Intergenerational Cooperation: an Experimental Study on Beliefs

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Abstract

We report on an experiment in which subjects older than 55 years old and subjects younger than 26 years old play repeatedly 4 versions of the centipede game. For each game we define four treatments that allow us to study cooperation and belief formation of these two age groups. We find that beliefs about the others' age group shape the outcome: while seniors are cooperative and generous with juniors when they incur lower opportunity costs, for juniors it is when playing with seniors that they learn the way to the theoretical solution by smoothly decreasing their cooperation levels.

Key Words: Centipede Game, Age differences, Decision Making, Beliefs, Social Preferences.

In this paper, we report on a series of experiments which study intergenerational cooperation through the implementation of centipede games in the lab, by inviting participants of both an older and a younger cohort.

Only few papers within the field of experimental and behavioral economics incorporate younger and adult age groups in their investigations (Kovalchik et al., 2005; Holm and Nystedt, 2005; Sutter, 2007; Güth et al., 2007; Charness and Villeval, 2009). However, only Holm and Nystedt (2005), Güth et al. (2007) and Charness and Villeval (2009) studied teams composed of different age groups. Holm and Nystedt (2005) run a trust game using two Swedish cohorts –one of 20 years old and the other one of 70 years old– and found that the younger cohort sent significantly higher amounts than the older cohort, and that first movers were more trustful with members of their own age cohort. Güth et al. (2007) run a large scale newspaper experiment where 5,132 readers of the German weekly, Die Zeit, participated in a three-person bargaining game and found that "proposing an equitable distribution gets more important and frequent with increasing age". Last, Charness and Villeval (2009) run their studies within the context of the labor market. Their results show two interesting findings from a public good experiment. First, the contribution of seniors is higher than of juniors in nearly all periods; second, heterogeneous teams are more cooperative than homogeneous teams.

The previous experimental studies reveal that there are indeed differences in trust, trustworthiness and cooperation among younger and older cohorts, and these differences become more or less salient depending on the age group of their matching team. Nevertheless, not much has been said on the repeated interaction among these cohorts. Understanding this is important because intergenerational conflicts may arise when interests of different age groups do not converge, for instance when it comes to evaluate the expected outcome of negotiations dealing with different national budget allocations (eg. pension fund policies, increasing taxes,...).

The reasons for choosing the centipede game for our studies relies on the following: First, it involves repeated interactions in a context where incentives to repeatedly reciprocate lead to increasing payoffs, unless one of the players defect, in which case he keeps more of the payoff than his matching partner. Second, it comprises a set of sequential interactions such that at each information node each player acts how he thinks best given his beliefs about the opponent. Third, following McKelvey and Palfrey (1992, p. 803) "we have chosen an environment in which we expect the Nash equilibrium to perform at its worst" to see the way different age groups deviate from rational predictions, and thus allows us to study the extent to which beliefs about the other generation's rationality and other regarding preferences affect the outcome of the game.

Our main finding is that for both age groups, belief formation about the age group of the opponent shapes the outcome as follows:

1. For both age groups, tâtonnement -or experimentation- mainly occurs when playing against subjects belonging to the same age group.

2. Juniors give their opponents the same chances to cooperate, regardless on whether they belong to the same or to a different age group.

3. Seniors prefer cooperating with seniors more than with juniors.

4. For seniors, reciprocity is payoff driven and occurs for lower opportunity costs.

The reminder of our paper is as follows. Section 2 explains the centipede game, and explicits our hypotheses. Section 3 discusses the experimental design, including the subject pool and the experimental procedures. Section 4 presents and discusses the results. Finally, Section 5 concludes.

1 The Centipede Game and Hypothesis

1.1 Centipede Game

The Centipede Game, first introduced by Rosenthal (1981), belongs to the family of sequential games, with perfect information, that are solved through Backward Induction, such as the game of Nim (Bouton, 1901-02) and the Chain Store (Selten, 1974). It can be described as follows. On sequential trials two players alternate in deciding whether to continue the game or to stop it. At every decision node the payoff distribution favors the player that has the opportunity to choose whether stopping or continuing the game; i.e. the mover. If the mover decides to stop, then the players receive the proposed distribution at that period. If instead of stopping the mover chooses to continue, the sum of the payoffs increases, and the distribution switches in favor of the other player: the mover is fined and the other player is rewarded. The game can continue until a terminal node. Even though the game offers the chance to the players to eventually increase their payoff, the game theoretical –or rational– solution predicts that the first mover should stop at the very first opportunity.

We illustrate the intuition behind the Backward Induction solution using Figure 1.

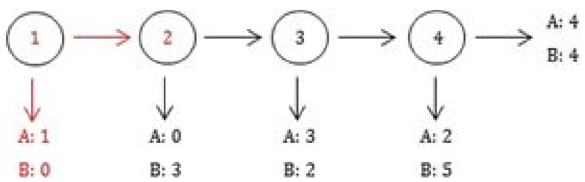


Figure 1: Centipede Game: Example

The sequence starts with two players –A and B– in node 1, and goes from left to right. The first row of the payoffs corresponds to player A, the second to player B. Let's assume the game reached node 4, where player B makes the last move of the game: he has to decide whether to stop or to continue. The payoff maximizing choice will be to stop, otherwise he would be choosing to have less instead of more (4 instead of 5). At the previous node, node 3, player A must choose between stopping the game and keep 3, or continuing to node 4 where he knows the rational choice would be for player B to stop and then he will have a payoff of 2. Both players face the same trade off in each node. Given that, the first mover –player A– will choose to stop the game at his very first opportunity even if it is clear that both players would be better off if they choose to continue. Stopping at the first opportunity results in the optimum choice for a rational mover, which in words of Colman (2003, p. 149), "is an almost intolerably counterintuitive conclusion".

As a matter of fact, existing experimental evidence suggests that most probably agents will not engage in backward induction as much as it is theoretically expected. Studies of the centipede game show that indeed only few players choose to stop the game at their very first chance (McKelvey and Palfrey, 1992; Fey et al., 1996; Nagel and Tang, 1997; Rapoport et al., 2003). Running a series of 4 nodes' and 6 nodes' centipede games, McKelvey and Palfrey (1992) find that less than 2% of the games result in the sub-game theoretical predictions, but also find that for only 5% of the games the last mover chooses to continue:

the majority of the games stop in the middle nodes. Later on, Fey et al. (1996) ran several 6 and 10 nodes' constant-sum centipede games to test for backward induction. In those games the sum of the payoffs are the same at every node, but the distribution changes along the game from equal to unequal in favor of one and the other player in turns. They found that the 10 nodes' centipede game exhibits higher number of rational outcomes, but these are still far from being the theoretical expected 100% of stops at the first node: on average, 52% of the games continue after the first node. The highest percentage of stops at the first node was found by Palacios-Huerta and Volij (2009). The authors run their experiments using subjects that are very much used to the backward induction argument –professional chess players– to find that nearly 70% of the games are solved through backward induction and that 100% of the Chess Grand Masters stop the game at their first opportunity. More interesting, their study considers 4 treatments, each of them combining students and chess players, and the stopping rates vary substantially among them. Finally, using chess players as well, Levitt et al. (2011) show results at odds with Palacios-Huerta and Volij (2009), since only 3.9% of the games stop in the first node. Moreover, they ran a race game to prove that stopping at the first node is not even related to an "inability to reason backwards" (Palacios-Huerta and Volij, 2009, 3).

Experimental evidence reveals the clear conflict between the theoretical prediction, and what seems to be an intuitive behavior: why do players deviate from the rational solution? One wave of research suggests that a player deviates from the rational choice when he believes there is a small probability that his matching partner will also deviate (Kreps et al., 1982; Petit and Sudgen, 1989; McKelvey and Palfrey, 1992). These beliefs would influence him to deviate in order to build a reputation of cooperation that would convince the partner to cooperate as well, thus reaching further nodes. A second wave of studies emphasizes on the role of other regarding preferences, such as fairness concerns and altruism, to explain what seems to be so far understood as an irrational behavior (Rabin, 1993; Fehr and Schmidt, 1999; Dufwenberg and Kirchsteiger, 2004). A third wave of research suggests that also the ability to reason following backward induction (Levitt et al., 2011) may prevent subjects to behave "rationally". All waves of literature would be contesting backward induction as the unique valid argument to predict and explain behavior in strategic situations.

Particularly when it comes to analyze the centipede game, it seems backward induction performing specially poorly would be related to its two assumptions behind: expected utility maximization and common knowledge. The first assumption conforms to the standard economic ones'. The second assumption implies that all the players know that all the players know that all the players are rational[1] (or irrational). When going backwards starting from the last node, backward induction makes sense. What would happen if we go forward from the first node? Do we arrive to the same conclusion about backward induction being the only rational choice? If player A stops the game at the first node,

[1]We assume in this paper that a rational player -or selfish money maximizer player- makes a rational move, being the orthodox rational move to stop at the first chance. For further discussion on rational player and rational moves, please refer to Binmore (1994)

that implies his expected utility of stopping exceeds his expected utility of continuing. If we look at the game, that is indeed not the case: the utility derived from the last nodes is higher than the one from the first nodes (if he reaches these nodes). Would it be irrational that player A moves toward trying to get to the last node? We do not think so. Following the first wave of literature, if his beliefs about player B include a small but sufficiently large chance that player B responds cooperatively and continues the game to the last node, player A will continue the game at the first node. Turning to player B, in case player A continues the game at the first node, he could believe that player A is an irrational player or that player A is asking for cooperation. What should player B do then? According to Aumann (1992), a rational player stops the game regardless how he got to the point of deciding.

Even though Aumann insists that backward induction holds still, it is yet not clear how player A decides: if he considers there is a chance that player B will continue the game, it is intuitively clear that there is no certain fact in which player A could in a first pass assess the expected outcome of stopping or continuing. It seems the game theoretical solution would only make sense if both players are 100% convinced about each other's rationality, and that this rationality is the one that dictates to stop at the first chance.

In summary, players stopping at their first opportunity seems logical, but "intuitively implausible" (Petit and Sudgen, 1989, p. 171): that is the backward induction paradox.

Given that backward induction is the game theoretical solution, but the "let's cooperate" is the practical one, we can suspect that many other pieces of the game theoretical puzzle could be misleading. Following Petit and Sudgen (1989), one player may believe that his opponent is rational, "but that does not entitle him to believe that [same thing] in subsequent rounds". If beliefs about the other change given my actions and given the others' actions in such a short period of time as the duration of a centipede game, when it comes to study individual decision making, we could think that it does not stay constant throughout our lives (Kovalchik et al., 2005; Holm and Nystedt, 2005; Sutter, 2007).

As long as there is one known final period with known payoffs, backward induction may hold. This is the case, for instance, when it comes to analyze sequential negotiations, educational choices, and/or pension funds options. Yet when the final period becomes blurry, rationality may be related to how to keep more, though not necessarily all, in order to cover for the time after the final period. This is exactly the case when uncertainty about whether one will over-live the statistical life expectancy starts gaining importance. All decisions made until then on how to share income among the society and with others may indeed be based on different motivations and intentions, and not necessarily on backward induction arguments or skills. In that context, other regarding preferences (Rabin, 1993; Fehr and Schmidt, 1999; Dufwenberg and Kirchsteiger, 2004), the altruist imitator strategy (McKelvey and Palfrey, 1992), and the ability to reason following backward induction (Gneezy et al., 2010; Levitt et al., 2011), may all play an important role in shaping this intergenerational conflict.

1.2 Hypotheses

The following sections aim at disentangling intergenerational cooperation using centipede games. Hence, we guide our study on the following.

Hypothesis 1 *Players stop the game at the first chance they have to move.*

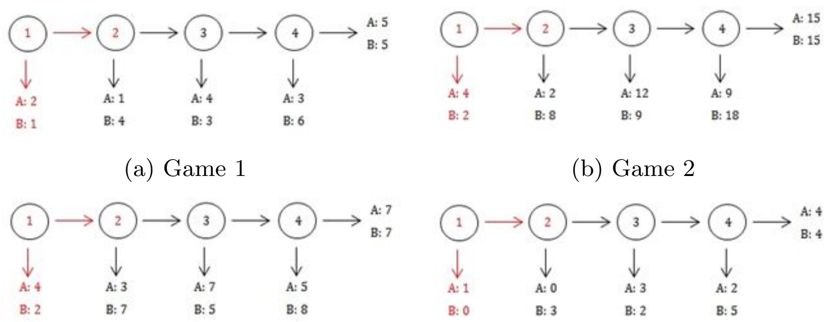
Hypothesis 2 *Playing the game repeatedly does not affect the behavior suggested in Hypothesis 1.*

Hypothesis 3 *Hypothesis 1 and Hypothesis 2 hold for all players, regardless of their own age and the age of their opponent.*

Hypothesis 4 *In case Hypothesis 1 and Hypothesis 2 are rejected, we do not expect systematic in-group differences among age groups.*

2 Experimental Design

We study four versions of the centipede game. The four centipede games have each four nodes, but different payoff specifications (Reny, 1992)(Game 1 to Game 4), as illustrated in Figure 2.



(a) Game 1 (b) Game 2

(c) Game 3 (d) Game 4

Figure 2: Payoff Specifications

As can be seen from Figure 2, if any of the games reach Node 4, the mover has here the choice to stop and keep a higher share of the total payoff, or to continue at his own stake to equally share the total payoff with his opponent (Rosenthal, 1981). Regardless of the strategy followed by each player to reach this one last Node, continuing here the game signals that the player equality concerns vis-à-vis his opponent enters his utility function: we call this player a benevolent player.

The different payoff specifications allow us to investigate whether the players change their strategies across treatments. We would expect them to always stop at their first chance, but if that does not occur, we would expect them to be consistent in their choices regardless of the payoff at stake. For instance, if a player stops the game in Node 3 of Game 1, we would expect him to take the same action if he is again a mover in Node 3 of Game 2, even if payoffs are higher. Alternatively, higher potential payoffs can be understood as higher opportunity costs of continuing the game. That is, if a player continues the game in Node 1 of Game 1 with an opportunity cost of 1 euro –his payoff is case his opponent then decides to end the game at his turn–, would he continue the game in Node 3 of Game 3, where his opportunity cost ascends to 3 euros? Last, in Node 2 of Game 2 we find one exception: continuing the game is the salient solution. Indeed, here both players will be better off if the game continues. Those players stopping here signal a non-benevolent player, as opposed to the benevolent player that continues the game if the game reaches Node 4.

The four games are played twice in order to test our Hypothesis 2 to 4. Here we need to disentangle the information at disposal in each decision node. On the one hand, we find information coming from learning effects derived from the specificities of each game (payoff functions) as well as from playing the centipede game repeatedly. On the other hand, we find information about the opponent's age group, as we explain in the Procedures. Hence, we confront the same player to the same decision twice to test on his actions and reactions.

2.1 Subject Pool

All participants were German native speakers with different backgrounds and income levels. To control for possible asymmetries across sessions we controlled for subjects' experience, and we only invited participants that have not previously taken part in an economic experimental study (Friedman and Cassar, 2004; Croson, 2005). All participants knew that only native German speakers were invited to take part of the sessions. This was desirable for two reasons. First, as our aim is at studying age related differences, we needed a homogeneous population in order to avoid stereotypes linked to different nationalities or languages. Second, we based much of our questionnaire on the European Social Survey[2] (ESS) run in Germany. In order to generalize the results of our research, we needed to approach our sample to the ESS one.

Our sample consists of 192[3] participants from the state of Bremen, Germany. Half of the sample was composed of participants aged between 18 and 26 years old, while the other half of the sample involved participants older than 55 years. The average age for the Juniors cohort was 21.7 years old, with a median of 21 and a standard deviation of 2.32. For the Senior cohort the average is of 63,8 years old, with a median of 63 and a standard deviation of 6.54. Both cohorts

[2]ESS Round 5: European Social Survey Round 5 Data (2010). Data file edition 3.0. Norwegian Social Science Data Services, Norway. Data Archive and distributor of ESS data.

[3]Unfortunately, a total of 21 participants did not show up to the session, for which the data points corresponding to their pairs was simulated, but drawn out of our sample. Given that, for some nodes, the total number of observations may not coincide with the number of games that continued at the previous node. Last, one session suffered of technical problems that forced us to cancel the centipede game from the schedule. All data points where missing completely at random.

exhibit similar figures to the ESS, except for the dispersion of the older cohort, which is of 8.13.

2.2 Procedures

The experiment took place at the Jacobs University Bremen Laboratory for Social Sciences. We conducted 16 sessions, each lasting less than 1 hour. At the beginning of each session, the instructions[4] were read out loud to all the participants to ensure common knowledge about the rules of the game. Participants were then matched in pairs and were asked to participate in 8 rounds, corresponding to playing twice the four games detailed in Figure 2. That said, in round 1 (R1) participants played game 1, in round 2 (R2) they played game 2, in round 3 (R3) they played game 3, in round 4 (R4) they played game 4, and in rounds 5 to 8 (R5 to R8) they played again games 1 to 4 in the same order and maintaining the same roles as before, thus allowing to control for experience. Before each round, the participants faced a screen informing them about the age cohort of the partner; i.e. whether the partner was older or younger than 55 years old. At least 4 matching groups took part in each session, and only one round at random was effectively payed.

The experiment was computerized and run utilizing the zTree software (Fischbacher, 2007). Figure 3 illustrates a picture of the screen as the participants would see it.

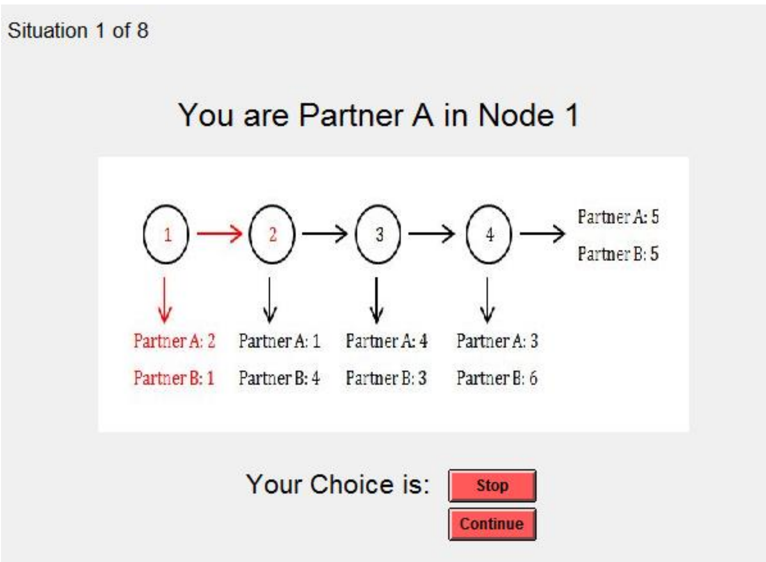


Figure 3: Centipede Game: A Picture of the Screen

[4]Instructions are available under demand. Please contact the Editor for further information

A set of control questions was asked to test for the participants' understanding of the experiment. After the 8 rounds, the participants realized a distributional preferences incentivized task (Balafoutas et al., 2012) and were then asked to solve a race game against the computer (Gneezy et al., 2010) to test for the ability for backward inductive reasoning. Finally, they filled out a survey composed of demographic and social (trust) questions taken from the ESS, as before mentioned. We payed all participants privately in cash at the end of the session.

3 Experimental Results and Discussion

Figure 4 and Figure 5 show stop rates at each node. Figure 4 pools data across players and rounds; Figure 5 pools data across rounds but distinguishes the data according to the age group of the players.

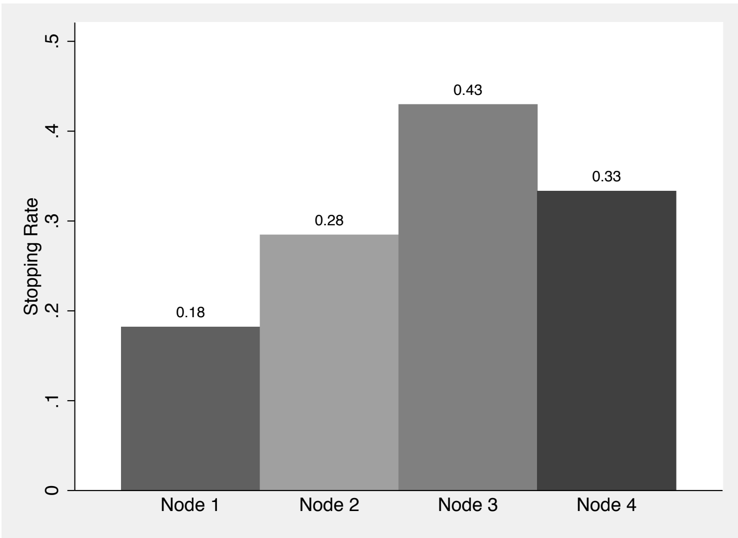
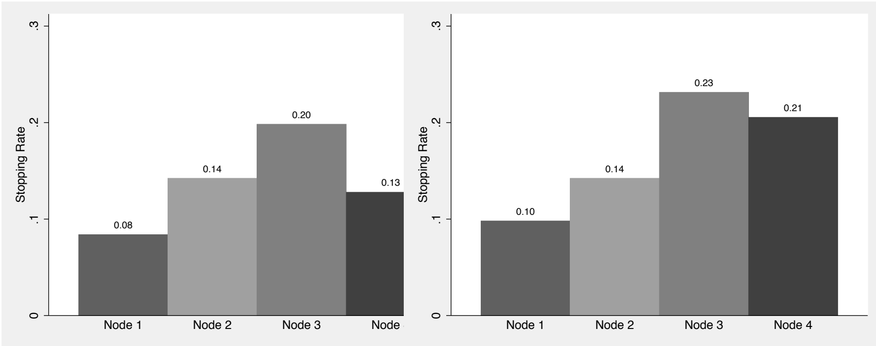


Figure 4: Pooled Rounds: Probability of Stopping, by Node

In line with previous research (cf. Introduction), Figure 4 and Figure 5 show that stop rates increase during the game until reaching the last Node. Indeed, contrary to the backward induction argument, only 18% of the games end at the first node. Then, after the first node, the probabilities of stopping are never even near to the theoretically expected 100% stopping rates. Moreover, in Node 4, 67% of the games continue. That said, our results are in line with previous experimental studies questioning the strength of the backward induction argument.

However, Figure 5 explicits another salient feature that we aim to discuss further in this article: even though overall both age groups exhibit similar probabilities of stopping in Nodes 1 to 3, that changes in Node 4: seniors show a



(a) Juniors (b) Seniors

Figure 5: Pooled Rounds: Probability of Stopping, by Age Group and Node

stopping rate nearly 60% higher that juniors. It seems that in the last node, there where continuing the game guarantees a loss for the mover, seniors' probability of stopping is higher than juniors'. This would be suggesting that seniors decision making would be payoff motivated.

From Figure 4 we observe that 70% of the players reaching Node 4 decide to continue the game to the equitable payoff, even if they have to incur into a loss.

Taken altogether, these first findings suggest there must exist non backward inductive arguments behind the choices of participants belonging to any age groups.

3.1 Backward Induction Reasoning

We have noted in the Introduction two reasons why a player might choose not to stop the game in the first node, and those are related to following a different strategy than backward induction, which could be resumed to altruist imitator (McKelvey and Palfrey, 1992) and other regarding preferences (Rabin, 1993; Fehr and Schmidt, 1999; Dufwenberg and Kirchsteiger, 2004). A third reason we mentioned is related to an inability to reason following backward induction (Gneezy et al., 2010; Levitt et al., 2011).

To test for backward induction, all subjects were asked to play a race to 20 game (Gneezy et al., 2010) against the computer. In this version of the game, both the computer and the players in turns choose a number between 1 and 9. The first to hit exactly 20, wins. The computer starts in order to make sure that the subjects have always the chance to win. If the participant wins, he increases his total earnings by 3 euros, otherwise he earns 0 euros. The race game allows us to observe the ability to follow backward induction reasoning, since it eliminates strategical concerns, as well as beliefs related to other regarding preferences.

In our sample we find that 79 players –half of the sample– successfully solved the race game, and 80 players did not. We are here particularly interested in whether those participants who successfully backward induct in the race game choose to stop at their first chance in the centipede. Table 1 shows the probability that the 79 players who successfully solved the race game stop at the first chance they have to move if that chance is in Node 1, next to the probability that the 80 players that did not successfully solved the race game stop at this same first chance. The last column indicates the outcome of the χ^2-test comparing both results. In only one of the 16 cases presented in Table 1 and Table 2 together the t-test shows significant results: Node 1, Round 7. Given that in Node 2, Round 7, does not hold, we can think that the result is due at random. We will investigate further on this in further section.

Table 1: Node 1: Stop Probability per Round when Race Game was Successfully Solved (SS) versus when Race Game was Unsuccessfully Solved (US)

	SS	US	χ^2-test
Round 1	6.67%	2.62%	$p = 0.392$
Round 2	17.65%	4.88%	$p = 0.074$
Round 3	22.22%	21.08%	$p = 0.897$
Round 4	14.29%	19.51%	$p = 0.564$
Round 5	24.44%	18.42%	$p = 0.507$
Round 6	23.53%	12.20%	$p = 0.197$
Round 7	38.64%	18.42%	$p = 0.045$
Round 8	20.00%	24.39%	$p = 0.647$

Table 2: Node 2: Stop Probability per Round when Race Game was Successfully Solved (SS) versus when Race Game was Unsuccessfully Solved (US)

	SS	US	χ^2-test
Round 1	25.00%	26.83%	$p = 0.860$
Round 2	22.22%	14.29%	$p = 0.387$
Round 3	48.83%	53.33%	$p = 0.513$
Round 4	21.62%	12.50%	$p = 0.319$
Round 5	26.67%	33.33%	$p = 0.513$
Round 6	18.92%	9.09%	$p = 0.241$
Round 7	44.00%	55.56%	$p = 0.405$
Round 8	41.18%	21.88%	$p = 0.092$

The 79 players who successfully solved the race game and thus proved to have skills to reason using backward induction, in the first two Nodes where the orthodox backward induction argument should hold, their probability of continuing is always higher than 50%. At Node 1 they stop, on average, in 2 of ten games; at Node 2 in 3 of 10 games. These results show that not stopping at the first chance is not driven by an inability of the mover to reason backwards.

3.2 Learning and Beliefs

In the centipede game, actions are conditioned on beliefs. Following Petit and Sudgen (1989), "beliefs are determined by the data at [our] disposal". Thus, our first choice is only based on information about the opponent's age group, while our choice in further nodes incorporates learning derived from our actions and the actions of others in previous nodes as well. In order to study beliefs in repeated interactions, we need to disentangle learning effects from the actions (and reactions).

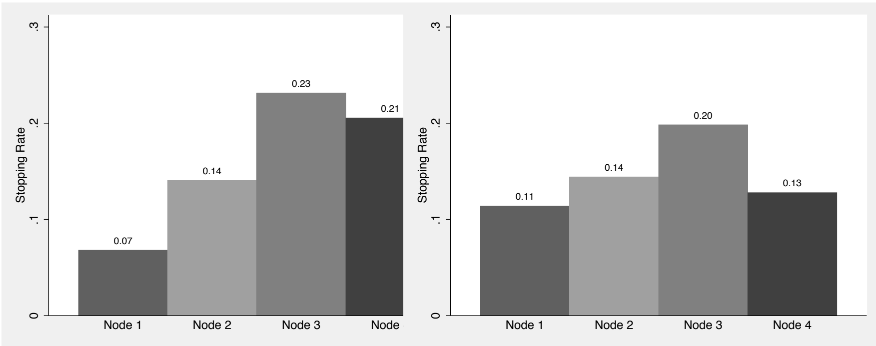
To explore the existence of a learning effect during the course of the experiment, we first look into the four games separately. A first glimpse into the data is shown in Table 3, which reveals that from Game 1 to Game 4 seniors seem to show a learning process that moves toward increasing the number of stops at the first node, hence converging to the backward induction solution. This is not true for the juniors, nor for the rest of the rounds for any age group.

Table 3: Stop Probability, per Age Group, Game and Node

Age Group	Node 1	Node 2	Node 3	Node 4
Game 1				
Juniors	17.1%	36.1%	36.2%	19.2%
Seniors	9.5%	20.8%	41.1%	36.1%
Game 2				
Juniors	14.3%	17.4%	42.9%	24.0%
Seniors	13.8%	15.3%	63.5%	51.9%
Game 3				
Juniors	25.9%	47.2%	53.1%	27.3%
Seniors	25.0%	51.7%	21.9%	47.1%
Game 4				
Juniors	11.4%	22.4%	28.0%	36.7%
Seniors	26.8%	26.5%	46.7%	29.4%

Learning effects could also be occurring within each game. Figure 6 exhibits the probability that the mover choses to stop the game at each node conditional upon reaching that node, differentiating R1-4 from R5-8. The number of games stopping in Node 2 and in Node 3 is similar for both R1-4 and R5-8. However, when looking at Node 1 and Node 4, we do find statistically significant differences among R1-4 and R5-8 (χ^2-test, $p = 0.005$ and $p = 0.029$ for Nodes 1 and 4, respectively). Investigating further, we observe that in Node 1 43 games stop in R1-4 and 45 games in R5-8, while in Node 4 these figures are of 72 and 28 respectively. This information reveals that a shift towards the backward induction solution occurs within each game as well.

As the players do not change their roles over the rounds, we could think that choosing to continue the game in R1-4 and to stop the game in R5-8 could be due to a learning effect: those passing first, realize that continuing the game would not always result in higher payoffs. If this is indeed a learning effect, then



(a) Rounds 1 to 4

(b) Rounds 5 to 8

Figure 6: Probability of Stopping, by Node

those players switching from "continue" to "stop" should not change their mind more than once, regardless of the generation of their opponent.

Table 4 and Table 5 display the proportion of games ending up in each terminal node differentiating per treatment, and their implied probability conditional on reaching that node, respectively. Implied probability refers here to the odds of stopping the game conditioned upon reaching that node. In Table 4 the absolute number of games can be found in between brackets underneath their corresponding odd[5].

Conforming to previous research results, for all treatments the implied stop probabilities increase as we get closer to the last node, except for those games arriving at the very last node where the number of observations is normally significantly lower than those in the previous nodes. Also, even though the number of players stopping at the first node is much higher than in previous experiments (cf. Introduction) where nearly 5% of the subjects stop at the very first node, we do find similar results when it comes to the middle nodes: nearly 60% of the games stop by Node 3.

Juniors

In Node 1, we find that in Treatment I juniors' stopping rate is weakly significantly different and higher in R1-4 compared to R5-8 (χ^2-test, $p = 0.057$). For Treatment II, however, these figure is significantly different and higher in R1-4 compared to R5-8 (χ^2-test, $p = 0.008$).

In Node 2, even though the stopping rates for Treatments I and II are higher in R5-8 than in R1-4 (17.6% to 31.3%, and 34.4% and 36.8%, respectively), the differences are not significant (χ^2-test, $p = 0.068$ and χ^2-test, $p = 0.784$, respectively), indicating no learning effects within treatments. In Node 3, as in Node 2, the stopping rates in R1-4 and R5-8 are not significantly different from each other in Treatment I (χ^2-test, $p = 0.771$), nor in Treatment II χ^2-test,

[5] For instance, in Table 5 Treatment 1.a., Node 2, the implied stop probability can be read as "29.7% of all the games stopped in Node 2".

Table 4: Stop Probability, per Treatment and Round

Treatment	Node 1	Node 2	Node 3	Node 4
I. Juniors vs Juniors				
a. R1 to R4	13.5%	17.6%	37.0%	40.0%
	(10)	(12)	(20)	(14)
b. R5 to R8	26.0%	31.3%	34.1%	22.2%
	(19)	(20)	(14)	(6)
II. Juniors vs Seniors				
a. R1 to R4	7.7%	34.4%	39.2%	25.0%
	(6)	(21)	(20)	(6)
b. R5 to R8	23.1%	36.8%	46.2%	11.8%
	(18)	(21)	(18)	(2)
III. Seniors vs Juniors				
a. R1 to R4	18.1%	33.8%	53.5%	48.3%
	(15)	(24)	(23)	(14)
b. R5 to R8	24.1%	36.1%	48.7%	50.0%
	(20)	(22)	(19)	(10)
IV. Seniors vs Seniors				
a. R1 to R4	14.6%	22.2%	40.4%	32.4%
	(12)	(16)	(21)	(11)
b. R5 to R8	18.3%	18.2%	41.2%	32.3%
	(15)	(12)	(21)	10)

$p = 0.509$).

Last, in Node 4, the proportion of players choosing to continue the game seems to increase from R1-4 to R5-8 in both Treatment I and Treatment II, though the number of observations is too small to derive conclusions in Treatment II. Still, it is important to point out that the number of games arriving to the last node is nearly the triple in the first four rounds than in the second four rounds (14 to 6, and 6 to 2 in Treatment I and in Treatment II, respectively).

For none of the Nodes we find significant differences when comparing average stopping rates in Treatment I and Treatment II (Node I χ^2-test, $p = 0.320$; Node II χ^2-test, $p = 0.500$; Node III χ^2-test, $p = 0.770$; Node IV χ^2-test, $p = 0.155$).

From these results we can infer that, in a first past, juniors do give seniors higher chances of cooperation, suggesting initial out-group favoritism (Coq et al., 2013), but this result is fastly reversed. Additionally, the results from Node 2 and Node 3 together would be suggesting that juniors would reveal themselves to behave as altruist imitators when playing against seniors as much as when playing against juniors. Overall, for juniors, learning effects are not different when facing an opponent of their same age group than when facing an opponent of a different age group.

Seniors

Table 5: Implied Stop Probability, per Treatment and Round

Treatment	Node 1	Node 2	Node 3	Node 4
I. Juniors vs Juniors				
a. R1 to R4	13.5%	29.7%	56.8%	75.7%
b. R5 to R8	26.0%	53.4%	72.6%	80.8%
II. Juniors vs Seniors				
a. R1 to R4	7.7%	34.6%	60.3%	67.9%
b. R5 to R8	23.1%	50.0%	73.1%	75.6%
III. Seniors vs Juniors				
a. R1 to R4	18.1%	47.0%	74.7%	91.6%
b. R5 to R8	24.1%	50.6%	73.5%	85.5%
IV. Seniors vs Seniors				
a. R1 to R4	14.6%	34.1%	59.8%	73.2%
b. R5 to R8	18.3%	32.9%	58.5%	72.0%

Turning our attention to the seniors, we find that in Treatment III, the number of players stopping at their first opportunity does not significantly differ from the first four rounds to the second four rounds, nor in Node I (χ^2-test, $p = 0.341$), nor in Node II (χ^2-test, $p = 0.786$). The differences are also not significant for Treatment IV, both for Node I (χ^2-test, $p = 0.528$) and for Node II (χ^2-test, $p = 0.555$), suggesting consistent behavior regardless of the age group of their opponent. However, the stopping rates in the first two nodes are lower in Treatment IV compared to Treatment III –though only highly significant for Node 2 (χ^2-test, $p = 0.007$)–, implying and in-group effect: in a first pass, seniors would be giving higher chance to cooperate to seniors than to juniors.

In Node 3, seniors do not exhibit significant differences in average stopping rates when comparing Treatment III to Treatment IV (Node 3 χ^2-test, $p = 0.156$; Node 4 χ^2-test, $p = 0.071$), nor they do between their choice in R1-4 compared to their choice in R5-8 in Treatment III (Node 3 χ^2-test, $p = 0.666$; Node 4 $p = 0.935$) and Treatment IV (Node 3 $p = 926$; Node 4 $p = 0.993$).

The significantly higher stopping rates in Treatment III compared to Treatment IV, suggest an initial in-group effect for the age group of seniors: seniors prefer cooperating with seniors more than with juniors. Together with the results from Table 5 showing that the number of games ending in Treatment IV is significantly smaller than in Treatment III, we can say that for seniors, the in-group effect offsets the learning effects.

Juniors and Seniors

A last result derives from the analyses of the effect of other regarding preferences within our games, and comes from looking at decisions in Node 2 in Game 2 and in Node 4 of all games.

In Node 2 of Game 2, seniors and juniors do not show significant differences in their stop probabilities (χ^2-test, $p = 0.734$). Additionally, choosing to continue the game, is here not associated to other regarding preferences (Balafoutas et al., 2012) for seniors (χ^2-test, $p = 0.097$) nor for juniors (χ^2-test, $p = 0.230$), which makes us believe that the altruist imitator strategy may be in place.

For the last node, we find that other regarding preferences are not associated to the decision of continuing the game, not for seniors (χ^2-test, $p = 0.211$) nor for juniors (χ^2-test, $p = 0.092$), which makes us think that the choice is related to positive reciprocity rather than to benevolence: people are willing to sacrifice their own payoff to help those that they think have been kind to them (Rabin, 1993). Additionally, when looking at the probability of stopping per age group at this node, we find that it is for seniors, on average, 15% higher than for juniors (χ^2-test, $p = 0.056$) and nearly the double when it comes to Game 2 where the stakes are much higher (χ^2-test, $p = 0.039$).

The validity of these results increase as we confirm they are not income related: we find no association between juniors' decision to pass in the last node and income (χ^2-test, $p = 0.880$), nor between seniors' decision to pass in the last node and income (χ^2-test, $p = 0.408$).

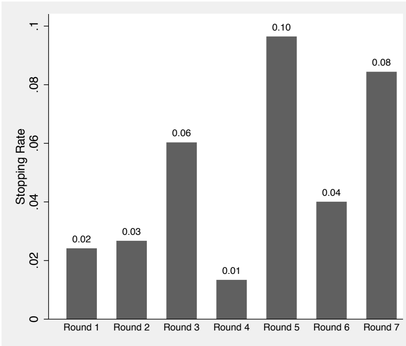
We complement the analysis by looking at profits of both age groups. Here we find that juniors do not show significant different profits when playing against juniors than when playing against seniors (two sided test, $p = 0.172$), but seniors do. Indeed, seniors matched with seniors exhibit significantly higher profits than when matched with juniors (two sided test, $p = 0.021$), and the magnitude is of nearly 20% higher (almost 1 sum). This difference remains significant for seniors playing against seniors and stopping in Node 4 (χ^2-test, $p = 0.038$), but at a magnitude of 45% difference (2 sums). This suggest that seniors, on average, reach higher nodes when playing against seniors, reinforcing the in-group argument, but in Node 4 they are more likely to stop than to continue. As a matter of fact, only for seniors this result goes in line with previous research suggesting that group identity manipulations increase positive reciprocity among in-group partners (Chen and Li, 2009).

So far these results imply that for seniors reciprocity is payoff and in-group driven, and occurs for lower opportunity costs.

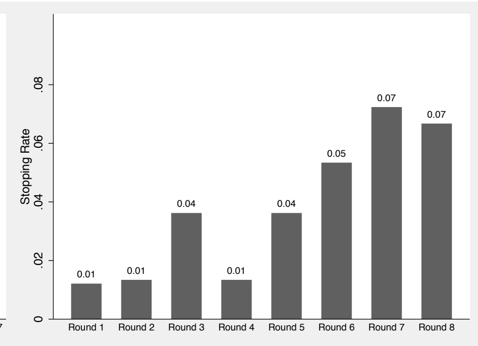
3.3 Beliefs and Age

We have so far analyzed learning effects within and between games over the course of the sessions. Focusing in beliefs purely based on the information about the opponent's age group requires analyzing only decisions in the first node more in detail, knowing ex-ante what corresponds to learning effects: do both age groups converge to the self interest equilibrium solution in the same manner? Figure 7 shows the stop probabilities at the first node at each round and for each treatment.

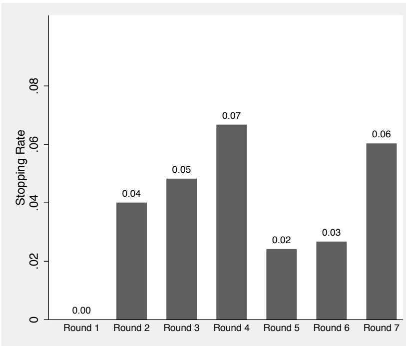
These figures show the reactions –per round– of both juniors and seniors to the different opponents they face. As we can observe, the convergence toward the backward induction solution seems to be happening in Treatment I across games; in Treatment II across rounds; in Treatment III from R1 to R4 and from R5 to R8; and in Treatment IV only in R1-R4. From R5 on, as the rounds



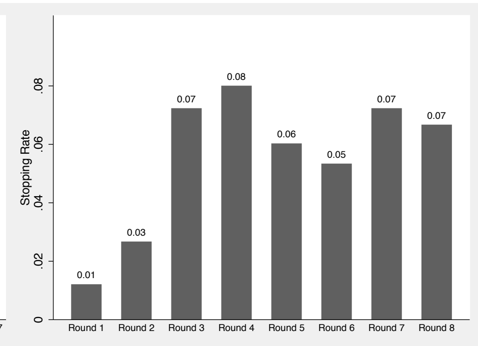
(a) Treatment I



(b) Treatment II



(c) Treatment III



(d) Treatment IV

Figure 7: Percentage of "Stop" in Node 1 per Round

repeat again, we can think that belief formation already occurred.

Following these lines, juniors when playing against juniors show lower rates of convergence than when playing against seniors. Indeed, in Treatment I their decisions are much more round-dependent than when playing against seniors, where they mostly choose to continue, until reaching R5 where they do just start stopping at increased rates, showing a clear adjustment of beliefs. Seniors converging from R1-4 and from R5-8 in Treatment III is showing that they do allow themselves to re-form beliefs about juniors, even though the higher stop rates in R5-8 compared to R1-4 would be also revealing more cautiousness. This is not the case when they play among themselves, where the stop rate increases from R1to R4, and then stays nearly constant and at relatively much higher levels compared to the rest of their choices, revealing that decisions are done regardless of the payoff specifications, thus favoring in-group partners.

Finally, in both Treatment I and Treatment IV (R5-8) where subjects play against their same age group, they seem to "experiment" (Palacios-Huerta and Volij, 2009, p. 17) with their decisions, by switching from stopping to continuing over and over. Hence, although behavior adjusts to beliefs about the other age group, tâtonnement or experimentation mainly occurs when playing against subjects belonging to the same age group, but seniors show a lower overall variance.

These results suggest that the age group identity of the players can define their payoffs and the others' (Akerlof and Kranton, 2000), and that seniors, different to juniors, incorporate age group identity as an argument of their utility function.

4 Concluding Remarks

In this study, we explore repeated sequential interactions among juniors and seniors. We used a centipede game to see how beliefs about the opponent's age group shape that interaction. We find that juniors and seniors adjust their decisions depending on who they play against. We showed that this behavior is not related to any inability to backward induct or to other regarding preferences, but depends on the players' beliefs about the other player's age group.

In the centipede game, cooperation leads to higher payoffs. In line with Chen and Li (2009) our findings show the existence of an in-group effect, but only for seniors, who exhibit the highest payoffs when playing against seniors. Tâtonnement or experimentation mainly occurs when participants play against subjects belonging to the same age group, and its variance is higher for juniors, suggesting that their in-group actions are driven by uncertainty.

Our results confirm the very recent findings of Tremewan and Wagner (2013) on the effects of group identity on outcomes, by showing that juniors and seniors behavior in a cooperation game depends on their beliefs about the behavior of the member of the other age group, and not –only– on other regarding preferences.

References

George A. Akerlof and Rachel E. Kranton. Economics and identity. *Quarterly Journal of Economics*, 115(3):715–753, 2000.

Robert J. Aumann. Irrationality in game theory. In F. Hahn and P. Dasgupta, editors, *Economic Analysis of Markets and Games: Essays in Honor of Frank Hahn*, pages 214–227. M.I.T. Press, 1992. ISBN 9780262041270. URL `http://books.google.de/books?id=Rg_HCz9X_okC`.

Loukas Balafoutas, Rudolf Kerschbamer, and Matthias Sutter. Distributional preferences and competitive behavior. *Journal of Economic Behavior & Organization*, 83(1):125–135, 2012. URL `http://ideas.repec.org/a/eee/jeborg/v83y2012i1p125-135.html`.

Ken Binmore. Rationality in the centipede. In *Proceedings of the 5th conference on Theoretical aspects of reasoning about knowledge*, TARK '94, pages 150–159, San Francisco, CA, USA, 1994.

Morgan Kaufmann Publishers Inc. ISBN 1-55860-331-X. URL http://dl.acm.org/citation.cfm?id=1028104.1028115.

C. L. Bouton. Nim, a game with a complete mathematical theory. *Annals of Mathematics*, 3:35–39, 1901-02.

Gary Charness and Marie-Claire Villeval. Cooperation and competition in intergenerational experiments in the field and the laboratory. *American Economic Review*, 99(3):956–78, June 2009. URL http://ideas.repec.org/a/aea/aecrev/v99y2009i3p956-78.html.

Yan Chen and Xin Li. Group identity and social preferences. *American Economic Review*, 99:431–457, 2009.

Andrew M. Colman. Cooperation, psychological game theory, and limitations of rationality in social interaction. *Behavioral and Brain Sciences*, 26(02):139–153, 2003. URL http://dx.doi.org.arugula.cc.columbia.edu:2048/10.1017/S0140525X03000050.

Chloe Le Coq, James Tremewan, and Alexander K. Wagner. Social centipedes: the impact of group identity on preferences and reasoning. Technical report, University of Vienna, September 2013.

Rachel Croson. The method of experimental economics. *International Negotiation*, 10(1):131–148, 2005.

Martin Dufwenberg and Georg Kirchsteiger. A theory of sequential reciprocity. *Games and Economic Behavior*, 47(2):268–298, May 2004. URL http://ideas.repec.org/a/eee/gamebe/v47y2004i2p268-298.html.

Ernst Fehr and Klaus M. Schmidt. A theory of fairness, competition, and cooperation. *The Quarterly Journal of Economics*, 114(3):817–868, August 1999. URL http://ideas.repec.org/a/tpr/qjecon/v114y1999i3p817-868.html.

Mark Fey, Richard D. McKelvey, and Thomas R. Palfrey. An experimental study of constant-sum centipede games. Working Papers 877, California Institute of Technology, Division of the Humanities and Social Sciences, 1996. URL http://ideas.repec.org/p/clt/sswopa/877.html.

Urs Fischbacher. z-tree: Zurich toolbox for ready-made economic experiments. *Experimental Economics*, 10(2):171–178, June 2007. URL http://ideas.repec.org/a/kap/expeco/v10y2007i2p171-178.html.

Daniel Friedman and Alessandra Cassar. *Economics Lab: An intensice course in experimental economics*, chapter The art of experimental design, pages 32–27. Routledge, 2004.

Uri Gneezy, Aldo Rustichini, and Alexander Vostroknutov. Experience and insight in the race game. *Journal of Economic Behavior & Organization*, 75(2):144–155, August 2010. URL http://ideas.repec.org/a/eee/jeborg/v75y2010i2p144-155.html.

Werner Güth, Carsten Schmidt, and Matthias Sutter. Bargaining outside the lab - a newspaper experiment of a three-person ultimatum game. *Economic Journal*, 117(518):449–469, 03 2007. URL http://ideas.repec.org/a/ecj/econjl/v117y2007i518p449-469.html.

Hakan J Holm and Paul Nystedt. Intra-generational trust–a semi-experimental study of trust among different generations. *Journal of Economic Behavior & Organization*, 58(3):403–419, 2005. URL http://EconPapers.repec.org/RePEc:eee:jeborg:v:58:y:2005:i:3:p:403-419.

Stephanie Kovalchik, Colin F. Camerer, David M. Grether, Charles R. Plott, and John M. Allman. Aging and decision making: a comparison between neurologically healthy elderly and young individuals. *Journal of Economic Behavior & Organization*, 58(1):79–94, September 2005. URL http://ideas.repec.org/a/eee/jeborg/v58y2005i1p79-94.html.

David M. Kreps, Paul Milgrom, John Roberts, and Robert Wilson. Rational cooperation in the finitely repeated prisoners' dilemma. *Journal of Economic Theory*, 27(2):245–252, August 1982. URL http://ideas.repec.org/a/eee/jetheo/v27y1982i2p245-252.html.

Steven D. Levitt, John A. List, and Sally E. Sadoff. Checkmate: Exploring backward induction among chess players. *American Economic Review*, 101(2):975–90, April 2011. URL http://ideas.repec.org/a/aea/aecrev/v101y2011i2p975-90.html.

Richard D McKelvey and Thomas R Palfrey. An experimental study of the centipede game. *Econometrica*, 60(4):803–36, July 1992. URL http://ideas.repec.org/a/ecm/emetrp/v60y1992i4p803-36.html.

Rosemarie Nagel and Fang-Fang Tang. Experimental results on the centipede game in normal form: an investigation on learning. Technical report, Hebrew University of Jerusalem, Center for Rationality and Interactive Decision Theory, 1997.

Ignacio Palacios-Huerta and Oscar Volij. Field centipedes. *American Economic Review*, 99(4):1619–35, September 2009. doi: 10.1257/aer.99.4.1619. URL http://www.aeaweb.org/articles.php?doi=10.1257/aer.99.4.1619.

Philip Petit and Robert Sudgen. The backward induction paradox. *The Journal o*, 86(4):169–182, 1989.

Matthew Rabin. Incorporating fairness into game theory and economics. *American Economic Review*, 83(5):1281–1302, December 1993. URL http://ideas.repec.org/a/aea/aecrev/v83y1993i5p1281-1302.html.

Amnon Rapoport, William E. Stein, James E. Parco, and Thomas E. Nicholas. Equilibrium play and adaptive learning in a three-person centipede game. *Games and Economic Behavior*, 43(2):239–265, 2003.

Philip J. Reny. Rationality in extensive-form games. *Journal of Economic Perspectives*, 6(4):103–118, Fall 1992. URL `http://ideas.repec.org/a/aea/jecper/v6y1992i4p103-18.html`.

Robert W. Rosenthal. Games of perfect information, predatory pricing and the chain-store paradox. *Journal of Economic Theory*, 25(1):92–100, August 1981. URL `http://ideas.repec.org/a/eee/jetheo/v25y1981i1p92-100.html`.

Reinhard Selten. The chain store paradox. Working Papers 018, Bielefeld University, Center for Mathematical Economics, July 1974. URL `http://ideas.repec.org/p/bie/wpaper/018.html`.

Matthias Sutter. Outcomes versus intentions: On the nature of fair behavior and its development with age. *Journal of Economic Psychology*, 28(1):69–78, January 2007. URL `http://ideas.repec.org/a/eee/joepsy/v28y2007i1p69-78.html`.

James Tremewan and Alexander K. Wagner. Group identity in coordination games. August 2013.