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Slingshot Challenge and Star Mines: Two digital games as a prisoner's dilemma to assess cooperation in children

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Abstract

The prisoner's dilemma (PD) has been widely adopted by researchers to investigate cooperation among adults and children. However, studies using the PD with children are not as extensive as experiments with adults. The main aim of this work was to introduce and show the feasibility and validity of two digital games with the structural features of a PD (Slingshot Challenge [SC] and Star Mines [SM]) to investigate children's cooperative behavior. In two experiments, 162 children aged 6 to 12 years played SC and SM in different conditions. It was observed that children understood the dynamics of a PD, and were highly motivated to play SC and SM. We found that participants were more cooperative playing SM than SC and cooperated conditionally as well. We also found that sex and first-trial cooperation were associated with higher levels of cooperation. The results support the utility of SC and SM as feasible, reliable, and valid instruments for assessing cooperative behavior in childhood.

Keywords Prisoner's dilemma · Digital games · Cooperation · Children

Introduction

Primates frequently engage in joint activities in order to accomplish tasks important to the group's maintenance which could not be achieved individually. However, only human beings seem to be capable of using communication to extend and coordinate their cooperative relationships over time (Moll& Tomasello, 2007; Tomasello, 2014; Wyman et al., 2013). From an early age, children show high motivation to engage in prosocial behaviors such as helping others, sharing valuable resources, and comforting (Vaish et al., 2010; Warneken& Tomasello, 2009). Also, they can coordinate their actions with a partner during a cooperative task when there is a common objective to be fulfilled, although they do not fully understand the reasons for adopting these costly behaviors (Brownell et al., 2006).

Some academics state that this tendency indicates that cooperation has evolutionary roots that are important in explaining the way children's moral judgments and sharing behaviors change during childhood. Indeed, young children (aged 3–4) understand norms of fairness (Damon, 1980; Smith et al., 2013), although they prefer distributions that favor themselves (Chernyak et al., 2017; Reis& Sampaio, 2019). On the other hand, the 7–8-year-olds adopt strictly egalitarian distributions, even when they have the chance of benefiting themselves from the inequality (Blake& McAuliffe, 2011; Blake& Rand, 2010; Fehr et al., 2008; Williams& Moore, 2014). Moreover, merit, amount of available resources, and the number of recipients become important variables in middle childhood that are considered in children's decisions about sharing (Posid et al., 2015; Sampaio& Camino, 2017).

Despite the evident egocentrism present in early childhood, even young children give more resources to partners who have previously given resources to them (Vogelsang& Tomasello, 2016). This conditional cooperation tends to increase as children get older (Keil et al., 2017). There is also some evidence of gender differences in children's cooperation: boys show more conditional cooperation and tend to be more dominant, while girls are more altruistic and egalitarian with their partners (Fehr et al., 2013; Hong et al., 2012). However, in a distributive situation in which the expectation of future

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interaction is low, children may be tempted to cheat, getting bigger payoffs (Alencar et al., 2008). Moreover, previous studies have shown that when anonymity is a possibility, children tend to share less than when their behaviors are known by other people (Grocke et al., 2019; Rapp et al., 2019; Sampaio& Pires, 2015). Thus, the prisoner's dilemma (PD) seems an interesting tool for investigating children's cooperation, because it does not constrain the selfish behavior that might emerge when someone decides not to cooperate.

Studies using the PD as a research method are already well-established and have produced significant insights that help explain human cooperation (Cárdenas et al., 2014; Fan, 2000; Lergetporer et al., 2014). The typical structure of a PD demands players to trust each other, and coordinate their perspectives since if both defect, they will be in a worse state than if they had cooperated with each other. In its classic conception (Rapoport& Chammah, 1965) individuals interact only once, with no expectation of new interactions with the same partner; accordingly, in a one-shot PD there is a tendency towards self-interested decisions. On the other way, cooperative behavior tends to increase when players know they will interact with each other repeatedly (an "iterated version" of PD) (Bó, 2005; Lange et al., 2011). Axelrod (1984) named it the "shadow of the future effect".

Studies demonstrated that simultaneous adult players tend to be more cooperative than second players of a sequential PD only when the outcomes are trivial (e.g., scores). On the other hand, first players tend to be more cooperative than simultaneous players when the outcomes are nontrivial (e.g., money) (Kiyonari et al., 2000). One reason for this is that when people play an iterated version of PD, they tend to play it as an assurance game (AG), in which cooperation produces better outcomes when both partners cooperate, in contrast to PD, in which defection is the dominant choice. This subjective transformation of PD in an AG diminishes selfish desires to defect and increases motivation to seek cooperation with the partner.

Studies using the PD with children are not as extensive as those with adults, particularly its iterated version. This may be due to children's difficulty in understanding this kind of game, or their lack of engagement when dealing with social dilemmas. Nonetheless, previous work has shown that children are able to act morally and coordinate perspective in a PD, provided that instructions are adapted (Fan, 2000) and their behavior is intensively monitored while they are playing (Matsumoto et al., 1986; Tedeschi et al., 1969).

For example, Fan (2000) found age effects in cooperation during a 10-round simultaneous PD, with 10- to 11-year-olds being more cooperative than their counterparts of 7 to 9 years. Also, the author showed that older children were generally more cooperative after an intervention in which they received a moral lecture explaining that mutual defection could increase personal gains, but only until the partner realized this and decided to no longer cooperate. Lergetporer et al. (2014) demonstrated that 7- to 11-year-olds' cooperation and their trust in the partner's willingness to cooperate increased when they played a simultaneous one-shot PD in the presence of a third party who might punish defection. Finally, Prétôt and McAuliffe (2020) observed that when children had the opportunity to communicate their decision before playing a simultaneous PD, they tended to cooperate and to defect more when they had cooperated and defected more in the first trials, respectively. Also, children were more cooperative after mutual cooperation, and cooperation increased over the six trials of the game.

Some challenges faced by researchers interested in investigating children's cooperation using PD involve the use of scenarios presented in physical labs, which reduces immersion (i.e., players are aware they are being part of an experiment, and not in an economic interaction with other real people) and forces children to act constrained, in order to maintain their moral reputation. The number of interactions between players and the small sizes and low variability of the samples are additional limitations in traditional studies. In this regard, digital tools may help to overcome these barriers, lowering costs of research, improving control over experimental conditions, and increasing the chance of recruiting a greater number of participants in a short period of time (Horton et al., 2011; Janssen et al., 2014; Rand, 2011).

Previous research shows the validity and feasibility of using digital tools to assess cooperation in adults. For instance, Horton et al. (2011) found no significant differences in the cooperative behavior of participants recruited either from Amazon Mechanical Turk (Mturk) or undergraduate courses of Harvard University. Amir et al. (2012) observed similar results to those found in experiments conducted in physical laboratories regarding the effects of payoff manipulations on adults' donation behavior during four economic games.

On the other hand, few experiments used digital tools for testing children's cooperation in the context of a PD. For instance, Sally and Hill (2006) used a computer-adapted version of a repeated PD to test cooperation in normally developed children and children with Autism Spectrum Disorder (ASD), and detected that 6-year-olds without ASD were less likely to cooperate in the first trial, but increased their mean rate of cooperation over the subsequent other 15 trials. On the other hand, 8- to 10-year-olds were more cooperative in the beginning and became more competitive throughout the game rounds. Blake et al. (2015) designed a graphical interface to investigate conditional cooperation in 10- to 11-year-olds and observed an increase in cooperation when participants knew they would play again with the same partners, instead of having a single interaction. This provides evidence of the shadow of the future at that age. Although this work demonstrates the feasibility of using that interface for future investigation, we consider that the field of research on children's cooperation might benefit from the use of digital tools with more familiar scenarios, closer to lifelike situations.

In the context of this research, we opted for developing a casual game (Kultima, 2009) because it is fun, simple, and easy to learn and play, consequently encompassing a diverse audience. This type of game is also easier to develop, maintaining flexibility for game creation and following a wide variety of mechanics and game modes. Additionally, children's familiarity and motivation to use digital tools nowadays is evident, especially in the case of mobile apps and devices. These aspects need to be considered by investigators during the design and interpretation of experiments. Thus, in the present work, we expected that presenting the PD in an intuitive manner would make it easier for children to understand its structural features.

The primary aim of this work was to introduce and show the feasibility and validity of two digital games (Slingshot Challenge and Star Mines) to investigate children's cooperation in the context of a PD particularly children younger than 10 years. As a second objective, we aimed to enhance our comprehension about the developmental trends of cooperation during childhood, testing the effects of gender on cooperative behavior during a PD. Third, we sought to produce more evidence concerning the "shadow of the future effect" during childhood, comparing conditional cooperation in one-shot versus iterated versions of the game. In order to reach these goals, we conducted two experiments with children from 6 to 12 years old where participants were instructed about the rules of both games and played a predetermined number of rounds.

Experiment 1

Method

Participants

Participants were 98 children (55 boys), ranging from 6 to 11 years old (M_{age} = 9.04; SD = 1.47) from the cities of Petrolina (78%) and Recife (22%) in Pernambuco, Brazil. Parents consented and children assented to participate. Due to procedural problems (the server received incomplete data from the matches, children had not answered the questions properly, or both), nine children were removed from the sample. The final sample comprised 89 children (47 boys) ranging in age from 6 to 11 years (M_{age} = 9.04; SD = 1.42). Thus, in the present study we aimed to evaluate whether the digital tools developed in this work would be valid for testing cooperative behavior from the age of 6.

Instruments

The Slingshot Challenge game

Slingshot Challenge (SC) is a casual shooter game that can be played in single-player or multiplayer mode. It has very straightforward gameplay, which simply consists in trying to hit cans using a slingshot. Each player has a specific color, and their slingshots and cans are colored accordingly. For each can hit, the player who has the same color earns one point. White cans are neutral, so players do not score with them. In Fig. 1C, it is the red player's turn, as one can see by the slingshot color. In this case, he/she earns one point for each red can hit, and the blue player gives one point for each blue can he/she hits.

At each round, there are two sets of three stacked cans on the right (Fig. 1B) and left sides (Fig. 1A) of a wall, and players can only aim at one of the stacks. An earlier version of this game was presented in Martins et al. (2017).

The way the cans are arranged may turn this game into a PD scenario. In this study, we put one can with the player color on one side (Fig. 1A), and two cans with the opponent color on the other side (Fig. 1B). Thus, aiming to hit the other player's cans represents cooperation, while defection is represented by aiming at their own set of cans. The cans were configured to transform the resulting score into a PD's payoff matrix (Table 1).

In order to keep the same number of cans on each side, white cans were included in each stack. Thus, on the player's side of the screen there were always one can of their own color, and two white cans, while on the other side there were always two cans of the opponent's color, and one white can. Figure 2 shows examples of SC gameplay screenshots.

As Slingshot Challenge was designed to be played in turns, participants decide whether to cooperate or not, already knowing how the opponent had played before. Children always made the first decision when they played Slingshot Challenge.

The Star Mines game

Star Mines (SM) is an action game that can also be played in a single-player or multiplayer mode. The goal of this game is to collect as many stars as possible. Players get one point for each star collected. There are two sets of stars falling from the sky apart from each other at two sides (Fig. 3A). Each set can be collected with a mine car (Fig. 3B). Players can drag the car either to the right or to the left. As the stars are falling at both sides, players have to decide to which side of the screen they will move their cars to catch the stars. When stars start falling, each player can only see what is happening on his/her side of the screen, because the other side is blocked by a heavy fog (Fig. 3C), namely they do not know the opponent's decision.

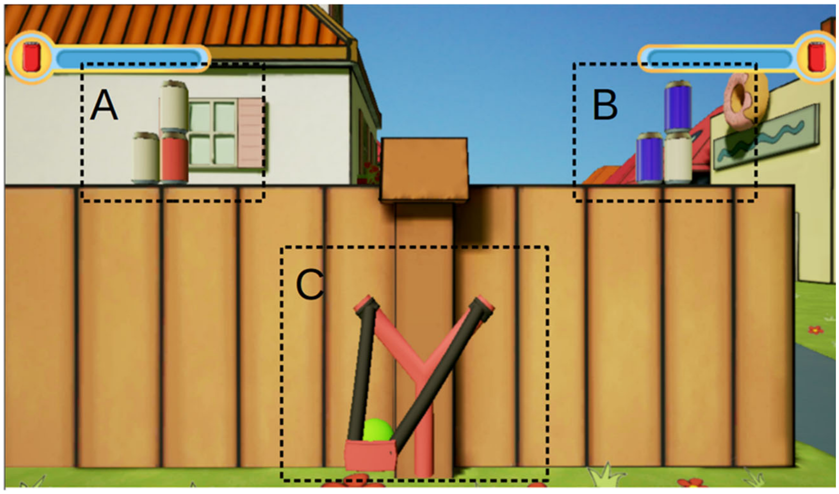

Fig. 1 Screenshot of the Slingshot Challenge gameplay showing stacked cans on the left (**A**) and on the right (**B**), with the red player aiming at the opponent's blue cans (**C**)

Considering these two options, if the player moves the car to the left side, the car stands on a stable rail (Fig. 4A); however, if the car is moved to the right side, it stands on an unstable platform (Fig. 4B) that is balanced only when there are two cars on it (Fig. 5).

Thus, if the player decides to move the car to the left, they will be sure to collect all stars falling on that side (Fig. 4A highlighted in red) and lose the other ones, but if the car is moved to the right, the number of stars collected will depend on the other player's decision. That is because if there is just one car on the platform, it tilts and the car falls down making that the stars that would be lost bounce on the platform edge and fall into the other player's car (Fig. 6), so the opponent catches her/his stars plus the other player's stars. But, if there are two cars on the unstable platform, it stabilizes and both collect all the stars that are falling at that side, respectively (Fig. 5).

To turn the dynamics of this game into another PD, the number of stars falling from each side was manipulated: one star falls on the left side, and two stars fall on the right side. Thus, dragging the car to the unstable platform (right side) represents cooperation, and defection is represented by dragging the car to the stable rail (left side). These scenes described are mirrored for the other player's perspective, resulting the same payoff matrix as described earlier (Table 1).

Table 1 Payoff matrix for Slingshot Challenge and Star Mines

		Player 1	
		Cooperation	Defect
Player 2	Cooperation	2, 2	0, 3
	Defect	3, 0	1, 1

Unlike Slingshot Challenge, in Star Mines, decisions are made simultaneously, without players knowing to which side the other player will drag his/her car. There is another distinct aspect in this game: because stars fall, players have limited time to make their decisions before stars get to the ground. Thus, if a player takes too long to decide and does not drag the car in time, the respective car will freeze, and no star will be collected by the delayed player. Consequently, if the other player decides to cooperate dragging the car to the platform, he/she will lose the stars too.

Both games were designed to have a first-person perspective rendered from the viewpoint of the player, because this allows players to identify themselves as actors during the game. In addition, it avoids issues like physical appearance of characters. SC and SM were developed for mobile devices because touchscreen interfaces are very familiar to children. Thus, throwing stones and dragging the cars would be intuitive to them (Martins et al., 2017).

Children played the games using 7-inch tablets and were instructed that they would receive stickers at the end of the experiment, but the number of stickers would depend on how many points they got: the more points they got, the more stickers they would receive. Stickers have been used to reward children for their participation and encourage them to behave as in an actual scenario in cooperation studies (Blake& Rand, 2010; Smith et al., 2013). Participants also answered two questions about the games: whether they had fun playing the games (using a four-point Likert scale from "no fun at all" to "very fun"), and which game they preferred.

Procedures

Data collection was conducted by four trained researchers at the children's schools. Children went to a separate room to play the games, and the experimenters told the participants

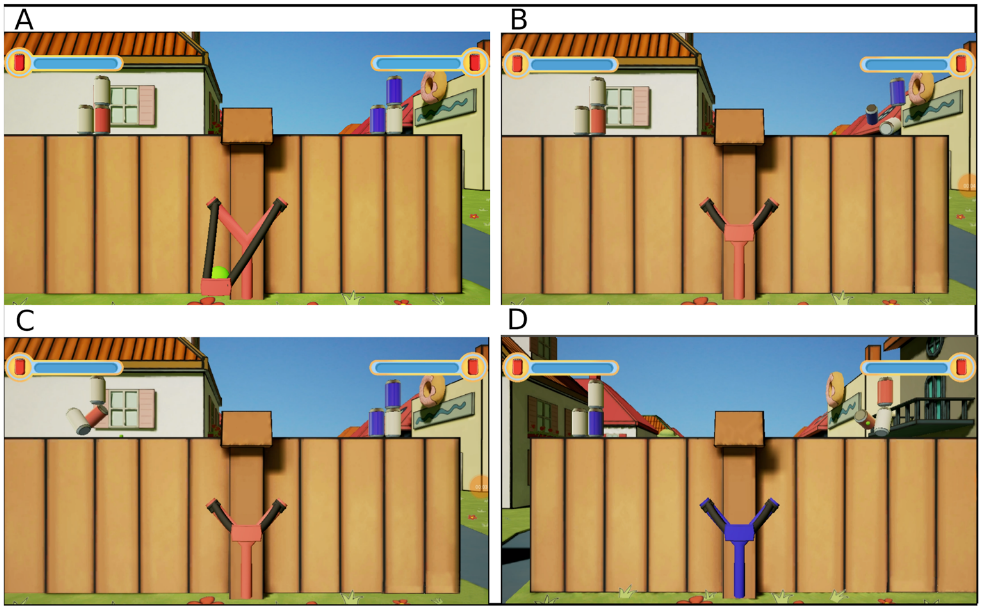

Fig. 2 Screenshots of the Slingshot Challenge gameplay. (**A**) Player 1 (red) aims at player 2's cans (blue). (**B**) Player 1 hits player 2's cans, and player 2 gains two points. (**C**) Player 1 hits their own cans, and player 1 gains one point. (**D**) Player 2 hits player 1's cans, and player 1 gains two points.

that they would be playing two games in which they would earn points that could be exchanged for stickers at the end. Also, children were informed they would play an online game with another child who was not at the school, so they would never meet the other player. However, they actually played against a non-player character (NPC) controlled by the software. Then, the experimenter explained how the games worked (one at a time), and showed a 60" video for each game (Supplemental Material: links for the videos of Slingshot Challenge and Star Mines gameplay). In these videos, all four possible combinations of decisions in the PD were illustrated in the following order:

(1) P1 cooperates and P2 cooperates; (2) P1 defects and P2 defects; (3) P1 cooperates and P2 defects; and (4) P1 defects and P2 cooperates.

For each combination, videos were paused to explain what the participant and their partner could do in each situation. Then, children were free to ask questions if doubts came about. After the explanation phase, the experimenter asked the following comprehension questions:

- *It is your turn. If you hit these cans (pointing to the participant's cans) who would gain the points? How many points would be gained?*

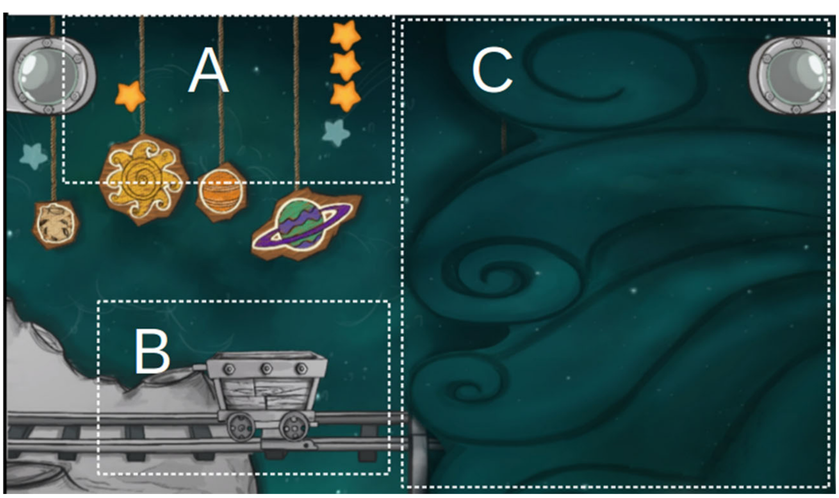

Fig. 3 Screenshot of the beginning of the Star Mines game before players' decisions

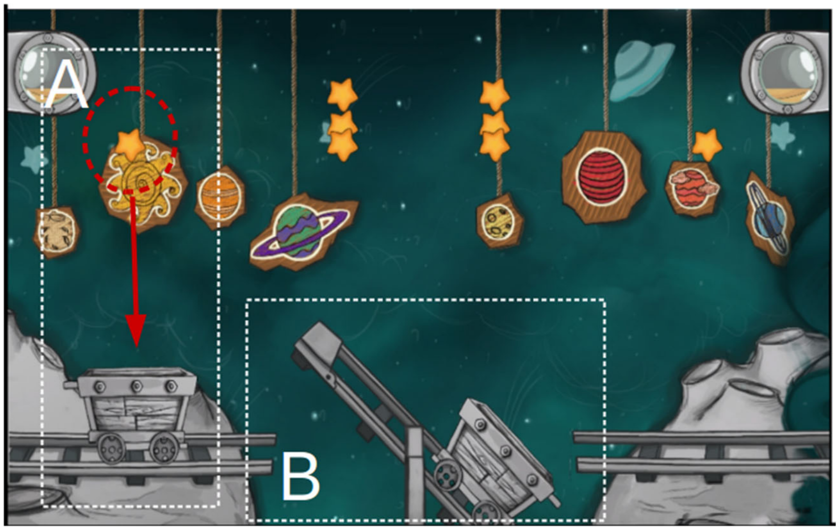

Fig. 4 Mine car dragged to the left standing on a stable rail (**A**) and the opponent's car falling due to the tilted platform (**B**)

- *If you hit these cans (pointing to the partner's cans), who would gain the points? How many points would be gained?*
- *Now it is the other child's turn. If he/she hits these cans (pointing to the participant's cans) who would gain the points? How many points would be gained?*
- *If he/she hits these cans (pointing to the partner ' s cans) who would gain the points? How many points would be gained?*

For Star Mines, the same structure was followed, changing the expressions "…hits these cans" for "…drags the car to this side." If the child answered incorrectly, the videos were displayed again, and the four comprehension questions were asked once more. When full comprehension was certified, children received a tablet to play the game. In order to make it easier for children to understand, only after finishing playing the first game were they instructed on the other game. The order of the games' presentation was alternated across children.

Participants were assigned to one of two conditions: one-shot ($n = 29$), in which participant played six one-trial matches of each game, or iterated ($n = 60$) in which participants played only one six-trial match of each game. In the one-shot condition, experimenters told the children that they would play each match with a different child, while in the iterated condition, experimenters explained that the six trials would be played with the same child. In the one-shot condition, a random decision strategy was set for the NPC, whereas in the iterated condition the NPC played using tit for tat (TFT), because it is a cooperative strategy that emphasizes reciprocity and stimulates cooperation (Axelrod, 1984). Table 2 shows how participants were allocated between the experimental conditions.

When children finished playing the second game, they were asked whether they wanted to keep on playing, and were allowed to play three extra six-round matches of any of the

Fig. 5 Two mine cars now stand on a stable platform collecting the stars that fall on the center of the screen

Fig. 6 Left car on the stable rail catching the bouncing stars due to the falling car of the opponent

two games against an NPC. The number of extra matches played was recorded, and that information was used as an index of how much children enjoyed playing SC and SM.

Participation in the study was voluntary, and children were allowed to take part in the experiments only if they provided an informed consent form from one of their parents. All procedures described in Experiments 1 and 2 were evaluated and approved by an ethics committee on human studies. Data were collected throughout the months of October, November, and December of 2017.

Results

To test the effects of experimental condition, sex, and type of the game on children's cooperation we established five variables: total cooperation (TC; percentage of trials in which children cooperated), first-trial cooperation (FT; percentage of children who cooperated in the first trial), remaining-trials cooperation (RTC; percentage of trials in which children cooperated, excluding the first trial), cooperation after cooperation (CAC; percentage of trials in which children cooperated after the other player had cooperated, excluding the first trial), and overall cooperation (OC; mean of TC in SC and in SM). Note that CAC was calculated only for children who played in the iterated condition, because only they expected to be playing with another child for six repeated trials.

Table 2 Sample description according to sex and experimental conditions

Conditions	Girls	Boys	Total
One-shot	16	13	29
Iterated	26	34	60
Total	42	46	89

We used nonparametric tests because the hypothesis of Gaussianity was rejected by a Kolmogorov–Smirnov test ($p < .05$). Results showed that 89 children (93.7%) correctly answered all the comprehension questions, one (1.04%) understood only Slingshot Challenge, and five (5.26%) did not understand either game, even after receiving new instructions. Answers from these participants suggested that they did not comprehend the payoff matrices of the games, and that they did not fully understand how the game scores were related to the target actions (hitting the cans or dragging the cars). Therefore, data for these children were excluded from further analysis. Overall, children under age eight needed to be instructed two or three times, and in a more careful and slower manner. On the other hand, 9- to 11-years-olds had no difficulty understanding the dynamics of the games, and sometimes even anticipated what would come next. Regarding the ability to play the games, younger children needed more practice; however, after playing a few times, they were able to master how to play them.

A total of 59 of the children who fully understood the games (66.3%) said that playing was very fun, four children (4, 5%) said it was a little fun, and no child said it was not fun to play the games. Regarding the game preference, 38 children liked Slingshot Challenge the most (42.7%), and 26 preferred Star Mines (29.2%), while 25 of them (28.1%) stated that they had no favorite game. Age and experimental condition were not related to the children's preferences and opinions concerning fun. Participants requested to play 2.14 (SD = 1.09) extra matches after they had already played both games. Forty-eight children (54%) asked to play all three extra matches, and some of them even requested to download the games to play at home. Fun levels and preferences for one of the games did not differ between boys and girls.

The Wilcoxon test showed significant differences in total cooperation ($z = -4.75$; $p < .001$) between SC (26.6%) and SM (43.6%). Also, the frequency of children cooperating in the first trial was higher (Cochran's Q = 29.400; $p < .001$) in SM (68.5%) than in SC (21.3%) (Fig. 7).

In order to analyze conditional cooperation, we compared the percentage of cooperation after the opponent's cooperation and defection in the previous round: in SM, children cooperated more often after cooperation than after defection ($z = -2.92$; $p = .02$), but not in SC ($z = -0.16$; $p = .88$). Next, we compared the specific percentage of cooperation after the opponent's cooperation between the games and observed a significant difference in cooperation after cooperation ($z = -2.04$; $p = .041$) between SC (14%) and SM (25.7%) (Fig. 7). There were no significant differences in the first-trial cooperation or total cooperation as a function of the experimental conditions.

The Mann–Whitney test demonstrated that cooperation after cooperation ($U = 692.00$; $p = .011$) was higher in girls (30.4%) than boys (16.2%) (Table 3). Also, girls started cooperating (31%) more frequently than boys (12%) when they were playing SC ($\chi^2 = 4.36$; $p = .037$), considering both conditions.

Also, we analyzed whether children who cooperated in the first trial cooperated more after the opponent's cooperation and in the remaining rounds. For this analysis, the remaining-trials cooperation was analyzed instead of the total cooperation, because neither cooperation after cooperation nor remaining-trials cooperation consider the first round, but total cooperation does. In both SC and SM, first-trial cooperation was associated with cooperation after cooperation ($U = 400.00$; $p = .004$ and $U = 528.00$; $p = .002$) and remaining-trials cooperation ($U = 465.00$; $p = .038$, and $U = 621.50$; $p = .033$). Specifically, children who started cooperating with the other player tended to cooperate more and to more frequently reciprocate the other player's cooperation in both games (Fig. 8).

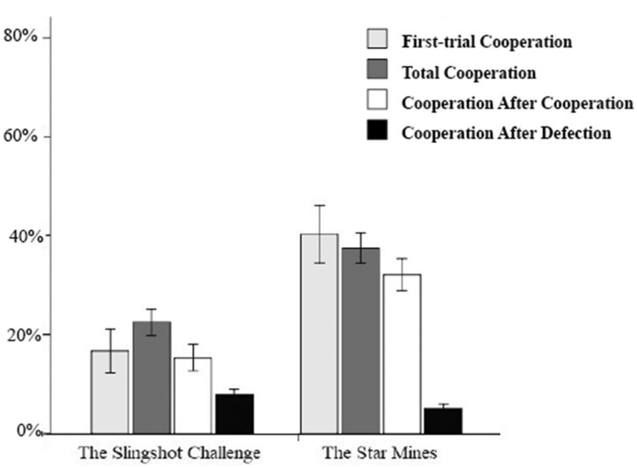

Fig. 7 Mean percentages of first-trial cooperation, total cooperation, cooperation after cooperation, and cooperation after defection by game in Experiment 1. Errors bars represent standard errors.

Table 3 Mean percentages of cooperation by game and sex in Experiment 1

		Girls	Boys
Slingshot Challenge	Total cooperation	29.3%	24.2%
	Cooperation after cooperation	17.2%	14.8%
Star Mines	Total cooperation	48.3%	39.3%
	Cooperation after cooperation	30.4%	16.2%
	Overall cooperation	38.9%	31.8%

Discussion

The results show that children were highly motivated to play Slingshot Challenge (SC) and Star Mines (SM), and that most participants easily understood the rules of the games. This is an important finding, because previous studies suggest that it is hard for children under 10 years old to understand the dynamics of a PD (Blake et al., 2015).

The levels of cooperation for SC were similar to those found in other studies using a one-shot physical version of the PD (Cárdenas et al., 2014; Lergetporer et al. (2014). The fact that conditional cooperation was not found in SC supports the argument that they may have played it as a one-shot game.

On the other hand, in SM cooperation levels were higher than those using a digital version of PD with children (Blake et al., 2015). Also, participants were more cooperative when they played SM than SC, which might have occurred because in SM, cooperation was more evident: once the platform is only balanced when both players move their cars to the center, children might frame the situation in terms of dependency between players. Also, this dynamic entails a visual cue for

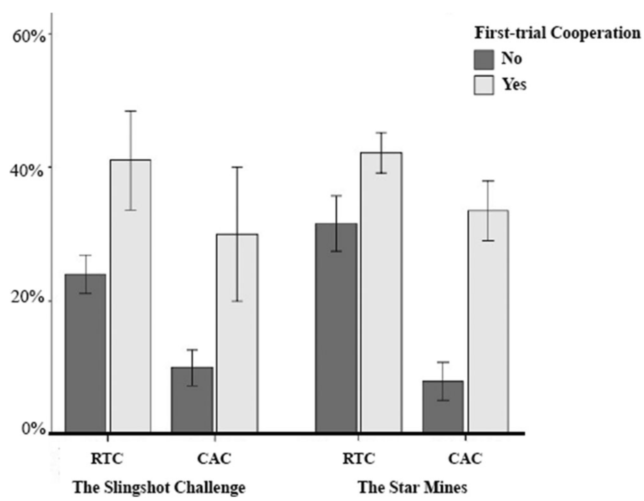

Fig. 8 Mean percentages of remaining-trials cooperation (RTC) and cooperation after cooperation (CAC) by decision to cooperate in the first trial for each game in Experiment 1. Errors bars represent standard errors.

players' cooperation, since the image of two cars falling or standing on the platform highlights the result of their decision.

In contrast, in SC they might have been more interested in winning the game (hitting as many cans as possible) than in scoring, which led them to compete instead of cooperating. Further investigation is necessary to test the hypothesis concerning of the effects of those visual cues in children' cooperation.

Supporting the validity of SC and SM for assessing children's cooperation, it was found that participants cooperated more often when the other player did the same, and that first-trial cooperation was positively associated with the other variables measuring cooperation in both games. This is in line with previous works (Blake et al., 2015; Keil et al., 2017). The use of a cooperation after cooperation strategy and first-trial cooperation was influenced by gender, which might confirm the hypothesis that girls tend to be more altruistic and egalitarian than boys. However, it is important to remember that there is no consensus in the literature about the emergence of gender differences in cooperation before adolescence (Cárdenas et al., 2012, 2014; Molina et al., 2013). In fact, gender influence was not widespread, pointing to the need to conduct other studies to address this question.

No differences were found between the one-shot and iterated conditions, so the shadow of the future did not increase cooperation, contrary to what was expected. This might have happened because children interpreted the six matches of the one-shot condition not independently, but as a type of game with six repeated trials. Thus, they tried to reciprocate the previous players, acting in a similar way as children in iterated condition.

Overall, the results point to the feasibility and validity of using SC and SM to assess children's cooperative behavior. In order to extend the findings of Experiment 1 we conducted a follow-up study in which children played an iterated version of the game with the NPC using a "tit-for-two-tats" strategy. That is known as a forgiving strategy (the player defects only when the opponent has defected twice in a row). Thus, in Experiment 2 we aimed to investigate whether cooperation would change as compared to Experiment 1, once participants might be tempted to take advantage of their opponents' benevolence (Axelrod, 1984). Finally, to facilitate comparison of the cooperation pattern in earlier rounds as compared to later ones, four additional rounds were included in this second experiment, for a total of 10 rounds.

Experiment 2

Method

A total of 72 (34 boys) 7- to 12-year-olds (M_{age} = 9.10 years; SD = 1.84) were recruited from four private schools in the city of Petrolina, Pernambuco, Brazil. None had participated in Experiment 1. Data were collected throughout the months of March, April, and May of 2019.

Procedures

The experiment took place in separate rooms of the schools attended by the children and lasted 20–30 minutes. Data collection was conducted by three trained researchers. After receiving instructions from the experimenters, children were asked about their general understanding of both games and were given the tablets to play individually.

We opted for nonparametric tests, due to rejection of the hypothesis of data normality of the Kolmogorov-Smirnov Test.

As in the previous experiment, total cooperation ($z = -3.41$; $p = .001$) was higher in SM (37.5%) than in SC (22.5%). Also, more children (Cochran's Q = 11.560, $p = .001$) started cooperating in SM (40.3%) than in SC (16.7%) (Fig. 9).

In this second experiment, children cooperated more often after an opponent's cooperation than after defection, in both games (SC: $z = -2.00$; $p = .45$ and SM: $z = -5.85$; $p < .001$). The Wilcoxon test showed significant difference in cooperation after cooperation ($z = -3.71$; $p < .001$) between SM (32.1%) and SC (15.3%) (Fig. 9).

Girls exhibited higher mean rates of total cooperation (U = 426.50; $p = .01$) and first-trial cooperation (U = 418.00; p = .008) than boys. No significant gender-related differences were observed in children's cooperative behavior in SM (Table 4).

Similar to what happened in Experiment 1, first-trial cooperation was associated with cooperation after cooperation (U = 194.00; $p = .006$ for SC and U = 418.00; $p = .017$ for SM), and remaining-trials cooperation (U = 230.50; $p = .045$ for SC and U = 451.50; $p = .046$ for SM) (Fig. 10).

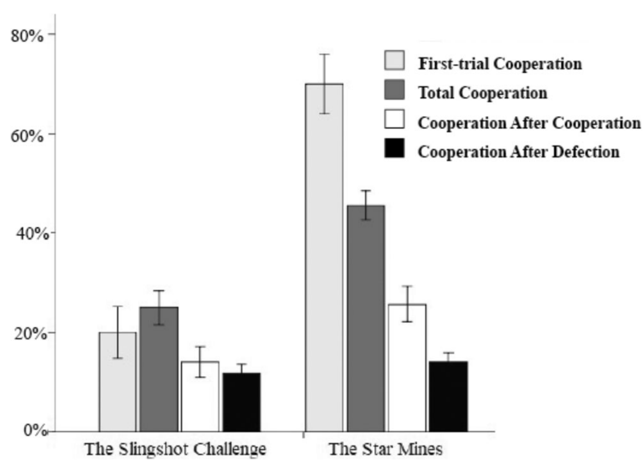

Fig. 9 Mean percentages of first-trial cooperation, total cooperation, cooperation after cooperation, and cooperation after defection by game in Experiment 2. Errors bars represent standard errors.

Table 4 Mean percentages of cooperation by game and sex in Experiment 2

		Girls	Boys
Slingshot Challenge	Total cooperation	27.9%	16.5%
	Cooperation after cooperation	18.1%	12.1%
Star Mines	Total cooperation	42.4%	32.1%
	Cooperation after cooperation	37.1%	26.4%
	Overall cooperation	35.2%	24.3%

To test whether cooperation decisions would change as a function of the other player's strategy, we compared children's cooperation in the six first trials of Experiment 2 (E2) with cooperation in the iterated condition of Experiment 1 (E1). No significant differences were found. On the other hand, children cooperated more often after opponent's cooperation in E2 (36%) than in E1 (26%) when they played SM (U = 1751.5; p = 0.04), but not during SC matches (U = 2103.5; p = 0.66).

We used logistic regression models with clustered standard errors at the level of the individual to compare cooperation over the matches in order to determine whether the trial number affected the children's behavior. The results revealed that cooperation in SM decreased significantly in both E1 and E2. No effects of trial number were found in SC rounds (Table 5).

It was observed that more children started cooperating when playing SM in E1 (70%) than in E2 (40.3%) (χ^2 = 11.63; p = .001) (Fig. 11).

In Experiment 2, as in Experiment 1, children cooperated more playing SM than SC. Furthermore, they changed their strategy depending on the game, although this variability in strategies did not affect the indexes of cooperation, which

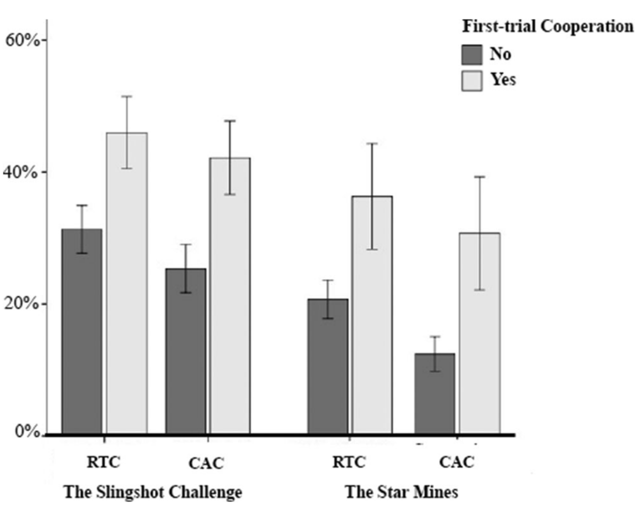

Fig. 10 Mean percentages of remaining-trials cooperation (RTC) and cooperation after cooperation (CAC) by decision to cooperate in the first trial for each game in Experiment 2. Errors bars represent standard errors.

Table 5 Results of the logistic regression for prediction of cooperation as a function of trial number

Experiment		Coefficients (SE)	
		Slingshot Challenge	Star Mines
E1	Intercept	−1.2 (.2)***	0.55 (0.2) **
	Trial	0.06 (.05)	−0.2 (.04)***
E2	Intercept	−1.1 (0.2)***	−0.2 (.2)
	Trial	0.01 (.03)	−0.05 (.02)*

*p < .05; ** p < .01; *** p < .001

were consistent in both games. We also found that children tended to cooperate less over trials only in SM, and that this tendency was more pronounced in E1 due to the high level of first-trial cooperation in SM in that experiment.

This might be because SM has a dynamic of simultaneous decisions, similar to a traditional PD, allowing the participant to observe the other player's behavior while making their decision about balancing or not balancing the central platform. On the other hand, Slingshot Challenge is played in alternating turns, so the player does not have the perspective of their partner's behavior, stimulating participants to compete (hitting as many cans as possible) more than cooperating. Thus, results of Experiment 2 reinforce the view that children might frame SC and SM differently (more competitive and more cooperative, respectively), and this might be an interesting feature to be explored in studies on cooperation during childhood.

The decision to cooperate in the first trial was associated with overall cooperation, cooperation after cooperation, and remaining-trials cooperation in both games, confirming the results of Experiment 1 and previous studies showing that children's decision to cooperate were contingent on their previous behavior (Blake et al., 2015; Prétôt& McAuliffe, 2020). However, a significant decrease in cooperation after the first trial was observed only for SM, as expected (Andreoni&

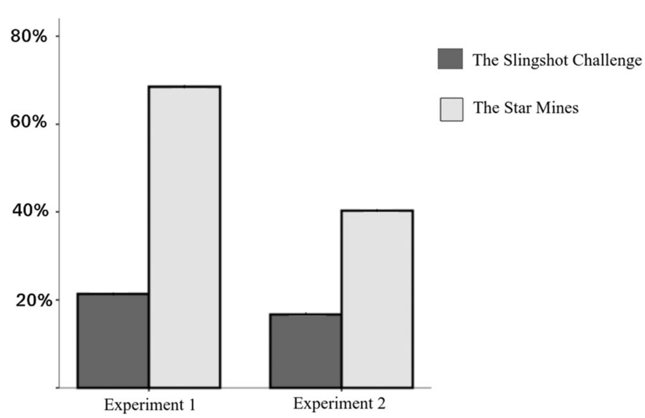

Fig. 11 Percentage of children cooperating in first trial, by game and experiment

Miller, 1993), and similar to what was observed in another work in which children played a PD with strangers (Blake et al., 2015).

Contrary to what was expected, cooperation in the six first trials of Experiment 2 did not differ significantly from what was observed in all the trials of the iterated condition of Experiment 1, confirming that the shadow of the future was not found in the present work. Additionally, the number of children cooperating in the first SM trial in Experiment 2 was significantly lower than in Experiment 1, suggesting that the perspective of playing more trials with the same player stimulated children to defect more. Why was this detrimental effect on cooperation not observed in SC as well? We may speculate that the more cooperative frame of SM increases the children's flexibility during the process of deciding whether to cooperate, allowing them to better track the other player's strategy before deciding whether or not to balance the central platform. On the other hand, the more competitive frame of SC stimulates and maintains cooperation in lower levels in comparison with the first trial. Further studies are necessary to better investigate these differential effects of the number of trials, and of the use of different game-theory strategies on the way children cooperate when they are playing SC and SM.

Concerning gender effects, results point out that girls were more cooperative than boys. It is important to note that gender differences in Experiment 2 were limited to SC, suggesting that the tendency of girls towards cooperating more is dependent on the context: in a more competitive situation they tended to cooperate more, while boys prefer to compete more and maximize their payoffs (Fehr et al., 2013; Sutter& Glätzle-Rützler, 2015). On the other hand, in a scenario where the situation is framed as more cooperative, boys and girls cooperate and defect at similar rates.

General discussion

Digital games can be an important tool for studies on social behavior because they are fun and are familiar to most people nowadays. Thus, this methodological resource has great potential for increasing participant engagement with behavioral experiments. The findings of Experiments 1 and 2 reveal that children as young as six years old were able to understand the dynamics of a PD, even in a very artificial setting in which a rigid strategy was used by the opponent. Moreover, children had fun and were motivated to continue playing both games for a considerable number of trials. This is an important feature when the research design demands children to be involved with tasks for longer periods of time.

Overall, the present study showed that minor contextual differences (number of trials, game-theory strategies involved) might impact on children's cooperative behavior, because although both games have the same payoff matrix, children behaved quite differently across the two experiments. Specifically, not only were children more or less cooperative depending on the game and the number of trials, but they changed their patterns of cooperation according to gender and as a function of the game strategy used by the other player. Thus, taking into account the interactions between children's characteristics and the structural arrangements of the PD is fundamental to understanding cooperative behaviors in childhood, and the configurations available for playing SC and SM can be a very helpful resource to deepen the investigation on this field of research.

The results suggest that the use of stickers as incentive was not effective, because it seems that children were more interested in winning the games, instead of getting a greater number of stickers. As such, using stickers as a distributive resource had no impact on children's decisions. We anticipated that this could happen, because children were told they would get more stickers if they scored more points, but they did not know the total number of stickers they could receive, nor did they have the opportunity to examine the stickers in person. This kind of knowledge is important for children to build a picture of how valuable the prize for winning the games is (Blake& Rand, 2010), and should be better controlled in future studies.

Furthermore, it was not tested if participants really believed they played with other children or with a computer, which could have impacted the way they played (Krach et al., 2008; Shechtman& Horowitz, 2003). Specifically, children may have disregarded the consequences of defection to their opponents, because they believed they were playing with a fictional person (the computer). These experimental characteristics might help to explain why we did not find evidence of the shadow of the future in children's cooperation, in contrast to Blake et al. (2015). Considering this, we suggest that future studies make the reward as valuable as possible to children, by making the outcome nontrivial (Kiyonari et al., 2000), and trying to motivate them to earn more points (hitting cans or catching stars), instead of only winning the game. Additionally, having two children play together, instead of with an NPC, along with the use of more distinct NPC strategies, could shed some light on this matter. In this regard, research has already shown no difference between virtual and in-person experiments in promoting cooperation among adult when playing a PD, at least when rewards are real money (Horton et al., 2011).

Cooperative games specify rules that determine how cooperation is achieved, allow communication and exchange, present mutual goals, and promote interdependence among players (Seif El-Nasr et al., 2010; Morschheuser et al., 2017; Nardi & Harris, 2009). Interaction in cooperative games might foster altruism by intrinsic gratification when the players perceive they are promoting collective well-being, which in turn invokes common goals and intentions (Riar et al., 2020). Cooperative features are reinforced by visual cues present in the two games, but we consider this to be more evident in SM: when both cars are on the unstable platform it is balanced, and the players can collect all the falling stars. On the other hand, in SC, cooperation and defection actions are only visible in the payoff.

Another suggestion for future studies is to explore the game setup options more deeply, producing variations, for example, in the payoff matrix of the games. In the present study, children got few points for cooperation; hence, changing rewards for cooperation and defection can steer different player behaviors (Rapoport, 1966). Even considering that distinct Rapoport indexes may not be effective for children, it should be kept in mind that the experiment by Tedeschi et al. (1969) relied on numeric values, and on two arithmetic abilities, since gains (sum) and losses (subtraction) were involved. This could have hindered children's evaluations of differences in Rapoport's index. The Star Mines and Slingshot Challenge games give children visual cues (number of stars and cans, respectively), which makes it easier for them to measure quantities, without needing to count (Barth et al., 2005).

Although previous studies had demonstrated the feasibility of assessing children's cooperative behavior using a PD (Blake et al., 2015; Cárdenas et al., 2012; Cárdenas et al., 2014; Lergetporer et al., 2014; Tedeschi et al., 1969), these works had some limitations, such as the need for adults to mediate the activity and to present detailed explanations, installation in a proper room for children to move around, and difficulty in preserving the player's anonymity.

In sum, our findings extend the previous work, showing that SC and SM are feasible and valid tools for investigating cooperation in childhood, including for children from six years of age, overcoming some limitations of the previous work.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.3758/s13428-021-01661-y.

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The authors declare no conflict of interest.

Data Availability Supplementary materials, including links to the games' source code, the data collected by the games used for analysis, and demonstration videos, are available at https://github.com/grecabral. None of the experiments was preregistered.

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