Do 7-year-old children understand social leverage?

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Introduction

When people can unilaterally influence the outcomes of an interaction, they are in a position of power or, in other words, they have leverage over others. Leverage can be achieved in different ways. People can use physical force to punish others so that they conform to their will (Marquart, 1986) and they can also use third-parties as social alternatives to end previously disadvantageous interactions (Barclay, 2013). The access to alternatives such as different social partners, contracts or rewards, just like the possession of unique resources, can be a source of leverage because it creates asymmetries between interacting individuals. For example, an individual in possession of a unique resource could ask for higher prices than other suppliers because her goods or services are better than those of her competitors.

While the example mentioned above applies mainly to human adult interactions in which some basic economic understanding is required, social transactions of this nature also occur during childhood (e.g. children bargaining over collectable items such as trading cards). Recent studies have investigated the strategies that young children use to resolve conflicts of interest at the dyadic (Grueneisen & Tomasello, 2017; Sánchez-Amaro, Duguid, Call, & Tomasello, 2017, 2019) and the group level (Grueneisen & Tomasello, 2019). However, little is known about whether children, who have minimal experience in market transactions, would use alternative options as leverage in social dilemmas.

Several studies have documented the development of children's abilities to coordinate towards mutual goals as well as to resolve conflicts of interest. After their second birthday children are already capable of actively coordinating their actions with peers to reach common goals (Brownell, Ramani, & Zerwas, 2006) and to solve simple problems cooperatively (Ashley & Tomasello, 1998). Later, between three and five years of age, children begin to demonstrate normative aspects of their collaborative activities, feeling committed to joint goals with their peers (Hamann, Warneken, Greenberg, & Tomasello, 2011). At the same age, children are

capable of solving collaborative tasks by considering the different roles that partners must adopt to solve a joint task (Fletcher, Warneken, & Tomasello, 2012) and to plan division of labour in collaborative tasks (Warneken, 2018; Warneken, Steinwender, Hamann, & Tomasello, 2014). From a very young age they also coordinate their decisions to collaborate in efficient ways (Wyman, Rakoczy, & Tomasello, 2013) and by the age of four years old, they are capable of forgoing a less preferred but secure reward to obtain a mutually preferred one (Duguid, Wyman, Bullinger, Herfurth-Majstorovic, & Tomasello, 2014).

When conflicts of interest arise, five-year old children develop strategies to resolve them. A conflict of interest occurs when there is no mutually beneficial solution, that is, children have different preferences for the outcome of an interaction. Several recent studies have focused on how children manage conflicts of interest in situations with the following structure: A pair of children are presented with an unequal reward distribution. The rewards are accessible for a limited amount of time and the high value reward is only accessible to the child that waits for her partner to act first. The conflict of interest arises because their preferences are not aligned: each child prefers the partner to act before them while the rewards are still accessible. Children have demonstrated the ability to establish cooperative strategies to overcome these conflicts of interest by taking turns to divide the rewards equally, even when this means that they receive no rewards on some turns, and communicate appropriately to coordinate their decisions (Grueneisen & Tomasello, 2017; Melis, Grocke, Kalbitz, & Tomasello, 2016; Sánchez-Amaro, Duguid, Call, & Tomasello, 2019). A turn-taking strategy is most efficient when the interaction is predictable, e.g. repeated interactions with the same amounts of resources and it is easy for participants to keep track of previous interactions. When the distribution of rewards is unpredictable five-year-old children abandon cooperative strategies such as turn-taking in favour of competitive strategies to maximize their rewards (e.g. waiting for a partner to act before them when that results in better rewards for the passive individual; Sánchez-Amaro et al., 2017). Finally, around the same age, children are able to maintain depletable resources by

generating their own rules and strategies such as distracting one another to prevent the collapse of a common pool resource (Koomen & Herrmann, 2018).

Common to all of these situations is that children face a social dilemma and they must decide between acting cooperatively or selfishly (Dawes, 1980). On the one hand acting selfishly (e.g. waiting for the partner to act) is more beneficial than cooperating (e.g. acting before the partner). On the other hand, pairs can avoid the worst outcome (being the recipient of a selfish act) if they both cooperate and thus still obtain some rewards. In all these social dilemmas the interaction is always symmetrical. That is, despite children's goals not being aligned, both partners have the same options available to them and are thus likely to share the same strategies. However, little is known about the strategies that children would use to overcome conflicts of interest when their interaction is asymmetrical. For example, when only one child can access a secure alternative and thus can avoid participating in the social dilemma. That is, when one child is in a position of leverage.

Understanding how leverage (in the form of alternative options) can affect the decisions we make in social dilemmas has been experimentally studied in adult humans. In a study by Binmore, Shared, & Sutton (1989) adult participants were asked to divide $7 between themselves and an anonymous recipient. The recipient could accept the offer or reject it for both the participants. Participants also knew that the recipient had the option to exit the negotiation and obtain a $4 alternative on his own. Under these conditions, participants offered recipients more than half the total amount (i.e. $4.50 instead of $3.50 each). This way participants ensured that recipients would accept their offer, avoiding a complete loss of the rewards. Evidence that adults understand others' positions of influence and adjust their decisions accordingly also comes from coordination games such as the Battle of Sexes (Cooper, DeJong, Forsythe, & Ross, 1994; Cooper, DeJong, Forsythe, & Ross, 1990). In an example of this two-player coordination game, two players (Player A and Player B) had the option to choose 600

77 lottery tickets for themselves and 200 for the other or vice versa. However, if both players chose
78 the 600 tickets for themselves, they would get no tickets. In addition, only Player A had the
79 opportunity to opt out and obtain a secure reward of 300 tickets for each player. The
80 experimenters found that players in position A chose the option that would provide them with
81 the highest reward (600 tickets for themselves and 200 for the partner) on a majority of trials.
82 In turn, players in position B anticipated this decision and chose 200 tickets for themselves. In
83 other words, Player A influenced Player B's decision through the use of leverage. In these
84 studies, adult participants played against anonymous partners and could not communicate.

85 Previous methods involving monetary rewards are hard to implement with young children.
86 Instead, when testing children's strategies in social dilemmas it is preferable to present them
87 with engaging scenarios in which they can interact and communicate as they would do in real
88 life situations. Our study explores whether children can use a position of leverage when their
89 personal preferences are not aligned. We build on a previous experiment (Sánchez-Amaro et al.,
90 2017) in which five-year-old children were presented with a dyadic anti-coordination game, the
91 Snowdrift (Sugden, 2004). In this game, each child would prefer their partner to be the one to
92 cooperate (by pulling a rope) because cooperation provides more rewards for the child who
93 waits (does not pull the rope). However, if both children wait for each other (i.e. mutual
94 defection), they lose the opportunity to obtain any rewards. To implement this social dilemma,
95 we presented children with an unequal reward distribution on two ends of a rotating tray. The
96 rewards were placed at both ends but only the one end could be accessed directly by pulling a
97 rope (henceforth the rope end), with the other end (the free end) moving towards the partner.
98 In the critical condition, the preferred reward was placed on the free end of the tray so that the
99 child could only obtain it by waiting for the partner to pull her rope. However, if both children
100 waited too long for their partner to act, all rewards were lost. We found that children behaved
101 strategically by pulling later when the preferred reward was not directly accessible to them. This
102 task deviates from more traditional implementations of social dilemmas in that children were

able to communicate, their decisions were inter-dependent (the actions of one child already determined what both children could obtain), they had limited time to act, and they were also familiar with each other (in the same class).

In the current study, we presented pairs of seven-year-old children with the same basic task: both individuals could either obtain one marble baited on the rope-end of the tray as reward when they pulled from their rope, or three marbles on the free end if they waited for their partner to pull. This created a conflict of interest, as both individuals would prefer their partner to pull before them. The difference with the previous study (Sánchez-Amaro et al., 2017) was that we added the possibility of using leverage. In this task one of the children could access an alternative, secure and exclusive reward (zero, two or four rewards, depending on the condition) in addition to the unequal reward distribution on the rotating tray accessible to both children. Henceforth, we call the child in possession of the alternative the *subject* and the child without an alternative the *partner*. The addition of potential leverage in the form of alternatives further differentiates our task from typical social dilemmas by creating asymmetries in the potential strategies for partners.

Subjects faced three conditions determined by the amount of rewards baited on the alternative. When there was no secure alternative (zero rewards; see Figure 1, scenario 1), both children had symmetrical options—they could only access the rotating tray- and thus there was no leverage. This re-created the snowdrift game presented to children in the previous study (Sánchez-Amaro et al., 2017). When the alternative consisted of two rewards (Figure 1, scenario 2), subjects could use it as leverage, operationalized as the possibility to access the alternative option instead of the rotating tray. This alternative is a greater reward than that for cooperation in the social dilemma, but less than they receive if the partner cooperated. Finally, when the alternative consisted of four secure rewards (Figure 1, scenario 3), subjects should always prefer the four rewards instead of accessing the rotating tray which either offered one or three

rewards. An important aspect of the game is that choices between the rotating tray and the alternative are irreversible. Subjects only maintain their leverage while they have both options available, i.e. until they have made a decision. Thus, subjects should wait for their partners to pull for one reward before acting, otherwise they would lose the advantage conferred by their leverage. At the same time, partners should be more likely to pull for one reward before all rewards were removed given that subjects could easily access two rewards.

The introduction of the leverage in the form of an alternative option adds complexity to our previous task. In this scenario, children need to understand that their strategies might differ depending on the leverage level presented to the subject. In addition, depending on the situation children might need to inhibit their access to the secure alternative. In the previous study with the same rotating tray, we tested five-year olds (Sánchez-Amaro et al., 2017) but given the potential increase in complexity and task demands we decided to test a sample of older children (seven-year-olds) first.

In line with previous studies, we expected children to demonstrate strategies that successfully avoid mutual defection in the social dilemma, i.e. children waiting for each other until the experimenter removed the rewards (Sánchez-Amaro et al., 2017, 2019). We also expected children to be able to track the relative rewards available in each condition. Thus, we expect that the higher the value of the alternative the more likely they would be to forego the access to the rotating tray in favour of the alternative option. Importantly, we expected the seven-year-old children to understand the potential function of their leverage position. This is demonstrated by two measures (see also Figure 1 for a summary of the main predictions). Firstly, when the alternative consisted of two secure rewards, we expected subjects to wait for their partner to pull first. Secondly, we expected decrease in time waiting (both when acting as subject and as partner) with an increase in the value of the alternative option. For example, when the alternative consisted of four rewards (more than the reward available in the rotating tray) we

expected children to access it directly and not wait for the other child. With regard to how children use communication, we expected children in both positions (as subject and as partner) to communicate in a similar manner when no child had leverage over the other. In contrast, when subjects had leverage over partners, we expected the latter to communicate more often: since subjects who hold the privileged position, partners need to persuade them to negotiate a better deal. Finally, we evaluated whether children would behave differently between sessions (the moment they changed their *subject-partner* roles). See Figure 1 for summary of the main hypotheses.

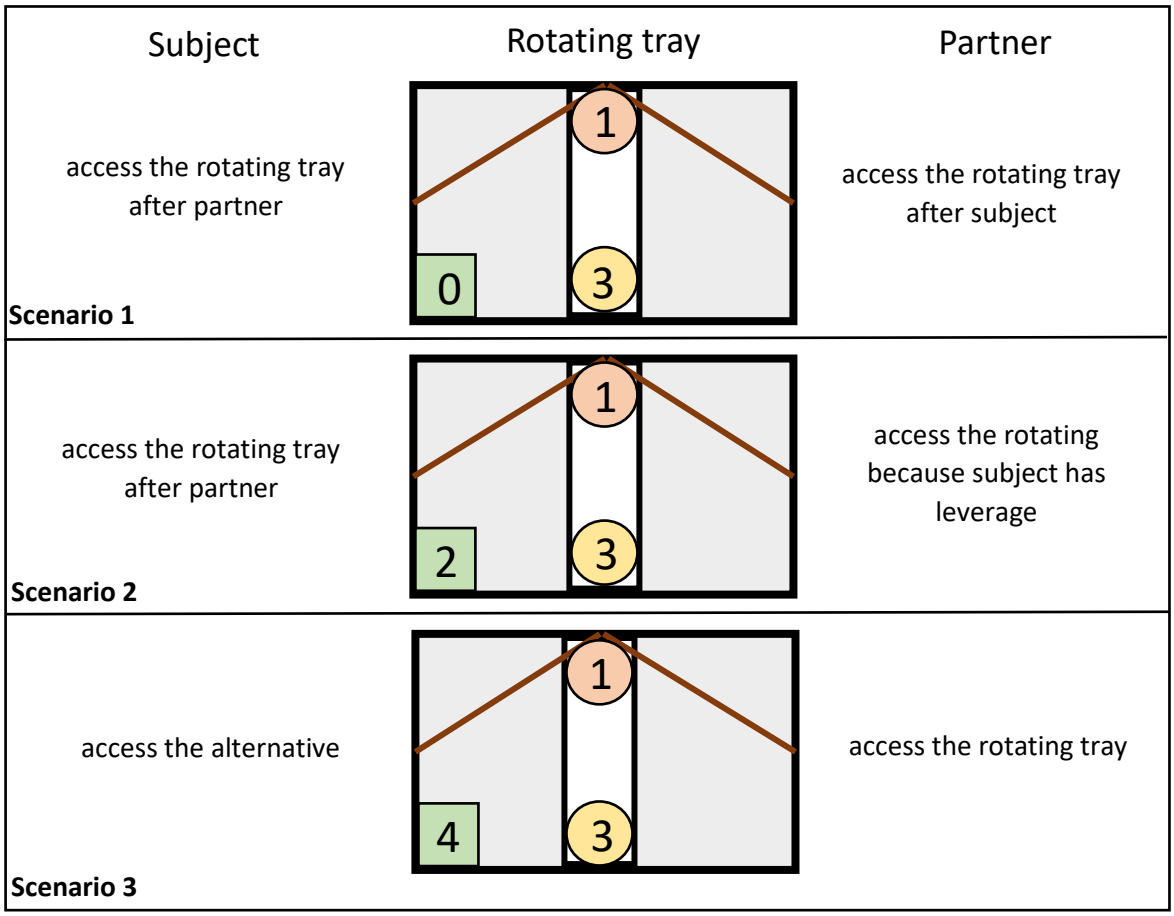


Figure 1: Representation of main hypothesis for subjects' and partners choices across the three different leverage levels (scenarios 1-3). If the rope is pulled by the subject the tray spins anti-clockwise and one reward becomes accessible to the subject, three to the partner and vice versa if the partner pulls the rope and the tray spins clockwise.

Material and methods

Subjects

We tested 20 pairs of 7 years and 0 months old to 7 years and 11 months old children (10 pairs of boys and 10 pairs of girls; M_{age}= 7y-5M-20D, SD= 4M) in German schools within the Leipzig city area. All participants were recruited from a database of children whose parents had provided written consent to take part in child development and comparative studies. Pairs were made up of children from the same school.

Apparatus

Pairs of children were presented with a rotating wooden tray positioned on top of a wooden platform, encased in a transparent plastic case (see Figure 2). In two of the corners of the case, on opposite sides, were transparent compartments approximately 3 cm x 3 cm (henceforth referred to as alternative platforms). Children faced each other across the box and had access to the rotating tray and one of the alternative platforms. A transparent lid covered the surface of the box from the top to prevent children from accessing the rewards. On each side of the apparatus, transparent plastic doors blocked the openings to the rotating tray and to the alternative platform. Children could slide the door to the right to access the ropes connected to the roped (low value) end of the rotating tray. To access the free (high value) end of the rotating tray children had to wait for their partner to pull (Figure 2b). The alternative platform could be accessed directly by sliding the door to the left (Figure 2d). When a child slid the door to either side, a locking mechanism prevented the door from returning to its original position—this way children could only access one of the two options on a given trial.

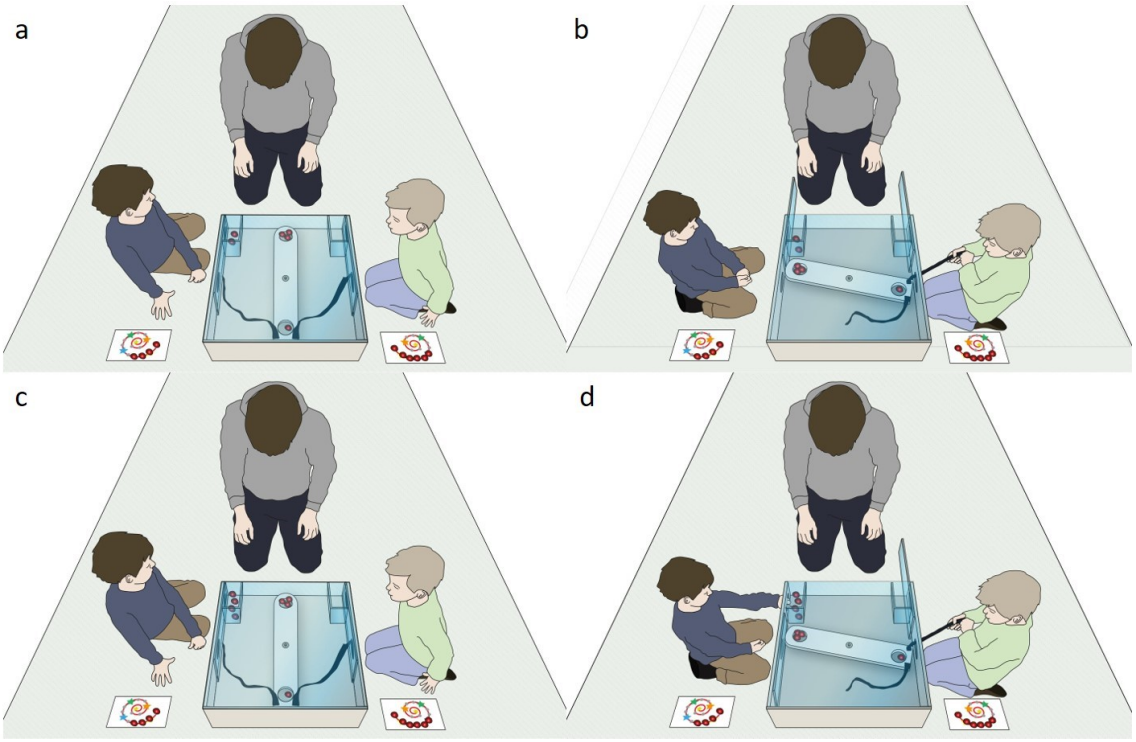


Figure 2: Representation of the apparatus. The *subject* is on the left side and has access to two rewards on the alternative (figures *a* and *b*) or four rewards on the alternative (figures *c* and d). In figure *b* the subject access the unequal distribution while in figure *d* the subject access the alternative.

Design and procedure

Before the test sessions, each child participated in three training phases.

Training phase 1

In the first training phase, pairs of children learned how to access the rewards from the rotating tray. After a period of warm-up in which an experimenter (henceforth E1) interacted with the children, E1 introduced children to the apparatus and to the second experimenter (henceforth E2). Children were told that E2 did not speak German; this way we minimized interactions between children and E2. This method has been successfully used on previous studies employing a similar methodology (Sánchez-Amaro et al., 2017; Sánchez-Amaro, Duguid, Call, & Tomasello, 2018a). Children were asked to sit at opposite sides of the apparatus to play a game—children

would change their sides after every training phase and test session. E1 told the children that the aim of the game was to obtain the maximum number of marbles from the wooden box and that E2 would control some parts of the apparatus (i.e. the blocking pegs and the positioning of the ropes). While E1 was referring to the rewards that children could get, E2 showed children a handful of small black wooden marbles. E1 told children that they could place their collected marbles inside the boxes beside them—these boxes were already prepared before the children came in. After that, E1 showed each child how to access the rotating tray by sliding the door to their right. Next, E2 baited the rotating tray with three marbles on the free end and one marble on the roped end of the tray. Each child performed one trial in which only the acting child had access to the roped end of the tray (i.e. the child pulling the rope obtained the rewards from that end while the other child obtained the rewards from the free end). After these two trials, children performed another two trials in which both of them had simultaneous access to their ropes and could decide which of them would pull. In all four trials the experimenters waited for children to make their decisions. If children hesitated to act, E1 encouraged them to pull from their ropes and collect the marbles. Once they finished the fourth trial, E1 informed children that they had obtained lots of marbles and that, in order to continue playing, one child should leave the room and wait for his or her turn.

Training phase 2

In the second training phase each child learned individually how to obtain rewards from the alternative platform and how to choose between the two options (alternative platform or rotating tray) to maximize the number of rewards. At the beginning of the second training phase E1 showed the child how to access their alternative platform by sliding the door to their left). E1 repeated to every child that they should try to obtain as many marbles as possible. In this training phase children were also allowed to retrieve the marbles from their partner's side, who was waiting outside the room. A child faced two types of trials differing in the number of rewards

baited on the rotating tray and the alternative options. In one type of trial, the child found one marble on each end of the rotating tray and four marbles on the child's alternative platform. To succeed, the child had to access the alternative platform. In the second type of trial, the child was presented with two marbles on each end of the rotating tray and two marbles on the child's alternative platform. In these trials, the child had to access both ends of the rotating tray.

Each child was presented with a minimum of four trials separated in two blocks. In the first block, a child experienced each type of trial once. If they failed to maximize the rewards on these two trials, they were allowed to try again until they obtained the best outcomes. Eleven children needed to repeat the first trial and one child needed to repeat the second trial (the maximum number of extra trials for a child were two). This allowed children to learn the contingencies of each type of trial. In the second block, each child experienced every type of trial once regardless of the result. Seven children fail one trial in the second block (5 children repeated the first trial and 2 children repeated the second trial).

Training Phase 3

In the third training phase the children played together again and experienced a no-conflict situation where they could either access one reward from each side of the rotating tray or from the alternative platform. E1 told children that they were ready to play together once again because they had had already learned the functions of the apparatus. This phase had four trials: two trials with one marble baited on each end of the rotating tray and two trials with one marble baited on each alternative platform. The presentation order of the trials was randomized. During this training phase, children did not receive help while making their decisions, but they were told the reason why they failed when that occurred. In three pairs, one child failed one trial.

Test sessions

After the third training phase, E1 told children that they were going to play the real game for better rewards. Concurrently, E2 showed children a handful of coloured glass marbles, the new type of rewards they were going to collect.

Afterwards, E1 invited children to follow her to another side of the room. E1 presented each child with a laminated paper sheet. Each paper sheet contained a spiral made up of 40 connected dots. Every five dots there was star-shaped. The size of the stars increased towards the centre of the spiral. E1 told children that they should collect as many marbles as possible and place each marble on a spiral dot—starting from the outer dots and filling them towards the centre. For each star they filled, they would obtain a surprise at the end of the game. The spirals were created in a way that it was impossible for any child to reach the last star (i.e. there were more dots than glass marbles). While children were informed how to use the laminated sheet, E2 removed the boxes containing the wooden marbles that children had obtained during their training. After children got their laminated sheets, they returned to their positions in front of the box. At that moment, E1 told them that she had to leave the room. Once they were alone with E2, the first session began.

Each pair of children participated in two test sessions. For the first session, children were randomly assigned the role of *subject* or *partner*. They changed roles between sessions—half of children played as subject in session one and the other half as subject in session two. Pairs of children performed six trials per session for a total of twelve trials. At the end of the first session E1 came in and told children to change their sides before they continued with the game. Afterwards, E1 left the room again and children completed their second test session.

Both children had access to the rewards baited on both ends of the rotating tray. However, only subjects could get rewards baited on their alternative platform. During test trials, the roped end of the rotating tray contained one glass marble while the free end contained three. The subjects' alternative platform could contain zero, two or four marbles (henceforth leverage levels zero,

two and four). Each leverage level was presented twice within a session and the trial presentation order was randomized within sessions. Thus, children experienced the same amount of trials per leverage condition (two trials) on each session (except for one pair in which the leverage level two was presented three times and the leverage level four was presented only once due to an error). For half of the pairs the subjects' alternative was always located on the right platform, and for the other half it was located on the left platform.

The test trial started when the experimenter simultaneously removed both pegs blocking the sliding doors. A trial lasted from the moment the experimenter removed the pegs until both children accessed the apparatus and obtained the rewards, or 15 seconds if one or both children did not act. After that time, the experimenter removed all the remaining rewards and ended the trial. Following previous methods (Sánchez-Amaro et al., 2017, 2019), we did not inform children about the time they had to access the rewards.

Coding

We investigated whether children used strategies to maximise their rewards; specifically, whether they used their position of leverage strategically (i.e. whether subjects obtain the three rewards more often than partners and whether subjects wait for partners to act; see Table 1). We were also interested in whether the conflict of interest would lead to a complete breakdown of coordination and some children would receive no rewards. To do this we focused on their actions and verbal communication during test trials.

We coded three aspects of the participants' actions: rewards distribution, choices made and their timing (latencies). We calculated the percentage of trials in which both children obtained rewards, only one child obtained rewards and when both children failed to obtain anything. We also recorded their choices. Within a trial, children had four different options: 1) access the rotating tray and pull, 2) access the rotating tray and wait, 3) access the alternative platform or 4) take no action. In addition to their choices, we took two latency measures: 1) from the time

E2 removed the blocking pegs (trial starts) until children either opened their access to the rotating tray or to their alternative platform and 2) from the time they access the rotating tray until they pulled their rope. We scored the same latency measure for subjects and partners using specialized video-coding software (Mangold Interact GmbH).

To code the verbal communication, we adapted a previous coding scheme used to study children's communication in a similar conflict of interest (see Sánchez-Amaro et al., 2019). As a first step we transcribed all verbal communication and pointing gestures that occurred from the moment E2 showed the rewards to the children (just before the rewards were baited on the box) until E2 showed the rewards to the children in a subsequent trial, or after E2 stood up to indicate the end of the session. We divided trials in two-time phases: from when E2 showed the rewards until the last child emptied the box (trial phase) and from the moment both children emptied the box until the next trial started (inter-trial-interval). As a second step communicative acts were assigned to categories that could indicate how children were solving the conflict of interest:

i) *Informative communication*: acts aimed at informing child's current or impending actions or intentions (e.g. "I am going to pull").

ii) *Imperative communication*: use of deontic verbs to guide others decisions (e.g. "you must pull").

iii) *Protests*: statements of disapproval or objection about another child's actions or intentions (e.g. "no, I also wanted").

iv) From the subjects' perspective we coded if children referred to their own leverage as part of their arguments (henceforth *reference to leverage*: e.g. "I am going to wait because I have this [indicating the leverage]" or "now I will access here [the leverage]"). From the partners' perspective we also coded their references to the

subjects' leverage (e.g. "you should pull here [as opposed to accessing the leverage] this time").

v) We coded whether children used arguments to refer to future or past actions (henceforth *turn-taking communication*: e.g. "next time you pull" or "next time it is my turn because..."). These types of arguments are expected if children engage in turn-taking strategies for cooperation.

vi) All other communicative acts were assigned to the category *other* (e.g. onomatopoeic sounds, unclear utterances).

For each child (either as subject or as partner) and each trial phase we coded whether they communicated or not in any of the ways described above. Thus, multiple categories could occur for each child within a trial phase. In total, each communicative act could appear four times within a trial.

In addition to verbal communication, we recorded points to three different locations: 1) the rotating tray, 2) the alternative platform (i.e. the leverage) and 3) other task-related points (i.e. pointing at the reward sheet, at the experimenter or at the other child).

Statistical analysis

All the analyses were run using R statistics (version 3.1.1). Generalized linear mixed models were used to investigate children choices (to either access the alternative platform or the rotating tray; Model 1) and communicative acts (whether leverage level, included as a 3-level factor, and trial phase influenced subjects' and partners' communicative acts (Model 4) (Baayen, Davidson, & Bates, 2008). To implement these models we used the "lme4" package (Bates, 2010). To obtain the P values for the individual fixed effects we conducted likelihood-ratio tests. We assessed the stability of these models by comparing the estimates derived from models based on all data with those obtained from models with the levels of the random effects excluded one at a time. The models were stable.

Mixed-effects Cox proportional hazard models (Models 2 and 3) were used to analyse subjects and partners latencies to act. For this purpose we used the "coxme" function from the "coxme" package (Therneau, 2012). This approach allows to analyse the variability attributable to the independent variables while controlling for right-censored data (i.e. when children did not act after the 15 seconds limit established by the experimenter). The results of the coxme models are reported as hazard ratios (HR). An HR greater than one indicates an increased hazard of acting (either opening the door in model 2, or pulling the rope in model 3) while an HR smaller than 1 indicated a decreased hazard of acting. In addition, we conducted likelihood-ratio tests to obtain the P values for the individual fixed effects.

To rule out collinearity we checked the variance inflation factors (VIF) for the GLMM and the coxme models. All VIF values were closer to 1.

Reliability

Choices and latencies

The inter-observer reliability based on 20% of the data was excellent. Cohen Kappa's were calculated to assess the reliability of children's choices from the left and the right side of the apparatus. Pearson R^2 were calculated to assess the reliability of latencies to open the doors and pull the ropes from both side of the apparatus. When children sat on the right side: latency to open the door (Cohen Kappa = 1, Pearson R^2 = 0.99) and latency to pull from the rope (Cohen Kappa = 1, Pearson R^2 = 0.99). When children sat on the left side: latency to open the door (Cohen Kappa = 0.96 (2% of data mismatch between observers), Pearson R^2 = 0.97) and latency to pull from the rope (Cohen Kappa = 0.96 (2% of data mismatch between observers), Pearson R^2 = 0.99).

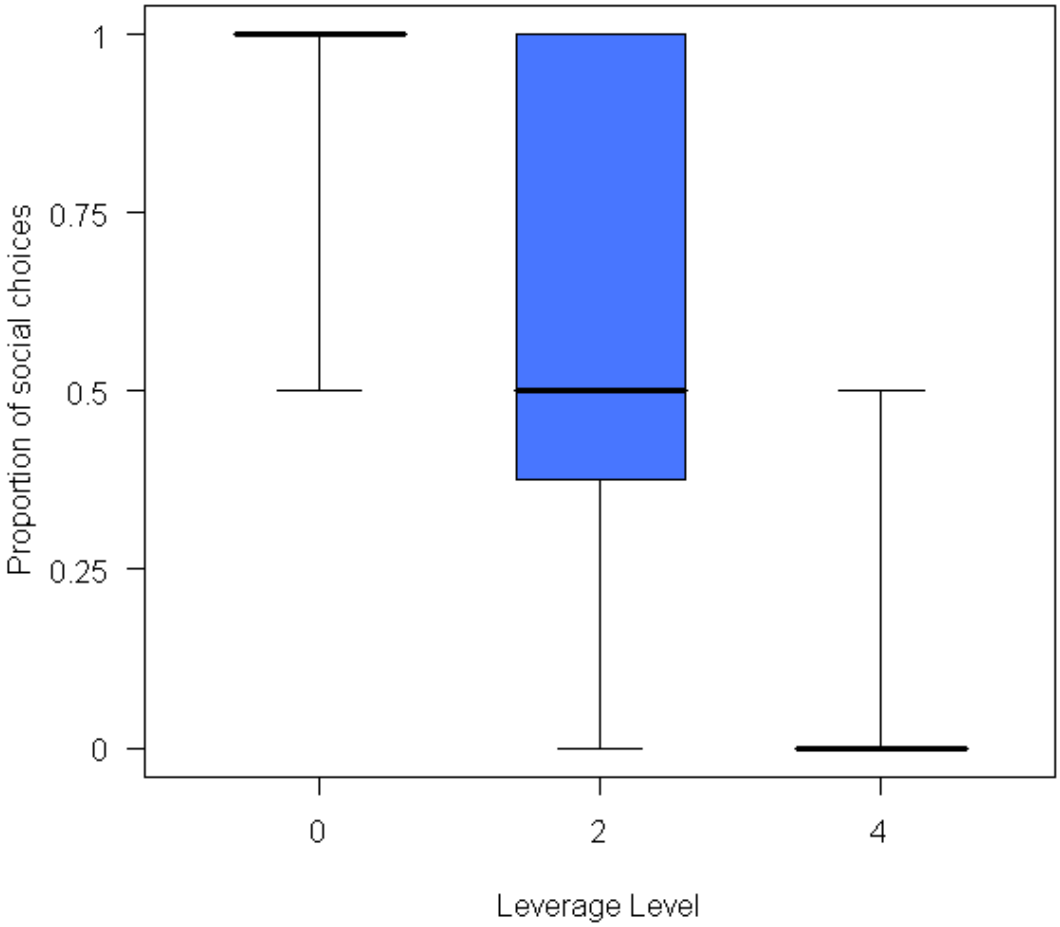
Communication

Based on 20% of the data, the inter-observer reliability was excellent. Cohen Kappa's were calculated to assess the reliability of communication coding and whether observers interpreted those communicative acts as informative acts of communication or not: occurrence of communication (Cohen Kappa = 1) and occurrence of informative acts (Cohen Kappa = 0.75). We only looked at informative acts of communication because we could analyse their impact separately. Informative acts of communication accounted for 57% of communication (each act appearing a maximum of four times per trial).

Results

Both children obtained rewards in a majority of trials (87.1%, 209 of the 240 trials), only one child obtained rewards in 5.8% of trials (14 of the 240 trials) and no children obtained rewards in 7.1% of trials (17 of the 240 trials). We found that subjects tried to maximize their rewards. This is reflected in their increasing likelihood to choose the alternative option with increasing reward value (GLMM: χ^2 = 74.35, df = 3, p<0.001, N = 240; Figure 3). When subjects had no alternative option, they accessed the rotating tray in most trials (90%, 72 of the 80 trials; only 6 children ever accessed the alternative). In contrast, when their alternative option consisted of four rewards—and thus the best outcome available—they accessed the rotating tray in only 5% of trials (4 of the 79 trials, 39 children accessed the alternative at least once). Interestingly, subjects chose to access the rotating tray in 42% of trials (34 of the 81 trials) when their leverage consisted of two marbles (28 children accessed the alternative at least once), significantly more often than when their leverage consisted of four marbles (GLMM: χ^2 = 68.42, df = 2, p<0.001, N = 240; see Table 1). In other words, in a substantial amount of trials children were willing to refuse two secure rewards to access the ropes connected to the rotating tray. In addition, we found that children who participated as subjects in the second session (after being partners) were less willing to access the rotating tray (in 40% of trials, 48 of the 120 trials) rather than the

406 alternative platform compared to children who participated as subjects in the first session (in
407 51.6% of trials, 62 of the 120 trials) (GLMM: $\chi^2 = 6.43$, df = 1, $p = 0.01$, N = 240).



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409 Figure 3: Proportion of social choices as a function of the level of leverage. The box-plots
410 represent the median (thick line) and interquartile range of the proportion of times that each
411 subject accessed the social choice (i.e. the unequal reward distribution). The dotted line
412 represents the model fitted values.

413 To use the leverage effectively, children in the role of subjects should access the rotating tray
414 after partners had already pulled from their ropes. Once both individuals only had access to their
415 ropes, they were in an equal position to obtain the best reward. Of the trials in which subjects

chose the social option rather than two secure rewards (42% of trials, 34 of the 81 trials), they made the most of their leverage, by waiting for the partner to pull before they access the social option, in 38% of those trials (13 of the 34 trials). In other words, subjects used their leverage strategically in 16% of the total trials (13 of the 81 trials). Subjects were able to maximize their rewards (i.e. obtain the three rewards from the free end of the rotating tray; see Table 1).

Table 1: Number and percentage of trials in which subjects access the alternative, subjects pull first and partners pull first. Also shown is the percentage of trials in which partners pulled before the subjects acted and the percentage of trials in which both refused to pull after or before accessing the rotating tray. Notice that the percentage of trials in which the partner pulls before the subject acts is only relevant when the leverage level is 2, and is a subset of trials in which the partner pulls first.

	Subject		**Partner**		**Subject and partner**	
	no pull	**pull**	**pull**		**no pull**	**no act/no pull**
Leverage level	**access alternative**	**First**	**First**	**before subject acts***	**after accessing the rotating tray**	**before accessing the rotating tray**
Leverage 0	6/ 80 trials (7.5%)	41/80 trials (51.25%)	24/80 trials (30%)	NA	7/80 trials (8.75%)	2/80 trials (2.5%)
Leverage 2	44/81 trials (54.3%)	11/81 trials (13.6%)	21/81 trials (25.9%)	13/81 trials (16%)	2/81 trials (2.5%)	3/81 trials (3.7%)
Leverage 4	74/79 trials (93.7%)	2/79 trials (2.5%)	2/79 trials (2.5%)	NA		1/79 trials (1.3%)

When we inspected the latencies to act (for the subject this was open the sliding door and choosing one option; for the partner this was pulling the rope connected to the rotating tray),

we found that both subject (coxme, χ^2 = 26.59, df = 2, p <0.001, N = 240; Figure S1) and partner (coxme, χ^2 = 8.84, df = 2, p =0.012, N = 240; Figure S2) latencies were affected by the subjects' leverage. Pairwise comparisons indicated that subjects waited to act a similar amount of time when they had no leverage and when their leverage consisted of two glass marbles (coxme,HR = 1.16, p =0.41, N = 240). That is, when they could not access the best rewards on their own, children in the role of subjects waited longer for their partners to act. In contrast, when subjects could access four glass marbles on the alternative platform, they acted significantly faster compared to when they had two (coxme,HR = 2.15, p <0.001, N = 240) or no alternative rewards (coxme, HR = 2.49, p <0.001, N = 240). Children in the role of partner also waited to act a similar amount of time when both children had no leverage and when the subject could access two alternative rewards (coxme,HR = 0.94, p =0.84, N = 240). Children in the role of partner also acted significantly faster when the subject could access four instead of two glass marbles from her alternative platform (coxme,HR = 0.32, p = 0.0161, N = 240). This is especially interesting from the partners' perspective as it suggests that children did not need to have the leverage themselves to understand its role during the interaction. In other words, children in the role of partner inferred what subjects would choose based on the subjects' leverage position before subjects had made a decision. We found no significant differences in latencies (either as *subject* or as *partner*) between sessions, so changes in partner role did not seem to have an effect (see ESM).

Children did not communicate more often during the dilemma phase than during the inter-trial-interval phases regardless of their role and or the leverage presented on the subject's alternative platform (GLMM: χ^2 = 6.43, df = 6, p = 0.37, N = 240; see Table S1). Additionally, we found no statistical differences in children informative acts of communication between trial phases, role and or condition presented (GLMM: χ^2 = 4.84, df = 6, p = 0.56, N = 240). Other categories of communication such as imperatives, protest, references to leverage and turn-taking occurred very rarely and thus we could not test whether they were influenced by trial phase, children

roles and leverage levels. Partners generally protested more than subjects (see Table S4). This might be explained by the fact that subjects obtained more rewards than partners in a majority of trials.

We found that children pointed in a minority of trials (17%; N = 40). In total, children performed 47 pointing gestures. Children in the subject role pointed slightly more often than children in the partner role (subjects producing 61% of points). Points towards the leverage accounted for 33% of trials while pointing gestures towards the rotating tray accounted for 24% of trials. However, a majority of pointing gestures (42%) were categorized as general pointing acts. Interestingly, 73% of communicative acts (16 of 22) containing references to the alternative option—the source of leverage—occurred in conjunction with pointing acts towards the rotating tray or/and the leverage.

Discussion

When presented with an asymmetrical social dilemma, we found some evidence that seven-year-old children used access to alternative rewards as leverage to maximize their own benefits. We expected that children would use their leverage strategically by waiting for their partners to act before them. We found that in over 15% of trials children initially in the position of leverage maintained it by waiting to make their decisions until their partners had already decided to pull for the lower reward. We also expected children to wait less with increasing amounts in the alternative. We found that children in the role of subject did wait less when the alternative contained four rewards but they did not differentiate between two or zero rewards on the alternative, presumably because in both cases they could maximise their own rewards by waiting for the partner, regardless of leverage. Similarly, children in the role of partner also waited less when the subjects had an alternative of four rewards as compared to zero or two rewards, but did not differentiate between two or zero rewards. It is conceivable that when subjects had zero or two rewards on the alternative, partners still had a chance to maximize

their own rewards by waiting. This is especially interesting from the partners' perspective because it suggests that children could anticipate the effect of alternative options on the actions of others.

In addition, we found that children playing the subject role accessed the alternative more often (regardless of the leverage level presented) in the second session (i.e. when they already had experience as a partner). However, the children's decisions were not entirely consistent with a thorough understanding of their leverage position. They still often accessed either their alternative option or the rotating tray before their partner had made a decision. In addition, we found that children rarely referred to the leverage. Perhaps this is due to the asymmetric nature of the interaction. They may have found little room for negotiation when their potential options were unequal. However, in those cases in which children verbally referred to the alternative option, they accompanied their utterances with pointing gestures towards the apparatus, most likely as a way to emphasize the source of leverage to their partner. In addition, we did observe that children in the role of partner (the disadvantaged position) generally protested more than their counterparts. In what follows, we discuss a number of possible reasons that could explain these results.

A simple account of our results could be that the task was too cognitively demanding for children to be able to use their leverage efficiently. They did not understand that, depending on the available alternatives, they could obtain more rewards by waiting for their partners to act. We find this explanation implausible as children passed several training phases before they entered the test phase, demonstrating that they understood the required actions to maximize rewards. In addition, the latencies to access the rewards as well as the pattern of decisions suggest that they partially understood the conflict of interest presented in the game. Moreover, previous studies using the same rotating tray suggested that five-year-old children understood a simpler version of the social dilemma (Sánchez-Amaro et al., 2017).

Given that they did understand the reward structure of the game, it is possible that children did not understand the social dilemma, but saw it as a non-social economic game. In this case we would expect children to choose the highest value reward they could access. Children in the subject role were equally likely to choose two rewards from the alternative option or the rotating tray (which would provide one reward if they pulled alone). From an economic perspective, this result makes sense as both options would lead to an average of two rewards over repeated trials. However, the timing of the children's actions, in this study as well as previous studies presenting children with similar social dilemmas (Sánchez-Amaro et al., 2017, 2019), are inconsistent with a non-social interpretation of their decision making. In addition, children were more likely to exploit the alternative option after having played as partner first, perhaps in an attempt to restore inequity between participants since partners usually got less rewards. Although, it is also possible that children playing as subjects in the second session already had more experienced and thus tried to maximize their rewards more often by accessing the alternative. Therefore, we suggest that children took into account the presence of the other child and her potential decisions, thus, interpreting the game as a social dilemma in which personal decisions directly affected each other's outcomes.

Nonetheless, children are clearly not using the position of leverage consistently or to its full potential. We suggest two potential drivers of their decisions. The first is that seven-year-olds may be willing to take the risk (i.e. choose the rotating tray instead of the two secure rewards) to get the higher reward, regardless of their strategic advantage with the leverage. Previous studies suggest that young children tend to be more risk-prone than adults in a number of different scenarios (Boyer, 2006; Harbaugh, Krause, & Vesterlund, 2002; Paulsen, Platt, Huettel, & Brannon, 2011). This is in line with our finding from the current study that children accessed the rotating tray, the risky option, in almost half of the trials when they had two as an alternative option (i.e. they had leverage). However, these studies usually present children with non-social gambling situations whereas, in our study the risk was a social one (e.g. the partner could also

decide to wait for them to pull). Adults are found to be more risk averse in social than non-social contexts (Bohnet & Zeckhauser, 2004) so we would need further studies to test this hypothesis with children.

A second explanation for the failure to use leverage is that children were trying to establish cooperative solutions to the unequal reward distribution and thereby restore equity between players (Warneken, 2018). From early on in ontogeny, children are willing to distribute the benefits generated through collaboration (Ulber, Hamann, & Tomasello, 2015; Warneken, Lohse, Melis, & Tomasello, 2011). One common way to distribute rewards over time is to engage in turn-taking, a strategy that children and adult humans use in a variety of social dilemmas to stabilize cooperation (Grueneisen & Tomasello, 2017; Helbing, Schönhof, Stark, & Hołyst, 2005; Melis et al., 2016; Sánchez-Amaro et al., 2019). In our task children did occasionally encourage their partners to engage in turn-taking strategies. However, a turn-taking strategy in this scenario would have been challenging due to the asymmetrical and variable options children faced across trials (see also Sánchez-Amaro et al., 2017). Instead, children may have found alternative strategies to reduce inequity between subject and partner payoffs. For example, when subjects had no leverage (their alternative option was empty) they pulled so their partner received the higher reward in the majority of trials (67%). This is also the condition in which we see the most protest from partners and could be one way of compensating for conditions when the subject usually gains more rewards. Consistent with the notion of restoring equity, we found that children acting as subjects second (in session two) were more likely to exploit the leverage, perhaps as a strategy to obtain more resources than they had obtained as partners. Studies suggest that an aversion towards disadvantageous inequality starts to develop early in ontogeny (LoBue, Nishida, Chiong, DeLoache, & Haidt, 2011; McAuliffe, Blake, Kim, Wrangham, & Warneken, 2013) followed by an aversion towards advantageous inequity around age 7-8 (Blake et al., 2015; Blake & McAuliffe, 2011). Furthermore, it is possible that some children let others obtain the best rewards to prevent reputational damage since both children were from the same

558 school (Engelmann, Over, Herrmann, & Tomasello, 2013; Fujii, Takagishi, Koizumi, & Okada,
559 2015). Future studies could then assess whether the degree of familiarity plays a major role in
560 children decision-making strategies in social dilemmas.

561 **Conclusions**

562 These results advance our understanding of how children overcome conflicts of interest with
563 peers by introducing a leverage component in a social dilemma. In that sense, this study deviates
564 from previous work showing how younger children coordinate actions when the potential
565 outcomes are symmetric and thus easier to predict (Grueneisen & Tomasello, 2017; Melis et al.,
566 2016). However, the current study was a demanding task for seven-year-old as illustrated by
567 their resulting actions. For the future, the introduction of leverage in different ways may help us
568 to understand children decision-making in these types of social conflicts from an earlier age. For
569 example, qualitative instead of quantitative differences between rewards may reduce the
570 computational load due to the number of items presented on a given trial. Furthermore, as
571 mentioned earlier, leverage can be instantiated in diverse ways including access to alternative
572 partners (e.g. a child that can access one game others cannot). In this regard, it would be
573 interesting to explore how children would make use of social leverage when alternatives are
574 social partners with distinct qualities and characteristics.

575 The current task also required children to wait for their partner to act before them to maximize
576 their chances of obtaining the best rewards. Thus, children with greater delayed gratification
577 skills would have had an advantage. Previous work has assessed the relationship between
578 executive inhibitory control and cooperative behaviour (Ciairano, Visu-Petra, & Settanni, 2007;
579 Giannotta, Burk, & Ciairano, 2011). Children with higher degree of inhibitory control were better
580 co-operators in a puzzle task. Future studies could investigate the relationships between
581 inhibitory control and decision-making in the context of social dilemmas. Finally, the resolution
582 of social conflicts through the use of coordination games is tightly linked with the use of Theory

of Mind abilities to predict and anticipate others' actions (Hedden & Zhang, 2002). We did not assess the role of Theory of Mind abilities in our task, children could observe and respond to the actions of their partner and were also free to communicate about future actions. Evidence from studies preventing children from communicating with each other has shown that after their sixth birthday, they are able to form first and second-order false-belief reasoning to coordinate actions when their interests are aligned (Grueneisen, Wyman, & Tomasello, 2015; Raijmakers, Mandell, van Es, & Counihan, 2014). Applying similar methods to coordination games with leverage could offer novel ways to explore the role of ToM abilities on coordination over conflict situations.

In sum, we found that by seven years of age, children seem to understand the potential role that individual alternatives play in a social dilemma, but they do not fully use it to their own advantage. Our findings could be the result of a trade-off between maximizing rewards, while maintaining long-term collaboration in complex scenarios where strategies such as turn-taking are hard to implement.

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608 **References**

609 Anderson, P. (2002). Assessment and development of executive function (EF) during childhood.
610 *Child Neuropsychology*, *8*(2), 71–82.

611 Ashley, J., & Tomasello, M. (1998). Cooperative problem-solving and teaching in preschoolers.
612 *Social Development*, *7*(2), 143–163.

613 Baayen, R. H., Davidson, D. J., & Bates, D. M. (2008). Mixed-effects modeling with crossed
614 random effects for subjects and items. *Journal of Memory and Language*, *59*(4), 390–412.

615 Barclay, P. (2013). Strategies for cooperation in biological markets, especially for humans.
616 *Evolution and Human Behavior*, *34*(3), 164–175.

617 Bates, D. M. (2010). lme4: Mixed-effects modeling with R. Berlin.

618 Binmore, K., Shared, A., & Sutton, J. (1989). An outside option experiment. *The Quarterly*
619 *Journal of Economics*, *104*(4), 753–770.

620 Blake, P R, McAuliffe, K., Corbit, J., Callaghan, T. C., Barry, O., Bowie, A., … Vongsachang, H.
621 (2015). The ontogeny of fairness in seven societies. *Nature*, *528*(7581), 258.

622 Blake, Peter R, & McAuliffe, K. (2011). "I had so much it didn't seem fair": Eight-year-olds reject
623 two forms of inequity. *Cognition*, *120*(2), 215–224.

624 Bohnet, I., & Zeckhauser, R. (2004). Trust, risk and betrayal. *Journal of Economic Behavior &*
625 *Organization*, *55*(4), 467–484.

626 Boyer, T. W. (2006). The development of risk-taking: A multi-perspective review.
627 *Developmental Review*, *26*(3), 291–345.

628 Brownell, C. A., Ramani, G. B., & Zerwas, S. (2006). Becoming a social partner with peers:
629 Cooperation and social understanding in one-and two-year-olds. *Child Development*,
630 *77*(4), 803–821.

631 Ciairano, S., Visu-Petra, L., & Settanni, M. (2007). Executive inhibitory control and cooperative
632 behavior during early school years: A follow-up study. *Journal of Abnormal Child*
633 *Psychology*, *35*(3), 335–345.

634 Cooper, R., DeJong, D. V, Forsythe, R., & Ross, T. W. (1994). Alternative Institutions for
635 Resolving Coordination Problems: Experimental Evidence on Forward Induction and
636 Preplaycommunication. In *Problems of coordination in economic activity* (pp. 129–146).
637 Springer.

638 Cooper, R. W., DeJong, D. V, Forsythe, R., & Ross, T. W. (1990). Selection criteria in
639 coordination games: Some experimental results. *The American Economic Review*, *80*(1),
640 218–233.

641 Dawes, R. M. (1980). Social dilemmas. *Annual Review of Psychology*, *31*(1), 169–193.

642 Duguid, S., Wyman, E., Bullinger, A. F., Herfurth-Majstorovic, K., & Tomasello, M. (2014).
643 Coordination strategies of chimpanzees and human children in a Stag Hunt game.
644 *Proceedings of the Royal Society of London B: Biological Sciences*, *281*(1796), 20141973.

645 Engelmann, J. M., Over, H., Herrmann, E., & Tomasello, M. (2013). Young children care more
646 about their reputation with ingroup members and potential reciprocators.
647 *Developmental Science*, *16*(6), 952–958.

648 Fletcher, G. E., Warneken, F., & Tomasello, M. (2012). Differences in cognitive processes
649 underlying the collaborative activities of children and chimpanzees. *Cognitive*
650 *Development*, *27*(2), 136–153.

651 Fujii, T., Takagishi, H., Koizumi, M., & Okada, H. (2015). The effect of direct and indirect

monitoring on generosity among preschoolers. *Scientific Reports*, *5*, 9025.

Giannotta, F., Burk, W. J., & Ciairano, S. (2011). The role of inhibitory control in children's cooperative behaviors during a structured puzzle task. *Journal of Experimental Child Psychology*, *110*(3), 287–298.

Grueneisen, S., & Tomasello, M. (2017). Children coordinate in a recurrent social dilemma by taking turns and along dominance asymmetries. *Developmental Psychology*, *53*(2), 265.

Grueneisen, S., & Tomasello, M. (2019). Children use rules to coordinate in a social dilemma. *Journal of Experimental Child Psychology*, *179*, 362–374.

Grueneisen, S., Wyman, E., & Tomasello, M. (2015). "I know you don't know I know…" Children use second-order false-belief reasoning for peer coordination. *Child Development*, *86*(1), 287–293.

Hamann, K., Warneken, F., Greenberg, J. R., & Tomasello, M. (2011). Collaboration encourages equal sharing in children but not in chimpanzees. *Nature*, *476*(7360), 328.

Harbaugh, W. T., Krause, K., & Vesterlund, L. (2002). Risk attitudes of children and adults: Choices over small and large probability gains and losses. *Experimental Economics*, *5*(1), 53–84.

Hedden, T., & Zhang, J. (2002). What do you think I think you think?: Strategic reasoning in matrix games. *Cognition*, *85*(1), 1–36.

Helbing, D., Schönhof, M., Stark, H.-U., & Hołyst, J. A. (2005). How individuals learn to take turns: Emergence of alternating cooperation in a congestion game and the prisoner's dilemma. *Advances in Complex Systems*, *8*(01), 87–116.

Koomen, R., & Herrmann, E. (2018). An investigation of children's strategies for overcoming the tragedy of the commons. *Nature Human Behaviour*, *2*(5), 348.

LoBue, V., Nishida, T., Chiong, C., DeLoache, J. S., & Haidt, J. (2011). When getting something good is bad: Even three-year-olds react to inequality. *Social Development*, *20*(1), 154–170.

Marquart, J. W. (1986). Prison guards and the use of physical coercion as a mechanism of prisoner control. *Criminology*, *24*(2), 347–366.

McAuliffe, K., Blake, P. R., Kim, G., Wrangham, R. W., & Warneken, F. (2013). Social influences on inequity aversion in children. *PLoS One*, *8*(12), e80966.

Melis, A. P., Grocke, P., Kalbitz, J., & Tomasello, M. (2016). One for you, one for me: Humans' unique turn-taking skills. *Psychological Science*, *27*(7), 987–996.

Paulsen, D., Platt, M., Huettel, S. A., & Brannon, E. M. (2011). Decision-making under risk in children, adolescents, and young adults. *Frontiers in Psychology*, *2*, 72.

Raijmakers, M. E. J., Mandell, D. J., van Es, S. E., & Counihan, M. (2014). Children's strategy use when playing strategic games. *Synthese*, *191*(3), 355–370.

Sánchez-Amaro, A., Duguid, S., Call, J., & Tomasello, M. (2017). Chimpanzees, bonobos and children successfully coordinate in conflict situations. *Proceedings of the Royal Society B: Biological Sciences*, *284*(1856), 20170259.

Sánchez-Amaro, A., Duguid, S., Call, J., & Tomasello, M. (2018a). Chimpanzees' understanding of social leverage. *PloS One*, *13*(12), e0207868.

Sánchez-Amaro, A., Duguid, S., Call, J., & Tomasello, M. (2018b). Chimpanzees and children avoid mutual defection in a social dilemma. *Evolution and Human Behavior*.

Sánchez-Amaro, A., Duguid, S., Call, J., & Tomasello, M. (2019). Chimpanzees and children avoid mutual defection in a social dilemma. *Evolution and Human Behavior*, *40*(1), 46–54.

Sugden, R. (2004). *The economics of rights, co-operation and welfare*. Springer.

Therneau, T. (2012). coxme: mixed effects Cox models. R package version 2.2-3. *Vienna, Austria: R Foundation for Statistical Computing*.

Ulber, J., Hamann, K., & Tomasello, M. (2015). How 18-and 24-month-old peers divide resources among themselves. *Journal of Experimental Child Psychology*, *140*, 228–244.

Warneken, F. (2018). How children solve the two challenges of cooperation. *Annual Review of Psychology*, *69*.

Warneken, F., Lohse, K., Melis, A. P., & Tomasello, M. (2011). Young children share the spoils after collaboration. *Psychological Science*, *22*(2), 267–273.

Warneken, F., Steinwender, J., Hamann, K., & Tomasello, M. (2014). Young children's planning in a collaborative problem-solving task. *Cognitive Development*, *31*, 48–58.

Wyman, E., Rakoczy, H., & Tomasello, M. (2013). Non-verbal communication enables children's coordination in a "Stag Hunt" game. *European Journal of Developmental Psychology*, *10*(5), 597–610.

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722 **Electronic Supplementary Materials**

723 Model 1: Subjects' choices

724 Model 1 investigated whether subjects would strategically use the leverage for their own
725 benefit. We hypothesize that if subjects would understand the potential use of the leverage
726 baited on the alternative platform, we would find a leverage effect in the direction of subjects
727 accessing more often their leverage the bigger it was. The full model included the test variable
728 leverage level (3-level factor) l and the control variables trial, session (which also accounts for
729 role order) and sex of the pair as fixed effects; pair, individual on the right side and individual on
730 the left side as random effects and the random slopes. The comparison between the full and the
731 null model was significant (GLMM: χ^2 = 74.36, df = 3, p<0.001, N = 240). We found a main effect
732 of leverage (see Table S1). Children accessed their leverage most of times when that consisted
733 of four rewards, and almost never when no leverage was available.

734 Table S1: Model 1 information

Term	Estimate	Standard Error	Chi-square	Degrees of freedom	p-value	CI (95%) of the model
Intercept	-2.79	0.56	-	-	-	-27.24, 1.35
Leverage (lev. 2)	3.14	0.57	68.42	2	<0.001	1.77, 31.39
Leverage (lev. 4)	6.26	0.79	68.42	2	<0.001	4.6, 58.53
Session	0.57	0.23	6.43	1	0.01	-0.08, 6.09
Trial	-0.0.6	0.23	0.07	1	0.79	-1.4, 0.79

Dyad sex (male)	0.15	0.56	0.07	1	0.79	-1.99, 2.77

735

736 Model 2. Subjects latency to access the apparatus.

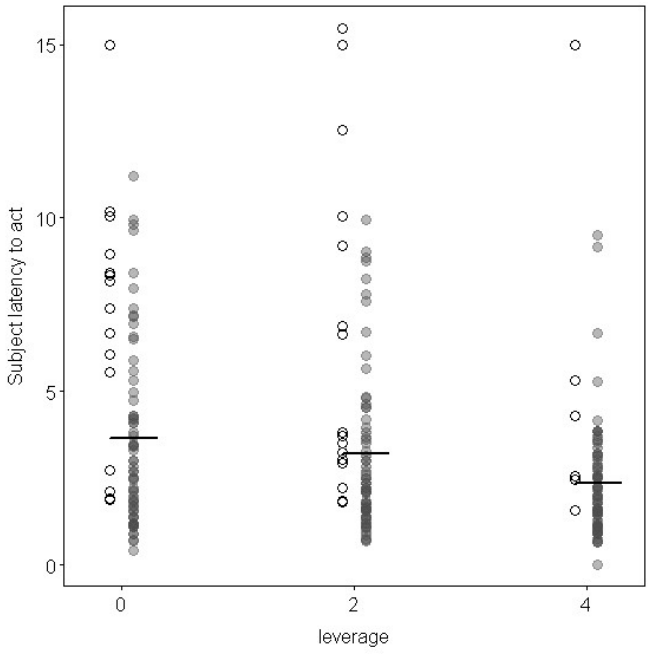
737 Model 2 investigated subjects' latencies to access the apparatus. We hypothesized that, if
738 subjects would understand the potential use of the leverage baited on the alternative platform,
739 they would wait longer to access the apparatus when the alternative platform consisted of zero
740 or two glass marbles instead of four. For this model we established a censor to account for trials
741 in which subjects did not open the door after 15 seconds and for trials in which partners pulled
742 from their rope before subjects acted. The censored data represented 17% of the total data (40
743 of 240 trials). The model included the test variable level of leverage and the control variables
744 trial, session (which also accounts for role order) and sex of the pair as fixed effect. Individual
745 identity was introduced as a random effect. The leverage level was significant (coxme, $\chi^2 = 26.59$,
746 df = 2, p <0.001, N = 240). Subjects waited longer to open the sliding door the smaller the
747 leverage was (see Table S2).

748 Table S2: Model 2 information

Term	Model coefficients	Standard error	HR (Hazard Ratios)	p-value	CI of model estimates
Leverage (lev. 2)	0.15	0.18	1.16	0.4	-0.36, 0.41
Leverage (lev. 4)	0.92	0.19	2.49	<0.001	-0.36, 0.38
Dyad_sex (male)	0.64	0.19	1.89	<0.001	-0.41, 0.42

Session	0.08	0.19	1.09	0.66	-0.39, 0.41
Trial	0.08	0.04	1.09	0.054	0.04, 0.08

Figure S1: Subjects' latency to access the apparatus as a function of the leverage level presented to the subject. The higher the level of leverage the faster the subject accessed the apparatus. The horizontal lines represent the average latencies. The blank dots represent the censored data: trials in which subjects did not open the access after 15 seconds and trials in which partners pulled their rope before subjects acted.



Model 3. Partners' latency to pull from the rotating tray.

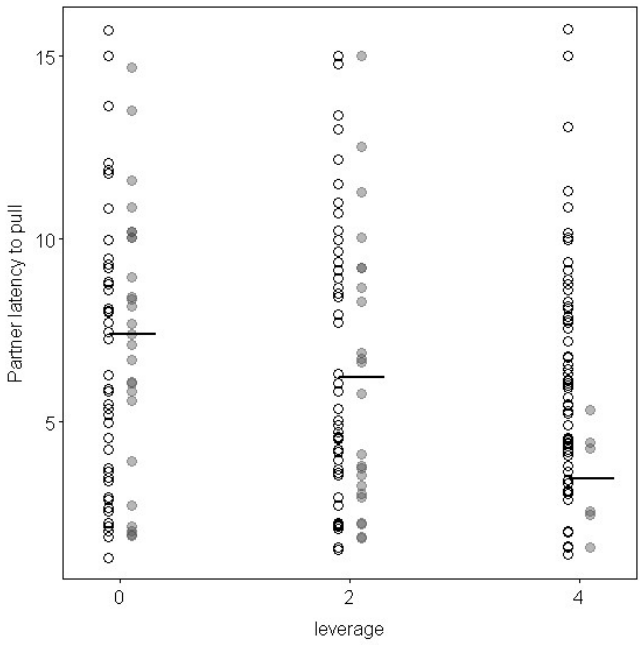
Model 3 investigated partners' latencies to pull from their rotating tray. We hypothesized that, if partners would understand the role of subjects' leverage, they would tend to pull faster the larger the subjects' leverage was—as the subjects would likely access its own alternative when this one consisted of four glass marbles. For this model we established a censor to account for trials in which the partner did not open the door after 15 seconds and for trials in which either

the subject opened their access to the leverage before the partners had pulled, or the subjects pulled before the partners. In other words, when partners had no chances to freely decide whether to pull or wait for subjects to act. The censored data represented 77% of the total data (185 of 240 trials). The model included the test variable level of leverage and the control variables trial, session (which also accounts for role order) and sex of the pair as fixed effect. Individual identity was introduced as random effect. The level of leverage was significant (coxme, χ^2 = 8.84, df = 2, p = 0.010, N = 240). Partners waited longer to open the sliding door the smaller the leverage of the subject was (see Table S3). In other words, partners waited longer to act when both had similar chances to obtain the highest reward baited on the free end of the rotating tray.

Table S3: Model 3 information

Term	Model coefficients	Standard error	HR (Hazard Ratios)	p-value	CI of model estimates
Leverage (lev. 2)	-0.06	0.29	0.94	0.84	-0.65,0.69
Leverage (lev. 4)	-1.2	0.47	0.3	0.01	-0.61, 0.72
Dyad_sex (male)	-0.58	0.37	0.56	0.12	-0.74, 0.73
Session	-0.51	0.37	0.6	0.17	-0.69, 0.71
Trial	0.12	0.08	1.12	0.16	0.13, 0.2

Figure S2: Partners' latency to access the apparatus as a function of the leverage level presented to the subject. The higher the level of leverage the faster the partner accessed the apparatus. The horizontal lines represent the average latencies. The blank dots represents' the censored data: trials in which partners did not open the access after 15 seconds and trials in which subjects pulled their rope before partners acted.



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782 Model 4. Communication

783 Model 4 investigated the occurrence of communication. In this model we included all trials. We
784 transformed our response into a binomial response where 1 meant the presence of any
785 communicative act for subjects and partners and 0 no presence of communication within a trial.
786 The full model included the communicator ID (subject or partner), the leverage phase and the
787 trial phase (trial and inter-trial-intervals) as well as the two-way interaction between
788 communicator ID and leverage phase. We expected children to communicate more during
789 interacting phases. In addition, we expected partners without leverage to communicate more
790 than subjects when the latter had access to alternative rewards. The control variables were trial,
791 session and sex of the dyad as fixed effects; pair and trial ID as random effects and all possible
792 random slopes. The comparison between the full and the null model excluding all test variables
793 was not significant (GLMM: $\chi^2 = 5.73$, df = 6, $p = 0.45$, N = 960). In addition, we tested a model
794 only including informative communicative acts (the most represented form of communication).
795 The comparison between the full and the null model excluding test variables was not significant
796 (GLMM: $\chi^2 = 5.49$, df = 6, $p = 0.48$, N = 960).

Table S4. Number of times each communicative type occurred per leverage level, child role and trial phase (maximum value per cell = 80).

	Phase 1					
	Subject			Partner		
	Leverage	Leverage	Leverage	Leverage	Leverage	Leverage
	0	2	4	0	2	4
Informative	37	32	32	35	34	35
Imperative	22	7	1	16	5	6
Protest	10	7	5	14	12	6
Leverage	4	2	1	2	1	1
Turn taking	8	5	1	6	4	2
Others	22	26	19	24	20	15
	Phase 2					
	Subject			Partner		
	Leverage	Leverage	Leverage	Leverage	Leverage	Leverage
	0	2	4	0	2	4
Informative	37	39	39	43	35	39
Imperative	3	1	1	3	1	0
Protest	5	1	0	3	4	7
Leverage	1	5	1	1	1	2
Turn taking	3	1	0	1	2	1
Others	14	15	18	14	16	9