

## Theory of Mind in Social Sciences: an Experiment on Strategic Thinking in Children

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# Theory of Mind in the Social Sciences: An Experiment On Strategic Thinking in Children

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## Abstract

This study investigates mentalizing and strategic thinking in children in elementary school age (from 7 to 12 years old). Drawing from previous literature in behavioral and experiments economics and cognitive science, we conduct experiments in which children of different ages make choices in a series of one-shot, simultaneous move two-person games in normal form. We test the ability of our subjects to reason strategically and compare their behavioral patterns with those of adult players engaged in similar tasks (Di Guida and Devetag 2012). Our results show that even younger children are capable of perspective taking: they seem to grasp the essence of strategic thinking, to recognize similarities across games, and behave consistently. In addition, children are sensitive to the attractive power of focal points (Di Guida and Devetag 2012), which are perceived as natural coordination devices even when they are not part of the game equilibria, in line with previous results. Children are also able to perceive the risk-return tradeoffs implied in strategic decisions, as shown by their preference for “safe” strategies (i.e., strategies yielding an acceptable payoff for any choice of the opponent). Finally, only a minority behaves according to naïve heuristics such as opting for the strategy giving the maximum payoff. Our findings contribute to the interdisciplinary literature on the origin of fairness-based norms within societies and on the cognitive and social determinants of strategic interaction.

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## 1. Introduction

Standard models of choice in economics and game theory descend from the famous *homo oeconomicus* paradigm: they assume that decision makers are fully rational and self-interested, always making an optimal use of information to obtain the maximum payoff available (Kreps 1990; Osborne and Rubinstein 1994; Camerer 2003). Game theory is the mathematical language describing rational choice in situations of strategic interaction, i.e., in multi-agent choice problems (henceforth: ‘games’) in which the outcome of an agent’s decision depends on the decisions of all other agents involved: in this case, the rationality paradigm implies that any acceptable strategy profile and solution concept (Nash equilibrium, backward and forward induction, signaling, etc.) must incorporate the decision maker’s correct understanding of other decision makers’ states of mind, i.e., of their beliefs and motivations as these can be inferred from the game incentive structure.

The large body of laboratory evidence collected by behavioral and experimental economists in the last two decades has convincingly shown that human agency is at odds with the *homo oeconomicus* paradigm in multiple ways: more specifically, laboratory data show that individuals are often unable to analyze an interactive decision problem from the perspective of the other decision maker(s). At the same time, however, they do seem to take others’ preferences into account, as many of their choices can only be explained by referring to motivations like altruism, cooperation, fairness and desire to reciprocate (for extensive reviews, see Kagel and Roth 1995; Camerer 2003; Chaudhuri 2009).

The descriptive inadequacy of the ‘perfect rationality plus self-interest’ yardstick is by now fairly established within economics, although no alternative framework has so far gained consensus, not even among those economists more inclined to abandon standard models based on utility maximization in favor of greater realism. The recent encounter with neuroscience has provided some of them with the unprecedented opportunity to open the “black box” of brain functioning and to directly tackle the core of our comprehension of human interactive decisions: the question of when and why we are able to understand and ‘share’ other people’s states of mind and feelings.

One of the most influential areas of research, originated within cognitive science and rapidly spread across disciplines as diverse as anthropology, economics and philosophy, is “mind reading” or perspective-taking, i.e., the ability – shared by humans and by a limited number of nonhuman primates – to understand, interpret and reason about the mental states of others (Cacioppo, Visser, and Pickett 2006). Social neuroscience investigates the neural circuits involved in our capacity to understand other peoples’ intentions, beliefs, and moods, a complex set of abilities globally referred to as “theory of mind” or “mentalizing” (Saxe 2006; Stone and Gerrans 2006). Alongside with the study of how people think about other people and represent their mental states, scholarly attention has been dedicated to understand what enables people to share the feelings of others, referred to as “empathy”. Normal adults are capable of both mentalizing and empathizing to a good extent, while children acquire these abilities gradually (Eisenberg and Mussen 1989; Murnighan and Saxon 1998; Warneken and Tomasello 2007) and autistic children and adults do not seem to possess a theory of mind, which might explain their failures in communication and several other ‘social cognition’ skills (e.g., Baron-Cohen 1995)

Perspective-taking, in its double version of mentalizing and empathizing, is the means by which human beings and other primates influence and are influenced by each other, contributing to the emergence of norms of cooperation within societies. For these reasons, they are both extremely interesting topics of investigation for social scientists and neuroscientists alike.

In game theory perspective-taking is essential: as a consequence, understanding when and why we are capable of “seeing” a game from the point of view of other decision makers allows us to better understand our mental models of strategic interaction, which may not at all coincide with the ‘true’

incentive structure (Camerer 1998): in other words, as recent evidence also suggests, in many settings we may be playing the ‘wrong’ game (Devetag and Warglien 2008).

In this study we investigate perspective-taking in children of various ages by using very simple, 2-person simultaneous move games, in line with the research tradition in behavioral economics and game theory. Our games (shown in Table 1) are designed so that different choices must be attributed to different behavioral principles, and to different hypotheses on the extent to which children incorporate beliefs and intentions of the other player in choosing their preferred option.

We aim to address the following broad questions: what type of “mental model” of an interactive situation do children in elementary school construct? Which features of the game are more salient? Are children inclined to exhibit prosocial behavior?

The broad questions above outlined trigger more specific questions in turn: are children attracted by “obvious” solutions such as focal points? Are they aware of risk-return tradeoffs when dealing with other decision-makers? Do they recognize dominance relations? Do they apply naïve heuristics, such as chasing the game highest payoff, with no consideration for the opponent’s likely intentions?

The reason to study child behavior in strategic settings is manifold: first of all, it interesting *per se*, as part of the ongoing research on the evolutionary roots of human sociality. Secondly, studying child strategic behavior can help us better understand the sources of “bounded rationality” in game playing: more specifically, if violations of the rationality paradigm are determined by lack of “mentalizing” ability we should observe the same patterns with even greater frequency in children, with varying intensity depending on age class, with older children being more able to think strategically than younger ones.

Our results show that children are, on average, remarkably sophisticated players. They are able to spontaneously coordinate on efficient and fair outcomes and are strongly attracted by focal points. They are also sensitive to risk and some of them consistently detect the presence of a dominant strategy in the opponent’s set of available moves. Naïve behavior, like picking the strategy leading to the highest payoff for oneself, is rarely observed.

Section 2 reviews some of the previous literature on mentalizing, fairness and strategic thinking in both children and adults. Section 3 describes the games and section 4 illustrates the experiment implementation in detail. Due to the use of a nonstandard subject pool, some of the features of the experimental design (e.g., matching rule) had to depart from the rules commonly employed in experiments on one-shot games. We adopted protocols similar to those adopted in previous experimental studies on decision-making employing children. Section 5 describes and discusses our experimental results and, finally, section 6 offers some concluding remarks.

## 2. Previous literature

The cross-fertilization between economics and neuroscience has affected both fields profoundly: in fact, while understanding the cognitive and neural determinants of “mind reading” and “empathy” is of obvious interest to economists to incorporate the sophistication of human choices in empirically-informed theories of altruism and strategizing, the use of economic models of decision-making (which, for example, imply the evaluation of tradeoffs) helps neuroscientists confront human and monkey decision making with a ‘rational’ benchmark and translate theories into simple and testable propositions (Powell 2003; Sanfey et al. 2003; Camerer, Lowenstein, and Prelec 2005). Scholars in both fields have made an extensive use of simple experimental games to explore issues as diverse as the origin of social norms, the emergence of other-regarding preferences and of perspective-taking, the way we represent our interactions with others, egalitarianism, parochialism (i.e., the tendency to prefer members of one’s own group to members of other groups) and emotion-

based decisions, to name a few. The results of these endeavors are encouraging the development of behavioral models and increasing our understanding of the evolutionary roots of human sociality (Blau 1964; Adams 1965; Fehr and Fischbacher 2004; Bowles 2006; Dawes et al. 2007; Boehm 2008; Devetag and Warglien 2008; Delton et al. 2011)

A famous example of the use of games by both neuroscientists and economists is the Ultimatum Game (henceforth UG, Güth, Schmittberger, and Schwarze 1982): in the UG, player 1 (the proposer) must propose a division of a sum of money between herself and player 2 (the responder) who can either accept or reject. If the proposal is accepted, the money is then divided accordingly; otherwise none of the players earns anything. The “rational choice” prediction, and the unique subgame-perfect equilibrium of the game, is for the responder to accept any offer above 0 (according to the principle of self-interest) and for player 1, anticipating this response, to offer the minimum possible amount to the responder and keep the rest for himself. Not surprisingly, most of the experimental evidence collected so far is at odds with the Nash prediction. Median offers revolve around 50% of the sum, and offers below 20% are quite often rejected, even in cases in which stakes are substantial (for reviews see Bearden (2001) and Chaudhuri (2009)). The behavior of the responder can be explained by conditional cooperation and costly punishment. Individuals are inclined to reciprocate both fairness and unfairness, and are willing to punish unfair behavior even at a cost to them. It is widely believed that both conditional cooperation and costly punishment have developed to sustain sharing of resources and cooperation within societies (Elster 1989; Fehr and Gächter 2000; Ostrom 2000; Fischbacher, Gächter, and Fehr 2001; Voss 2001; Bowles, Choi, and Hopfensitz 2003; Heinrich 2003; Fehr and Fischbacher 2004). The behavior of the proposer can be explained both by other-regarding preferences and by anticipation of probable rejection in case of an unfair offer. The anticipation of the responders’ reaction, in fact, requires that the proposer “reads” the game from the perspective of the other player, also anticipating her likely negative emotional reaction in case the offer is perceived as unfair. Both “mentalizing” and “empathizing” hence are needed in order for the proposer to maximize his chances of obtaining a positive gain from the negotiation. Research on the UG has shown that specific categories of individuals (e.g., children, autistic adults, chimpanzees, economists, and members of the Machiguenga tribe in the Peruvian amazon, among others!) make lower offers compared to the general population mean (Bearden 2001; Camerer 2003; Sanfey et al. 2003; Oosterbeek, Sloof, and van de Kuilen 2004; Jensen, Call, and Tomasello 2007; Warneken et al. 2007). Studies on the Ultimatum Game and on other similar games conducted with populations belonging to small-scale hunter-gatherer societies suggest that, while all the societies have a concern for fairness, the judgment of what constitutes a fair offer changes considerably across societies (Heinrich 2004).

Parallel to the anthropological studies of fairness-based norms are those on the emergence of other-regarding behavior in children (Eisenberg and Mussen 1989; Thompson, Barresi, and Moore 1997). Research has shown that, for example, three-year-olds are reluctant to sustain costs to punish unfair behavior, while eight-year-olds are much more willing to do so, suggesting that preference for fairness is not innate but develops gradually over the course of childhood (Fehr, Bernhard, and Rockenbach 2008; Blake and McAuliffe 2011; Geraci and Surian 2011). The ability to construct correct beliefs about others’ beliefs and intentions likewise develops with age, and even when children possess a ‘theory of mind’, they may still lack the ability to act consistently i.e., to coordinate choices and beliefs, especially when the alternative is very attractive or ‘salient’ (Di Guida, Girotto, Warglien 2007).

Studies employing adults have pointed out that the ‘equality’ principle (which would imply, for example, a 50-50 allocation in the case of the Ultimatum Game) tends to be preferred in virtue of its being “salient”, and any allocation (among many possible) implying an equal division of resources among two (or multiple) parties is what Thomas Schelling (1960) called a “focal point”, a solution that “stands out” because of its uniqueness. Fair divisions and symmetric allocations, hence, would

emerge not only out of a concern for fairness or because of other-regarding preferences, but also because they represent efficient solutions to difficult coordination problems. Recent evidence provides further support to this conjecture. Di Guida and Devetag (2012) define “focal point” any outcome of a game yielding symmetric payoffs that are significantly higher than any other payoffs obtainable from the game: in short, a “focal point” is an outcome implying relatively attractive and equal earnings for all players. The authors have shown that focal points tend to be selected even when they are not Nash equilibria, and their share increases as the complexity of the decision problem increases, suggesting that they are chosen because they represent attractive and easy solutions to a decision problem that is perceived as cognitively demanding. Di Guida and Devetag (2012) showed that adult players are also attracted by strategies that present good risk/average return profiles. Analysis of these subjects’ eye movements (Devetag, Di Guida, and Polonio 2013) revealed that they pay attention almost exclusively to their own payoffs, neglecting the other player. In other words, they act as if they did not possess a ‘theory of mind’ and implicitly transform strategic uncertainty into parametric uncertainty. While picking a strategy that pays off well on average does not require any perspective-taking on the other player, choosing a focal point does require that the player who selects it believes that focality or “Schelling” salience (Mehta, Starmer, and Sugden 1994) will be recognized by the opponent. In game theory jargon, a focal point is based on common knowledge of focality, in that all players must be confident enough that all other players will pick the focal point, and all players must believe that all players believe, and so on ad infinitum.

Based on these and other findings on strategizing and other-regarding preferences in adults and children, we aim to test the extent to which children of different schooling ages are attracted by “focal points”, by “safe” strategies, and by preferences for fairness and altruism. Our findings add evidence to the literature on ‘mind reading’ and ‘empathy’ in strategic settings, and confirm results on the evolution of sociality.

### 3. The games

Our children had to play six two-person simultaneous moves games (see Table 1) always in the role of Row Players, with the designated experimenter in the role of Column Player. Games were designed to address specific questions: i) are 7-12 year-olds already affected by the attractive power of focal points (as defined in Di Guida and Devetag 2012)? ii) Do children tend to look for “safe” options, treating the game as an individual choice? iii) How often do children of different ages pick the highest profit (maxi-maxi strategy)? iv) Do children coordinate spontaneously when facing an easy coordination problem?

For each of the research questions above outlined we control for the effect of age, gender, and presence of siblings in the family.

Game 1 is designed to observe the effect of Focal Points in the presence of a “safe” strategy. Cell (R1,C1) is a focal point, having high symmetric payoffs for both players (Di Guida and Devetag 2012). R2 is a “safe” option, yielding the same payoff for any possible choice of the opponent. Of the two, R1 is also the choice corresponding to the maxi-maxi principle (i.e., the strategy giving the highest maximum payoff), while R2 is the one with the highest average payoff.

In Game 2 the focal point has been removed by breaking payoff symmetry (as in Di Guida and Devetag 2012) and leaving everything else invariant. Note that the highest payoff for the Row player is still R1.

Game 3 presents a weak focal point (in R1) versus a “risky” (i.e. high payoff variability) strategy with the highest maximum and the highest average (R2). A “weak” focal point is defined as an outcome with symmetric payoffs which are low comparing with the other obtainable payoffs (as in Di Guida and Devetag 2012).

In Game 4, R1 has a focal point in (R1,C1), while R2 is a dominant strategy (therefore safe).

Game 5 is a classical Prisoner’s Dilemma, with a weak focal point (R1,C1) and a dominant strategy (R2).

Game 6 is a pure coordination game with an obvious focal point: the game allows us to test whether Schelling salience (Metha, Starmer, and Sugden 1994) is perceived by children when there are no conflicting options.

Game 1	C1^	C2	Game 2	C1	C2^	Game 3	C1^	C2
R1	4,4*	1,1	R1	4,2	1,3	R1	3,3	2,2
R2	3,1	3,2*	R2	3,2	3,1	R2	5,1	1,3
Game 4	C1	C2^	Game 5	C1^	C2	Game 6	C1^	C2
R1	4,4	1,3	R1	3,3	1,4	R1	4,4*	1,1
R2	5,1	2,3*	R2	4,1	2,2*	R2	1,1	2,2*

Table 1: \* pure strategy Nash Equilibrium, ^ choices of the experimenter (Column Player)

## 4. Experimental design and implementation

The experiments were conducted with students belonging to 15 classes (3 for each grade) across 3 different schools in the district of Treviso (Italy) during spring 2011. A total of 213 children<sup>1</sup> in the 7-12 age range<sup>2</sup> participated in the study (see Table 2).

Grade	N. Participants (Male)
1	39 (22)
2	46 (21)
3	39 (24)
4	47 (25)
5	42 (24)
Total	213 (116)

Table 2: Number of participants per grade and gender

First, the experiment was briefly introduced by the teachers, who anticipated the visit of someone who would present a new activity to the students. Children had previously given the teacher the permissions signed by their parents. The teachers explained that the children would need to remain in class for the whole duration of the activity, but that participation was voluntary and those who preferred not to participate would be assigned an alternative task. Then the experimenter entered the classroom and was introduced to the children.

The experimenter described the procedure in detail. To make children accustomed with the mechanism, various examples were drawn on the blackboard. Children were actively involved in the explanation of the rules and had to verbally answer to some questions. After the instruction

<sup>1</sup> 55% of them were male, but we miss information about the gender of one child.

<sup>2</sup> From grade 1 to 5, average age 9 years old, St. Dev. 1 year and 3 months; median 9. We miss information about the year of birth of 2 children.

phase was over and all clarifying questions had been answered, children received a form reporting the six games (see Appendix A). The games were presented in two possible sequences: 1-2-3-4-5-6, or 4-5-6-1-2-3.<sup>3</sup> To simplify the identification of the payoffs, those of the row player were visualized in dark grey, with circles for R1 and squares for R2, while those of the column player were in light grey, with stars for C1 and triangles for C2.

Children always played as row players, with the experimenter playing as column. We chose to avoid matching children with one another to avoid potential confounds due to relationship-specific emotions (empathy, sympathy, envy, anger, etc.). Moreover, to further reduce the risk of mistakes due to confusion, we also avoided anonymous matching and role switching. Children made their choice simultaneously and independently.

Once the instruction phase was over, the six games were played one at a time and according to the order reported on the sheet. Once all subjects had marked their preferred choice (row) in all the games, one game was randomly selected. The experimenter then announced her choice publicly for the selected game and marked it on the blackboard, explaining the possible outcomes. Children's choices were matched individually with the experimenter's choice. The payoff consisted in a popular gummy bracelet for each "experimental point" earned in the game selected.

## 5. Experimental results

We decided to merge data from first and second graders, and those from fourth and fifth graders<sup>4</sup>. We then consider three age groups: first and second graders (henceforth age group 1, N=85, average age 7 years and 6 months, 51% males), third graders (henceforth age group 2, N=39, average age 9 years, 61% males), fourth and fifth graders (henceforth age group 3, N=89, average age 10 years and 6 months, 56% males). Age groups do not differ significantly as far as gender proportions are concerned<sup>5</sup>.

An overview of the data is presented in Table 3.

	G1	G2	G3	G4	G5	G6
Age Group 1	0.53	0.35	0.39	0.24	0.38	0.79
Age Group 2	0.54	0.44	0.28	0.41	0.41	0.69
Age Group 3	0.35	0.29	0.42	0.24	0.24	0.81
Total	0.46	0.34	0.38	0.27	0.32	0.78

Table 3: Ratio of R1 choices for each game and age group

### The attractive power of Focal Points

To measure the attractive power of focal points we focus on Games 1 to 4. Di Guida and Devetag (2012) and Devetag, Di Guida, and Polonio (2013) have shown that outcomes (i.e., cells) with high and symmetric payoffs exert an attraction on adult players even when they are not Nash equilibria. In particular, when participants are given the choice between a strategy leading to a focal point or a "safe" strategy giving a higher average payoff, a remarkable share (from a minimum of 32% to a

<sup>3</sup> A set of  $\chi^2$  tests, reveals no significant difference for each game (for all games, p-values > 0.52) in the two sequences, therefore we pool the data in the analysis presented.

<sup>4</sup> Results do not change if we divide the children in two age groups: old (fourth to fifth grade) and young (first to third grade). Results with the two age groups division are available from the authors upon request.

<sup>5</sup> Pearson  $\chi^2(2) = 1.35$ , p-value = 0.51, N = 213.

maximum 47%, Di Guida and Devetag (2012)) selects the focal point strategy, implicitly assuming that the other player will make the same choice with sufficiently high probability.

In Game 1, observed choice distributions are similar to those observed with adult subjects: however, younger children seem more attracted by R1 than older ones. In age group 1 and 2, in fact, R1 is chosen by the majority (53% and 54%, respectively), while the percentage declines to 35% for age group 3 (the differences are significant according to a set of two samples tests of proportions; p-value = 0.01 for age group 3 vs. 1, and p-values = 0.04 for age group 3 vs. 2).

The effect of the focal point is particularly evident when comparing choice distributions in Game 1 and 2, where the focal point has been removed. For each age group, the share of choices of R1 in Game 2 is always lower than the corresponding share in Game 1 (35%, 44%, and 29% for age group 1, 2, and 3, respectively<sup>6</sup>). A Logit estimation reveals that the predicted probability of choosing R1 in game 2, decreases significantly by 0.21 if R1 has been chosen in Game 1<sup>7</sup> (and it takes values -0.20 for children in age group 1; -0.22 for children in age group 2 and -0.18 for children in age group 3). Similarly, the correlation between the two games is negative overall (Spearman correlation coefficient  $\rho = -0.18$ , p-value < 0.01), indicating that many subjects shift from the focal point strategy to the safe strategy once the focal point is removed (we remind the reader that the focal point is removed by simply lowering the Column player's payoff hence breaking the symmetry, with no payoff consequences for the Row player).

Looking at correlation values by age group separately, it appears that the negative correlation increases with age, resulting not statistically significant for age group 1, to then become significant for the remaining two age groups<sup>8</sup>, suggesting that recognition of focal points, and hence coordination ability may develop parallel to the development of perspective-taking (Eisenberg and Mussen 1989) and of preference for fairness (Fehr, Bernhard, and Rockenbach 2008; Blake and McAuliffe 2011; Geraci and Surian 2011).

The previous finding is confirmed when restricting our attention to children choosing R1 in Game 1 but not in Game 2 (see Figure 1): in age group 1, 67% of the children do so, a share not significantly different<sup>9</sup> from that in group 2, where it equals 71%. In age group 3, instead, 90% of the children choosing R1 in Game 1 then opt for R2 in Game 2, and this percentage is significantly higher than the percentage in age groups 1 and 2 (two sample test of proportions, comparison with age group 1: p-value = 0.04, with age group 2: p-value = 0.01). This result suggests that older children switch from R1 to the safe strategy R2 in Game 2, probably expecting their opponent to play their best reply, C2, in response to R1. This datum further supports the increase in perspective-taking and strategic thinking with age.

As showed in Di Guida and Devetag (2012), symmetry is not alone sufficient to create a focal point in normal form games, payoff magnitude being equally important. Our data seem to suggest that this is the case with children as well. R1 choices in Game 1 are positively correlated<sup>10</sup> with those in Game 4 (where the focal point is (4,4) as in Game 1), and negatively correlated<sup>11</sup> with those in Game 3 (where the focal point (3,3) has lower magnitude), suggesting that subjects that are attracted by the (4,4) focal point in Game 1 are attracted by the same focal point in Game 4, but change their choice when the focal point payoff magnitude is reduced to (3,3) as in Game 3. When calculating correlation values by age group, we find significant positive correlations between choices in Game 1 and Game 4, and negative correlations between those in Game 1 and Game 3

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<sup>6</sup> According to a set of two-samples tests of proportion, differences in the proportion of R1 are significant only for age group 1 (p-value = 0.01).

<sup>7</sup> See Table B1 in Appendix B.

<sup>8</sup> Correlation by age group: age group 1:  $\rho = -0.05$ , p-value > 0.1; age group 2:  $\rho = -0.33$ , p-value < 0.05; age group 3:  $\rho = -0.31$ , p-value < 0.01.

<sup>9</sup> According to a Two sample test of proportions.

<sup>10</sup> Spearman correlation coefficient = 0.21, p-value < 0.01.

<sup>11</sup> Spearman correlation coefficient = -0.15, p-value < 0.05.

only for children in age group 3, suggesting that between 3<sup>rd</sup> and 4<sup>th</sup> grade children develop sensitivity to payoff magnitude<sup>12</sup>.

Similarly, with a Logit estimation we observe that the predicted probability of choosing R1 in Game 4 increases significantly by 0.19 when R1 is also chosen in Game 1 (and it is equal to 0.16, 0.22, and 0.18 for children in age groups 1, 2, and 3, respectively).<sup>13</sup> When looking at Game 3, we calculate that the predicted probability of choosing R1 in Game 3 decreases significantly by 0.15 when R1 is also chosen in Game 1 (and it is equal to 0.15 in age groups 1 and 3 and to 0.13 in age group 2)<sup>14</sup>.

When restricting the analysis to children choosing R1 in Game 1 (see Figure 1), we notice that the percentage of children choosing R1 in both Games 1 and 4 is equal to 27%, 38%, and 52% in age groups 1, 2 and 3 respectively, with the only significant difference observed between age group 1 and 3<sup>15</sup>. Finally, when comparing Game 1 and 3, the percentage of children choosing R1 in both games is equal to 33% in age group 1, 24% in age group 2, and 29% in age group 3 and it does not differ significantly across age groups.

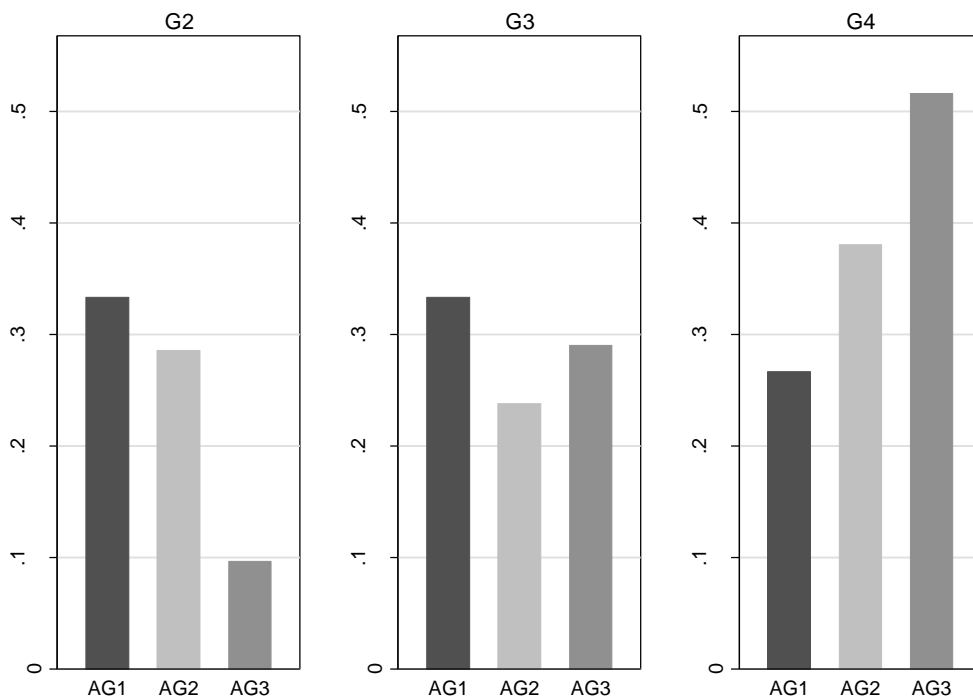


Figure 1: Ratio of children who choose R1 in Games 2, 3 and 4 after choosing R1 in Game 1, by age group. AG1, AG2, and AG3 indicate age group 1, 2 and 3, respectively.

### The effect of riskiness

A strategy can be defined as “safe” when the variance of the payoffs associated with that strategy is null or low. In Di Guida and Devetag (2012) between 47% and 92% of adult players choose the strategy giving the highest average payoff (calculated under the assumption that the opponent’s

<sup>12</sup> Age group 3, correlation Game 1 and Game 3:  $\rho = -0.19$ , p-value  $> 0.1$ ; correlation Game 1 and Game 4:  $\rho = 0.48$ , p-value  $< 0.01$ .

<sup>13</sup> See Table B.2 in Appendix B.

<sup>14</sup> See Table B.3 in Appendix B.

<sup>15</sup> Two-samples test of proportions, p-value = 0.01.

choices are equally likely) when that strategy is also safe. To measure preference for “safeness” we focus on Games 1, 2, 4, and 5.

Our evidence shows that children are sensitive to safety: in fact, a relevant percentage of them choose the safe strategy R2 in Game 1 (despite the presence of the focal point) and Game 2 (between 46% and 65% in Game 1, and between 56% and 71% in Game 2<sup>16</sup>), then R2 in Game 4 and Game 5 where the strategy is dominant (between 59% and 76% both games<sup>17</sup>).

Due to the presence of the focal point in Game 1, we take the share of the safe strategy in Game 2 as a benchmark (when moving from Game 1 to Game 2 preferences for the safe strategy increase: 52% of the children choosing R2 in Game 2 where indeed choosing R1 in Game 1)

From a Logit estimation we calculate that the predicted probability of choosing R2 in Game 4 decreases significantly by .16 when R2 is also chosen in Game 2 (it is equal to 0.20 in age group 2, and 0.15 in both age group 1 and 3).<sup>18</sup> This happens because cell (R1,C1) in Game 4 is a focal point, attracting part of the players.

However looking at Game 2 and game 5, again using a Logit estimation we calculate that the predicted probability of choosing R2 in Game 5 increases significantly by 0.18 when R2 is also chosen in Game 2 (and it is equal to 0.19, both in age groups 1 and 2 and it is equal to 0.15 in age group 3)<sup>19</sup>.

We find similar results when looking at correlations. Overall, choices in Game 2 and Game 4 are negatively correlated (Spearman correlation coefficient = -0.15, p-value = 0.03), while they are positively correlated in Game 2 and Game 5 (Spearman correlation coefficient = 0.2, p-value < 0.01), suggesting that children choosing “safe” act consistently.

Figure 2 shows the ratio of safe choices in games 4 and 5, given a safe choice in Game 2.

When comparing Game 2 and Game 4, 68% of the children choosing the safe strategy in Game 2 choose it also in Game 4. When looking at the age groups, this percentage is equal to 76% for children in age group 1, 50% for children in age group 2 and 68% for those in age group 3. According to a set of two-sample test of proportion, children in age group 2 are significantly less coherent than children in age group 1 (p-value = 0.01) and in age group 3 (p-value = 0.06).

When comparing Game 2 and Game 5, 74% of the children choosing R2 in Game 2, also choose R2 in Game 5 (71% of children in age group 1; 68% of children in age group 2 and 79% of children in age group 3), with no significant trend associated to age.

Finally, we focus on subjects who choose R2 both in Game 4 and 5, where R2 is not only the safe but also the dominant strategy. Over all, they are the 69% of total subjects. When considering age groups, R2 captures the 66% in age group 1, 43% in age group 2, and 81% in age group 3. These numbers indicate that the majority of children are able to detect simple dominance.

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<sup>16</sup> Symmetrically to what we reported about focal points, in Game 1, there percentage of children choosing the safe strategy in age groups 3 is significantly higher than in age groups 1 and 2. Also, the percentage of children choosing the safe strategy in age group 3 is significantly higher than in group 2 (two samples test of proportion, p-value = 0.06).

<sup>17</sup> The percentage of children choosing the safe strategy in age group 3 is significantly higher than in group 2 (two samples test of proportion, p-value = 0.08). The percentage of children choosing the safe strategy in age group 3 is significantly higher than in group 2 and in group 1 (two samples test of proportion, both p-values= 0.02).

<sup>18</sup> See Table B.4 in Appendix B.

<sup>19</sup> See Table B.5 in Appendix B.

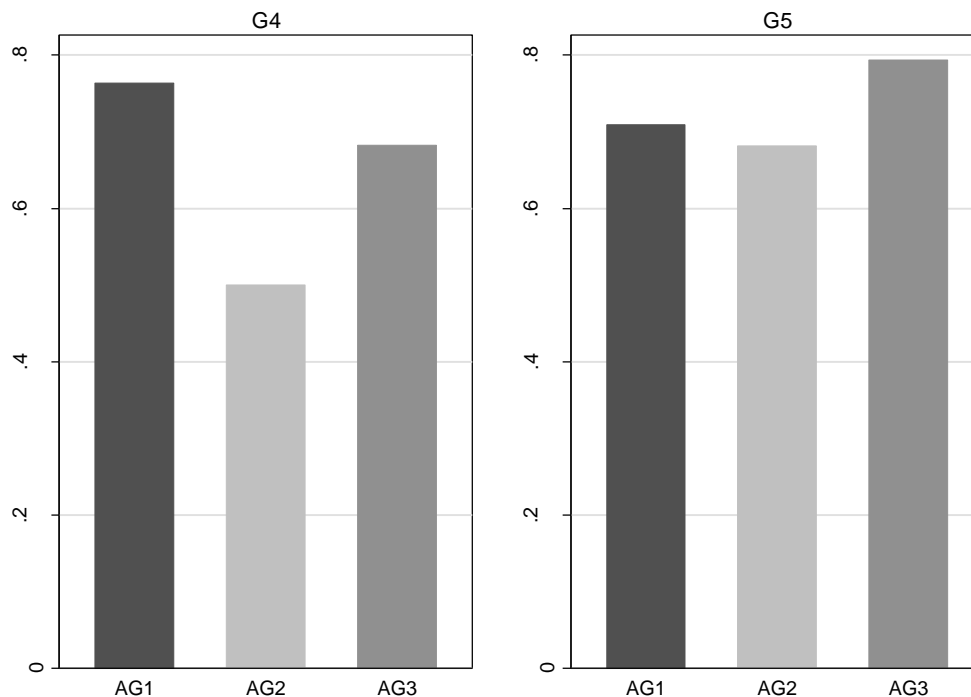


Figure 2: Ratio of children who chose the safe strategy in games 4 and 5, after choosing it in Game 2, by age group. AG1 , AG2 and AG3 indicate age group 1, 2 and 3, respectively.

### The maximaxi and the “altruistic” strategies

Subjects with a limited capacity of strategizing are often attracted by the strategy that gives them the highest possible single payoff, the so called “maximaxi” strategy (see Costa-Gomez, Crawford, and Broseta 2001). Although this appears as a very plausible strategy in the case of children, we do not observe it in our data.

By comparing correlation values between R1 in Game 1 and the other games, we observe that the correlation between the strategies with the highest possible payoffs excludes this hypothesis. As previously stated, Game 1 is negatively correlated with Game 2 (the “maximaxi” strategy is R1 in both cases), it is positively correlated with Game 4 (the “maximaxi” strategy is in two different rows), and it is positively correlated with Game 5<sup>20</sup> (Spearman correlation coefficient = 0.14, p-value < 0.05, the “maximaxi” strategy is in two different rows).

We also exclude that children aim at the cell with the highest “overall” payoff, i.e., the highest payoff sum. This strategy is defined as the “altruistic” strategy in the behavioral economics literature (see Costa-Gomez, Crawford, and Broseta 2001). In Games 2, 4, and 5 the strategy with the highest payoff sum is never the one chosen by the majority<sup>21</sup>. In Game 1, 2 out of 3 age groups choose the “altruistic” strategy in high percentage, but note that this is also the strategy leading to the focal point.

When looking at the consistency of maximaxi choices across games, and restricting the analysis to those children who choose R1 in Game 1 (see Figure 3), it can be noticed that the percentage of those choosing R1 in Game 2 decreases with age (being in age group 3 significantly lower than in

<sup>20</sup> Except for the age group 2, where the correlations between Game 1 - Game 4 and Game 1 - Game 5 are negative, but not significant.

<sup>21</sup> We do not consider Game 3 since two strategies give the same highest overall payoff: (R1,C1) and (R2,C1). Also, we do not include in the analysis Game 6, that is analyzed separately given its peculiar structure.

the other two age groups<sup>22</sup>). The same trend is observed when looking at the consistency of the maximaxi choices in Game 1 and 4, with older children showing significantly lower consistency than young children (two sample test of proportion for age group 1, p-value = 0.01). When looking at the consistency of choices in game G1 and G5, we observe the highest ratio for each age group: however, no age trend emerges.

However, even if children appear to choose the maximaxi strategy consistently in games 1, 4, and 5, the low consistency rate observed in Game 2 suggests that children are probably driven by other considerations. In fact, in Game 1 the maximaxi strategy is also the one leading to the focal point, while in games 4 and 5 the maximaxi strategy coincides with the dominant one.

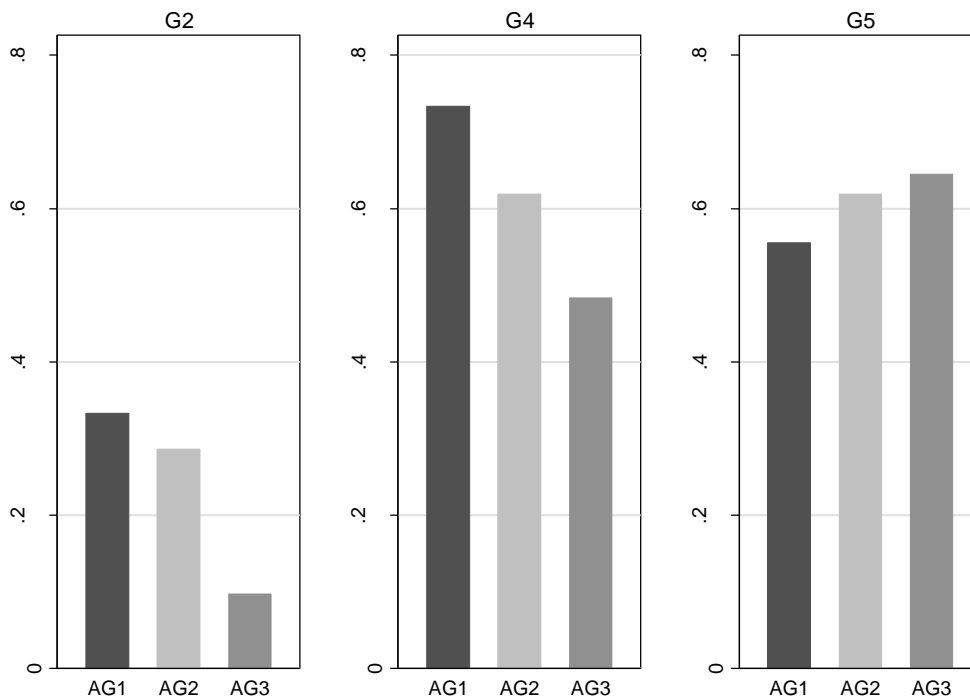


Figure 3: Ratio of children who chose the maximaxi strategy in games 2, 4 and 5, after choosing R1 in Game 1, by age group. AG1, AG2 and AG3 indicate age group 1, 2 and 3, respectively.

### The coordination game

In Game 6, the majority of subjects choose R1 (ranging from 69% to 81%). Also, R1 in Game 6 is negatively correlated with all but one game (the correlation with Game 2 is positive, but the coefficient is about 0). These results suggest that the large majority of our subjects recognize the attractive power of focal points (and for this reason subjects coordinate on it in the coordination game), although only a part of them opts for the strategy leading to it when other options are available, in particular, when a “safe” strategy is available. The frequency of R1 is such that the possibility of random behavior is excluded.

These findings suggest that even young children seem to grasp the typical tradeoff between risk and return typical of economic decision-making settings; more specifically, even young children seem to be aware both of the power of focal points and Schelling salience, and of the risks implied by strategic uncertainty. Both phenomena require perspective-taking.

<sup>22</sup> Two sample proportion test, p-value .04 and .00 for age groups 1 and 2, respectively

When looking at the consistent shift in behavior, by focusing on those children choosing R1 in Game 6 we find a similar pattern for Game 1, 4 and 5. Specifically, 78% of the children choosing R1 in game 6 chose R2 in Game 5, 75% choose R2 in Game 4, and 57% choose R1 in Game 1. Figure 4 reports consistent behavior by age group. Children that follow this pattern may be considered as “refined” since they consistently adapt their strategy according to the strategic situation they are facing: they coordinate when a coordination device is present (in Game 1 the focal point, in Game 6 cell (R1,C1)) and choose the dominant strategy when possible (R2 in both Game 4 and 5).

Considering consistency in behavior between Game 1 and Game 6 we find that the proportion of older children choosing R1 in both games is significantly lower than the proportion of younger children making the same choice (two sample proportion test, p-value = 0.02 and 0.00, for the comparison to age group 1 and 2 respectively).

Consider now the shift in behavior from R2 in Game 4 and 5 to R1 in Game 6. When looking at Game 4, we find that children in age group 2 shift significantly less often than children in the other two age groups (two sample proportion test, p-value = 0.01 and 0.00, for the comparison to age group 1 and 3 respectively), while no significant differences emerge between children in group 1 and 3. Finally, when looking at the consistent shift in behavior between R2 Game 5 and R1 in Game 6, we find that children in age group 3 shift from R2 to R1 significantly more often than younger children.

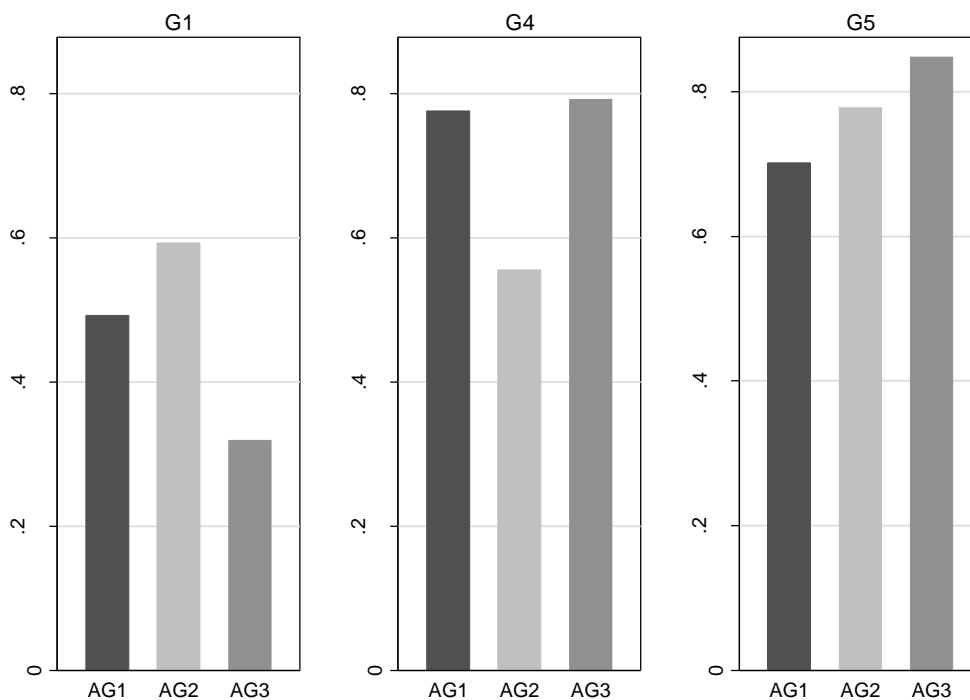


Figure 4: Ratio of “refined” strategy in games 1, 4 and 5, given a R1 choice in Game 6, by age group. AG1 , AG2 and AG3 indicate age group 1, 2 and 3, respectively.

We also controlled for gender and presence of siblings in the family, but no significant effect emerged.

## 6. Conclusions

In the last decades, research in interactive decision-making has convincingly proven that individuals are not the selfish and rational utility-maximizers of standard economic models. Several new models have been proposed, some of which introduce other-regarding preferences in the utility function (Rabin 1993; Fehr and Schmidt 1999), or limited cognitive capacity (Stahl and Wilson 1994, 1995; Camerer et al. 2004), and bounded rationality in various forms (Gigerenzer and Selten 2001; Crawford 2003). Although the behavioral models differ in many respects and all depart from the “rational” benchmark, they still assume that players form sophisticated beliefs about other players’ behaviors, and act consistently with these beliefs.

The recent interdisciplinary literature on “mind reading” has fostered a plethora of studies on the mechanisms and conditions that favor or impede our understanding of the thoughts and feelings of others, including the conditions that allow us to “see” a game from the vantage point of our opponent and to act moved by empathy, altruism and desire to reciprocate.

Behavioral evidence on “mind reading” in game playing is mixed: laboratory data suggest inconsistency between beliefs and choices (Costa-Gomes and Weizsäcker 2008), acting **as if** the player has no beliefs at all (Weizsäcker 2003), or “suboptimal” behavior deriving from incorrect and/or simplified mental representations of the situation at hand (Devetag and Warglien 2008). Di Guida and Devetag (2012) show that when players face an interactive decision problem they have never encountered before look first for *natural* or *obvious* solutions, some of which imply “neglecting” the other player and transforming the game into an individual decision making problem, while others imply relying on focal points leading to fair outcomes.

In this paper, we investigate whether the behavioral patterns identified in Di Guida and Devetag (2012) can be found in children in the age range 7-12, to test whether what appear as *natural* solutions of cognitively complex games to adults are perceived analogously by children. Overall we observe that children are fairly sophisticated, coordinating whenever possible and detecting dominant strategies when available.

More specifically, results show that children in the first years of elementary school are already able to capture Schelling salience, as proved by their attempts to coordinate on cells that provide a “good” outcome<sup>23</sup> for both players. All children coordinate when facing a pure coordination game (Game 6), but elder children are the most consistent in choosing the focal point (Game 1 and Game 4). These results are perfectly in line with the “theory of mind” literature, according to which *egocentrism* is overcome between second and third grade (Piaget and Inhelder 1972).

Several children choose a “safe” strategy (i.e., a strategy giving a good payoff for any possible choice of the opponent). However, many opt for this strategy as a “second best”, opting for the focal point whenever available (as in Game 1 and Game 4).

Interestingly enough, children choose the focal point (giving a good payoff to both players), but neglect both the cell with the maximum payoff (which would benefit one player only and which would suggest lack of strategic thinking, *maximaxi* strategy), and the cell with the highest payoff sum (the so-called *altruistic* strategy in the behavioral literature, which in our case necessarily benefits one player more than the other, otherwise the outcome would be categorized as focal point).

We observed only minor age effects and no effect at all due to gender and presence of siblings in the family.

Overall, our results suggest that some specific characteristics of a strategic situation trigger strategic thinking and perspective taking, while others do not. “Autistic” choice heuristics (such as picking a strategy with a good risk/return profile for themselves, which can be applied in the absence of any beliefs on the other player’s behavior) tend to be abandoned with age, although the

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<sup>23</sup> See the games with salient focal points and the coordination game.

differences in shares are not significant: hence, when adult players exhibit this type of strategy it may be the consequence of a conscious decision to ignore the other player's intentions and beliefs rather than of sheer inability to "read" their minds.

Our findings also support the conjecture that fairness-based norms and preferences for equality may have developed within societies in virtue of their innate "salience" and because they represented efficient solutions to difficult allocation problems. Further research should explore this conjecture by testing the power of "fair" focal points across societies and cultures.

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## **Authorizations**

The experimental design received the approval of the “Ethical Committee” of the University of Trento (protocollo 2011-008). The experiment was part of the activities conducted and financed within the project [Laboratorio Comportamentale](#).

Before starting the experiment we collected the authorization both of the principals of each school and of all the teachers involved.

Parents signed the consent form a few days before the experiment took place.

Children were free to refuse to participate, even if parents authorized them.

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Financial supports from "Fonds de la Recherche Fondamentale Collective" (research grant "Preference dynamics in adaptive networks", n° 2.4614.12) are gratefully acknowledged. We thank Marco Piovesan, all teachers and children involved in the experiment. The usual disclaimer applies.

# Appendix A: Experimental Form

1

	STELLA	TRIANGOLO
CERCHIO		
QUADRATO		

---

2

	STELLA	TRIANGOLO
CERCHIO		
QUADRATO		

---

3

	TRIANGOLO	STELLA
CERCHIO		
QUADRATO		

4

STELLA

TRIANGOLO

CERCHIO	
QUADRATO	

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5

TRIANGOLO

STELLA

CERCHIO	
QUADRATO	

---

6

STELLA

TRIANGOLO

CERCHIO	
QUADRATO	

## Appendix B: Econometric Tables

	(1)	(2)
	Logit regression	Marginal Effects
Dependent Variable	Choice of R1 in Game 2 (dummy = 1 if R1 is chosen; 0 otherwise)	
Game 1 (dummy = 1 if R1 is chosen; 0 otherwise)	-.922*** (.305)	-.205*** (.067)
Age Groups = 1		-.205*** (.063)
Age Group = 2	.375 (.406)	-.217*** (.065)
Age Group = 3	-.457 (.333)	-.176*** (.057)
Constant	-.149 (.271)	-
N	213	213
Log pseudolikelihood	-131.09	-

Note: \*\*\*, \*\*, \* denotes significant at 1%, 5% and 10% level. In model (1) standard errors are adjusted for 213 clusters in subject.

Marginal effects for Game 1 are calculated holding the other variables at their mean.

Table B.1: Probability of choosing R1 in Game 2, Logit regression (1) and marginal effects (2)

	(1)	(2)
	Logit regression	Marginal Effects
Dependent Variable	Choice of R1 in Game 4 (dummy = 1 if R1 is chosen; 0 otherwise)	
Game 1 (dummy = 1 if R1 is chosen; 0 otherwise)	.978*** (.341)	-.185** (.063)
Age Groups = 1	-	.163*** (.053)
Age Group = 2	.847* (.449)	.220*** (.068)
Age Group = 3	.188 (.379)	.178*** (.066)
Constant	-1.760*** (.367)	-
N	213	213
Log pseudolikelihood	-116.81	-

Note: \*\*\*, \*\*, \* denotes significant at 1%, 5% and 10% level. In model (1) standard errors are adjusted for 213 clusters in subject. Marginal effects for Game 1 are calculated holding the other variables at their mean.

Table B.2: Probability of choosing R1 in Game 4, Logit regression (1) and marginal effects (2)

	(1)	(2)
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	Logit regression	Marginal Effects
Dependent Variable	Choice of R1 in Game 3 (dummy = 1 if R1 is chosen; 0 otherwise)	
Game 1 (dummy = 1 if R1 is chosen; 0 otherwise)	-.620** (.30)	-.146** (.069)
Age Groups = 1	-	-.145** (.067)
Age Group = 2	-.484 (.427)	-.126** (.061)
Age Group = 3	-.484 (.427)	-.146** (.066)
Constant	-.484 (.427)	-
N	213	213
Log pseudolikelihood	-138.15	-

Note: \*\*\*, \*\*, \* denotes significant at 1%, 5% and 10% level. In model (1) standard errors are adjusted for 213 clusters in subject. Marginal effects for Game 1 are calculated holding the other variables at their mean.

Table B.3: Probability of choosing R1 in Game 3, Logit regression (1) and marginal effects (2)

	(1) Logit regression	(2) Marginal Effects
Dependent Variable	Choice of R2 in Game 4 (dummy = 1 if R2 is chosen; 0 otherwise)	
Game 2 (dummy = 1 if R2 is chosen; 0 otherwise)	-.857** (.36)	-.163** (.068)
Age Groups = 1	-	-.151** (.061)
Age Group = 2	.914** (.434)	-.202** (.081)
Age Group = 3	-.044 (.359)	-.148** (.065)
Constant	-.921*** (.267)	-
N	213	213
Log pseudolikelihood	-118.43826	-

Note: \*\*\*, \*\*, \* denotes significant at 1%, 5% and 10% level. In model (1) standard errors are adjusted for 213 clusters in subject. Marginal effects for Game 1 are calculated holding the other variables at their mean.

Table B.4: Probability of choosing R2 in Game 4, Logit regression (1) and marginal effects (2)

	(1)	(2)
	Logit regression	Marginal Effects
Dependent Variable	Choice of R2 in Game 5 (dummy = 1 if R2 is chosen; 0 otherwise)	
Game 2 (dummy = 1 if R2 is chosen; 0 otherwise)	.823*** (.308)	.177*** (.066)
Age Groups = 1	-	.186*** (.065)
Age Group = 2	.076 (.403)	.189*** (.065)
Age Group = 3	-.640* (.342)	.147*** (.055)
Constant	-.812*** (.255)	-
N	213	213
Log pseudolikelihood	-127.77079	-

Note: \*\*\*, \*\*, \* denotes significant at 1%, 5% and 10% level. In model (1) standard errors are adjusted for 213 clusters in subject. Marginal effects for Game 1 are calculated holding the other variables at their mean.

Table B.5: Probability of choosing R2 in Game 5, Logit regression (1) and marginal effects (2)

## Appendix C: Instruction for the experimenter

We report here a copy of the instruction that the experimenter used. This form was used as a benchmark, but the experimenter was free to adapt it to the special needs of each specific class. The modifications were kept to a minimum and the experimenter paid attention not to alter the information provided. An English translation of the instruction is available upon request.

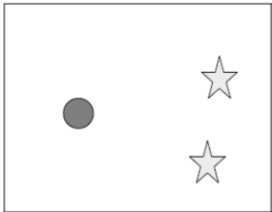
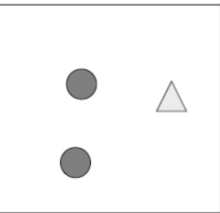


Ora faremo un'attività tutti assieme. In palio ci sono questi braccialetti (*lo sperimentatore li mostra*). Tutti voi vincerete almeno un braccialetto, e quanti braccialetti vincerete dipenderà dall'esito dell'attività.

Ora vi spiegherò le regole dell'attività, se non avete capito qualcosa alzate la mano che ve lo rispiego. Non siate timidi e non abbiate paura.

Mi raccomando, non parlate con i compagni durante il gioco. Cercate di restare in silenzio.

Ora vedremo insieme alcune tabelle, contenenti tante figure di colori diversi. In ogni tabella ci sono varie figure: cerchi, quadratini, stelle e triangoli.

Ecco un esempio di tabella. Vedete? Ci sono delle stelle, dei quadrati, dei cerchi e dei triangoli (*lo sperimentatore disegna alla lavagna una tabella come quella sotto e indica uno a uno i vari tipi*).

	STELLA	TRIANGOLO
CERCHIO		
QUARDATO		

Ecco come si gioca svolge l'attività: Ora vedrete 6 tabelle diverse. In ogni tabella dovete cercare di vincere cerchi o quadratini. Per ogni quadratino o cerchio che vincerete, vi verrà dato un braccialetto.

Come si vincono i cerchi e i quadratini? E' facile!!! In ogni tabella dovete scegliere se volete i cerchi o i quadratini. Mentre voi deciderete, io sceglierò se voglio le stelle o i triangoli.

Vinceremo tanti braccialetti quante sono le figure che si trovano nella casella che contiene sia le figure che scegliete voi, che quelle che scelgo io. Facciamo un esempio:

	STELLA	TRIANGOLO
CERCHIO		
QUADRATO		

In questa tabella voi dovete scegliere se preferite la riga che contiene i cerchi o quella che contiene i quadrati (*con la mano indica ciascuna riga mentre parla*). Vedete, i cerchi sono tutti in questa riga, mentre i quadratini in quest'altra (*indica*).

Io invece sceglierò o le stelle o i triangoli (*indica le colonne*). Vedete, le stelle sono tutte in questa colonna, mentre i triangoli in quest'altra (*indica*).

Voi non sapete cosa sceglierò io, se le stelle o i triangoli, quindi non potete scegliere una casella (*e indica una casella come esempio*) e dire "voglio questa", ma solo una riga: o cerchi o quadrati (*e mostra ancora le righe*). Se ad esempio voi scegliete cerchio e io scelgo stella allora saremo in questa casella (*indica la casella*). Visto che c'è un cerchio solo voi vincerete un braccialetto, mentre io ne vincerò due perché ci sono due stelline. Se invece voi scegliete quadrato e io scelgo stella, saremo in questa casella (*la indica*), voi vincerete un braccialetto perché c'è solo un quadratino mentre io vincerò due braccialetti perché ci sono due stelline. Cosa succede se invece voi scegliete cerchio e io triangolo? (*e lo sperimentatore deve cercare di far rispondere ai bambini, coinvolgerli in qualche modo, così che capiscano bene il meccanismo*) Cosa succede se voi scegliete quadrato e io scelgo triangolo? (*come prima, far rispondere ai bambini*).

Allora bambini, avete capito come si gioca? Volete che ve lo rispiego? (*in base alla situazione si rispiega o si procede*).

Bene, allora cominciamo a giocare tutti insieme.

Ora consegnerò a tutti un foglio come questo (*lo mostra*). Non scrivete nulla e aspettate che tutti abbiano il loro foglio.

(*consegna terminata*)

In ogni foglio ci sono 6 tabelle. Le vedremo assieme, proiettate una alla volta, come abbiamo fatto con la prova. Voglio che ciascuno di voi guardi attentamente le tabelline e scelga in ognuna se vuole i cerchi o i quadratini. Dovrete solo fare una crocetta sulla parola Cerchio o sulla parola Quadrato.

Non fatele tutte subito, ma una alla volta, quando ve lo dirò io.

Mi raccomando, non parlate, ma prendete le vostre decisioni da soli.

Potete scegliere sempre la stessa figura o cambiare, come preferite.

Ricordate che in palio ci sono i braccialetti! Alla fine la maestra sorteggerà una tabellina e voi vincerete tanti braccialetti quante sono le figure che avete vinto in quella tabella.

Siete pronti? Cominciamo!

Questa è la prima tabellina. Guardatela bene e pensate: cosa preferite? Cerchi o quadrati? Non ditelo ad alta voce, ma decidete da soli. Fate una crocetta sulla figura che preferite.

Bene anche io ho scelto. Ora passiamo alla seconda tabellina. . Questa è la seconda tabellina. Guardatela bene e pensate: cosa preferite? Cerchi o quadrati? Non ditelo ad alta voce, ma decidete da soli. Fate una crocetta sulla figura che preferite.

Bene anche io ho scelto. Ora passiamo alla terza tabellina.  
(così fino a che la sesta tabellina è completata).

Bravissimi!!! Siete stati molto bravi. Ora facciamo la maestra sorteggerà uno di questi foglietti con i numeri delle tabelle.

E' uscito il numero xxxxx! Ora vediamo quanti braccialettini avete vinto.

Restate fermi al vostro posto, ora passeremo e vi daremo il premio.

*(lo sperimentatore passa di banco in banco, controlla la vincita dei bambini e consegna i braccialetti.)*

Grazie a tutti e ancora bravissimi!!!