The shadow of the future: 5-Year-olds, but not 3-year-olds, adjust their sharing in anticipation of reciprocation

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Article info
Article history:
Received 19 May 2014
Revised 17 August 2014
Available online 19 September 2014

Keywords:
Reciprocity
Delay of gratification
Sharing
Altruism
Cooperation
Prosocial development

Abstract
Cooperation can be maintained if individuals reciprocate favors over repeated interactions. However, it is not known when during development the psychological capacities to engage in contingent reciprocation emerge. Therefore, we tested when children begin to differentiate between reciprocal and nonreciprocal interactions in their resource sharing. We compared the sharing behavior of 3- and 5-year-olds in two situations. In an experimental condition, the child and a puppet partner alternated the roles of donor and recipient. In a control condition, the puppet had no opportunity to reciprocate. Results showed that 5-year-olds, but not 3-year-olds, increased their sharing toward a potential reciprocator. In addition, we found that children’s ability to delay gratification was positively related to their tendency to share in both conditions. These findings show that reciprocity in anticipation of repeated interactions emerges during middle childhood. Moreover, our results highlight the importance of the ability to delay gratification as a prerequisite for children’s sharing. We discuss how children’s emerging cognitive abilities enable reciprocal sharing in situations where a child must react to or anticipate a partner’s behavior.

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Introduction

Reciprocity provides a powerful mechanism for sustaining cooperation because current costs can be outweighed by long-term benefits. For example, when two individuals interact repeatedly and give away resources in response to prior sharing (tit-for-tat), both individuals are better off in the long term than if they had never given up a resource in the first place. However, although apparently simple, such acts of contingent reciprocation require that individuals possess several psychological capacities (Trivers, 1971). In fact, these psychological constraints are important to explain the presence or absence of contingent reciprocity across species (Schino & Aureli, 2009; Stevens, Cushman, & Hauser, 2005) and can elucidate when during ontogeny children become able to cooperate reciprocally (Warneken & Tomasello, 2013). Therefore, we first review what psychological capacities have been proposed as necessary prerequisites for contingent reciprocity and then assess when these capacities are predicted to emerge during development.

One prerequisite is to discriminate between cooperators and defectors. Cooperative interaction is vulnerable to defectors who reap the benefits while paying a lower cost or no cost at all (Axelrod & Hamilton, 1981; Trivers, 1971). Therefore, a key cognitive requirement to avoid cheaters is to discriminate between different individuals and evaluate their social behavior. The basic components of this ability appear to be early emerging: face recognition and discriminating between individuals are already in place during the first months of life (e.g., Di Giorgio, Leo, Pascalis, & Simion, 2012). Moreover, children as young as 7 months might already be able to discriminate between cooperative and uncooperative agents (Hamlin, Wynn, & Bloom, 2007). Several studies show that, at least by 2 or 3 years of age, children begin to apply this ability when choosing with whom to cooperate (Dunfield & Kuhlmeier, 2010; Vaish, Carpenter, & Tomasello, 2010). Therefore, children display the basic capacity to discriminate between individuals and evaluate their social behaviors during infancy and apply them to cooperative behaviors during early childhood.

A second prerequisite is the numerical ability to track the amount of resources exchanged (Schino & Aureli, 2009; Stevens & Hauser, 2004). The basic numerical abilities required seem to be early emerging as well. Several studies have pointed out that even infants could discriminate between large sets of objects based on their quantity (e.g., Xu, Spelke, & Goddard, 2005). Thus, by the age at which children are able to engage in cooperative interactions with others, they are able to at least track the approximate amount of resources shared beyond a simple assessment of whether sharing occurred or not.

Although these first two prerequisites concern the ability to track prior or current interactions, a third prerequisite is that individuals are able to determine whether one will likely interact with a given partner again in the future (Axelrod & Hamilton, 1981; Trivers, 1971). Adults adjust their cooperative behaviors depending on whether interactants will meet again—the so-called shadow of the future (Axelrod & Hamilton, 1988). More concretely, individuals are less likely to make sacrifices in one-shot interactions than in repeated interactions (Palfrey & Rosenthal, 1994). Similarly, if the number of interactions is fixed in advance, humans decrease their contributions markedly as they approach the end of the sequence (B6, 2005). Concerning children, we know of no study that has assessed at what age children begin to differentiate between one-shot and repeated interactions.

A fourth prerequisite is the ability to delay gratification. Once individuals have identified how current costs could be recouped through future reciprocation, they still need to overcome the temptation to choose the immediate benefit (Rachlin, 2000). This is particularly challenging because even adults have a strong tendency to prefer instant gratification over delayed benefits. In fact, delay of gratification has been proposed to be the major constraint for several animal species, making reciprocity very limited or even nonexistent among nonhuman animals (Stevens & Hauser, 2004). In humans, the ability to delay gratification and make decisions that benefit their future selves progressively develops as children mature. Several studies reveal major changes between 3 and 5 years of age. For example, 3-year-olds typically decide to keep a smaller immediate reward, forgoing the opportunity to obtain a larger reward only minutes later. In contrast, 4- and 5-year-olds prudently choose the larger delayed reward over a smaller but immediate one (e.g., Lemmon & Moore, 2007). This age trend points to a more general ability to make decisions based on future needs, such as to select the correct tool to
secure an anticipated future solution (Russell, Alexis, & Clayton, 2010; Suddendorf, Nielsen, & von Gehlen, 2011; Warneken, Steinwender, Hamann, & Tomasello, 2014), and to choose appropriately in the present to avoid an undesirable future state, such as boredom (Busby & Suddendorf, 2005; Metcalf & Atance, 2011). Some authors have suggested a cognitive parallelism between acting on behalf of others and acting on behalf of one’s own future self because both require the individual to override current immediate goals in favor of noncurrent goals (Moore, Barresi, & Thompson, 1998). When adults need to allocate resources or tasks to the self in the present, the self in the future, or another person, they treat their future self similarly to another person while favoring their current self (see Liberman & Trope, in press, for a review; see also Pronin, Olivola, & Kennedy, 2008; Rachlin, 2002). In fact, neuroscientific studies showed that both thinking about others and thinking about the future self rely on the same core brain network (Buckner & Carroll, 2007).

The findings about a parallelism between individual and prosocial decision making led to the hypothesis that contingent reciprocity and delay of gratification should co-emerge over development. To assess this hypothesis, we first review studies on the early development of contingent reciprocity. We then describe research on children’s emerging ability to delay gratification and its relation to prosocial sharing behavior.

The development of reciprocity

One common approach to studying reciprocity has been to ask whether children use a “reciprocity norm,” defined as an obligation of returning favors when sharing resources (Gouldner, 1960). The acceptance of such a reciprocity norm is considered a cornerstone in the development of autonomous morality marked by mutual respect and cooperation between individuals (Piaget, 1932). Whereas some works have focused on children’s moral evaluation of the characters involved in a series of hypothetical situations (e.g., Durkin, 1959), others have examined the effect of reciprocity on children’s actual behavior at 5 years of age and older (e.g., Peterson, Hartmann, & Gelfand, 1977). In these studies, children were presented with fictitious situations in which an actor displayed a prosocial or hostile act either spontaneously or in response to previous kindness or hostility. Subsequently, children were asked to evaluate the goodness of the actor or to decide how many resources they would share with the actor. One problem of these previous studies is that if they included measures of actual sharing at all, they neither assessed reciprocity in the sense of contingent reciprocity nor included a temporal sequence of favors given and received. One exception is Levitt, Weber, Clark, and McDonnell (1985), in which children were more likely to share a toy if the partner child had shared one with them previously. However, the absence of experimental control over what was shared and how, the correlational nature of the study, and the fact that children switched roles only once limit its viability for current purposes.

A recent wave of studies has used more structured situations to assess when in development children attune their prosocial responses toward their partner over repeated trials, thereby addressing the issue of contingent reciprocity. Two separate studies used a turn-taking version of the so-called prosocial choice game in which both players alternate the position of recipient and donor over several trials (House, Henrich, Sarnecka, & Silk, 2013; Sebastián-Enesco, Hernández-Lloreda, & Colmenares, 2013). Donors needed to choose between a prosocial option (1:1 payoffs) that delivered identical rewards to both players and a selfish option (1:0 payoffs) that delivered a reward to only the donor. Sebastián-Enesco and colleagues (2013) paired 2.5-year-olds with two different adult partners: one who always chose the prosocial option (cooperator) and one who always chose the selfish option (defector). Overall, children were more likely to choose the prosocial option over the selfish option, but their choices were unrelated to their partner’s behavior. Using the same paradigm, House and colleagues (2013) tested pairs of same-aged children at 3 to 8 years. Results showed that only children aged 5.5 years and older responded to their partner’s previous choice when deciding whether or not to choose the prosocial payoff. Using a different task, Warneken and Tomasello (2013) investigated whether 2.5- and 3.5-year-olds adjust their sharing depending on the prior behavior of a puppet play partner. Specifically, when children ran out of toy cubes needed for a game, the puppet still had many cubes left. The puppet was either cooperative by sharing some of her toy cubes, uncooperative by not sharing at all, or explicitly uncooperative by not sharing and saying that she did not want to share.
During the test phase, the roles were reversed so that children were still “rich” at the time when the puppet had run out of resources. Results showed that older children, but not younger children, tailored their sharing according to the level of cooperativeness of their partner. This suggests that by 3.5 years of age, children take into account their partner’s actions and intentions when deciding how much to share with the partner (see Olson & Spelke, 2008, for a similar age effect in hypothetical scenarios). Moreover, Leimgruber, Shaw, Santos, and Olson (2012) assessed to what extent 4-year-olds’ sharing is based on previous sharing received from third parties (generalized reciprocity). Children were tested in a sequence of one-shot prosocial decisions in the prosocial choice game where a child first played the role of recipient and immediately afterward played the role of donor with a different peer. In the role of donor, children could choose between 4:1 and 4:4. Results showed that children were more likely to give the same amount of resources they had previously received from a different partner, suggesting that they based their prosocial decisions on how they had been treated in the past.

In summary, children become increasingly selective in their prosociality in that their prosocial responses begin to be mediated by their past experience with different partners. However, although these studies show that children might be enlightened by the past, it is not clear whether they attend to the shadow of the future. When do children provide resources to others in the present in order to obtain return benefits? To act in this way, children must be able to adjust their current behavior depending on whether the partner has the option to reciprocate the favor or not. To our knowledge, no previous study has addressed whether children understand the potential selfish benefits from contingent reciprocity.

Indirect evidence comes from studies on children’s reputation management strategies. Engelmann, Over, Herrmann, and Tomasello (2013) measured how many stickers 5-year-olds would share with an anonymous partner in a one-shot interaction while another peer was watching. Results showed that children shared more when the observer would have the opportunity to share with them immediately afterward than when no such opportunity existed. This suggests that children gave more resources to the absent partner to gain a good reputation in front of the observer. However, although this study provides evidence for reputation formation (indirect reciprocity), it does not measure contingent direct reciprocity over repeated encounters. Moreover, Engelmann and colleagues tested only 5-year-olds, leaving open whether younger children would share strategically. These problems also apply to older studies in which children at 5 or 6 years of age preferred to be nice toward an absent partner who would know their identity (e.g., Dreman & Greenbaum, 1973; Peterson, 1980). Here as well, social desirability or reputation might account for these findings, and no younger children were included.

Taken together, prior studies suggest that starting at around 5 years of age, children are more prosocial when it influences how others view their behavior. However, more research is needed to examine the extent to which children take their partner’s opportunity for reciprocal sharing into account when deciding how much to share. To address this question, it is necessary to present children with a situation in which their partner displays a strategy contingent on children’s move over repeated rounds and to compare it with a situation in which their partner is not able to reciprocate the child’s previous sharing.

Delay of gratification and prosocial behavior

Although we know of no study that has assessed delay of gratification in relation to reciprocity specifically, several studies have assessed how the ability to delay gratification is related to children’s prosocial sharing behavior more generally (see Moore & Macgillivray, 2004, for a review). In the typical paradigm, 3- to 5-year-olds make decisions about resources distributed either between self and other (social version) or between current and future self (individual version). Whereas in the individual version children can choose to have one sticker for self now or two stickers for self later, the social version included choices in which sharing was costly (two stickers for self, one sticker for each) or noncostly (one sticker for self, one sticker for each). Results showed that older children were better at delay of gratification and also shared more resources with another person in different situations. Importantly, even when controlling for age, children’s greater delay of gratification was associated with greater sharing. Therefore, these studies suggest that development of sharing and delay of gratification might go hand in hand (see Garon, Johnson, & Steeves, 2011, for similar results).
In the current study, we addressed two main questions. Our first question was whether children increase their sharing in repeated interactions. Children could share resources with an animated puppet who either would have access to better resources in the subsequent interaction (experimental condition) or would have no resources at all (control condition). Therefore, if children take their puppet partner’s opportunity for subsequent reciprocation into account, they should share more in the experimental condition than in the control condition. Based on the findings that children’s foresight abilities undergo a major improvement between 3 and 5 years of age, we expected that older children, but not younger children, would selectively increase their sharing. Second, we measured the predicted association between delaying for the future and reciprocal sharing within individuals. Following the theoretical proposals on contingent reciprocity, one might expect that children who are more willing to delay for the future would also be more likely to share with their puppet partner in situations where children’s prosocial acts in the present can lead to greater personal benefits in the subsequent interactions (i.e., our experimental condition). For these purposes, we tested children of two different age groups: 3-year-olds, because previous studies have shown that at around that age children start to modulate their prosocial responses based on their past experience, and 5-year-olds, because they develop the ability to act in the present in light of benefits for their future self.

Method

Participants

The final sample consisted of 72 children. We tested 36 3-year-olds (M = 3;7 [years;months], range = 3;3–3;11, 18 females) and 36 5-year-olds (M = 5;6, range = 5;1–5;11, 18 females). Children were randomly assigned to conditions with equal numbers of boys and girls at both ages. An additional 9 children were tested but excluded due to fussiness (n = 3), experimenter error (n = 3), or game preference (consistently preferring the low-attractive game over the high-attractive game; see “Procedure” section below) (n = 1) or because they did not understand the instructions (n = 2). Children were recruited from a database of families from the greater Boston area in the northeastern United States and were individually tested in a psychological laboratory. Informed consent was obtained from the parents of all children who participated in the study.

Design

All children participated in a delay of gratification task and a reciprocity task. The order of task presentation was fixed, with the delay of gratification task presented first. In the reciprocity task, children were randomly assigned to either the experimental or control condition.

Setup and materials

The setup consisted of two small tables with two opposite chairs each. Each table represented different and consecutive steps. Participants always started at Table 1 (first step) and then moved to Table 2 (second step). Children were presented with two zigzag ramps for which they needed golf balls (see Fig. 1). The low-attractive zigzag ramp consisted of two connected ramps (~55 cm long) attached to a closed red box underneath (58 cm long × 17 cm wide × 20 cm high), hereafter referred as to the “red machine.” The ball was inserted through a funnel, rolled down the ramps, and fell into the box. The high-attractive zigzag ramp consisted of several colorful ramps—a big ramp (58 cm long), two small ramps (~25 cm long each), and a twist (20 cm in diameter)—decorated with jingle bells and attached to a box (61 cm long × 25 cm wide × 20 cm high) that contained a xylophone, hereafter referred to as the “green machine.” The ball was directly dropped through the big ramp, creating a jingle sound when making contact with the bells, and fell into the box. The high-attractive zigzag ramp consisted of several colorful ramps—a big ramp (58 cm long), two small ramps (~25 cm long each), and a twist (20 cm in diameter)—decorated with jingle bells and attached to a box (61 cm long × 25 cm wide × 20 cm high) that contained a xylophone, hereafter referred to as the "green machine." The ball was directly dropped through the big ramp, creating a jingle sound when making contact with the bells, and fell into the box, producing a musical sound when rolling down through the xylophone. Balls inserted into both games ended up in the closed box and, thus, could not be used again. During testing, the red and green machines were both located behind same-color barriers, each placed near Tables 1 and 2, respectively. The barriers were used to prevent
children from seeing the puppet playing with the machines. We ran two preference tests for zigzag ramps to ensure that all children actually preferred the green machine over the red machine. A preference pretest was administered at the beginning before the delay of gratification task. Children were presented with both the red and green machines side by side. Experimenter 1 (E1) encouraged children to insert a ball into each machine and then to identify their favorite machine. At the end of the experiment, children received a total of five balls, one by one, that they could insert into either the red or green machine (preference posttest).

Tasks

Delay of gratification task

At Table 1 children could play with the red machine, whereas at Table 2 they could play with the green machine. Children first stayed at Table 1 for 45 s and then moved to Table 2 for another 45 s. Before starting the game, children received four balls and were asked to decide how many balls they wanted to use immediately with the red machine at Table 1 and how many balls they wanted to use later with the green machine at Table 2. The puppet did not participate in this task.

Sharing task

The sharing task had two conditions that were tested between participants. In the experimental condition, children and the puppet took turns in allocating the balls. Both players first played at Table 1 with the red machine, where children were the donors and the puppet was the recipient, and then moved to Table 2 to play with the green machine, where the roles were reversed. Donors received four balls and could decide to give some of these balls to the recipient. Children were always the donors at Table 1, and the puppet was always the donor at Table 2. When playing the donor, the puppet used a tit-for-tat strategy by sharing the same number of balls at Table 2 that children had previously shared with the puppet at Table 1. In the control condition, the setup at Table 1 was the same. The difference was that at Table 2, instead of the green machine and balls, two sheets of paper and two identical sets of pens were waiting for children and the puppet to be used for individual drawing. Therefore, the puppet never had control over the resource and, thus, had no opportunity to reciprocate (see Fig. 2).

Procedure

Participants and two experimenters entered the experimental room while parents waited in an adjacent room, where they could monitor the session on a video screen. The session began with a 5- to 10-min warm-up play period during which children became comfortable interacting with a large
hand puppet. One experimenter (E1) was in charge of presenting the tasks and explaining the rules to both children and the puppet, whereas a second experimenter (E2) was the puppeteer, operating the puppet throughout the session and never breaking character. The puppet was a large hand puppet similar to a Muppet (~40 cm high). The puppet's name and appearance (hairdo) were matched to children's gender. We decided to pair participants with a puppet partner to systematically manipulate and control for children's partner behavior (matching most closely with Kanngiesser & Warneken, 2012; Warneken & Tomasello, 2013, who used the same puppets; see Paulus & Moore, 2011, and Rakoczy, Warneken, & Tomasello, 2008, for other studies using similar methods).

**Training phase**

After the warm-up phase, we administered a training phase to ensure that children understood the two-step sequence of Table 1 and Table 2. Children needed to choose between two puzzle sets at Table 1, taking into account which puzzle piece the puppet had available at Table 2. Specifically, the puppet was at Table 2 with one puzzle piece (e.g., the head of a giraffe or lion). Children were at Table 1, where E1 presented two sets of incomplete puzzles for children to choose from (e.g., the bodies of a giraffe or lion). After children had chosen a puzzle and put it together, they then moved to Table 2, where the puppet and children finished the puzzle together. We administered two training trials. For each trial, we used a different set of animal puzzles and counterbalanced the order across participants.

**Test phase**

**Delay of gratification task**

The delay of gratification task (hereafter referred to as the DoG task) consisted of two identical trials. E1 placed the red machine behind the red barrier located near Table 1 and placed the green machine behind the green barrier located near Table 2. E1 explained that participants would play with each machine at its corresponding table. E1 told children that they would start playing at Table 1 and then would move to Table 2 and play there for the same amount of time. E1 invited children to sit at Table 1 and placed four balls on the center part of the table and two plates (a red plate and a green plate) at each side of the balls. Then, E1 told participants that they could decide how many balls...
E1 checked children's comprehension by asking participants with which machine they would play at Tables 1 and 2, respectively, and which was the plate for each game. If children did not correctly refer to each machine and plate, the instructions were repeated. After children had divided the balls between the red and green plates, E1 took the green plate with her and sat at a desk located in a corner of the room. Children could then use the balls on the red plate to play with the red machine. E1 explained that they could play alone until she was done with her work, turning away and then pretending to work. After 45 s, E1 announced that her work was done and invited children to move to Table 2. Children sat at Table 2 and received the green plate, and E1 worked at her desk for 45 s. If children did not have any ball for playing with a given machine or ran out of balls before the 45-s period was over, E1 told them to wait at the corresponding table until she was done with her work. When the period was over, the second trial was administered in the same way as the first trial.

Sharing task

The sharing task consisted of four trials. In both the control and experimental conditions, the puppet and children started playing at Table 1, where children could decide to share some of their balls with the puppet to play with the red machine, and then continued at Table 2, where the activity varied according to the condition.

In the experimental condition, the green machine was located at Table 2. E1 informed participants that each player would receive four balls. Children would decide at Table 1, and the puppet would decide at Table 2. At each table, there were two plates: one for the puppet and one for children. E1 started to explain the rules at Table 2 to ensure that children understood that the puppet was subjected to the same deciding rules as them. Then, E1 invited both players to start the game at Table 1 and gave the same instructions to children. E1 placed four balls on the center part of Table 1 and told children that all of the balls were theirs but that if they wanted they could decide to give some balls to the puppet. E1 verified that children understood whose turn to decide was at each table, and whose plate belonged to each player, either the puppet or children. If children did not correctly answer any of these questions, the instructions were repeated. Then, children were told to distribute the balls between plates as they wished. During the allocation, E1 faced away and pretended to be distracted. For a period of 45 s during which E1 pretended to work, each player was allowed to play with the red machine placed behind the red barrier one by one while the other player waited at Table 1 from which there was no visual access to the game. If one of the players had no balls to play with the ramp, the player was instructed to stay at the chair until E1 was done with her work. When the period was over, E1 invited both players to move to Table 2, where it was now the puppet’s turn to decide. E1 repeated to the puppet the same instructions she had given to children, and the procedure was identical to that for Table 1. The puppet gave away the same number of balls as children had done at Table 1. After the 45-s period, E1 moved on to the next trial. The procedure for the remaining three trials was identical to that for Trial 1 with the exception that in Trials 3 and 4 no more comprehension questions were asked.

In the control condition, instead of the green machine, two identical sets of drawing materials were placed on Table 2. E1 explained that they would do some drawings at Table 2. The procedure at Table 1 was identical to that of the experimental condition. Before playing the game, E1 asked children what they could do at each table, either playing with the red machine or drawing, and whose plate at Table 1 belonged to each player, either the puppet or children. After the 45-s period, E1 invited both players to move to Table 2 and encouraged them to draw until she was done with her work. The same procedure was used for the remaining trials with the exception that for Trials 3 and 4 no more comprehension questions were formulated.

Coding and preliminary results

All data were videotaped and coded by E1 during testing. We measured (a) which puzzle children chose during training, (b) which game children chose during the preference pretest, (c) how many balls children saved for playing with the green machine in the DoG task, (d) how many balls children shared with the puppet in the sharing task, and (e) how many balls children inserted into the green
machine during the preference posttest. A second rater independently coded the responses of 23 children randomly selected to assess interrater reliability (κ = 1.00).

**Comprehension questions in DoG and reciprocity tasks**

Children at both ages understood the instructions given at each task from the very beginning. On average, 86% of the questions were answered correctly in the DoG task and 95% in the reciprocity task.

**Preference tests**

In the preference pretest, the vast majority of children at both ages said that they preferred the green machine over the red machine (72% of 3-year-olds and 94% of 5-year-olds from the final sample). Moreover, during the preference posttest, children inserted significantly more balls into the green machine compared with the red machine (binomial test, $p < .05$, $n = 72$). This preference for the green machine was equally strong at both age groups (3-year-olds: $Mdn = 5.0$; 5-year-olds: $Mdn = 4.5$; Mann–Whitney $U$ test: $U = 621.00$, ns). In terms of individuals, 68 of 72 (93.6%) inserted more balls into the green machine.

**Training phase**

Children at both ages selected the correct puzzle piece significantly above chance level in both training trials (binomial tests, $p < .05$, $ns = 72$). Children's performance during training was not affected by puzzle order (Mann–Whitney $U$ test: $U = 621.00$, $ns$), trial (McNemar test: $\chi^2(1, N = 72) = 0.41$, $ns$), or age (Mann–Whitney $U$ test: $U = 778.00$, $ns$).

**Statistical approach for main data analyses**

We analyzed the data with generalized linear mixed-effect models (GLMM) using the lme4 software package (Version 0.999999-2 in R; Bates, Maechler, & Bolker, 2013; R Core Team., 2013). Due to the characteristics of our dependent variables, we used a Poisson distribution with a log link. The models were fitted by the Laplace approximation, and model selection was based on pairwise comparisons using $F$ tests. We sequentially deleted fixed terms from a full model (main effects and first- and second-order interaction effects) to find the most parsimonious model that fit the data. Preliminary analyses indicated that gender had no significant effect on any of our dependent variables and, thus, was not included in the analyses reported below.

All models included participant identification (ID) as a random effect to account for repeated measures. Our first set of analyses explored age differences and the effect of experience in the DoG task (models for DoG). A second set of analyses was aimed at determining the factors that predicted children's sharing with the puppet (models for sharing behavior). In a last step, we assessed to what extent the ability of delaying better rewards contributed to children's propensity to share.

**Results**

We first assessed children's performance on the DoG task. The corresponding models for DoG as outcome variable included the predictors age, trial number, and the first-order interaction as fixed terms. Both age and trial number were significant predictors (log likelihood ratios: age, $\chi^2(1) = 7.32$, $p < .01$; trial number, $\chi^2(1) = 7.32$, $p < .01$), whereas removing the Trial $\times$ Age interaction did not yield a significant reduction in fit (log likelihood ratios: $\chi^2(1) = 0.09$, $ns$). Thus, our final model included the main effects of trial and age (see Table 1). These analyses showed that children were more likely to save balls in the second trial ($M = 1.89, SD = 1.22$) than in the first trial ($M = 1.32, SD = 1.07$). Moreover, older children ($M = 1.89, SD = 1.00$) were significantly more likely to save balls to play with the more attractive game later than were younger children ($M = 1.32, SD = 1.28$).

We next examined children's sharing behavior, asking whether it varied as a function of age and condition. The mean numbers of balls that children at both age groups shared in each condition are displayed in Fig. 3. Inspection of our data revealed that the rate of sharing across trials formed a bimodal distribution, with the vast majority of children either sharing half of their resources (proportion of
trials with equal splits = .57) or not sharing at all (proportion of trials giving zero balls = .30). Broken down by age group, we found that 3-year-olds showed similar distributions in both conditions (experimental: equal splits = .58, zero splits = .39; control: equal splits = .57, zero splits = .36; all ns = 18). In contrast, 5-year-olds were nearly three times less likely to make zero splits in the experimental

### Table 1

<table>
<thead>
<tr>
<th>Models for sharing behavior</th>
<th>Full fixed-term model</th>
<th>Final model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[Estimate (SE)]</td>
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<tr>
<td><strong>5-year-olds</strong></td>
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<td>−0.31 (0.14)*</td>
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<td>0.16 (0.05)**</td>
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<td>Condition * Trial</td>
<td>0.28 (0.51)</td>
<td></td>
</tr>
<tr>
<td>Condition * DoG score</td>
<td>0.02 (0.23)</td>
<td></td>
</tr>
<tr>
<td>Random effect (participant ID)</td>
<td>−0.26 (0.52)</td>
<td>−0.16 (0.18)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Models for DoG</th>
<th>Full fixed-term model</th>
<th>Final model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[Estimate (SE)]</td>
<td></td>
</tr>
<tr>
<td><strong>Age (5-year-olds vs. 3-year-olds)</strong></td>
<td>0.41 (0.21)*</td>
<td>0.36 (0.13)**</td>
</tr>
<tr>
<td>Trial</td>
<td>0.41 (0.21)*</td>
<td>0.36 (0.13)**</td>
</tr>
<tr>
<td>Age * Trial</td>
<td>−0.08 (0.27)</td>
<td></td>
</tr>
<tr>
<td>Random effect (participant ID)</td>
<td>0.05 (0.16)</td>
<td>0.08 (0.13)</td>
</tr>
</tbody>
</table>

**Note.** The dependent measure for models for sharing behavior was the number of balls shared with the puppet, and the dependent measure for models for DoG was the number of balls saved for future use. For the full models, results of all tested terms are given. For the final model, results of terms that were included based on pairwise model comparison are given. Cells display β values with standard errors in parentheses. Coefficients of categorical predictors indicate the estimated effects of predictors relative to the following baseline levels: age = 3 years, condition = control. P values reflect goodness-of-fit tests.

* p < .10.
* * p < .05.
* ** p < .001.

![Fig. 3. Mean numbers of balls shared with the puppet across trials by condition for each age group in the sharing task. Error bars represent standard errors.](image)

trials with equal splits = .57) or not sharing at all (proportion of trials giving zero balls = .30). Broken down by age group, we found that 3-year-olds showed similar distributions in both conditions (experimental: equal splits = .58, zero splits = .39; control: equal splits = .57, zero splits = .36; all ns = 18). In contrast, 5-year-olds were nearly three times less likely to make zero splits in the experimental
Thus, we compared children's performance on the DoG task and the experimental condition of the sharing task, where they needed to give away some resources to the partner, compared with the DoG task as in the experimental condition than in the control condition (proportion = .11) compared with the control condition (proportion = .32), whereas the proportions of equal splits remained identical in both conditions (experimental: proportion = .32; control: proportion = .53; all ns = 18). Moreover, older children were substantially more likely to share more than half of the balls with the puppet when they played in the experimental condition (proportion = .17) compared with the control condition (proportion = .03, all ns = 18).

We then analyzed which predictors best explained children's rate of sharing. Our models included three predictors (condition, trial number, and age group) and all their first-order interactions and the second-order interaction as fixed terms. Only the exclusion of age group yielded a significant reduction in fit (log likelihood ratios: $\chi^2(1) = 3.90, p < .05$; see Table 1). Thus, older children were significantly more likely to share with the puppet than were younger children. Neither condition nor trial number significantly predicted children's sharing in this analysis. A visual inspection of the data suggested that this was probably due to the uniform distribution of the amount of balls shared by 3-year-olds. Thus, we decided to analyze the data for each age group separately. In each age group analysis, condition, trial number, and the first-order interaction were considered as predictors. For the 3-year-old group, none of these factors predicted children's sharing. Interestingly, the random effect was found to be nonsignificant in all models, highlighting a lack of interindividual variability among this younger age group in either condition. For 5-year-olds, we found that removing the trial factor and the Trial $\times$ Condition interaction from the model did not yield a significant reduction in fit (log likelihood ratios: trial, $\chi^2(1) = 1.58, ns$; Trial $\times$ Condition, $\chi^2(1) = 3.29, ns$). Thus, these terms were dropped. However, removing condition from the model reduced fit significantly and, thus, was included in further models (log likelihood ratios: $\chi^2(1) = 5.79, p < .05$). Thus, our final model on sharing in 5-year-olds included condition as a fixed term, revealing that the older children shared significantly more balls in the experimental condition than in the control condition (see Table 1).

After establishing the effects of age and condition on children's sharing, we next assessed the hypothesis that delay of gratification might play an important role in children's sharing ability. A first correlational analysis showed that children who chose to save more balls for playing with the more attractive apparatus also shared more balls with the puppet (Spearman's rho: $r_s(69) = .28, p < .05$). Moreover, when controlling for age, the positive relationship remained significant ($r(69) = .25, p < .05$), indicating that delay of gratification uniquely contributed to sharing behavior over and above age. In a next step, we added the DoG score as an additional predictor to our initial analysis with condition, trial number, age group, and their interactions on the number of balls shared with the puppet. We found that the DoG score was a relevant predictor for explaining the overall amount of sharing given that its exclusion from the model significantly reduced its fit (log likelihood ratios: $\chi^2(1) = 7.09, p < .01$). Children who were better at delay of gratification were also more likely to share with the puppet. The analyses of 5-year-olds' sharing behavior yielded a very similar picture. The final model for 5-year-olds included both the main effects of condition and DoG score as fixed terms (log likelihood ratios: $\chi^2(1) = 14.70, p < .001$; see Table 1). In contrast, the number of balls shared by 3-year-olds was not affected by their tendency to delay gratification (log likelihood ratios: $\chi^2(1) = 0.38, ns$). Interestingly, none of the analyses performed showed a significant interaction of Condition and DoG score. This finding indicates that the relationship between delaying rewards and sharing behavior held across conditions whether acts were reciprocated or not. In other words, the role of the ability to delay gratification was not exclusive to those sharing situations in which children could act strategically by sharing balls with their partner for the less attractive game to obtain a return benefit when playing the more attractive game.

So far, we have established a significant positive relationship between children's propensity to share and their ability to delay gratification. However, one concern is that this relationship is due to children perseverating in their behavior across both the DoG and sharing tasks without considering the consequences. Therefore, we analyzed whether children were equally likely to give balls away in the DoG task as in the experimental condition of the sharing task. Note that the number of balls that children “invested” in both tasks yielded the same outcome—to play the same number of times with the high-attractive game. However, one would expect children to be more reluctant to give away resources in the sharing task, where they needed to give away some resources to the partner, compared with the DoG task, where they needed to give away some resources to themselves in the future. Thus, we compared children's performance on the DoG task and the experimental condition of the
reciprocity task using Wilcoxon signed rank tests. The analyses showed that both younger and older children saved the same number of balls in the DoG task as they shared with the puppet in the experimental condition of the reciprocity task (3-year-olds: Mdn_{DoG} = 1.00; Mdn_{rec} = 1.63, Z = 31.50; 5-year-olds: Mdn_{DoG} = 2.00, Mdn_{rec} = 2.00, Z = 88.00; all ns = 18, all ps > .10). In contrast, when comparing children’s performances in the control condition, where no benefits were obtained from sharing with the puppet, we found that older children tended to save more balls (Mdn = 2.00) for the future in the DoG task than they shared with the puppet (Mdn = 1.37) (Z = 23.00, p = .06). Younger children, however, performed similar in both the DoG task (Mdn = 1.75) and the control condition (Mdn = 1.75) (Z = 31.50, ns). Taken together, these analyses show that the 5-year-olds differentiated between the consequences of their behavior in the DoG and sharing tasks. This suggests that the positive relationship between delay of gratification and sharing is not due to confusion or perseveration errors but rather is reflective of a common ability that leads children to make more prudent decisions.

Discussion

We investigated at what age children adjust their sharing depending on whether a recipient can subsequently reciprocate the favor. Results showed that 5-year-olds were sensitive to the possibility of reciprocation by sharing more resources with a partner who subsequently reciprocated than with a partner who was unable to reciprocate. In contrast, 3-year-olds shared the same amount in both conditions, suggesting that they did not take into account the partner’s opportunity to reciprocate their favor. Second, we investigated the ability to delay gratification as a potentially important prerequisite for reciprocal sharing. Here we found that children’s delay for better rewards was positively related to their willingness to share with others. Interestingly, the relation between delaying gratification and sharing was not confined to the situation in which reciprocity might emerge but rather to children’s general decisions to share with others across both conditions.

Previous research on reciprocal sharing has shown that 3.5-year-olds are sensitive to others’ prior sharing when they distribute resources and, thus, “look back” when making their decisions (Olson & Spelke, 2008; Warneken & Tomasello, 2013). Our findings expand this line of research by investigating when children “look ahead,” taking into account whether their own sharing might influence the opportunity for a partner’s subsequent sharing with them. Our results show that such strategic reciprocity emerges later in development compared with past event-driven reciprocity. Therefore, whereas 3.5-year-olds can reliably modulate their prosocial responses contingent on past experiences, they might still have problems in linking their current sharing decisions with their partner’s subsequent moves.

Moreover, 3-year-olds saved the same number of balls in the DoG task as they shared with the puppet in both conditions of the reciprocity task, suggesting that they do not act for the sake of a more rewarding future. These findings are congruent with a large body of works examining the development of foresight abilities showing that 3-year-olds are strongly present-oriented in their choices (see Atance & Metcalf, 2013, for a review). On the other hand, 5-year-olds invested the same number of resources in these situations in which they could obtain something better in the subsequent step (DoG task and experimental condition of reciprocity task) but gave fewer resources away when such actions did not yield future benefits (control condition of reciprocity task).

Overall, children who were better at delaying for future rewards were also more willing to share with others. However, this was true whether reciprocation was possible or not. Thus, we did not find a specific link between the ability of delaying gratification and reciprocal sharing per se, as was theoretically postulated. This hypothesis had been derived from a theoretical account characterizing individuals as purely self-interested “rational actors” who would share with others only if it resulted in a delayed selfish benefit (Stevens & Hauser, 2004). This is why a fundamental prerequisite for rational actors to engage in bouts of reciprocation is their ability to delay immediate gratification (paying a cost now) for the sake of a more rewarding future (a return benefit provided by the partner). This picture changes slightly when we assume that children are not entirely self-interested but also have prosocial motivations to act on behalf of others, as a large body of works has shown (reviewed in Hepach, Vaish, & Tomasello, 2013). In this case, the ability to delay gratification plays a role in children overriding their immediate urge to keep everything for themselves not only in situations with potential
future self-benefit but also in children’s attempts to act prosocially. Therefore, our results are congruent with the proposal by Moore and Macgillivray (2004) that, at least in humans with their prosocial inclinations, the ability to delay gratification contributes to prosocial sharing because it requires overriding one’s own current selfish interests.

One main goal of this study was to assess for the first time whether children “look ahead” and modulate their prosocial responses toward a given partner who would (or would not) be able to reciprocate. Reciprocity conceptualized in such way is framed within so-called partner control models (Noë, 2006). Partner control models describe the choices that people make about how to act (e.g., how much to share), as contrasted with partner choice models that describe how people decide with whom to interact. Thus, these models describe different types of situations and might be supported by different psychological abilities. In partner control models, reciprocity emerges from the temporal delay between giving and receiving, and the abilities to delay gratification and mentally connect one’s own current behavior to the potential future behavior of a social partner are particularly relevant. However, such future-oriented abilities are not necessarily required for partner choice. For example, Schino and Aureli (2009) suggested that reciprocal partner choice could be based on an emotionally based system that allows individuals to bookkeep past interactions with different social partners. Thus, it is possible that there are differences in the ontogenetic emergence of selective prosociality in situations of partner choice versus partner control. Recent evidence supports this view. Specifically, around their second birthday, children can discriminate among potential partners in terms of their cooperativeness and choose with whom to interact based on this social evaluation (e.g., Dahl, Schuck, & Campos, 2013; Dunfield & Kuhlmeier, 2013). However, children do not begin to adjust their prosocial responses toward a fixed partner until after their third birthday (Warneken & Tomasello, 2013). These findings suggest that the mechanisms enabling partner choice are in place earlier than the mechanisms necessary for partner control.

The current study has several limitations and raises new questions for future research. Further studies are needed to assess how robustly children’s delay of gratification and sharing behavior are coupled. We presented two closely matched tasks in a fixed order because we were interested in exploring individual differences in the ability of delaying gratification and sharing. Because the tasks were structurally similar and involved the same resources, one concern is that children simply continued to divide up the balls in the reciprocity task as they had previously done in the DoG task. However, as reported, although there were correlations between tasks in that children who saved more balls also shared more balls, there were also significant differences in the number of balls that children saved versus shared. Specifically, children systematically saved more balls than they shared with the puppet, suggesting that they were not simply perseverating and did understand the consequences of their behavior. Nevertheless, future research should address whether the results hold when the DoG and reciprocity tasks are more dissimilar.

One further concern is that although our design measured children’s differentiation between repeated interactions and unidirectional decisions, it did not fully disentangle the effect of past experience and the expectation of future reciprocation. Recall that within each trial, the puppet mirrored children’s sharing in the subsequent step. Therefore, in all subsequent trials, children could have reacted to their partner’s previous sharing. Although a visual inspection of sharing events suggests that 5-year-olds increased their sharing over the first trials, trial number was found to be nonsignificant. Taken together, this indicates that 5-year-olds might have already had a basic notion that sharing would pay off because the partner would be able to share resources subsequently. This interpretation receives indirect support from other studies on tool use and episodic foresight that show how, by 5 years of age but not earlier, children engage in future-oriented behaviors directed either to themselves (Atance & Meltzoff, 2005) or to others (Thompson, Barresi, & Moore, 1997). Thus, it seems at least plausible that the 5-year-olds in our study were able to attend to the potential benefits of sharing. In contrast, 3-year-olds, who lack the abilities of foresight and planning in other domains as well (see McCormack & Atance, 2011, for a review), did not consider that their behavior might lead to reciprocation. Therefore, the developmental co-emergence of these general cognitive skills in other domains between 3 and 5 years of age map nicely onto our found age effect in the domain of reciprocal sharing, suggesting that it may be grounded in a general cognitive ability that emerges in this age range. Further evidence of the notion that children were actually attending to
the opportunity for subsequent reciprocation (rather than just responding to how the partner had treated them in the previous trial) comes from the finding that 3-year-olds did not alter their sharing. Previous work has shown that 3-year-olds share differently depending on how a person had shared with them in the past. If this were all that is required in this task, we would have expected 3-year-olds to differentiate between conditions as well. However, because they did not differentiate, it indicates that children's increase in sharing is at least in part due to children's emerging ability to assess the partner's opportunity for future reciprocation.

Acknowledgments

The research reported here was partly funded by a grant from the Science of Generosity Initiative of the John Templeton Foundation to F.W. and by a grant (PSI2011-29016-C02-01) and a studentship (AP2009-00159) from the Ministerio de Ciencia e Innovación (Spain) to C.S.-E. We thank Kerrie Pieloch, Laura Kim, Alex Licht, Francesca Smith, Isamar Vega, Emily Wong, and Pamela Wong for their collaboration in the collection of data. We also thank Patricia Kanggiesser, as well as two anonymous reviewers, for helpful comments on the manuscript.

References


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