportion of altruists (AQRE+ALT).

The degree of rationality λ is smaller in the outgroup treatment, suggesting subjects make more errors when interacting with outgroups, consistent with our regression results in Section 3.3. However, as is clear from a comparison of Figures 2 and 5, this model fits the data poorly. We also follow McKelvey and Palfrey (1992) and test whether a proportion of altruists ϕ in the population, who are assumed to always play continue, improves the fit of the model (AQRE+ALT), but find a much higher fraction of altruists in the outgroup than in the ingroup treatment which contradicts a strong prior about the impact of group identity on social preferences. Finally, the performance of both models in terms of the Akaike Information Criterion (AIC) is inferior to the PRT model in Section 3.3.

In a level-k model subjects are assumed to be of one of a hierarchy of types, reflecting differences in their depths of reasoning (first introduced in Stahl and Wilson, 1994, 1995; Nagel, 1995). Level zero (L0) is defined exogenously, whereas higher levels best respond to their beliefs, possibly with some noise. Following Kawagoe and Takizawa (2012), we consider a level-k model of the centipede game with three different level zero types (L0): random normal form (RNF), random behavioral strategy (RBS), and altruists (ALT) who are assumed to always continue (for specifications refer to Appendix A.1).

Table 6 summarizes our level-k estimates. We find large differences between the distributions of cognitive levels in our two treatments, with subjects tending to be categorized as lower levels in the outgroup treatment. This holds for all of the three L0 specifications considered. The large number of unsophisticated L1 subjects in the outgroup treatment is intuitively appealing if outgroup member are perceived as less sophisticated than ingroup members, which is in line with the idea that group affiliation is aimed at increasing self-esteem. However, in a level-k model differences in behavior can result only from differences in beliefs, whereas the beliefs we have elicited do not differ between treatments. This rules out the possibility that the level-k estimates can explain the totality of our results, even though such estimates fit the data quite well (comparing estimated strategies to the empirical strategies, see Appendix A). We take the rather extreme shifts of the type distribution towards L1s in the outgroup treatment as further evidence that these players find it more

Model	Data	Level 1	Level 2	Level 3	Level 4	λ	Log L	AIC
RNF	Ingroup	0.31	0.25	0.41	0.03	0.056	-55.18	223.60
	Outgroup	0.66	0.11	0.22	0.00	0.047	-52.68	
RBS	Ingroup	0.44	0.25	0.29	0.02	0.076	-52.08	223.46
	Outgroup	0.77	0.11	0.13	0.00	0.083	-52.71	
ALT	Ingroup	0.26	0.12	0.60	0.02	0.050	-51.92	223.82
	Outgroup	0.45	0.00	0.55	0.00	0.032	-53.05	

Table 6: Estimation results of level-k model.

difficult to predict the behavior of their matching partner and are more likely to assume they act randomly. Moreover, the PRT model is also preferred based on the AIC.

Given that the assignment to treatments was random, there is no convincing reason why the cognitive ability of subjects playing outgroups should be lower than those playing ingroups. Level-k estimations however illustrate nicely how the sophistication of play changes with group affiliation in the game. In this respect, our level-k results support recent work suggesting that level-k reasoning can also be interpreted as beliefs about others (Georganas et al., 2013; Burchardi and Penczynski, 2011; Agranov et al., 2012).[17]

More generally, the PRT estimates and the results in the discussion show that strategic sophistication is a function of the environment and can be manipulated, as in our case, through changes in group affiliation. The result that subjects' reasoning depends on the group affiliation is also consistent with a recent neuroscientific study of Baumgartner et al. (2012) which identifies differences in the activation of the mentalizing system (a region associated with social reasoning or projection in the brain) of subjects when facing ingroup and outgroup behavior.

5 Conclusion

This paper tested the hypothesis that social preferences drive behavior in the one-shot centipede game. We used a group identity manipulation (cf. Tajfel and Turner, 1979; Chen and Li, 2009) which has been shown in various economic settings to increase altruism, the propensity to positively reciprocate and the desire for social-welfare maximization. We

[17] Georganas et al. (2013) find that subjects' levels are largely uncorrelated with an assortment of cognitive ability tests and that subjects perform as higher types when they know that they are playing with a subject who has performed well in those tests. Moreover, both Georganas et al. (2013) and Burchardi and Penczynski (2011) show that subjects' estimated levels vary unsystematically across different types and even small variations of games. Agranov et al. (2012) find that subjects' cognitive levels are endogenous, i.e. influenced by the beliefs they hold about their opponents' cognitive ability.

found no evidence that the effect of strengthened social preferences plays a decisive role for behavior in the centipede game. On the contrary, participants interacting with outgroup members continue longer and earn significantly higher payoffs than those playing members of the own group.

In the analysis of the game we allowed for the possibility that group identity not only affects own and others' payoffs through changes in preferences, as posited by theoretical work (Akerlof and Kranton, 2000; Shayo, 2007), but also impacts a player's social reasoning about her partner's behavior, e.g. through social projection (Acevedo and Krueger, 2005; Ames et al., 2011). Depending on the game's structure and the complexity of the strategic environment, these two forces can have countervailing effects on behavior.

Given the exponentially-increasing payoff structure in the one-shot centipede game we considered, a player should only stop if she is sufficiently confident that her partner will stop at the next node. To explicitly account for the underlying uncertainty about the other player's behavior in the introspection process we estimated a prospective reference theory model. Results showed that subjects playing an ingroup member treat stated first-order beliefs as much more informative than those playing an outgroup member. That is, subjects relied in ingroup interactions much more on their assessment of the partner's predicted behavior than in outgroup interactions. Moreover, our finding that strategic sophistication of participants, e.g. in level-k models, varies strongly in group affiliation is in full accordance with our interpretation of results. In summary, our research shows that group affiliation influences not only social preferences of players but also their underlying reasoning processes.

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A Appendix: Additional material (for online publication)

A.1 Specification of alternative models

This section provides some details on the estimation specifications of the agent quantal response equilibrium model and the level-k model whose results have been discussed in Section 4.

Agent quantal response

Quantile Response Equilibrium (QRE) is a model for normal-form games that allows for errors in actions by players but is a fully consistent equilibrium model in that players correctly adjust their strategy to account for the error structure (McKelvey and Palfrey, 1995). Agent Quantile Response Equilibrium (AQRE), developed by McKelvey and Palfrey (1998), extends this concept to extensive-form games under the assumption that the errors made by a player (or agent respectively) at different nodes are independent and realized only when the node is reached. In the version we estimate, errors are in the form of a logistic probabilistic choice function, i.e. the probability a player chooses to stop at decision node $j \in \{1, 2, \ldots, 6\}$ is,

$$p_j = \frac{e^{\lambda u(stop)}}{e^{\lambda u(stop)} + e^{\lambda u(continue)}}$$

where $u(.)$ is the expected utility of choosing a given action, and λ is an error parameter to be estimated. Note that we interpret λ here as determining the likelihood of making an error but it can also be interpreted as the sensitivity to payoff differences; the logistic choice function can also be derived from a latent variable model with random shocks to preferences. As λ approaches infinity, players best respond to their beliefs, and at zero players play randomly.

Following McKelvey and Palfrey (1992), we estimate two different specifications of the model. In the first model (AQRE), all players are assumed to act purely self-interested. The second model (AQRE+ALT) assumes there is a proportion of altruists $\phi \in [0, 1]$ in the population who choose to continue with probability one at each decision node. In the first model (AQRE) it is straightforward to calculate the stopping probabilities as functions of λ recursively from the final decision node. The second model (AQRE+ALT) is slightly more complex as players must update their beliefs about the probability their partner being an altruist as the game progresses. At the first node, the player type 1 belief about the proportion of altruists is β_1 which equals the prior ϕ. At the second node, player type 2 uses Bayes' rule to update her belief, which yields

$$\beta_2 = \frac{\phi}{\phi + (1-\phi)(1-p_1)}$$

and so on. We thus obtain the equations for the stopping probabilities p_j given the beliefs about the portion of altruists in the population β_j at each node, that is

$$\begin{aligned}
p_6 &= (1 + exp(-64\lambda))^{-1} \\
p_5 &= (1 + exp(\lambda[32(1-\beta_5)p_6 + 256(\beta_5 + (1-\beta_5)(1-p_6)) - 64])^{-1} \\
&\vdots
\end{aligned}$$

The log likelihood function is then given by,

$$LL = \sum_{j=1}^{6} m_j\, ln\left((1-\phi)p_j\right) + n_j\, ln\left(\phi + (1-\phi)(1-p_j)\right)$$

where m_j and n_j are the number of subjects who choose to stop or continue at decision node j, respectively. The estimations were performed by a grid-search method. For each pair of numbers λ and ϕ, the system of belief and stopping probability equations were solved simultaneously, and the log likelihood value was calculated using the resulting stopping probabilities. Furthermore, we assumed for the estimation that subjects would choose to stop at all nodes after their first decision to stop (which was the case for all but 3 of our 96 subjects in the data).

Level-k

For the level-k analysis, we follow the basic modeling setup of Kawagoe and Takizawa (2012), who essentially apply the assumptions of Costa-Gomes and Crawford (2006) to the centipede game. The only difference to the approach of Kawagoe and Takizawa (2012) is that we use, for the formation of the log likelihood function, individual strategies rather than outcomes.

In a level-k model, subjects are assumed to be of one of a hierarchy of types, each believing (with probability one) that their partner is of the type one level lower. Level zero (L0) is defined exogenously, see specifications below. Errors in play are modeled by a logistic choice function, i.e. the probability a player i of (level-k) type t selects strategy s_k is

$$p_{i,t,k} = \frac{e^{\lambda u(s_k)}}{\sum_{l=1}^{4} e^{\lambda u(s_l)}}$$

where $u(s_k)$ is the expected utility of choosing s_k, given the player's belief about their partner's (level-k) type, and λ is an error parameter to be estimated. Note that for the purposes of this estimation we are assuming subjects are making their decisions at each node to conform to a preselected pure strategy (s_k) of the game in normal-form (i.e. stop at first decision node, stop at second decision node, stop at third decision node, or always continue). We assume that subjects are only of levels one to four, and that the distribution of types is the same amongst player types one and two. This yields the following log likelihood function,

$$LL = \sum_{i=1}^{2} \sum_{k=1}^{4} m_{i,k}\, ln \left(\sum_{j=1}^{4} \sigma_j\, p_{i,t,k} \right) \tag{4}$$

where $m_{i,k}$ is the number of player "i"s choosing strategy s_k, and σ_j is the proportion of strategy level-k type in the population. We perform estimations for three specifications of type L0:

1. Random in normal-form (RNF): L0 choose each strategy of the normal-form game with equal probability, that is select stop or continue at each decision nodes with probability $\frac{1}{4}$, $\frac{1}{3}$, and $\frac{1}{2}$ at decision nodes one, two, and three respectively.

2. Random in behavioral strategies (RBS): L0 choose stop or continue with equal probability at each decision node.

3. Altruistic (ALT): L0 always continue.

A.2 Additional figures

Outcomes and strategies in raw data

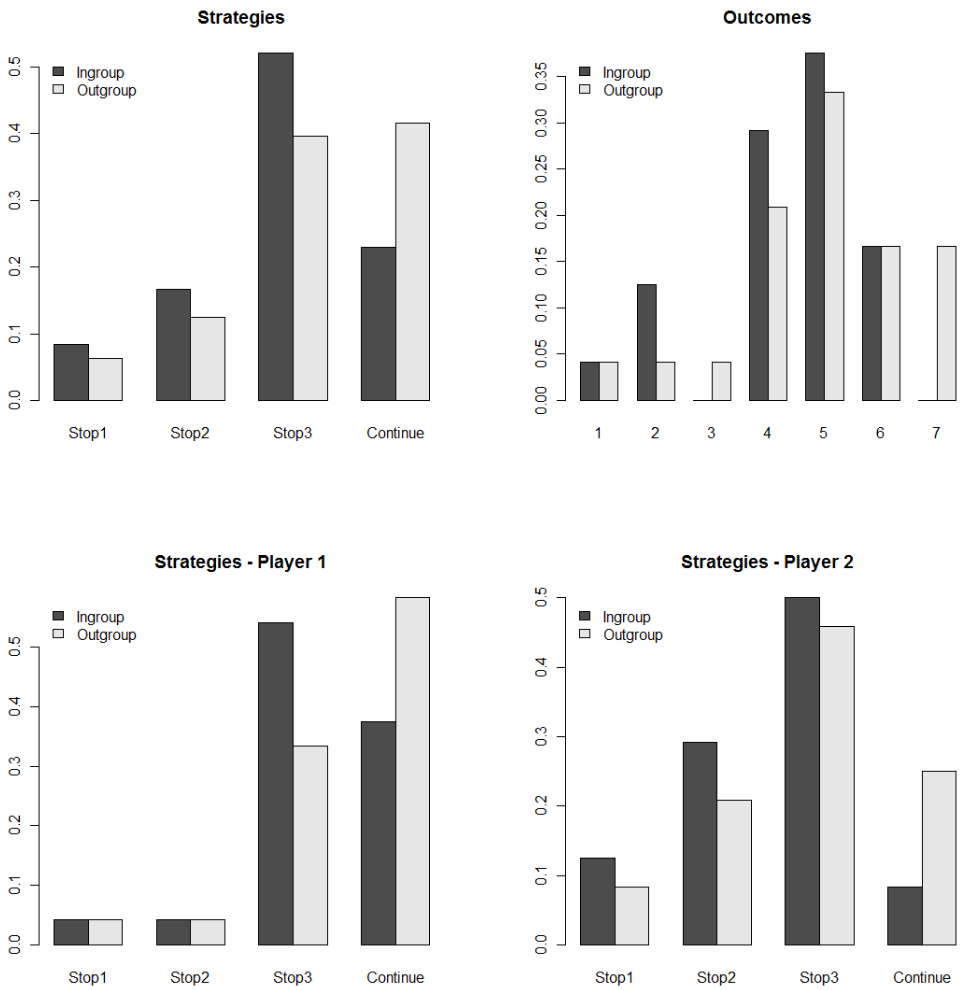


Figure 4: Outcomes and strategies in the centipede game.

Outcomes and strategies estimated by AQRE

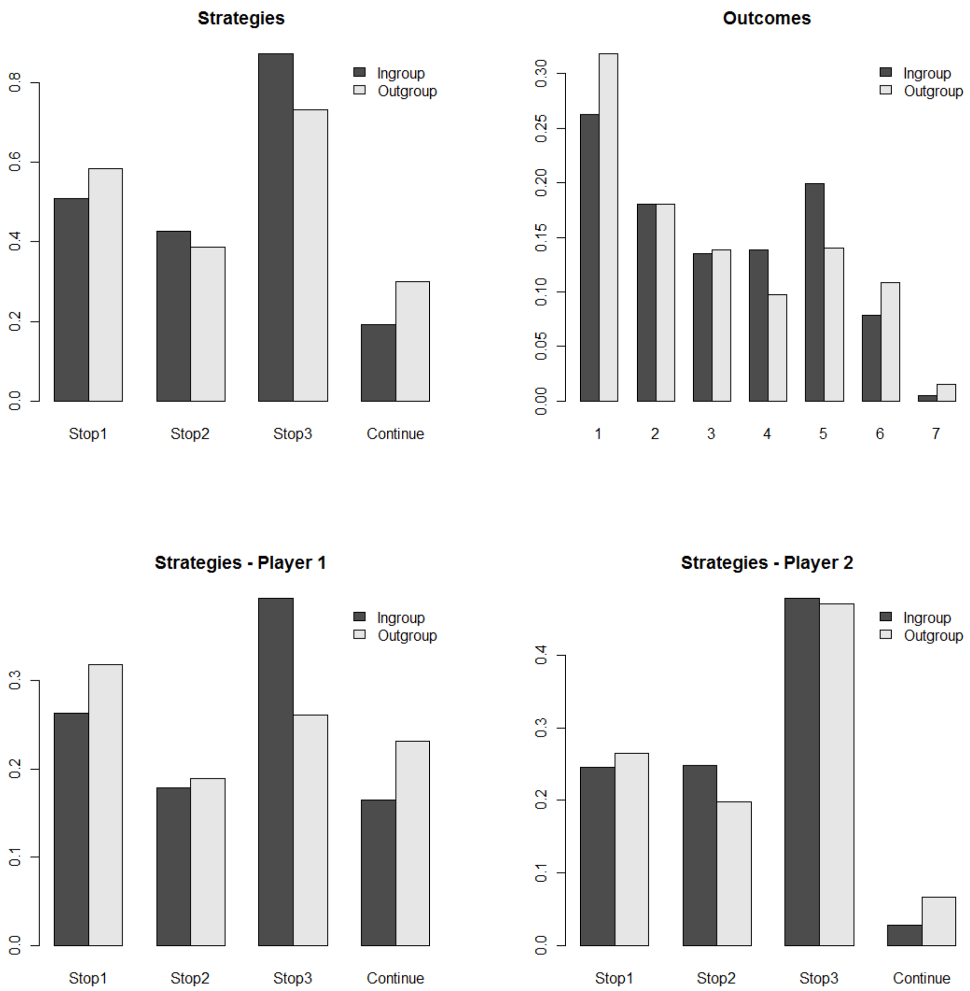


Figure 5: Outcomes and strategies estimated by AQRE.

Outcomes and strategies estimated by level-k (RBS)

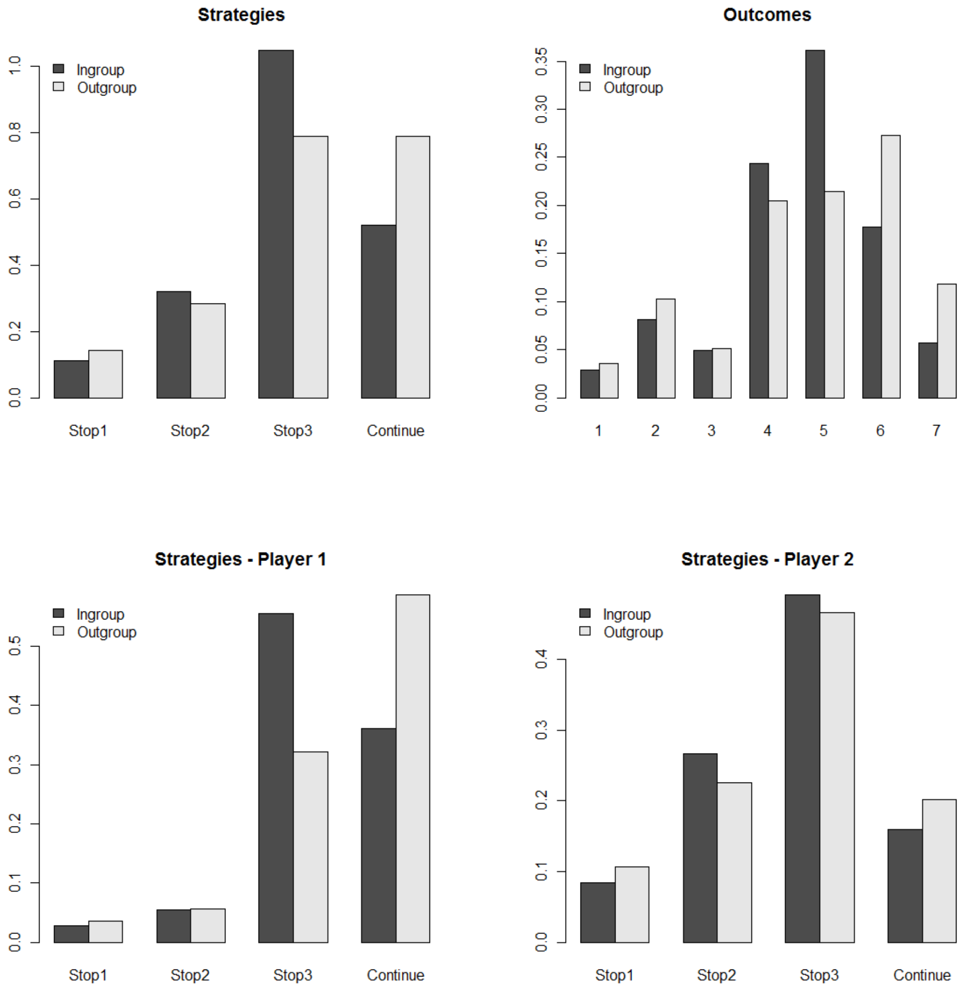


Figure 6: Outcomes and strategies estimated by level-k (RBS).

B Appendix: Instructions (not for publication)

In the following we provide the English translation of the experimental instructions. Participants received instructions regarding the general procedure, the group identity manipulation and the centipede game. Note that the instructions for the group identity manipulation were adapted from Chen and Li (2009). Instructions of each part were shown to participants just prior to the respective part. Instructions in the original language (German) are available upon request.

General instructions *[written]*

Welcome to this economic experiment! The experiment in which you are about to participate is part of a research project on decision-making.

If you have a question, now or during the experiment, please raise your hand and remain silent and seated. An experimenter will come to you to answer your question in private.

If you read the following instructions carefully, you can earn a considerable amount of money in addition to the **3 Euro**, which you receive just for participating in the experiment. How much money you can earn additionally depends both on your decisions and the decisions of the other participants.

It is therefore very important that you read these instructions, and all later onscreen instructions, very carefully.

During the experiment you are not allowed to communicate with the other participants. Violation of this rule will lead to the exclusion from the experiment and all payments.

We will not speak of Euros during the experiment, but rather of points. Your whole income will be calculated in points. At the end of the experiment, the total amount of points you earned will be converted to Euros at the following rate:

20 Points = 1 Euro.

At the end of the experiment you will be privately and anonymously paid in cash the amount of points you earned during the experiment in addition to the 3 Euro you receive for participation.

In the following we describe to you the general procedure of the experiment: You will be asked to make various decisions in two consecutive parts of the experiment. In each of the 2 parts you can earn points for your decisions. How much points you can earn in each part will be announced before you have to make your decisions. After all decision-making parts of the experiment, a questionnaire concludes the experiment.

All the information you require for making decisions in part 1 of the experiment will be displayed directly on screen. You will receive all the information you require for part 2 of the experiment after completion of part 1 of the experiment.

Instructions for part 1 of the experiment *[on-screen]*

Welcome to part 1 of the experiment.

In the following you will be shown 5 pairs of paintings by two artists. The paintings were created by two distinct artists. Each pair of paintings consists of one painting being made by each artist. For each pair, you are asked to choose the painting you prefer. Based on the paintings you choose, you (and the other participants) will be classified into one of two groups.

You will then be asked to answer questions on two more paintings. For each correct answer, you will earn additional points. You may get help from other members or help others in your own group while answering the questions.

The composition of the groups remains fixed for the rest of the experiment. That is, you will be a member of the same group for the whole experiment.

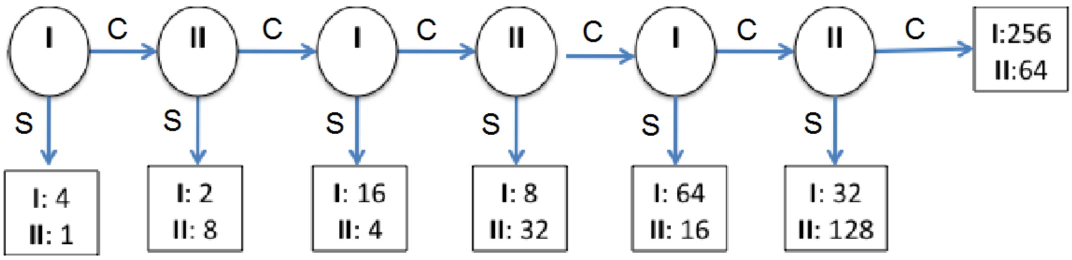
After part 1 has finished, you will be given further instructions about the course of the experiment.

Instructions for part 2 of the experiment *[written]*

In part 2, you are asked to make decisions. The game depicted below describes a game between two players who make decisions in turn. This picture will be shown to both players, called **player I** and **player II**. It summarizes all possible decisions players can make as well as all the points player I and player II can earn in the game depending on its outcome.

Both players (I and II) have on each of their 3 decision nodes, which are depicted by a circle marked I and II respectively, the possibility to choose either **Continue (C)** or **Stop (S)**. This means player I decides between Continue (C) or Stop (S) on the first circle (read from left) and at all other circles marked with **I**. Similarly, player II decides between Continue (C) or Stop (S) on all circles marked with **II**.

How much points each player earns in the game depends on the decisions of both players. The points player I and player II receive in each of the possible outcomes of the game, are depicted in the respective quadratic box below.



General structure of the decisions: The two players (I and II) decide sequentially and alternately. The game begins at the first circle marked with I (see upper left corner in the picture) There, player I chooses to play either Continue (C) or Stop (S). If player I chooses Stop (S), the game ends and player I receives 4 points and player II receives 1 point. If player I chooses on her first circle marked with I to Continue (C) then play proceeds and it is player II's turn to decide (see first circle II, read from left in the picture). Player II then chooses either Continue (C) or Stop (S). If player II chooses Stop (S), the game ends and player I receives 2 points and player II receives 8 points. If player II chooses Continue (C), then play proceeds to the next circle marked with I where player I chooses again between Continue (C) and Stop (S). And so on.

Your decisions: Before you make decisions in this game at the computer screen, you will be informed about whether you are a player I type or a player II type. Your player type will be drawn randomly and your type will remain fixed for all decisions. You will then be asked, separately for each of your three decision nodes, to choose either Continue

(C) or Stop (S). Please bear in mind that, at the time of your decisions you do not yet know the decisions of the other player.

The outcome and your point earning from the game is calculated as follows: As soon as all players made their decisions, each player I is randomly and anonymously matched with a player II. All decisions of these two players are then combined to calculate the outcome of the game and with it the respective point earning of each player. You will be informed about the outcome and your points in the game after all decisions have been made. It is therefore important that you made your decision in the game carefully, since they influence the outcome and the points you earn.

If you have questions regarding the explanation of the game, please raise your hand now. You will receive all further explanations directly on screen.

C Appendix: Sample screenshots (not for publication)

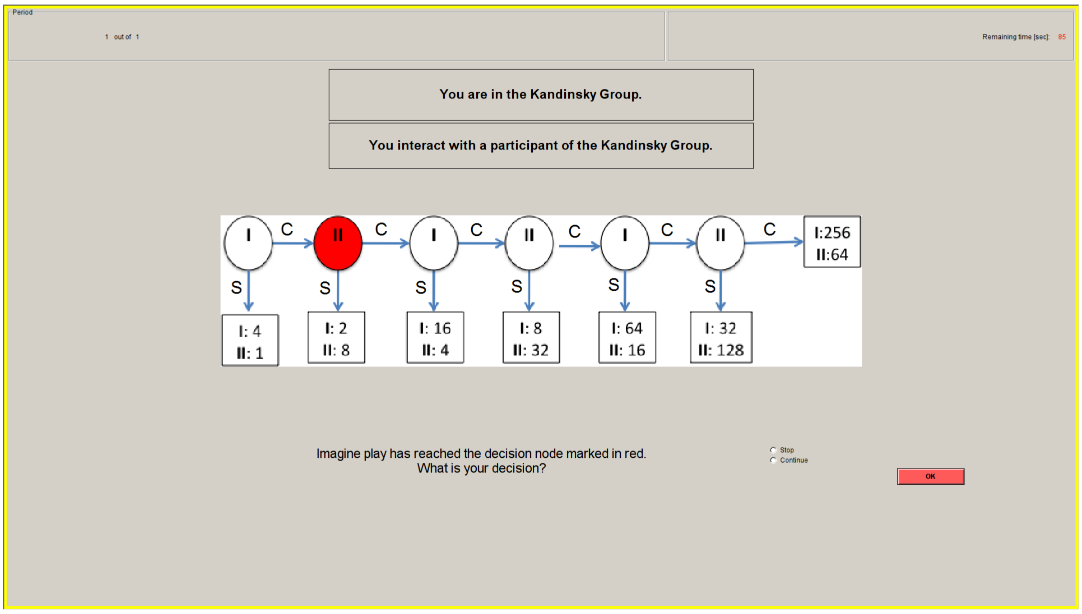


Figure 7: Sample screenshot of decision in centipede game (game at decision node 2).

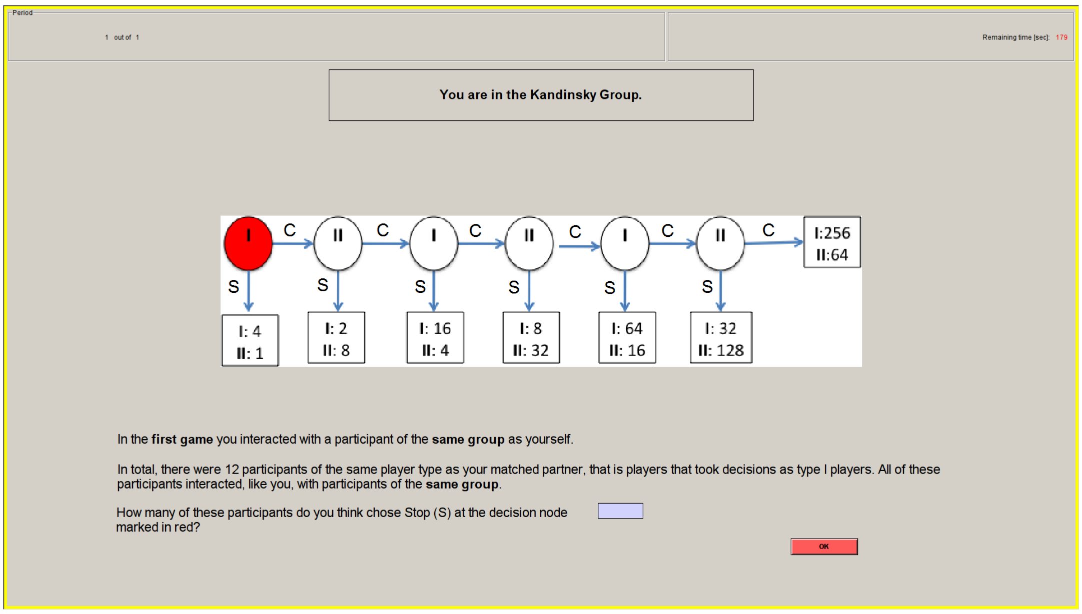


Figure 8: Sample screenshot of belief elicitation task (belief about population behavior at decision node 1).