12-2020

Does Nonbinding Commitment Promote Children's Cooperation in a Social Dilemma?

Laurent Prétôt

Katherine McAuliffe

Journal of Experimental Child Psychology 200 (2020) 104947

Contents lists available at ScienceDirect

Journal of Experimental Child Psychology

journal homepage: www.elsevier.com/locate/jecp

Does nonbinding commitment promote children's cooperation in a social dilemma?

Laurent Prétôt *, Katherine McAuliffe

Department of Psychology, Boston College, Chestnut Hill, MA 02467, USA

ARTICLE INFO

Article history:
Received 9 December 2019
Revised 27 June 2020
Available online 26 August 2020

Keywords:
Communication
Nonbinding commitment
Promises
Cooperation
Social dilemma
Prisoner's dilemma game

ABSTRACT

Communication is a powerful tool for promoting cooperation in adults and is considered one of the most important solutions to social dilemmas. One feature that makes communication particularly useful in cooperative contexts is that it allows people to advertise their intentions to partners. Some work suggests that adults cooperate more after making nonbinding commitments to cooperate (i.e., commitments they do not need to uphold) than when they are not allowed to communicate their intentions to their partners. However, we know little about whether nonbinding commitments play a similar role in children. We addressed this gap by testing 6- to 9-year-old children in a simultaneous version of the iterated prisoner's dilemma game. In the *communication* condition, children could communicate their intended decision prior to their actual choice, whereas in the *silent* condition, they could not communicate. Overall, children in the communication condition were no more likely to cooperate than children in the silent condition. However, in the communication condition, but not in the silent condition, children's behavior was contingent on their previous decision; they were more likely to cooperate or defect when they had previously cooperated or defected, respectively. In addition, they rarely reversed their intended decisions in the game. Our findings suggest that, although nonbinding commitment does not promote children's cooperation in general, it may encourage children to stick to their chosen strategy, perhaps for the sake of appearing consistent. More broadly, these results contribute to our emerging understanding of the ways in which children solve social dilemmas.

* Corresponding author.
E-mail address: laurent.pretot@gmail.com (L. Prétôt).

https://doi.org/10.1016/j.jecp.2020.104947
0022-0965/

Introduction

Cooperation—a behavior that provides benefits to others and that is selected because of these benefits (West, Griffin, & Gardner, 2007)—can lead to positive outcomes, yet is often at odds with self-interest. Given this tension, each individual must decide whether to invest in cooperative endeavors or to save one's investments and enjoy the spoils of what others have contributed. Should I donate to National Public Radio or simply continue to enjoy its programming? Should I respect fishing quotas or catch as many fish as I am able? These situations, referred to as *social dilemmas* (Dawes, 1980; Hardin, 1968; Messick et al., 1983; Ostrom, 1990, 2001), characterize many of the problems facing human society today (Van Lange & Joireman, 2008). Thus, studying how to promote cooperation in the face of social dilemmas is essential not only because we can gain a better understanding of human psychology and behavior but also because we can leverage these insights to help tackle large-scale, real-world social dilemmas.

One classic instance of a social dilemma, which we adopted in the current study, is the prisoner's dilemma game (Axelrod & Hamilton, 1981; Flood, Dresher, & Tucker, 1950/2010). In a one-shot scenario, when two players choose to cooperate, they maximize their combined payoff. Yet, each player has an incentive to defect because defection yields higher personal rewards regardless of what the partner does. In a repeated scenario, however, a variety of strategies can promote cooperation, including *tit-for-tat,* in which each player copies the opponent's last move (Rand & Nowak, 2013).

Communication has been heralded as one of the most important solutions to social dilemmas (Balliet, 2010; Sally, 1995). Indeed, there exists a large literature on the general role of communication in influencing adult cooperation. However, we know much less about the extent to which communication promotes cooperation in children and, thus, how fundamental communication is to solving cooperative problems. To address this gap, we tested whether allowing children to make a nonbinding commitment—operationalized here as a nonbinding declaration of intended decision (Dawes, McTavish, & Shaklee, 1977)—would influence rates of cooperation compared with a condition in which communicating intentions was not possible. To this end, we designed a child-friendly version of the classic prisoner's dilemma game with a nonbinding commitment component that was based on work with adults (Dawes et al., 1977). Before describing our approach in detail, we first review literature on the role of communication in social dilemmas in adults and then review what we know about how children solve social dilemmas via communication.

Communication and social dilemmas in adults

In an early study, Deutsch (1958) investigated the effect of motivational orientation and communication on cooperation in a two-player prisoner's dilemma game. The motivational orientations were created by verbal instructions to the participants that were framed as *cooperative* (motivation toward mutual benefits), *individualistic* (motivation toward self-interests), or *competitive* (motivation toward self-interests and doing better than the partner). There were four communication conditions: *communication* (participants were allowed to communicate freely via written notes prior to making their decisions simultaneously and in secret), *no communication* (participants were not allowed to communicate), *non-simultaneous* (one participant made his or her decisions prior to the other participant without communication), and *reversibility* (this was the same as the no-communication condition except that after participants made their decisions and decisions were announced, participants were allowed to change their decisions as many times as they wanted within 30 sec). Participants cooperated more in the communication condition than in the no-communication condition. Surprisingly, however, levels of cooperation in the reversibility condition were comparable to those in the communication condition, indicating that knowing the partner's intentions and having the opportunity to swap decisions was sufficient to promote cooperation. This suggested that communication in the form of a nonbinding commitment—that is, one that could be reversed without penalty—was sufficient to explain the increase in cooperation in the communication condition.

Building on Deutsch's (1958) early findings, Dawes et al. (1977) suggested three non-mutually exclusive levels at which communication in social dilemmas may be effective: (a) *humanization,* where the opportunity to communicate allows participants to get to know each other and be concerned about each other's welfare; (b) *discussion,* where relevant information raised through discussion allows participants to appeal to or persuade others to mutually cooperate; and (c) *commitment,* where participants' statement of their own intended decisions allows them to show their good intentions to others.

To begin to distinguish among these alternatives, Dawes et al. (1977) tested cooperation across four communication conditions: *relevant communication* (participants could talk about the game for 10 min prior to making a decision), *communication plus vote* (participants could talk about the game and make a nonbinding verbal commitment to cooperate or defect), *irrelevant communication* (participants could talk but were instructed to discuss an irrelevant topic), and *no communication.* Participants cooperated more in the relevant-communication and communication-plus-vote conditions than in the no-communication and irrelevant-communication conditions, indicating that humanization alone is not a viable explanation for the effects of communication. Surprisingly, participants were not more cooperative in the communication-plus-vote condition (73%) than in the relevant-communication condition (72%) despite the fact that all participants committed to cooperate. Although the Dawes et al.'s (1977) study showed that communication affects cooperation, we cannot make inferences from their work about the effects of commitments *per se* because their study did not include a condition that isolated the effects of commitment.

In a review of the literature on communication and cooperation in social dilemmas, Balliet (2010) added to Dawes et al.'s (1977) model, emphasizing three ways in which face-to-face communication can enhance cooperation. First, the dynamism and fluidity of face-to-face communication allows partners to address issues more accurately and effectively; that is, both partners can engage in sequential discussion until they successfully address any issues and find solutions to the cooperative problem. Second, social cues such as seeing or hearing each other, engaging in eye gaze, and touching one another can serve as honest signals of others' commitment to cooperate, which in turn increases cooperation. Third, cooperation can be promoted via solicitations or commitment to cooperate. This aspect of communication is particularly relevant to our study because it requires an understanding of others' expectations, an ability that emerges during childhood (Rakoczy & Schmidt, 2013).

Together, adult work to date has emphasized the key roles of discussion and commitment in promoting cooperation in social dilemmas. However, we know much less about the extent to which these factors affect cooperative decisions in children. In the next section, we review the developmental literature on communication in social dilemmas, with an emphasis on the role of nonbinding commitment in children's decision making.

Communication and social dilemmas in children

What research exists on the role of communication in social dilemmas in children has focused principally on the potential importance of discussion. Several studies have shown that children cooperate more when they are given the opportunity to communicate face-to-face with a real partner. For instance, a recent study by Grueneisen and Tomasello (2017) used a child-friendly version of another social dilemma, the snowdrift game, to investigate whether children can converge on a mutually beneficial outcome. Whereas defection always generates a higher payoff than cooperation in the prisoner's dilemma game regardless of the partner's strategy, the optimal strategy in the snowdrift game is a mix of cooperation and defection. In the game, each paired participant controlled an automated toy train carrying marbles that was moving toward the other train. To avoid a crash, at least one of the trains needed to "swerve," which came with a cost because some marbles were lost on the way. Therefore, the "group optimal" solution was for only one participant to swerve and the other to go straight. Importantly, children could see one another and communicate freely with each other at all times (although a barrier prevented them from physically interfering with each other's choices). In the game, children learned to coordinate their efforts by adopting a turn-taking strategy based on explicit joint agreements, which guaranteed a fair distribution of the rewards. In addition, children's proficiency in creating rules followed a developmental trend, with older children more often than younger children creating decision rules that followed a principle of impartiality based on arbitrary criteria (e.g., "the blue train always goes straight"; Grueneisen & Tomasello, 2019). Other studies have similarly reported effects of face-to-face interactions and free talk on children's cooperation in social dilemmas (Duguid, Wyman, Bullinger, Herfurth-Majstorovic, & Tomasello, 2014; Koomen & Herrmann, 2018; Sánchez-Amaro, Duguid, Call, & Tomasello, 2017, 2019).

Of course, communication need not be verbal to work efficiently. For example, Matsumoto, Haan, Yabrove, Theodorou, and Carney (1986) found overall increased levels of cooperation in a version of the iterated prisoner's dilemma game after children expressed an emotion of happiness as compared with absent or negative feedback in the game. As with adults, even minimal nonverbal cues, such as mutual eye contact or smiles, can signal commitment and promote children's cooperation in other social dilemmas (e.g., the stag hunt game; Siposova, Tomasello, & Carpenter, 2018; Wyman, Rakoczy, & Tomasello, 2013).

Although there is plenty of evidence showing that verbal and nonverbal communication can help to increase cooperation in both adults and children, work on the role of commitment specifically has begun only recently. Most of this work has centered on the importance of promises in maintaining prosocial interactions in children. Nonbinding commitments, as we have operationalized them above, are conceptually related to "promises" in the developmental literature, with a major difference being that the latter are normatively binding (Kanngiesser, Köymen, & Tomasello, 2017). Children as young as 3 years already understand the normative implications and obligations associated with promises (Kanngiesser et al., 2017). In addition, they collaborate more when they can make joint commitments (Gräfenhain, Behne, Carpenter, & Tomasello, 2009; Kachel, Svetlova, & Tomasello, 2018; Kachel & Tomasello, 2019). Around 5 years of age, promises—in the form of verbal commitments to not cheat—help children to resist the temptation to cheat (e.g., by peeking in a card game; Heyman, Fu, Lin, Qian, & Lee, 2015). From 5 or 6 years of age, children show selective trust in others using promise-keeping and helping behaviors to guide their decisions (Isella, Kanngiesser, & Tomasello, 2018). Promises play a key role in truth telling throughout development; for example, when they are asked to promise to tell the truth, 3- to 11-year-olds are more likely to tell the truth (Lyon, Malloy, Quas, & Talwar, 2008; Talwar, Lee, Bala, & Lindsay, 2002, 2004) and 8- to 16-year-olds are more likely to be honest about their own transgressions (Evans & Lee, 2010).

Although we know a lot about how promises and other forms of binding commitments influence behavior in children, research on the role of nonbinding commitment has only recently begun. In a recent study, Kachel and Tomasello (2019) tested the role of implicit and explicit joint commitments in 3- and 5-year-olds. Pairs of children played a collaborative game in the form of a pulling task in which participants needed to pull a rope connected to a block that moved and pushed rewards toward openings from which they could be retrieved. There were three conditions: a *no-commitment* condition (parallel play in which each player controlled a separate block), an *implicit-commitment* condition (both children controlled the same block), and an *explicit-commitment* condition (both children controlled the same block *and* formed an explicit commitment to pull together). Unlike the no-commitment condition, the two commitment conditions required both players to cooperate by pulling on the rope to retrieve the rewards. Importantly, children could choose to defect at any time by opting out of the game and opening a chamber that contained a "bribe" reward. Overall, children cooperated more in the explicit-commitment condition. However, there was a developmental trend, with older children cooperating more in both commitment conditions than in the no-commitment condition and younger children cooperating more in the explicit-commitment condition than in the no-commitment condition, with cooperation in the implicit-commitment condition falling in between. Together, these findings suggest that from 5 years of age, children already show a strong sense of commitment, whether it is explicit or implicit.

Together, work on the roles of both verbal and nonverbal communication on cooperation has highlighted similarities in the ways in which adults and children solve social dilemmas, suggesting that solutions to cooperative problems via communication may be deeply anchored in development. Despite this, one aspect of communication that has not received much attention in the social dilemma literature is the role of nonbinding commitment in children's cooperative behavior. This is an important question because we know that young children already have an emerging understanding of commitments and use this understanding to guide their decisions in social contexts. However, we do not know whether they are able to apply this understanding to situations of conflicting interests. Exploring this question will shed new light on how children begin to solve social dilemmas.

The current study

In a preregistered study, we investigated whether nonbinding commitments promote children's cooperation in a social dilemma. Specifically, we tested whether children would cooperate more in an adapted version of the iterated prisoner's dilemma game when they had the opportunity to make a nonbinding commitment—that is, when they could communicate their intention to cooperate or defect—compared with when they were not allowed to communicate their intended decision. We hypothesized that giving participants the opportunity to communicate their intended decisions prior to making actual decisions would reduce uncertainty about what they would do in the game. In cases where partners committed to cooperation—even knowing that they could reverse their decision with no penalty—we expected an increase in mutually cooperative outcomes.

In our iterated prisoner's dilemma game, 6- to 9-year-old children could communicate face-to-face with a real partner. The partner was an adult confederate who always verbally committed to cooperation and followed through on the commitment (*communication* condition) or simply always cooperated (*silent* condition). An unconditionally cooperative confederate partner is a relatively novel aspect of our task given that previous work had partners play a tit-for-tat strategy (i.e., play what the participant played in the previous trial; Downs & Smith, 2004; Li, Zhu, & Gummerum, 2014; Sally & Hill, 2006). However, we reasoned that having the partner always cooperate would boost levels of cooperation across conditions while helping to simplify the task for children. In addition, it would allow us to examine cooperation over trials, specifically asking whether children are more likely to cooperate across conditions when their partner has been consistently cooperative. Supporting this reasoning, a recent study revealed that children are more likely to cooperate when the partner had cooperated in the previous round and were more likely to defect when they had cooperated and the partner had defected (Blake, Rand, Tingley, & Warneken, 2015).

We used a manual version of the intuitive, child-friendly version of the prisoner's dilemma game designed by Blake et al. (2015). We predicted that children would cooperate more in the communication condition relative to the silent condition. In addition, we expected older children to cooperate more than younger children in the game regardless of condition. Finally, because children interacted repeatedly with the same partner (who always cooperated), we examined whether their probability of cooperation varied across repeated rounds and whether the relationship between trial number and cooperation differed by condition.

Method

Participants

We tested 165 6- to 9-year-old children (83 girls) in a laboratory and in public spaces (parks and museums) in the Boston area. Children were divided into two age groups: 6- and 7-year-olds (n = 85, 44 girls; M_{age} = 83.65 months, SD = 7.14, range = 72–95) and 8- and 9-year-olds (n = 80, 39 girls; M_{age} = 106.98 months, SD = 6.65, range = 96–120) (see Table S1 in the online supplementary material for a sample breakdown), including 1 male participant whose birthday was on the testing day (turned 10 years old). In addition, we tested 11 children who were excluded due to the participant's desire to stop the study prior to starting or completion (n = 3), direct parental intervention (n = 1), experimenter error (n = 1), or the participant being outside of our age range (n = 1, 5-year-old), because a parent relayed to us that the child was not typically developing (n = 4), or because we found out that the parent was not the legal guardian only after study completion (n = 1). Our preregistered plan was to stop data collection once we reached our goal of 20 children per condition and age group for a total of 160 participants. Our aim was to be roughly balanced with regard to participant gender within condition and age categories. Note that our cell sizes are inexact due to opportunistic testing and exclusions and because we invited any interested child in our age range to participate in our study once we were set up on a given testing day.

Design

We used a between-participants design in which children were assigned to one of two conditions: *communication* or *silent* (see details on each condition in "General procedure" section). Within condition, children and the confederate adult partner (male) made six decisions in which they chose to cooperate or defect in a prisoner's dilemma game. The partner always cooperated in the game, and decisions were made simultaneously.

Apparatus

The prisoner's dilemma game apparatus consisted of two similar, but independent, parallel tilting trays (one for each player) with different colored sides (we used a combination of blue–yellow and red–green; see Fig. 1A; see also Fig. S1 in the supplementary material; for other studies using this apparatus, see Dunham & Schulz, 2017, and Prétôt, Gonzalez, & McAuliffe, 2020). On each tray, we placed small rewards (dried beans) that could be traded for a prize at the end of the game. The number

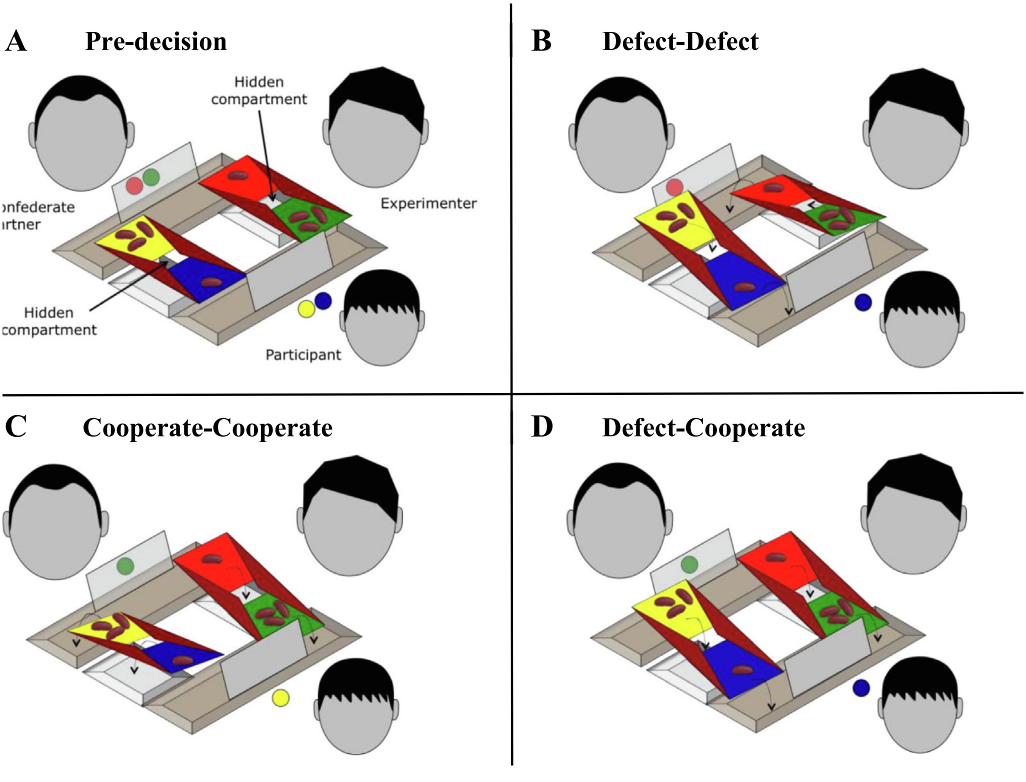

Fig. 1. The prisoner's dilemma game apparatus consists of two independent trays that operate in a seesaw-like fashion and deliver rewards to the players. Prior to each decision, both trays are positioned in their neutral flat position (A). Both players make decisions using color tokens that match the side of the tray they want to choose. For instance, the child participant (seated on the right) can choose the blue side (i.e., defect, which delivers one reward to the participant; B, D) or the yellow side (i.e., cooperate, which delivers three rewards to the partner; C), whereas the confederate adult partner (seated on the left) can decide whether to choose the red side (i.e., defect; B) or the green side (i.e., cooperate; C, D). Decisions are made privately behind barriers before being revealed to both players by the experimenter. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

of rewards on each tray matched the classical prisoner's dilemma game payoff matrix (Fig. 2) such that defecting led to the highest individual payoff in any given trial, but mutual cooperation led to the highest combined payoff. The trays worked in a seesaw-like fashion and could be tilted toward or away from the participant by pushing or pulling the tray to deliver rewards to the players or to a hidden compartment (Fig. 1A), in which case the rewards were removed from play. Prior to playing the game, each player received a pair of choice tokens that matched the colors of their trays. To make a decision, they would pick up one of the two tokens and place it in a small compartment of the apparatus located in front of them (Fig. S1). All decisions were made privately behind an opaque barrier so that players could not see each other's choice before the experimenter revealed them publicly (i.e., in front of both players).

On any given trial of the prisoner's dilemma game, the participant and the partner had two options: They could either choose to pull the tray toward themselves and receive one reward (which constituted a *defect* decision) or choose to push the tray toward the partner and deliver three rewards to the partner (which constituted a *cooperate* decision). Thus, there were three possible scenarios in the game. First, if both players defected, the trays tilted toward themselves, resulting in one reward delivered to each player (defect–defect; Fig. 1B) and the other six rewards falling into the hidden compartments and being removed from play. Second, if both players cooperated, each tray tilted toward each other, resulting in three rewards delivered to each player (highest combined payoff; cooperate–cooperate; Fig. 1C) and the other two rewards falling into the hidden compartments. Third, if one player cooperated and the other player defected, the cooperator's tray tilted toward the defector and the defector's tray also tilted toward the defector, resulting in four rewards delivered to the defector (highest individual payoff), no reward delivered to the cooperator (lowest individual payoff; defect–cooperate; Fig. 1D), and the other four rewards falling into the hidden compartments.

General procedure

Overview

After receiving parental consent for all participants and written assent for participants 8 years and older, each participant was brought to a testing area that consisted of a table and the prisoner's dilemma game apparatus. The experimenter asked both the participant and the partner to sit face-to-face at the table, with the experimenter sitting in the middle at an equal distance from each player. Once seated, the participant was asked for verbal assent. The testing procedure consisted of six phases: (1) trading comprehension check, (2) token comprehension check, (3) barrier comprehension check, (4) talk comprehension check, (5) prisoner's dilemma game main trials, and (6) debrief questions. Note that Phases 1–3 were identical between conditions, whereas Phases 4–6 differed between conditions. The entire experimental script is available in the supplementary material.

		Player 2	
		Cooperate	*Defect*
Player 1	**Cooperate**	**3** / *3*	**0** / *4*
	Defect	**4** / *0*	**1** / *1*

Fig. 2. In the prisoner's dilemma game, if either Player 1 or Player 2 cooperates while the other player defects, the defector receives four rewards (highest individual payoff) and the cooperator receives none (lowest individual payoff). If both players cooperate, each player receives three rewards (highest combined payoff). If both players defect, each player receives one reward.

Trading comprehension check

First, the experimenter told the players that they would be playing a game in which they would earn beans that could be exchanged for a prize at the end. To ensure that the participant understood how trading the beans worked, the experimenter gave the participant four beans that could be traded for either a large sticker or four small stickers (the order of presentation was counterbalanced across participants). After trading the beans for the sticker(s), the participant was asked to rate three new prizes that were used as incentives for the prisoner's dilemma game: a pencil, a slinky, and a stuffed animal. Specifically, the experimenter presented the three prizes and asked the participant which was their favorite and which was their least favorite. The experimenter then asked the partner—the adult confederate—the same questions in the same order. The partner's ratings always matched those of the participant. We did this to ensure that the prizes were perceived as equally valuable to both parties. After establishing prize ranks, the experimenter displayed the prizes on a prize board in ranked order (see Fig. S2 in the supplementary material) and explained that the different prizes lined up with how many beans each player would need to receive each prize. Specifically, if either player got "a bunch" of beans, that player would receive their favorite prize; if either player got a "medium" number of beans, that player would receive their second favorite prize; and if either player got a "small" number of beans, that player would receive their least favorite prize. Because prize value was calibrated to each participant, we ensured that each participant was incentivized to collect as many beans as possible.

At the end of the demonstration, participants were asked two comprehension questions to ensure that they understood how trading beans worked. Each question was asked and answered separately; children were asked (a) what they would do with their beans at the end of the game and (b) what their partner would do with his beans at the end of the game. If children answered a question incorrectly, they were given further explanation and/or demonstration and then were asked again. The majority of children answered the two questions correctly either spontaneously or with further explanation and/or demonstration (Question 1: 98%; Question 2: 99%). A minority of children answered the questions incorrectly after the third attempt (Question 1: 2%; Question 2: 1%). In these cases, the experimenter restated the correct answer before moving on with the task.

Token comprehension check

Following the trading comprehension phase, each child was taught how to use the prisoner's dilemma game apparatus (Fig. 1). All demonstrations were first directed at the participant and then at the confederate adult partner. Tray assignment was counterbalanced across participants such that approximately half of the participants controlled the blue–yellow tray (and the partner controlled the red–green tray), whereas the other half controlled the red–green tray (and the partner controlled the blue–yellow tray).

The experimenter first placed one bean on each side of the trays in their neutral flat position (Fig. 1A), starting with the participant's tray (side opposite to the participant first), for a total of four beans. The experimenter then demonstrated the choices available in the game by showing the participant how choosing a particular tray (defined by its color) would affect the delivery of the resources to the partners differently. The experimenter always stated the participant's choices first, starting with the side of the tray nearest the participant. For example, if the participant was in charge of the tray with the blue and yellow sides, the participant could choose either the blue side (i.e., defect, where it delivers one reward to the participant; Fig. 1B and 1D) or the yellow side (i.e., cooperate, where it delivers three rewards to the partner; Fig. 1C), whereas the partner, who would be in charge of the tray with the red and green sides, could choose either the red side (i.e., defect; Fig. 1B) or the green side (i.e., cooperate; Fig. 1C and 1D).

Children were then introduced to the choice tokens they would use to make decisions in the game. The participant and the partner received two color tokens each (combination of blue–yellow and red–green tokens, which were matched to tray color and thus similarly counterbalanced across participants; Fig. 1A and Fig. S1), starting with the partner, and were told that they would use them to indicate which side of their tray they wanted to choose. For example, if the partner was in charge of the tray with the red and green sides, he could choose either the red token to pick the red side or the green token to pick the green side, whereas the participant, who would be in charge of the tray with the blue and yellow sides, could choose either the blue token to pick the blue side or the yellow token to pick the yellow side.

Following these explanations, participants were asked four comprehension questions to ensure that they understood the contingencies of the apparatus and how to make decisions using the tokens. Each question was asked and answered separately. The experimenter first placed one bean on each side of the trays and asked children (1) which color token they would need to choose *and* where would they need to put it so that they would get one bean in their box and their partner would get none (participant's *defect* option) and (2) which color token would the partner need to choose *and* where would the partner need to put it so that the partner would get one bean in his box and the child participant would get none (partner's *defect* option). Following Question 2, the experimenter again placed one bean on each side of the trays and asked (3) which color tokens would children *and* their partner need to choose so that they would get two beans in their box and the partner would get none (*defect–cooperate* option). Following Question 3, the experimenter placed another bean on each side of the trays for a final time and asked (4) which color tokens would they *and* the partner need to choose so that their partner would get two beans in their box and they would get none (*cooperate–defect* option). If children answered a question incorrectly, they were given further explanation and/or demonstration and then were asked again. The majority of children answered all four questions correctly either spontaneously or with further explanation or demonstration (Question 1: 99%; Question 2: 99%; Question 3: 90%; Question 4: 97%). A minority of children still answered the questions incorrectly after the third attempt (Question 1: 1%; Question 2: 1%; Question 3: 10%; Question 4: 3%). In these cases, the experimenter explained the correct answer before moving on with the task.

Barrier and talk comprehension checks

Before beginning the game, the experimenter told the participant that there were two rules in the game. The first rule was that both players would be making decisions behind barriers so that neither player could see what token the other player chose (Fig. 1 and Fig. S1). To ensure that the players understood this, the experimenter would start by asking the participant, and then the partner, to secretly put one of their tokens, "for fun," in the small token compartment in front of them. The participant was then asked whether they could see what color token the partner had chosen. Next, the partner was asked whether he could see what color token the participant had chosen. If children answered the question incorrectly, they were given further explanation and/or demonstration and then were asked again. All children answered the question correctly either spontaneously or with further explanation and/or demonstration.

The second rule differed between the two conditions. In the communication condition the players were allowed to tell each other which color token they would choose in the game, whereas in the silent condition, participants were not allowed to talk during the game. Children in the communication condition were then given practice trials using another set of tokens (combination of white–black tokens). For these trials, the participant and the partner were asked to put their finger on one of their two tokens and, after the experimenter counted to three, to say out loud the color of their token at the same time. This practice was administered up to three times or until they practiced correctly. The majority of children responded correctly either spontaneously or with further explanation (99%). One child still answered the question incorrectly after the third attempt (1%). In this case, the experimenter made sure to tell the child the correct answer before moving on with the task. The experimenter then told participants that they would now play for real and reminded them that they could make any decision they wanted in the game.

Prisoner's dilemma game

Participants were presented with six test trials, all of which started with the experimenter placing beans on the trays according to the prisoner's dilemma game payoff structure (Fig. 2). Trials differed between the two conditions. In the communication condition, participants and their partner were first asked to put their finger on the token they thought they were going to choose in the game and, after the experimenter counted to three, to say out loud the color of their token at the same time. Players were then asked to make a final decision. The experimenter stated each player's intended and final decisions, along with the outcome, prior to enacting the final decisions simultaneously. Both stated and final choices of participants were reported. In the silent condition, however, participants and their partner were only asked to make one decision in private. Therefore, unlike the silent condition, the communication condition gave participants the opportunity to change their decision if they so desired. Prior to each final decision in both conditions, the players were reminded that they could make any decision they wanted. Following a decision, the experimenter displayed the selected tokens within view of the players and enacted their final choice. Players were allowed to keep their beans and trade them in for a prize at the end of the game. The confederate adult partner played the cooperative option at all times, and participants were never informed about the number of trials they would play in the game.

Debrief questions

At the end of the procedure, the experimenter asked children a series of postexperimental questions to gain insight into *why* they made the decisions they made. Participants in both conditions were asked why they cooperated or defected (where applicable). In addition, children who reversed their decision in the communication condition were asked why they said they would cooperate or defect (where applicable) and actually defected or cooperated (where applicable).

Data coding and analysis

Preregistered analysis plan

The study was preregistered (access link: http://aspredicted.org/blind.php?x=du9cb7). With consent, sessions were videotaped. Our main variable of interest was whether children cooperated or defected (binary response: cooperate = 1, defect = 0) in the prisoner's dilemma game across conditions, age groups, and gender. Children's decisions were live coded by the experimenter and later recoded by an independent video coder. Videos were available for 142 of 165 participants (86%). To assess reliability, we compared the codes of our measure of interest between the live codes and the video codes. The results of the inter-rater analysis revealed a high level of agreement (kappa = .995). Disagreements between live and video coding were resolved by rewatching the video.

In line with our preregistration, we asked whether children cooperated more with a partner in the prisoner's dilemma game when they could communicate their intended decision prior to their actual choice than when they were not allowed to communicate. Frequency of cooperation relative to defection was our main variable of interest. We compared cooperation across conditions, age groups, and gender. We also examined cooperation over time and asked whether behavior was contingent on previous behavior. Note that we originally intended to code social referencing such as looking toward the partner, experimenter, or audience (who was watching and how many people were watching) and unintentional cueing. However, our session videos did not allow us to code for these behaviors because we selected a camera angle that allowed us to code for participants' choices while keeping a full view of the testing area.

All statistical analyses were conducted with R statistical software (Version 3.5.1; R Core Team, 2018). Decision data were analyzed using generalized linear mixed models (GLMMs) with a binary response term (Bolker et al., 2009). Mixed models were run using the package *lme4* (Bates, Mächler, Bolker, & Walker, 2014). In all models, participant identity (ID) was fit as a random effect (intercepts) to control for repeated measures. Our modeling procedure was as follows. We first created a full model, which included our predictor variables of interest: condition (silent or communication), age group (6- and 7-year-olds or 8- and 9-year-olds), gender (female or male), and trial number (1–6). Because results from our full model were similar regardless of whether age was entered as a categorical variable or a continuous variable (see Table S2 in the supplementary material), we opted to use age categories for our analyses and figures for ease of presentation. We compared our full model with a null model, which included only our random effect term (participant ID), and found that the full model was better than the null model, which included only participant ID as random intercepts (likelihood ratio test (LRT), $\chi^2(4) = 10.301$, $p = .036$; Table 1). Second, we created a model that included condition, trial number (2–6), previous choice (cooperate = 1, defect = 0), and our interaction of interest (Condition × Previous Choice). Data and code are available in the supplementary material.

Table 1
Estimates (and standard errors) of fixed effects in mixed models predicting participants' prisoner's dilemma game cooperative behavior.

	Cooperation		Previous choice
	Null	Full	Full
(Intercept)	−1.03 (0.16)***	−1.32 (0.37)***	−0.09 (0.47)
Condition: communication		−0.28 (0.33)	−1.09 (0.55)*
Age group: 8 and 9 years		0.00 (0.33)	
Gender: male		−0.21 (0.33)	
Trial		0.15 (0.05)**	0.03 (0.07)
Previous choice: cooperate			−2.50 (0.39)***
Condition: communication × cooperate			1.34 (0.50)**
Akaike information criterion	1128.98	1126.68	917.03
Bayesian information criterion	1138.78	1156.07	945.32
Log likelihood	−562.49	−557.34	−452.52
Number of trials	990	990	825
Number of participants	165	165	165
Variance: participant ID (intercept)	2.90	3.02	8.10

Note. Cooperate = 1; defect = 0. Age group was fit as a categorical predictor. Baselines for factors were as follows: age group = 6- and 7-year-olds, condition = silent, gender = female, previous choice = defect. The table also shows goodness-of-fit statistics.
* $p < .05$. ** $p < .01$. *** $p < .001$.

Exploratory analyses

We conducted two exploratory analyses in addition to those we preregistered. First, we examined children's stated and final decisions in the communication condition to see whether any type of decision strategy emerged. There were two possible strategies. First, participants could state that they would cooperate or defect and then *actually* cooperate or defect, respectively, in the game (i.e., they could uphold their commitment and stick to their intended decision). Alternatively, participants could state that they would cooperate or defect and then *actually* defect or cooperate, respectively, in the game (i.e., they could renege on their commitment and reverse their decision). Children's stated decisions were live coded by the experimenter and later recoded by an independent video coder. Videos of stated decisions were available for 70 of 83 participants (84%). To assess reliability, we compared the codes of our measure of interest between the live codes and the video codes. The results of the inter-rater analysis revealed a high level of agreement (kappa = .989). Disagreements between live and video coding were resolved by rewatching the video. We used an exact binomial test/sign test to examine participants' stated and final decisions in the communication condition to see whether they stuck to or reversed their decision in the game.

Second, we examined participants' responses to the debrief questions. Because participants rarely reversed their decision (see details in Results; see also Fig. S3 in the supplementary material), we only analyzed responses to why they cooperated or defected in the game. For each question, children's open-ended justifications were coded into three conceptual categories. Each justification was included in at least one category using a binary system ("yes" or "no"). The categories were not mutually exclusive, and a single participant's response could be included in multiple categories (for a similar approach, see Ahl, Duong, & Dunham, 2019, and Prétôt et al., 2020). Transcriptions were made from video recordings first. If the video recording was not available or was inaudible or incomplete, transcriptions were made from the experimenter's live coding sheet (cooperate question: 35%; defect question: 36%).

Responses could fall into three categories: (a) *joint transfer* (references to transfer of resources between self and other, "we," successful cooperation, reciprocity, or both partner actions led to outcome; e.g., "So both of us could get three," "So we would get an equal amount"), (b) *individual transfer* (references to transfer of resources to self or other, give to other, or share; e.g., "Because I wanted to get a few beans," "So he would get some"), (c) *other* (range of answers without a clear category, including "I don't know" and no answer; e.g., "Because I wanted to," "I just wanted to switch it around"). The coding of open-ended responses was conducted by two coders who were blind to condition.

All three categories applied to the analysis of the cooperate question. However, because there was no instance of joint transfer for the defect question, we analyzed only individual transfer and other for the defect question. The results of the inter-rater analyses for our categories of interest (joint and individual transfer) revealed a medium to high level of agreement for the cooperate question (kappa $\geq$ .792) and a high level of agreement for the defect question (kappa = .900). We resolved all disagreements for both cooperate and defect questions by consensus. We used a Fisher's exact test to examine children's responses to the debrief questions, with a comparison between their mention of individual transfer and joint transfer across conditions and age group.

Finally, we conducted two supplementary analyses. First, we ran our full GLMM, which modeled cooperation as a function of condition, age group, and gender using a Bayesian framework (see Table S3 and Fig. S4 in the supplementary material). We also ran a sensitivity analysis based on this same model, which showed that we had approximately 80% to detect a positive effect condition of size .85 (log odds; see Fig. S5).

Results

General analysis

As Fig. 3 shows, children were more likely to defect than cooperate in the prisoner's dilemma game (see intercept terms in Table 1). In the communication condition, children cooperated in 160 of 498 trials in total (32%); older children (8- and 9-year-olds) cooperated in 82 of 246 trials (33%), whereas younger children (6- and 7-year-olds) cooperated in 78 of 252 trials (31%). Girls cooperated in 87 of 252 trials (35%), whereas boys cooperated in 73 of 246 trials (30%). When examining Trial 1 only, 21 of 83 children cooperated (25%).

In the silent condition, children cooperated in 176 of 492 trials in total (36%); older children cooperated in 78 of 234 trials (33%), whereas younger children cooperated in 98 of 258 trials (38%). Both girls and boys cooperated in 88 of 246 trials (36%). When examining Trial 1 only, 12 of 82 children cooperated (15%).

Are children more likely to cooperate after they communicate?

Contrary to our predictions, children's choices in the prisoner's dilemma game were predicted by neither condition [LRT, $\chi^2(1) = 0.725$, $p = .395$; Fig. 3A], nor age group [LRT, $\chi^2(1) = 0.000$, $p = .993$], nor gender [LRT, $\chi^2(1) = 0.400$, $p = .527$]. However, trial number predicted children's behavior; children were increasingly likely to cooperate over the six trials [LRT, $\chi^2(1) = 9.136$, $p = .003$; Fig. 3B].

Is behavior contingent on children's previous behavior?

When we examined whether the probability of cooperation in previous trials predicted cooperation in subsequent trials, we found an interaction between condition and previous behavior [LRT, $\chi^2(1) = 7.039$, $p = .008$; Table 1]. As Fig. 4 shows, in the communication condition, but not in the silent condition, children were more likely to cooperate in the prisoner's dilemma game when they had cooperated in a previous trial and were more likely to defect when they had defected previously (for a breakdown of the data by age group, see Fig. S6 in the supplementary material).

Do children's stated decisions influence final decisions?

When examining stated and final decisions in the communication condition, we found that children followed their stated decision more often than they reversed their decision (two-tailed exact binomial/sign test, $p < .001$; Fig. S3A); 58 of 83 participants (70%) followed their stated decision, for a total of 438 of 498 trials total (88%), whereas 25 of 83 participants (30%) reversed their decision,

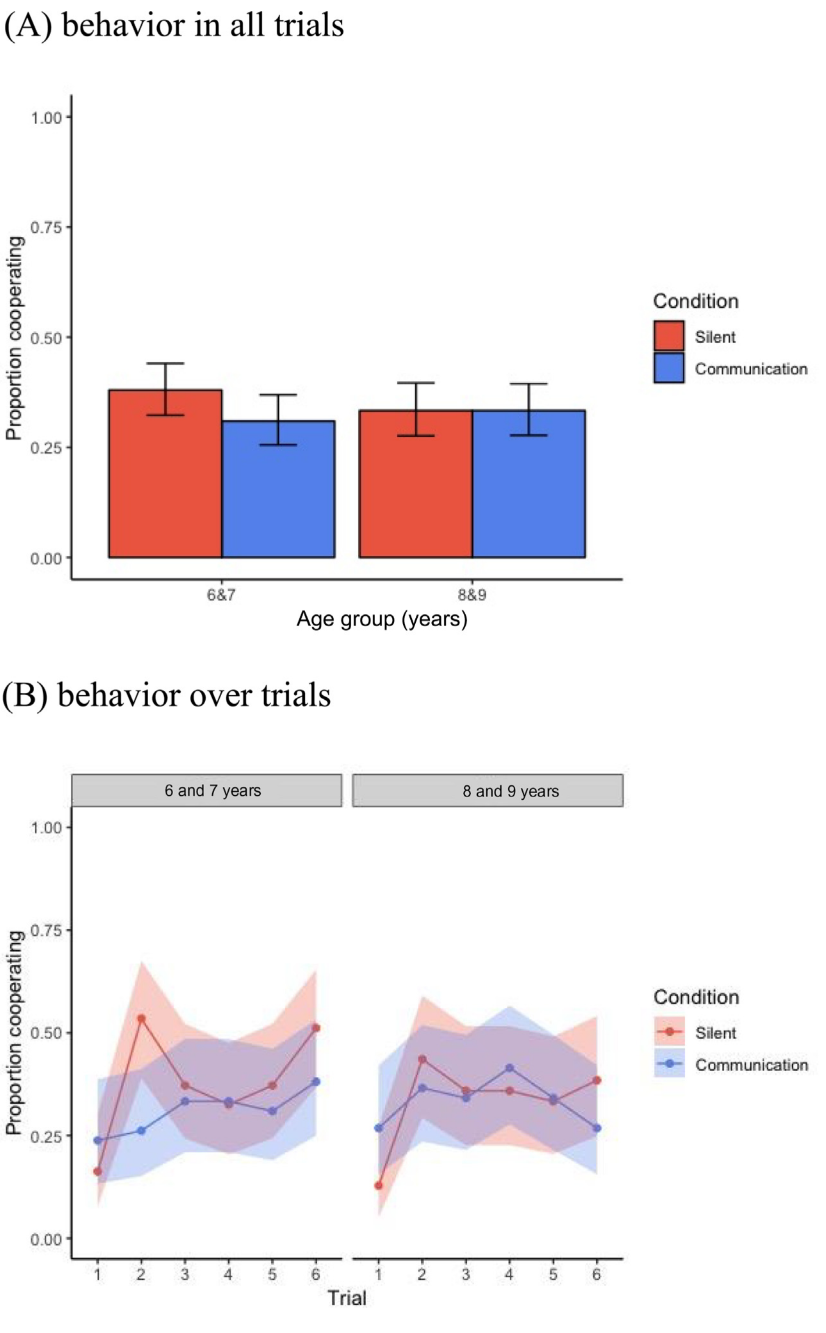

Fig. 3. Proportions of trials in which children cooperated across silent and communication conditions in all six trials shown by age group (A) and over trials shown by trial number and age group (B). Error bars show confidence intervals.

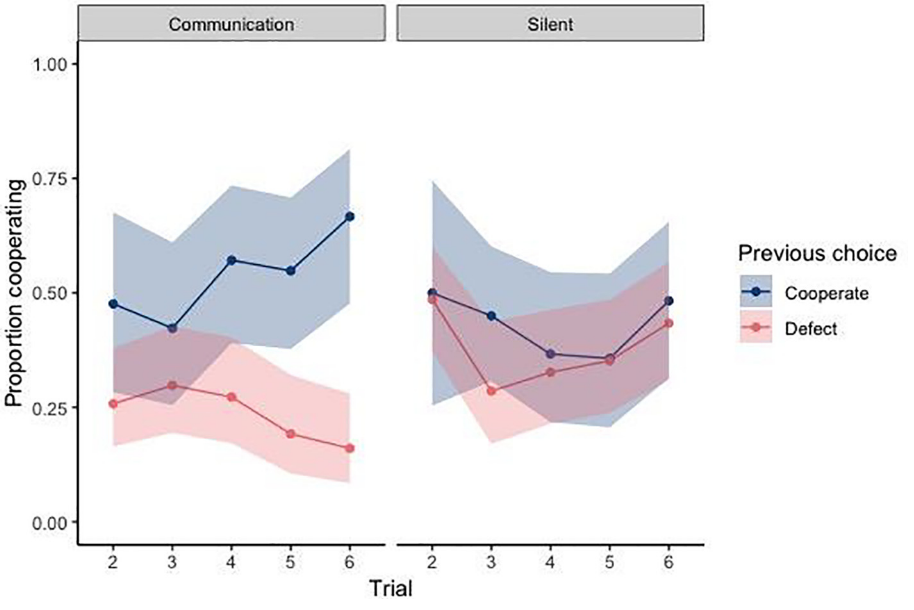

Fig. 4. Proportions of trials in which children cooperated after they had cooperated or defected in the previous trial across the communication and silent conditions. Proportions are shown per trial number. Error bars show confidence intervals.

for a total of 60 of 498 trials total (12%). When examining Trial 1 only, 8 of 83 participants reversed their decision (10%). Together, these results suggest that children were relatively honest about their intentions and were consistent about it throughout the game.

When examining stated and final decisions for only those participants who reversed their decisions, we found no difference between age groups (two-tailed exact binomial/sign test, $p = .699$; Fig. S3B); 6- and 7-year-old children reversed their decision in 32 of 60 trials (53%), with 20 of 32 trials in which they said they would cooperate but chose to defect (63%), whereas 8- and 9-year-old children reversed their decision in 28 of 60 trials (47%), with 16 of 28 trials in which they said they would cooperate but chose to defect (57%).

Further analyses of the different strategies children used revealed that children were no more likely to state that they would cooperate and then defected in the game than to state that they would defect and then cooperated (two-tailed exact binomial/sign test, $p = .155$; Fig. S3C); children stated that they would cooperate but defected in the game in 36 of 60 trials (60%), whereas children stated they would defect but cooperated in 24 of 60 trials (40%).

Do children make decisions based on group or individual benefits?

Children's responses to debrief questions revealed that they referred to individual transfer more often than joint transfer when asked both the cooperate question (30% vs. 17%; Fisher's exact test, $p = .039$; see Table S4 in the supplementary material) and the defect question (67% vs. 0%; Fisher's exact test, $p < .001$). When examining responses across conditions and age groups, we found that older children mentioned *individual transfer* significantly more in the defect question, and marginally more in the cooperate question, than younger children (defect question, Fisher's exact test, $p = .026$; cooperate question, $p = .064$; Table S4). No other comparisons were significantly different.

Discussion

Our study revealed two main findings. First, unlike adults in similar circumstances, children were not more cooperative when they could make a nonbinding commitment than when they did not have the opportunity to communicate. Second, children's decisions to cooperate were contingent on their previous behavior, and this relationship varied by condition; in the communication condition, but not in the silent condition, children were more likely to stick to their past behavior by cooperating if they had cooperated and by defecting if they had defected. In addition, children generally followed their stated decisions even though they could have reversed decisions with impunity.

Previous work on social dilemmas with adults has emphasized the importance of communication via discussion and commitment in promoting cooperation. Although communication, broadly defined, is known to play a similar role in children, research on the potential role of nonbinding commitment (i.e., a declaration of intended decision) in promoting children's cooperation in social dilemmas has only begun recently (Kachel & Tomasello, 2019). The goal of the current study was to capture this by designing a child-adapted version of the classic adult prisoner's dilemma game. Contrary to our predictions, we found no evidence that communication improved cooperation in children. This is an interesting finding in light of more recent adult findings that show the cooperation-enhancing effect of commitment in social dilemmas (reviewed in Kerr & Kaufman-Gilliland, 1994). In fact, commitment is so strong in adults that some have argued that it is as effective as if commitments are enforced (Radlow & Weidner, 1966). Our finding suggests that nonbinding commitments might not be as powerful in children as they are in adults.

It is surprising that children were not more likely to cooperate when they could verbally commit given recent results showing that children as young as 5 years not only understand the implications and obligations of commitments and adhere to them but also become more cooperative when they make commitments (regardless of whether those are explicit or implicit; Kachel & Tomasello, 2019). In addition, we know that children in the age range of our study are already concerned about their reputations (Engelmann, Herrmann, & Tomasello, 2016). Therefore, it is unlikely that our participants, who were older than in previous studies, failed to cooperate more in the game because they did not have an understanding of nonbinding commitment or did not care about their reputations. Instead, it may be that nonbinding commitment does not occur as spontaneously and frequently in children as it does in adults.

Another main finding of our study is that behavior was contingent on children's previous behavior in the communication condition but not in the silent condition. Specifically, children who had cooperated before were more likely to cooperate in the future, whereas those who had defected before were more likely to defect in the future. This result aligns nicely with previous work showing that 10- and 11-year-old children use conditional strategies when playing a computerized version of the prisoner's dilemma game (Blake et al., 2015). In this study, children were more likely to cooperate when their partner had cooperated in the previous trial than when they had defected. In other words, mutual cooperation in the past promoted mutual cooperation in the future. In our study, we found somewhat similar results in that children were more likely to cooperate after mutual cooperation, but only when they could communicate, suggesting that there was something about making their intention public that reinforced their own behavior in the game. This further indicates that children do not want to appear hypocritical (in either direction), which aligns with our result that they rarely reversed their decisions in the game. Together, our results support previous findings showing that children may learn about their own preferences from observing their past behavior (Bem, 1967) and that they are more likely to be generous in the future when they can perceive themselves as generous partners (Chernyak & Kushnir, 2013). Alternatively, and non-mutually exclusive to our previous point, children may simply continue to cooperate or defect because they want to stay self-consistent in front of the experimenter, their partner, and/or other audience members (Eisenberg, Cialdini, McCreath, & Shell, 1987).

The finding that children rarely reversed their decisions in the communication condition is interesting and worth exploring further. Children mostly defected in the game and were honest about their intentions to do so. Specifically, similar numbers of children committed to defect (77%) or cooperate

(23%) as defected (75%) or cooperated (25%), respectively, in the game. This is interesting in light of the results from Dawes et al.'s (1977) study showing that adults typically commit to cooperate (100%), yet they are much less likely to end up cooperating in the game (73%). These results suggest that children are more honest than adults under similar conditions, lending support to our claim that children were consistent in their responses to avoid appearing hypocritical. Of course, an alternative explanation is that children were being more "honest" because they were incapable of deceiving their partner. However, we believe that this is unlikely given existing evidence that children begin to tell lies at a very young age (Evans & Lee, 2013; for a review, see Lee, 2013). Therefore, we believe that children in our study could have deceived their partner if they wanted to do so. This is an area that would benefit from future empirical exploration.

Previous research has shown that when children can communicate freely, they often inform others about their intentions (e.g., via joint agreements), which in turn promotes cooperation. In this regard, our findings are somewhat puzzling. Why did we not find any direct effect of communication on cooperative behavior in our study? After all, we initially hypothesized that giving participants the opportunity to communicate their intended decision prior to making a decision would increase cooperation by reducing uncertainty about the outcome of the game while increasing trust toward the partner. We propose two non-mutually exclusive explanations for why there was no effect of nonbinding commitment in our study: the presence of an adult partner and the fact that the partner always cooperated in the game. Note that we chose to have the partner cooperate on each trial because our primary goal was to maximize the likelihood that participants would find the highest combined payoff in the game. Supporting this, previous work on the prisoner's dilemma game and other social dilemmas has shown that children are more likely to cooperate if the partner cooperates (i.e., they use conditional cooperation strategies; Blake et al., 2015; Hermes et al., 2019). Nevertheless, these two explanations are worth exploring.

Regarding the first possibility, the presence of an adult partner may have influenced children's behavior in two non-mutually exclusive ways. First, playing with an adult may have increased children's motivation to cooperate. Supporting this hypothesis, previous findings have shown that children not only give priority to adult authority over peer authority (Laupa & Turiel, 1986) but also engage in selective learning from adult models over peer models (especially in the context of games; Rakoczy, Hamann, Warneken, & Tomasello, 2010). Therefore, it is reasonable to assume that children would cooperate more when paired with an adult partner. Second, if children perceived the adult partner as someone who was genuinely cooperative and who had good intentions, perhaps they believed that the partner wanted to help them get their favorite toy, thereby reinforcing their decision to defect in the game in order to reach this goal. However, because the rates of cooperation in our study (up to 36%) are situated within the range of those found in previous studies on children and the iterated prisoner's dilemma game, most of which did not involve adult partners (Blake et al., 2015; Cárdenas, Dreber, von Essen, & Ranehill, 2014; Fan, 2000; Matsumoto et al., 1986), it seems unlikely that either explanation can account for children's behavior in our task.

Regarding the fact that the confederate partner always cooperated in the game, children may have learned over time and thus *anticipated* that the partner would always cooperate. If they picked up on this pattern, having the opportunity to communicate or not becomes irrelevant to motivate children's decisions in the game. In other words, the partner's unconditional cooperation may have attenuated the effect of nonbinding commitment on cooperation. Alternatively, it is possible that by making the partner unconditionally cooperative, we unintentionally created a situation in which children understood that they could take advantage of the partner's cooperation for their own benefit; that is, they had the insight that defection was the best strategy in the face of unconditional cooperation. In this case, the temptation to defect may have been too high for children to prefer cooperation. However, we believe that this explanation is unlikely to account fully for our findings for two reasons. First, if children wanted to take advantage of the situation, we would see higher rates of defection over time, which we did not observe (Fig. 3B). Second, if nonbinding commitment had an effect that was obscured by the partner's unconditional cooperation, we would expect higher rates of cooperation in Trial 1 compared with subsequent trials specifically in the communication condition. However, in an exploration of these trial effects, we did not see this pattern of results. Specifically, when examining the percentage of cooperation across trials, children cooperated on 25% of first trials (21 of 83 trials) and on 33% of subsequent trials (139 of 415 trials). Thus, it does not seem as though children were more likely to cooperate on their first trial prior to experiencing the partner's unconditional cooperation.

Finally, our results should be viewed in light of the possibility that some aspects of our procedure could explain the absence of an effect of verbal nonbinding commitment on cooperation. First, and most importantly, unlike more classic studies on communication in social dilemmas (e.g., Dawes et al., 1977; Grueneisen & Tomasello, 2017), discussion in our study was discouraged. Thus, it remains possible that giving children the opportunity for unrestricted discussion would have promoted cooperation in the game. Of course, the latter would not have tested the specific aspect of communication—nonbinding commitments—that we wished to explore. However, future work should certainly seek to better understand the different kinds of communication that may influence children's cooperation in this context.

Second, we note that, despite our effort to design a child-friendly version of the prisoner's dilemma game, this paradigm still remains a relatively complex cooperative scenario. In particular, the prisoner's dilemma game differs from other social dilemmas (e.g., stag hunt game, snowdrift game) in that the risks associated with playing the cooperative option in the game make it more difficult to achieve mutual cooperation (if one partner cooperates and the other defects, the defector gets everything and the cooperator gets nothing). Therefore, it is possible that our weak effect of commitment on cooperation was due to the children's primary preference for defection in the game (regardless of whether they could verbally commit or not). Thus, we encourage future work to extend our study using different social dilemma paradigms.

Third, unlike most work on the effects of communication with adults, we employed a confederate partner as opposed to studying spontaneous behavior from two participant players. Therefore, it would be interesting to investigate whether replacing the confederate with a real partner—a peer (e.g., Kachel & Tomasello, 2019) or otherwise—would change our pattern of results. In addition, to our knowledge, no study so far has ever compared whether—and, if so, how—*playing* with an adult versus peer partner influences children's cooperative behavior in social dilemmas. Thus, we view this as a fruitful avenue for future work.

In conclusion, our findings suggest that nonbinding commitments are more limited in their effects on cooperation in children than in adults. Our results contribute to the large body of work that has explored the positive effect of nonbinding commitment on cooperation in adults and the growing literature on the effect of communication on children's cooperative decisions in social dilemmas. The current findings add to the developmental literature in important ways, suggesting that some aspects of communication might not work as well in children as in adults, paving the way for future work in this area. More broadly, these results contribute to our emerging understanding of the ways in which children begin to solve social dilemmas.

Data availability

The data and code are available at the following link: https://osf.io/z4njf/?view_only=8152b582245a4f1bbbdcbf0669691534.

Acknowledgments

L.P. was funded by a Swiss National Science Foundation (SNSF) mobility fellowship (P2SKP1_174803). K.M. was funded by an Azrieli Global Scholar award from the Canadian Institute for Advanced Research. We thank all our participants and their families for making this study possible. We are also grateful to Peter Blake for feedback on an earlier version of the manuscript, Justin Martin and Linda Chang for their help with the sensitivity analysis, Daniel Gil and Quinlan Taylor for being the confederate partners, the many research assistants who helped with the study, and Scott Mackie for his help in designing the apparatus.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jecp.2020.104947.

References

Ahl, R. E., Duong, S., & Dunham, Y. (2019). Children employ wealth cues when predicting others' sharing. *Developmental Psychology, 55*, 303–314.

Axelrod, R., & Hamilton, W. D. (1981). The evolution of cooperation. *Science, 211*, 1390–1396.

Balliet, D. (2010). Communication and cooperation in social dilemmas: A meta-analytic review. *Journal of Conflict Resolution, 54*, 39–57.

Bates, D., Mächler, M., Bolker, B., & Walker, S. (2014). Fitting linear mixed-effects models using lme4. ArXiv. Retrieved from http://arxiv.org/abs/1406.5823.

Bem, D. J. (1967). Self-perception: An alternative interpretation of cognitive dissonance phenomena. *Psychological Review, 74*, 183–200.

Blake, P. R., Rand, D. G., Tingley, D., & Warneken, F. (2015). The shadow of the future promotes cooperation in a repeated prisoner's dilemma for children. *Scientific Reports, 5*, 14559.

Bolker, B. M., Brooks, M. E., Clark, C. J., Geange, S. W., Poulsen, J. R., Stevens, M. H. H., & White, J.-S. S. (2009). Generalized linear mixed models: A practical guide for ecology and evolution. *Trends in Ecology & Evolution, 24*, 127–135.

Cárdenas, J. C., Dreber, A., von Essen, E., & Ranehill, E. (2014). Gender and cooperation in children: Experiments in Colombia and Sweden. *PLoS One, 9*(3), e90923.

Chernyak, N., & Kushnir, T. (2013). Giving preschoolers choice increases sharing behavior. *Psychological Science, 24*, 1971–1979.

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

Dawes, R. M., McTavish, J., & Shaklee, H. (1977). Behavior, communication, and assumptions about other people's behavior in a commons dilemma situation. *Journal of Personality and Social Psychology, 35*, 1–11.

Deutsch, M. (1958). Trust and suspicion. *Journal of Conflict Resolution, 2*, 265–279.

Downs, A., & Smith, T. (2004). Emotional understanding, cooperation, and social behavior in high-functioning children with autism. *Journal of Autism and Developmental Disorders, 34*, 625–635.

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

Dunham, Y., & Schulz, J. (2017, June). Mapping the links between self-control and cooperation. Paper presented at the Philosophy and Science of Self Control Capstone Conference, Tallahassee, FL.

Eisenberg, N., Cialdini, R. B., McCreath, H., & Shell, R. (1987). Consistency-based compliance: When and why do children become vulnerable? *Journal of Personality and Social Psychology, 52*, 1174–1181.

Engelmann, J. M., Herrmann, E., & Tomasello, M. (2016). The effects of being watched on resource acquisition in chimpanzees and human children. *Animal Cognition, 19*, 147–151.

Evans, A. D., & Lee, K. (2010). Promising to tell the truth makes 8- to 16-year-olds more honest. *Behavioral Sciences & the Law, 28*, 801–811.

Evans, A. D., & Lee, K. (2013). Emergence of lying in very young children. *Developmental Psychology, 49*, 1958–1963.

Fan, C. P. (2000). Teaching children cooperation — An application of experimental game theory. *Journal of Economic Behavior & Organization, 41*, 191–209.

Flood, M., Dresher, M., & Tucker, A. (2010). Prisoner's dilemma: Game theory. Beau Bassin: Betascript Publishing. (Original work published 1950).

Gräfenhain, M., Behne, T., Carpenter, M., & Tomasello, M. (2009). Young children's understanding of joint commitments. *Developmental Psychology, 45*, 1430–1443.

Grueneisen, S., & Tomasello, M. (2017). Children coordinate in a recurrent social dilemma by taking turns and along dominance asymmetries. *Developmental Psychology, 53*, 265–273.

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

Hardin, G. (1968). The tragedy of the commons. *Science, 162*, 1243–1248.

Hermes, H., Hett, F., Mechtel, M., Schmidt, F., Schunk, D., & Wagner, V. (2019). Do children cooperate conditionally? Adapting the strategy method for first-graders. *Journal of Economic Behavior & Organization*. https://doi.org/10.1016/j.jebo.2018.12.032. Advance online publication.

Heyman, G. D., Fu, G., Lin, J., Qian, M. K., & Lee, K. (2015). Eliciting promises from children reduces cheating. *Journal of Experimental Child Psychology, 139*, 242–248.

Isella, M., Kanngiesser, P., & Tomasello, M. (2018). Children's selective trust in promises. *Child Development, 90*, e868–e887.

Kachel, U., Svetlova, M., & Tomasello, M. (2018). Three-year-olds' reactions to a partner's failure to perform her role in a joint commitment. *Child Development, 89*, 1691–1703.

Kachel, U., & Tomasello, M. (2019). 3- and 5-year-old children's adherence to explicit and implicit joint commitments. *Developmental Psychology, 55*, 80–88.

Kanngiesser, P., Köymen, B., & Tomasello, M. (2017). Young children mostly keep, and expect others to keep, their promises. *Journal of Experimental Child Psychology, 159*, 140–158.

Kerr, N. L., & Kaufman-Gilliland, C. M. (1994). Communication, commitment, and cooperation in social dilemma. *Journal of Personality and Social Psychology, 66*, 513–529.

Koomen, R., & Herrmann, E. (2018). An investigation of children's strategies for overcoming the tragedy of the commons. *Nature Human Behaviour, 2*, 348–355.

Laupa, M., & Turiel, E. (1986). Children's conceptions of adult and peer authority. *Child Development, 57*, 405–412.

Lee, K. (2013). Little liars: Development of verbal deception in children. *Child Development Perspectives, 7*, 91–96.
Li, J., Zhu, L., & Gummerum, M. (2014). The relationship between moral judgment and cooperation in children with high-functioning autism. *Scientific Reports, 4*, 4314.
Lyon, T. D., Malloy, L. C., Quas, J. A., & Talwar, V. A. (2008). Coaching, truth induction, and young maltreated children's false allegations and false denials. *Child Development, 79*, 914–929.
Matsumoto, D., Haan, N., Yabrove, G., Theodorou, P., & Carney, C. C. (1986). Preschoolers' moral actions and emotions in prisoner's dilemma. *Developmental Psychology, 22*, 663–670.
Messick, D. M., Wilke, H., Brewer, M. B., Kramer, R. M., Zemke, P. E., & Lui, L. (1983). Individual adaptations and structural change as solutions to social dilemmas. *Journal of Personality and Social Psychology, 44*, 294–309.
Ostrom, E. (1990). *Governing the commons: The evolution of institutions for collective action*. Cambridge, UK: Cambridge University Press.
Ostrom, E. (2001). Social dilemmas and human behaviour. In R. Noë, J. A. R. A. M. van Hooff, & P. Hammerstein (Eds.), *Economics in nature: Social dilemmas, mate choice and biological markets* (pp. 23–41). Cambridge, UK: Cambridge University Press.
Prétôt, L., Gonzalez, G., & McAuliffe, K. (2020). Children avoid inefficient but fair partners in a cooperative game. *Scientific Reports, 10*, 10511.
R Core Team (2018). *R: A language and environment for statistical computing*. Vienna, Austria: R Foundation for Statistical Computing.
Radlow, R., & Weidner, M. F. (1966). Unenforced commitments in "cooperative" and "noncooperative" non-constant-sum games. *Journal of Conflict Resolution, 10*, 497–505.
Rakoczy, H., Hamann, K., Warneken, F., & Tomasello, M. (2010). Bigger knows better: Young children selectively learn rule games from adults rather than from peers. *British Journal of Developmental Psychology, 28*, 785–798.
Rakoczy, H., & Schmidt, M. F. H. (2013). The early ontogeny of social norms. *Child Development Perspectives, 7*, 17–21.
Rand, D. G., & Nowak, M. A. (2013). Human cooperation. *Trends in Cognitive Sciences, 17*, 413–425.
Sally, D. (1995). Conversation and cooperation in social dilemmas: A meta-analysis of experiments from 1958 to 1992. *Rationality and Society, 7*, 58–92.
Sally, D., & Hill, E. (2006). The development of interpersonal strategy: Autism, theory-of-mind, cooperation and fairness. *Journal of Economic Psychology, 27*, 73–97.
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*, 20170259.
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*, 46–54.
Siposova, B., Tomasello, M., & Carpenter, M. (2018). Communicative eye contact signals a commitment to cooperate for young children. *Cognition, 179*, 192–201.
Talwar, V., Lee, K., Bala, N., & Lindsay, R. C. L. (2002). Children's conceptual knowledge of lying and its relation to their actual behaviors: Implications for court competence examinations. *Law and Human Behavior, 26*, 395–415.
Talwar, V., Lee, K., Bala, N., & Lindsay, R. C. L. (2004). Children's lie-telling to conceal a parent's transgression: Legal implications. *Law and Human Behavior, 28*, 411–435.
Van Lange, P. A. M., & Joireman, J. A. (2008). How we can promote behavior that serves all of us in the future: Social and temporal orientations. *Social Issues and Policy Review, 2*, 127–157.
West, S. A., Griffin, A. S., & Gardner, A. (2007). Social semantics: Altruism, cooperation, mutualism, strong reciprocity and group selection. *Journal of Evolutionary Biology, 20*, 415–432.
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*, 597–610.