Do 7-years-old children understand social leverage?

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Abstract

Individuals with an advantageous position during a negotiation possess leverage over their partners. Several studies with adults have investigated how leverage can influence the coordination strategies of individuals when conflicts of interest arise. In this study we explored how pairs of seven-year-old children solved a coordination game (based on the Snowdrift scenario) when one of the children had leverage over the other. We presented a social dilemma in the form of an unequal reward distribution on a rotating tray. The rotating tray could be accessed by both children. The child that waited longer to act received the best outcome but if both waited too long, they would lose the rewards. In addition, one child could forego the access to the rotating tray for an alternative option—the leverage. Although children did not always use their leverage strategically, children with access to the alternative were less likely to play the social dilemma, especially when their leverage was larger. Furthermore, children waited longer to act as the leverage decreased. Finally, children almost never failed to coordinate. The results hint to a trade-off between maximizing benefits while maintaining long-term collaboration in complex scenarios where strategies such as turn-taking are hard to implement.

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. For instance, people can use physical force to punish others so that they conform to their will (Marquart, 1986). They can also use third-parties as social alternatives to end previously disadvantageous interactions (Barclay, 2013). The access to alternatives—different social partners, contracts or rewards—can be a source of leverage because it creates asymmetries between interacting individuals (i.e. person A does not need person B as much as person B needs person A). People in possession of unique resources is one example. In such a situation, the seller could ask for very high prices because she would be in a position of leverage since her goods are very difficult to find and are in high demand.

While the example mentioned above applies mainly to human adult interactions in which some basic economic understanding is required, social transactions of this nature do 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). Little is known, however, about whether children, who have minimal experience in market transactions, would use alternative options as leverage to coordinate and maximize outcomes 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. For instance, children take turns to divide the rewards equally even when this means 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). However, a turn-taking strategy is most efficient when the interaction is predictable (e.g. when the same amounts of resources are constantly in play) the upcoming rewards are always the same). When the distribution of rewards is unpredictable (e.g. when there is random variation in the amount of resources in play) and it is difficult to keep track of previous interactions, five-years old abandon a turn-taking strategy for alternative strategies to maximize their rewards while still avoiding mutual defection (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 (Koomen & Herrmann, 2018). In all of these situations, children face a social dilemma between acting cooperatively or selfishly (Dawes, 1980). On one hand unilateral social defection provides a better payoff than unilateral cooperation, but on the other hand individuals are better off if they all cooperate than if they all defect. However, in all these social dilemmas the interaction is always symmetrical. That is, despite children's goals not being aligned, both partners are likely to share the same strategies (e.g. wait for the partner to act before them). In contrast, little is known about the strategies that children would use to overcome conflicts of interest when one child can access a secure alternative and thus avoid participating in the social dilemma. That is, when one child is in a position of leverage.

How leverage (in the form of alternative options) can affect the ways we negotiate has been experimentally studied in adult humans. When adults were asked to anonymously divide $7 but the recipient has the option to halt the negotiation and obtain a $4 alternative, their partners offer them shares of $4.5 instead of splitting the total amount in two halves (i.e. $3.5 for each participant) (Binmore, Shared, & Sutton, 1989).

Adults in a position of leverage can also influence others' strategies to coordinate over conflicting interests. Experiments with coordination games such as the Battle of Sexes has found that adults understand others' positions of influence and adjust their decisions accordingly (Cooper, DeJong, Forsythe, & Ross, 1994; Cooper, DeJong, Forsythe, & Ross, 1990). In this two-player coordination game Player A and Player B could coordinate to either get 600 or 200 tickets for a lottery. However, if both chose the 600 option, they would get no tickets. Alternatively, only Player A had the opportunity to opt out and obtain a secure reward of 300 tickets for each player. The experimenters found that players in position A chose the option that would provide them with the highest reward (600 tickets for themselves and 200 for the partner) on a majority of trials. In turn, players in position B anticipated this decision and chose 200 tickets. In other words, Player A influenced Player B's decision through the use of leverage. In these studies, adult subjects played against anonymous partners and could not communicate. However, such methodology is hard to implement with young children. When testing children's strategies in social dilemmas it is preferable to present them with engaging scenarios in which they can interact and communicate as they would do in real life situations.

Our study explores whether children can use a position of leverage when their personal preferences are not aligned. We build on a previous experiment (Sánchez-Amaro et al., 2017) in which five-year-old children were presented with a dyadic anti-coordination game, the Snowdrift (Sugden, 2004). In this game, subject A prefers to defect—thus obtaining the highest benefit, if partner B cooperates. However, if partner B decides to defect, then subject A should change her strategy and cooperate since mutual defection is the worst-case scenario. To implement this social dilemma, we presented children with an unequal reward distribution on two ends of a rotating tray. The rewards were placed at both ends but only the interior end could be accessed directly by pulling a rope, with the other end moving towards the partner. In the critical condition, the preferred reward was placed on the end of the tray so that the child could only obtain it by waiting for the partner to pull her rope. However, if both children waited too long for their partner to act, the rewards were removed. We found that children behaved strategically by pulling later when the preferred reward was not directly accessible to them. This 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 interior 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 prefer their partner to pull before them. We then added leverage to this task by offering one of the children access to an alternative, secure and exclusive reward (zero, two or four rewards) in addition to the unequal reward distribution on the rotating tray which was accessible to both children. Henceforth, we call the child in possession of the leverage the *subject* and the child without leverage the *partner*. The addition of leverage further differentiates our task from typical social dilemmas since our participants' potential outcomes were most of the time asymmetrical.

When there was no secure alternative (zero rewards, i.e., no leverage), both children had symmetrical options. In contrast, when the alternative consisted of four secure rewards, subjects should always prefer the four rewards instead of accessing the rotating tray. In the crucial condition, the alternative option was two marbles. Thus, subjects could use their leverage (i.e. the possibility to access the alternative option instead of the rotating tray) to influence their partner's decision. Given that they had both options available, subjects should wait for their partners to pull for one reward before acting, otherwise they would lose the advantage conferred by their leverage position. At the same time, partners should be more likely to pull for one reward before all rewards were removed. 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 literature, we expected children to successfully avoid mutual defection in the social dilemma (Sánchez-Amaro et al., 2017, 2019). We also expected a positive relationship between the times children acting as subjects would access the alternative option and the value of the alternative (zero, two or four rewards). That is, the higher the value of the alternative the more likely they would be to forego the access to the rotating tray. In addition, we expected the seven-years-old children to understand the potential function of their leverage position. For instance, when the alternative consisted of two secure rewards, we expected subjects to wait for their partner to pull first. In addition, we expected a negative correlation between time waiting for a child (both when acting as subject and as partner) and the value of the alternative option. For example, when the alternative consisted of four rewards (more than the reward available in the rotating tray) children were expected to access it directly and to not wait for the other child. With regard to the children's 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 table 1 for summary of the hypotheses.

Alternative Rewards	**Rewards on the Rotatory Tray (RT)**	**Subject**	**Partner**
Zero	One on the interior end and three on the free end	• Access RT • High latency to pull	• Access RT • High latency to pull
Two	One on the interior end and three on the free end	• Access RT if partner acts before them • Higher latency than partner	• Access RT • Lower latency than partner • Communicate more than subject
Four	One on the interior end and three on the free end	• Access secure alternative • Low latency to act	• Access RT • Low latency to pull • Communicate more than subject

Table 1: Representation of main hypothesis for subjects' and partners choices, latencies and communicative acts across the three different leverage levels.

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 1). 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 interior (low value) end of the rotating tray. To access the exterior (high value) end of the rotating tray children had to wait for their partner to pull (Figure 1b). The alternative platform could be accessed directly by sliding the door to the left (Figure 1d). 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.

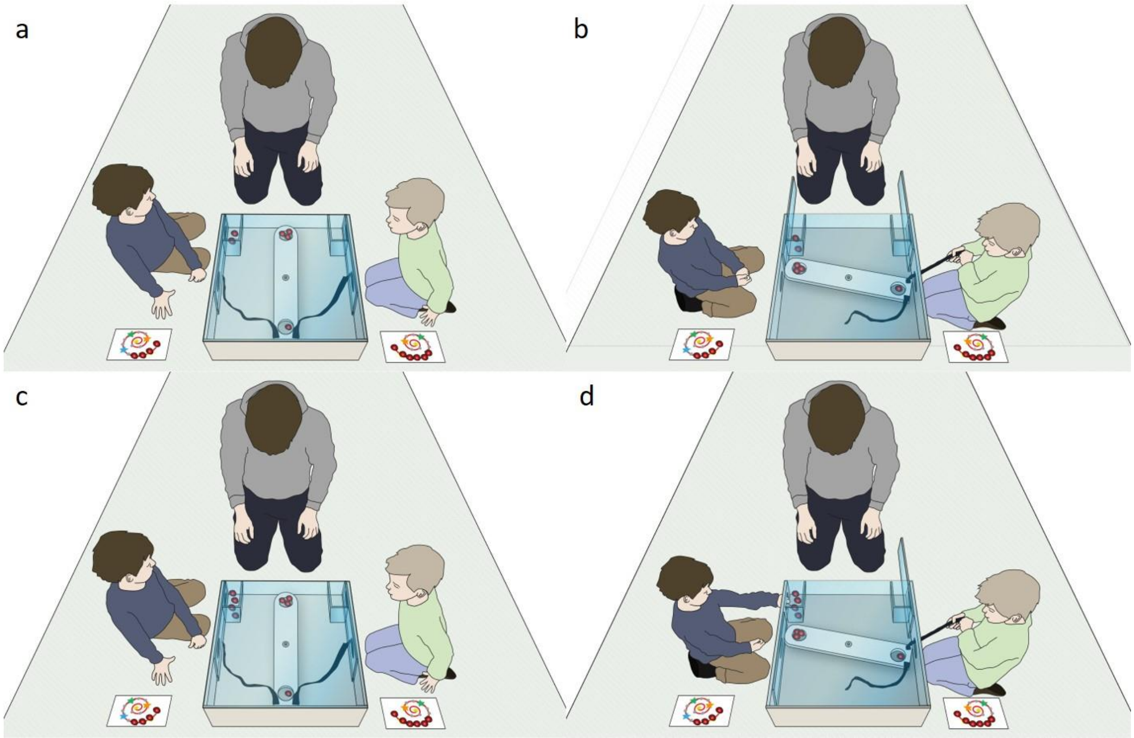

Figure 1: Representation of the apparatus. The *subject* is on the left side and has access to two rewards on the alternative (figures *a* and *b*) or four rewards on the alternative (figures *c* and d). In figure *b* the subject access the unequal distribution while in figure *d* the subject access 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 exterior end and one marble on the interior end of the tray. Each child performed one trial in which only the acting child had access to a rope connected to the interior end of the tray (i.e. the child pulling the rope obtained the rewards from the interior end while the other child obtained the rewards from the exterior 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 interior end of the rotating tray contained one glass marble while the exterior 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. For half of the pairs the leverage (i.e. the position occupied by the child acting as subject) 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.

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 partner 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.

To code the verbal communication, 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 the following categories:

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 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 (87.5%). In addition, only one child obtained rewards in 5.5% of trials. No children obtained rewards in 7% of 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= 37.03, df = 1, p<0.001, N = 240; Figure 2). When subjects had no alternative option`, they accessed the rotating tray in almost every trial (90% of 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 (39 children accessed the alternative at least once). Interestingly, subjects chose to access the rotating tray in 42% of trials when their leverage consisted of two glass marbles (28 children accessed the alternative at least once). 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 were more willing to access the rotating tray (in 60% of trials) rather than their alternative option compared to children who participated as subjects in the first session (in 48% of trials) (GLMM: χ^2= 6.43, df = 1, p= 0.01, N = 240).

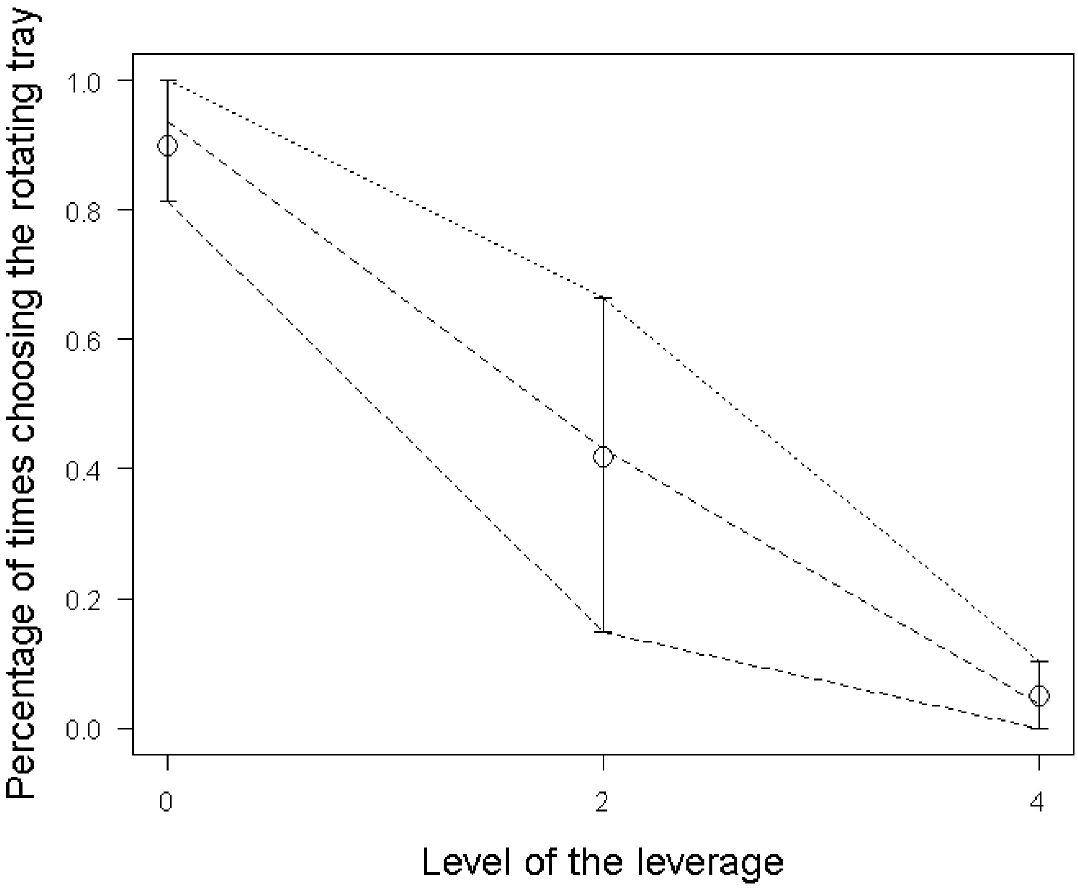

Figure 2: Percentage of choices for the rotating tray as a function of the level of leverage. As the reward value on the alternative increased, subjects forego the access to the social choice (i.e. the unequal reward distribution).

To use the leverage effectively, children in the role of subjects should access the rotating tray after partners had already pulled from their ropes. Once both individuals had simultaneous access to their ropes, they were in an equal position to obtain the best reward. In this regard, children' timing to act was consistent with them using their leverage strategically in 38% of those trials in which they refused to access their two secure rewards. In other words, in only 16% of trials, subjects were able to maximize their rewards (i.e. obtain the three rewards from the free end of the rotating tray).

When we inspected the latencies to act (i.e. open the sliding door thus choosing one option for the subject; pull the rope connected to the rotating tray for the partner), we found that both subjects (coxme, χ^2 = 21.15, df = 1, p <0.001, N = 240; Figure S1) and partners (coxme, χ^2 = 23.59, df = 1, p<0.001, N = 240; Figure S2) waited significantly longer the smaller the subjects' leverage was. That is, when no child had leverage both waited for each other to increase their chances to obtain the rewards baited on the exterior end of the tray. In contrast, when the subject could access four glass marbles baited on the alternative platform, partners and subjects acted more quickly. This is especially interesting from the partners' perspective as it shows that children did not need to have leverage to understand their 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 benefits. Specifically, in over 15% of trials children in the position of leverage (when the subject's alternative is two rewards) waited to make their decisions (i.e. maintained their leverage) until their partners had already decided to pull for the lower reward. Children (playing as subjects and as partners) also waited longer to act the smaller the subjects' leverage was. This is especially interesting from the partners' perspective suggesting 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 leverage more often (regardless of the leverage level presented) in the second session (i.e. when playing as subjects' second). 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 no clear communicative pattern in the sense 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, 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) 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, a situation in which adults are found to be more risk averse (Bohnet & Zeckhauser, 2004) so we would need further studies to test this hypothesis.

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

Conclusions

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

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

Model 1: Subjects' choices

Model 1 investigated whether subjects would strategically use the leverage for their own benefit. We hypothesize that if subjects would understand the potential use of the leverage baited on the alternative platform, we would find a leverage effect in the direction of subjects accessing more often their leverage the bigger it was. The full model included the test variable leverage level and the control variables trial, session (which also accounts for role order) and sex of the pair as fixed effects; pair, individual on the right side and individual on the left side as random effects and the random slopes. The comparison between the full and the null model was significant (GLMM: χ^2 = 37.03, df = 1, p<0.001, N = 240). We found a main effect of leverage (see Table S1). Children accessed their leverage most of times when that consisted of four rewards, and almost never when no leverage was available

Table S1: Model 1 information

Term	Estimate	Standard Error	Chi-square	Degrees of freedom	p-value	CI (95%) of the model

Intercept	0.26	0.34	-	-	-	-0.81, 1.59
Leverage	2.42	0.3	37.03	1	<0.001	1.72, 8.77
Session	0.52	0.2	6.43	1	0.01	0.02, 1.56
Trial	-0.03	0.21	0.019	1	0.89	-0.95, 0.59
Dyad sex	-	-	0.15	1	0.69	-

Model 2. Subjects latency to access the apparatus.

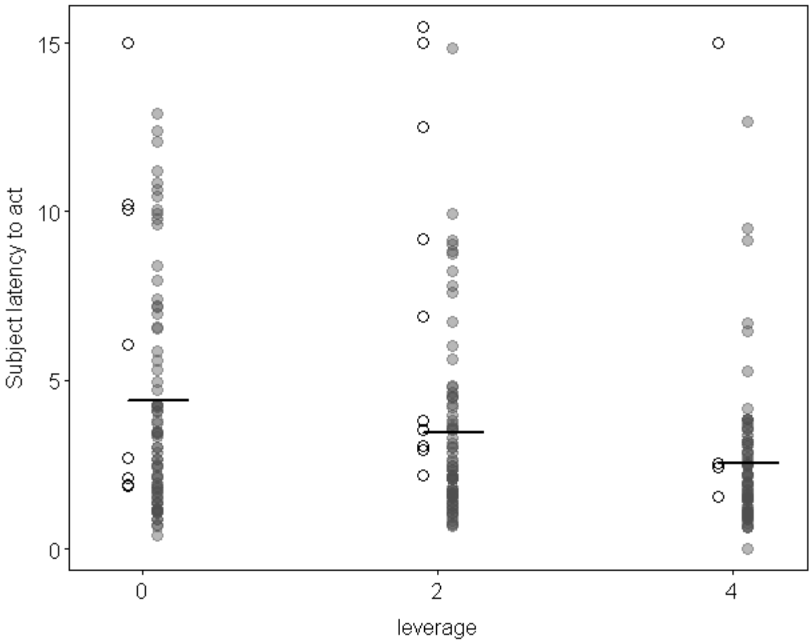
Model 2 investigated subjects' latencies to access the apparatus. We hypothesized that, if subjects would understand the potential use of the leverage baited on the alternative platform, they would wait longer to access the apparatus when the alternative platform consisted of zero or two glass marbles instead of four. For this model we established a censor to account for trials in which subjects did not open the door after 15 seconds and for trials in which partners pulled from their rope before subjects acted. The censored data represented 12% of the total data (25 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 a random effect. The leverage level was significant (coxme, χ^2 = 21.15, df = 1, *p* <0.001, N = 240). Subjects waited longer to open the sliding door the smaller the leverage was (see Table S2).

Table S2: Model 2 information

Term	Model coefficients	Standard error	HR (Hazard Ratios)	p-value	CI of model estimates
Leverage	0.21	0.05	1.24	<0.001	-0.08, 0.1
Dyad_sex (male)	0.63	0.19	1.87	0.001	-0.4, 0.38

Session	0.066	0.19	1.07	0.73	-0.39, 0.41
Trial	0.064	0.04	1.07	0.12	0.03, 0.07

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.



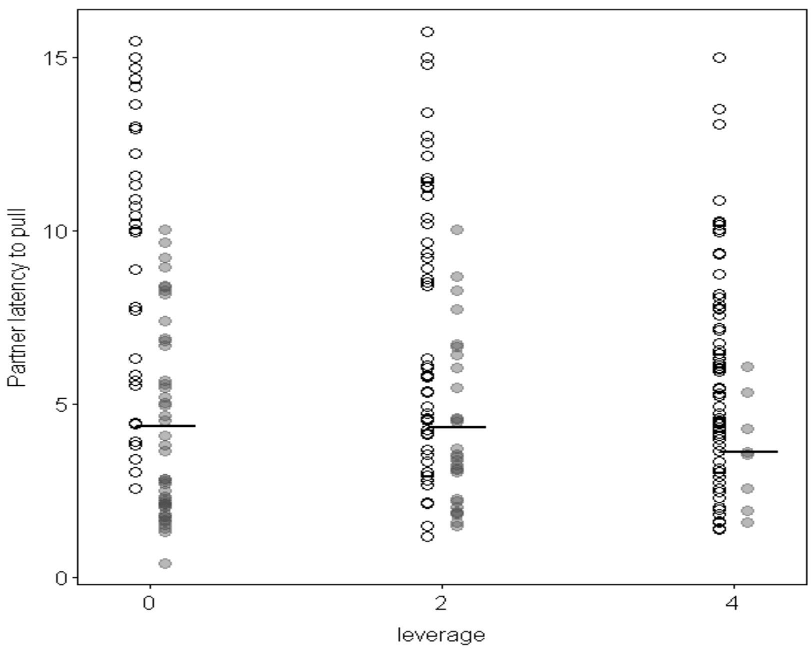
Model 3. Partners' latency to pull from the rotating tray.

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 67% of the total data (159 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 = 23.59, df = 1, p <0.001, 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	-0.37	0.08	0.69	<0.001	-0.15, 0.14
Dyad_sex (male)	-0.14	0.33	0.87	0.67	-0.62, 0.63
Session	-0.03	0.32	0.97	0.93	-0.64, 0.62
Trial	0.11	0.07	1.11	0.14	0.1, 0.14

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.



Model 4. Communication

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