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Dinâmicas Interacionais e Expectativas como Preditores da Cooperação no Dilema do Prisioneiro

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Interactional Dynamics and Expectations as Predictors of Cooperation in the Prisoner's Dilemma

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Abstract: Children's cooperation has been investigated through games that present dilemmas to understand how children make decisions in interactive situations. The aim of the study was to investigate the cooperative behavior of 75 children (52% girls) aged 6 to 11, their justifications for their decisions, and their expectations regarding a game partner. Cooperation was assessed using the digital games Slingshot Challenge and Star Mines, which were structured as Prisoner's Dilemma games and played in both public and private contexts. Verbal responses were subjected to content analysis, and the data were analyzed using inferential statistics. The results indicated an association between children's expectations regarding their partners, their justifications, and their behavior, such that those who expected cooperation cooperated more. It is concluded that cooperative behavior in childhood is dynamic and contextual, with children demonstrating adaptive flexibility in interactional dynamics.

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Keywords: cooperative behavior, child, prisoner dilemma, decision making

Dinâmicas Interacionais e Expectativas como Preditores da Cooperação no Dilema do Prisioneiro

Resumo: A cooperação infantil tem sido investigada por meio de jogos que apresentam dilemas, a fim de compreender como as crianças tomam decisões em situações interativas. O objetivo do estudo foi investigar o comportamento cooperativo de 75 crianças (52% meninas) de 6 a 11 anos, suas justificativas para as decisões e suas expectativas em relação a um parceiro de jogo. A cooperação foi avaliada por meio dos jogos digitais Slingshot Challenge e Star Mines, estruturados como Dilema do Prisioneiro, jogados em contextos público e privado. As respostas verbais foram submetidas à análise de conteúdo e os dados avaliados através de estatísticas inferenciais. Os resultados indicaram associação entre o que as crianças esperavam dos parceiros, suas justificativas e seu comportamento, sendo que aquelas que esperavam cooperação cooperaram mais. Conclui-se que o comportamento cooperativo infantil é dinâmico e contextual, onde as crianças demonstram flexibilidade adaptativa na dinâmica interacional.

Palavras-chave: comportamento cooperativo, criança, dilema do prisioneiro, tomada de decisões

Dinámicas Interaccionales y Expectativas como Predictores de Cooperación en Dilema del Prisionero

Resumen: La cooperación infantil ha sido investigada mediante juegos que presentan dilemas para comprender cómo los niños toman decisiones en situaciones interactivas. El objetivo del estudio fue investigar el comportamiento cooperativo de 75 niños (52% niñas) de 6 a 11 años,

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sus justificaciones para las decisiones y sus expectativas con respecto a un compañero de juego. La cooperación fue evaluada mediante los juegos digitales Slingshot Challenge y Star Mines, estructurados como el Dilema del Prisionero y jugados en contextos público y privado. Las respuestas verbales fueron sometidas a análisis de contenido y los datos se evaluaron mediante estadísticas inferenciales. Los resultados indicaron una asociación entre las expectativas de los niños sobre sus compañeros, sus justificaciones y su comportamiento, de modo que quienes esperaban cooperación cooperaron más. Se concluye que el comportamiento cooperativo en la infancia es dinámico y contextual, y que los niños demuestran flexibilidad adaptativa en la dinámica interaccional.

Palabras clave: conducta cooperativa, niño, dilema del prisionero, toma de decisiones

Understanding human social life involves analyzing key behaviors that function in joint work and the division of effort among individuals, or within groups, to achieve goals that would be more costly to attain individually (Henrich & Muthukrishna, 2021; Townsend et al., 2023; Wolf & Tomasello, 2025), such as cooperation. Evidence indicates that this class of behavior emerges as early as around 14 months (Vizmathy et al., 2024) and tends to undergo important modifications throughout childhood.

Studies show that the complexity and frequency of cooperative interactions tend to increase due to socialization, communication, and the advancement of capacities such as decision-making, argumentation (Domberg et al., 2018; Grueneisen & Warneken, 2022; Köymen et al., 2020; Ruland et al., 2023), and critical evaluation of peers' behavior (Levy et al., 2021).

Researchers have dedicated themselves to investigating how cooperation emerges and can be sustained, and how sociocognitive and contextual variables may relate to cooperative behavior from childhood onward. From this perspective, some studies seek to understand how

children reconcile individual and collective interests (Blake & Rand, 2010; Blake et al., 2015; Cabral et al., 2022; Park et al., 2022; Sampaio & Camino, 2017) and adapt their own behavior to the specific dynamic of the interactive situation, for example, by suppressing short-term selfish impulses in favor of long-term goals (Grueneisen & Tomasello, 2019).

Other findings highlight the effects of contextual variables, such as the presence of an observer, which increases the likelihood of children sharing more resources and behaving more prosocially than when alone (Pal & Hilbe, 2022; Raihani & Power, 2021; Xia et al., 2023).

To investigate the interactive dynamics involved in children's cooperation, researchers have employed the Prisoner's Dilemma (PD), which, in its classical form, refers to a scenario where two individuals, accused of a crime, are detained and placed in separate cells (Axelrod & Hamilton, 1981). The consequences of their choices determine the rewards or punishments they will face, with defection being an individually advantageous strategy, as it guarantees a reduction in sentence regardless of the other's decision. However, if both choose to defect, the outcome will be suboptimal for the pair, whereas if they choose to cooperate, the outcome will be beneficial for both (Axelrod & Hamilton, 1981).

In the single-round PD, defection tends to be the dominant strategy because, regardless of the other player's decision, defecting offers the best individual reward in the short term. Nevertheless, this outcome does not include the potential benefits of mutual cooperation, which would lead to a maximization of combined rewards (Prétôt & McAuliffe, 2020). In contrast, when the game is iterated (iPD), players interact more than once, and the possibility of future interactions introduces incentives to use strategies that reward cooperation and punish defection (Park et al., 2022). Although the adaptive tit-for-tat strategy is associated with the stability of cooperation in an iPD, it can be restored by "forgiving" strategies in response to initial defection (Yamamoto & Goto, 2024). Thus, initial defection by the partner

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is met with defection, but cooperation is subsequently sought to be reestablished.

Despite a significant number of studies investigating children's cooperation through the PD (e.g., Blake et al., 2015; Cabral et al., 2022; Hermes et al., 2020; Prétôt et al., 2024), research tends to prioritize the analysis of behavior itself rather than what children think about the cooperative situation. Thus, investigating the reasoning that children employ to make decisions and their expectations regarding their partners' behavior constitutes an opportunity to study the sociocognitive and developmental processes underlying cooperative behavior.

Given the above, the aim of the study was to investigate the cooperative behavior of 75 children (52% girls), aged 6 to 11, their justifications for their decisions, and their expectations regarding a game partner. Cooperation was assessed using two digital games structured as a Prisoner's Dilemma, played in public and private contexts. In this sense, it sought to assess whether children's behavior would change when they were in the presence of an observer (public context) and when they could make their decisions alone (private context).

Method

Participants. The study included a non-probabilistic sample comprising $n = 75$ participants (52% girls), aged 6 to 11 years ($M = 9.15$; $SD = 1.83$), who were classified into three age groups: 6 to 7 years ($n = 21$; $M = 6.86$; $SD = .35$; 52.4% girls), 8 to 9 years ($n = 22$; $M = 8.64$; $SD = .49$; 50% girls) and 10 to 11 years ($n = 32$; $M = 11.00$; $SD = .71$; 53.10% girls). All children were recruited from four public elementary schools.

Only children within the target age range for the study were included in the sample. These children were duly enrolled in school at the time of data collection, and their parents or legal guardians authorized their participation by signing the Informed Consent Form (ICLF). The children themselves also verbally agreed to participate and signed the Child Assent Form (CAF). Exclusion criteria involved children with a history of neurological or psychiatric

diseases, motor impairments, diagnosed developmental or learning disorders, or visual and auditory problems that would prevent them from identifying and handling the instruments. Such children were not included in the sample.

Instruments. To assess cooperation, two digital games were used (see supplementary material): *Slingshot Challenge (SC)* and *Star Mines (SM)*, which function as versions of the Prisoner's Dilemma (Cabral et al., 2022). In SC, the objective is to hit cans positioned on a wall using a slingshot during alternating rounds between players. If the player hits cans matching the color of their own slingshot, the points corresponding to the number of colored cans are awarded to themselves. However, if they hit cans matching the color of the other player's slingshot, the points are awarded to the opponent. In this sense, hitting the other player's cans represents cooperation (i.e., increasing the other participant's score), while defection occurs when aiming at one's own set of cans.

In SM, however, the objective is to collect stars falling from the sky using a minecart that moves across platforms to the sides or to the center of the screen, within a pre-established time limit. In SM, decisions occur simultaneously, and players decide without knowing what their partners have done. Each player can only collect the stars falling on their side by moving the cart to the side or attempt to collect the stars in collaboration with the other by moving the cart to the center platform. However, to acquire the stars falling in the center of the screen, both players must move their carts to the central platform, which is unstable and requires the balance of both carts to remain level. If only one cart is positioned on the central platform, it tilts, resulting in the cart falling and the stars that would have been lost rebounding and falling into the other player's cart. Thus, positioning the cart at the center of the platform represents cooperation, while positioning it on the sides corresponds to defection. The scoring for both games was configured to replicate a Prisoner's Dilemma payoff matrix (see supplementary

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material).

The children played both games with a Non-Playable Character (NPC), that is, a pre-programmed strategy serving as the child's partner during the matches. Nevertheless, they were informed that there was another child of the same age and sex participating with them, but in another school. In SC, the NPC was programmed to begin the first round by not cooperating and, from the second round onward, to repeat the participant's decision from the previous round. In contrast, in SM, the NPC was configured to cooperate in the first round, regardless of the participant's initial decision, and to repeat the participant's decision in the remaining rounds. That is, in both games, the NPC was programmed to adopt a tit-for-tat (eye for an eye) strategy from the second round onward, which tends to generate higher levels of cooperation in iterated contexts (iPD) (Axelrod & Hamilton, 1981).

The children were informed that, at the end of the match, they would receive a number of stickers corresponding to the total points accumulated in the rounds of each game (1 point = 1 sticker). To assess the children's degree of satisfaction with these stickers, a graphic Likert-type scale adapted for children, using Smiley Faces, was employed.

Procedures

Data collection. The children played one match of 10 rounds of each game, using a 7-inch tablet, individually, in a single session, and in rooms previously made available by the schools. Explanatory videos illustrating the possible movements in the digital games were shown, followed by practice trials, to ensure that the participants were properly familiarized with the activities to be performed. To minimize order effects, the sequence of game presentation was alternated between participants. Furthermore, they were divided into two groups, so that one part played in a public context ($n = 36$; $M_{\text{age}} = 9.11$; $SD_{\text{age}} = 1.93$; 50% girls), in which the researcher was present and observed the child during the activities, and

another part in a private context ($n = 39$; $M_{\text{age}} = 9.18$; $SD_{\text{age}} = 1.76$; 53.8% girls), without the presence of the researcher.

In the pre-game phase of SC and SM, the children were also questioned about their expectations regarding the other player's behavior, with the question, "*How do you expect the other child who will play with you to behave during the game?*" After the 10 rounds of each game, the participants were asked about their own behavior during the rounds, through the question: "*How did you do in the rounds of this game?*" All answers were recorded and transcribed.

Data analysis. To assess cooperative behavior in the digital games, five main variables were considered: CR1 = cooperation in the first round; CR2 = cooperation in the second round; CR3 = cooperation in the third round; CT10 = total cooperation across the 10 rounds; CC = conditional cooperation, that is, when the child cooperated after the other player's cooperation. For this last variable, only data from the third round onward were included in the calculation, because all cooperations in the second round of SM would be conditional, whereas no cooperation in the second round of SC would be conditional due to the NPC's strategy. These treatments were included to evaluate possible effects of the initial NPC programming in both games. The creation of these five variables allowed the cooperative behavior to be analyzed round-by-round as well as globally, across the matches as a whole.

The corpus for the content analysis comprised verbatim transcripts of the children's responses to the pre-game question regarding their expectations of their partner's behavior and to the post-game question regarding their own behavior during each SC and SM match. The responses were examined using an inductive approach to content analysis, in which recurrent meanings identified in the corpus were organized into analytical categories (Castro et al., 2011). Furthermore, each child's complete response to each question was considered a

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unit of analysis (McKibben et al., 2022).

The raters initially examined the corpus to identify recurrent meanings and organize them into analytical categories. After the categories had been established, two independent raters coded the complete corpus. To this end, each rater received a spreadsheet (Excel) containing the verbatim transcripts of the justifications and expectations reported by the children and classified each unit according to the categories identified during the initial analysis.

Through the systematic examination and comparison of the responses, semantically similar contents were grouped into two recurrent categories. The task assigned to each evaluator consisted of conducting a content analysis, assessing each response individually, with the aim of identifying the presence or absence of indicators related to the two defined axes: (1) the presence or absence of cooperation (34% of responses) and (2) the presence or absence of strategic play (61% of responses). The first axis involved both the expectation that the partner would act cooperatively and the justification that the child themselves had played in a cooperative manner. The second axis was associated with the presence or absence of deliberate planning to maximize gains or avoid losses, whether individually or cooperatively.

Responses where it was not possible to identify clear expectations or justifications were classified as undefined (e.g., "I wasn't thinking about anything, I just wanted to have fun") and were excluded from the corresponding analyses involving the content-derived variables (5%). All responses were analyzed independently by both raters. Inter-rater agreement was calculated before consensus as the percentage of responses for which both raters assigned the same classification. Agreement for expectations was 82.20% in SM and 81.70% in SC, whereas agreement for reported behaviors was 82.20% in SM and 82.20% in SC. Disagreements were discussed by the raters and resolved through dialogue, with the participation of a third rater when consensus could not initially be reached (Hemmler et al.,

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2022). The categories established through the coding and consensus process were subsequently converted into categorical variables and included in the inferential statistical analyses (McKibben et al., 2022).

Ethics Committee Approval Statement

The study was registered in the Brazil Platform (CAEE 74715223.1.0000.0282), and approved by the Research Ethics Committee of the University Hospital of the Federal University of the São Francisco Valley (CEP HU-Univasf), under opinion No. 8.409.755. All ethical principles required for research involving human participants were followed, and all procedures were explained to participants through the Informed Assent Form. Data collection and analysis were conducted with full respect for participants' integrity. Anonymity, confidentiality of responses, and the voluntary nature of participation were ensured. No conflicts of interest were identified at any stage of the study.

Results

The results indicate that the stickers were well accepted as tangible rewards by the children, given that 98.7% indicated being "happy" and "very happy" to receive them.

To analyze the possible effects of public and private context on children's cooperative behavior, as well as of sex and age, a MANOVA was conducted, with a post hoc power analysis performed using G*Power software (Cohen's $d = 0.80$). The MANOVA results indicated no effects of sex (Pillai's trace = .10; $p = .58$), context (Pillai's trace = .12; $p = .46$), or age (Pillai's trace = .35; $p = .13$) on cooperation rates in CR1, CR2, CR3, CT10, and CC in SC and SM. As no significant effects of these variables were identified, the data were pooled to conduct the subsequent analyses.

Initially, a paired-samples t-test indicated no significant differences in CR1 [$t(74) = -$

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1.72; $p = .30$] or in CT10 between the games [$t(74) = 1.72$; $p = .08$]. On the other hand, the results showed that cooperation rates in CR2 [$t(74) = 2.70$; $p = .009$; $d = .044$] differed significantly between the games. When comparing cooperation rates in the first and second rounds (Table 1), it is observed that there was a significant decrease between them only in SC [$t(74) = 2.10$; $p = .039$; $d = .42$]: CR1 ($M = 0.47$; $SD = 0.50$) and CR2 ($M = 0.31$; $SD = 0.46$). Conversely, in SM, cooperation remained stable [$t(72) = -1.91$; $p = .84$] between the first ($M = .51$; $SD = 0.50$) and second round ($M = .52$; $SD = 0.50$). Significant correlations between CR1 and CT10 were also identified in both SM ($r_{pb} = .58$; $p < .001$) and SC ($r_{pb} = .26$; $p = .023$).

Table 1

Mean Percentages of Cooperation in Star Mines (SM) and Slingshot Challenge (SC)

Variables	Games			
	SM		SC	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
CR1	51.0%	50.3%	47.0%	50.2%
CR2	52.0%	50.3%	31.0%	46.4%
CR3	69.0%	46.4%	39.0%	49.0%
CT10	53.7%	35.1%	42.1%	30.3%
CC	38.7%	40.6%	27.0%	30.8%

*Note. CR1 = Cooperation in the first round; CR2 = Cooperation in the second round; CR3 = Cooperation in the third round; CT10 = Total cooperation across the 10 rounds; CC = Total conditional cooperation.

To further analyze the potential effects of cooperative behavior in the first round, comparisons were made between children who started the games cooperating and those who did not cooperate in the first round. For CT10, significant differences were observed [$t(73) = -2.32$; $p = .32$; $d = .53$] between the group of children who started SC cooperating ($M = 5.06$; $SD = 2.82$) compared to those who started SC not cooperating ($M = 3.48$; $SD = 3.04$). On the other hand, in SM, there were significant differences regarding CT10 [$t(71) = -6.01$; $p < .001$; $d = 1.40$] when comparing children who cooperated ($M = 7.42$; $\sigma = 2.86$) and those who did not cooperate ($M = 3.43$; $SD = 2.80$) in the first round.

To assess whether there would be relationships between cooperative behavior and the children's answers to questions about their strategies and expectations, it was first tested whether those who claimed to have played cooperatively showed higher cooperation indicators than those who claimed to have played without cooperating. The t-test results indicated that only regarding CT10 in SC [$t(69) = 7.08$; $p < .001$; $d = 1.79$] were there differences between children who stated they had cooperated ($M = 5.63$; $SD = 2.48$) during the match and those who said they had not cooperated ($M = 1.39$; $SD = 2.03$). Regarding CT10 results in SM, there were no significant differences [$t(68) = 1.18$; $p = .24$].

It was also tested whether the expectation of cooperation impacted decisions during the matches, and the t-test results indicated [$t(69) = 2.29$; $p = .02$; $d = .56$] that those who expected cooperation from the other cooperated more during their matches in SM regarding CT10 ($M = 6.15$; $SD = 3.43$), when compared to those who did not expect cooperation from their game partners ($M = 4.24$; $SD = 3.19$). Regarding SC, no significant differences were observed [$t(67) = 1.37$; $p = .17$] between children who expected cooperation ($M = 4.89$; $SD = 2.88$) and those who did not expect game partners to act cooperatively ($M = 3.85$; $SD = 3.21$).

When analyzing the children's verbal responses regarding cooperation and strategy, a statistically significant association was identified, using the chi-square test (with Yates' correction), between expectation of cooperation and expectation of the other player's strategic play in SM [$\chi^2(1, n = 73) = 6.60$, $p = .01$]. However, as one of the cells had an expected frequency less than 5, Fisher's exact test was conducted as a complement, confirming the significance ($p = .008$). Thus, children with an expectation of cooperation from the other tended to expect them to be strategic more frequently (Figure 1a).

The chi-square test (with Yates' correction) also revealed a statistically significant association between the expectation of cooperation and the child's report of cooperative behavior during SM [$\chi^2(1, n = 70) = 6.44$, $p = .011$]. Thus, children with an expectation of

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cooperation from their partners tended to state that they had cooperated effectively (Figure 1b). A further statistically significant association was observed between the expectation of strategic play by the partner and reports of adopting more strategic behavior in the game [$\chi^2(1, n = 70) = 12.630, p < .001$, with Yates' correction]. As one of the cells had an expected frequency less than 5, Fisher's exact test was conducted as a complement, confirming the significance of the result ($p < .001$) (Figure 1c). In contrast, no statistical evidence was found for an association between playing cooperatively and playing strategically [$\chi^2(1, n = 72) = .058, p = .80$].

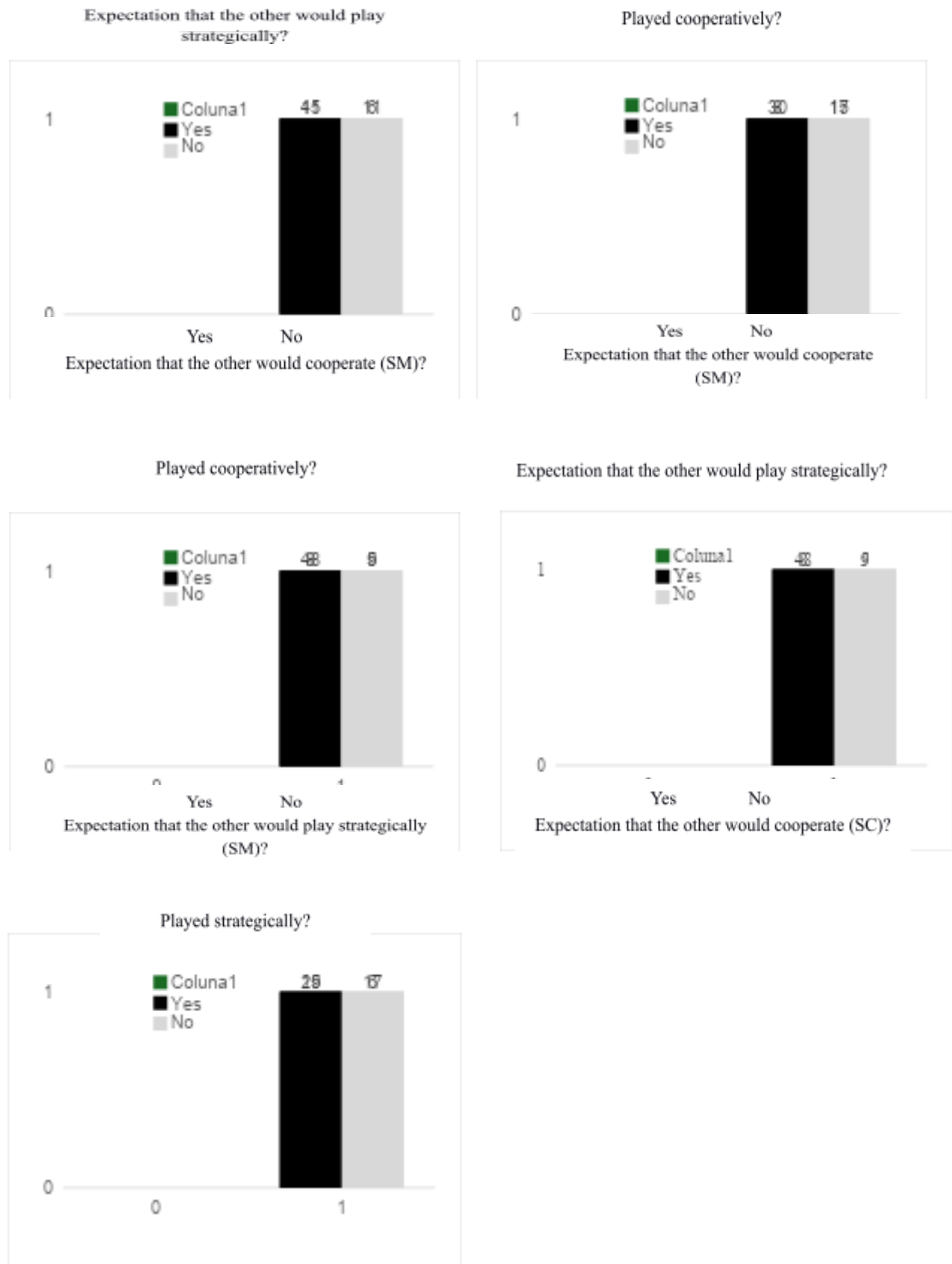
Regarding SC, it was observed that children who expected cooperation also had a higher expectation that the other would be strategic, whereas those without an expectation of cooperation had a lower strategic expectation (Figure 1d) [$\chi^2(1, n = 69) = 8.51, p = .004$, with Yates' correction]. The expectation of cooperation did not predict the children's responses regarding having been cooperative; that is, they cooperated regardless of expectation [$\chi^2(1, n = 67) = .798, p = .372$, with Yates' correction].

Children with an expectation of strategic behavior from the other played more strategically [$\chi^2(1, n = 67) = 4.568, p = .033$, with Yates' correction], whereas those without such an expectation also stated they had not employed strategies to play the matches (Figure 1e). There was no significant association between the responses of children who stated they had cooperated during the game and those who said they had played strategically [$\chi^2(1, n = 71) = 2.135, p = .144$, with Yates' correction].

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Figure 1

Expectations of Cooperation and Strategic Play by the Other Player as a Function of How the Child Themselves Played (Cooperating or Strategically) for SM and SC



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Discussion

The results suggest that decision-making involving children's cooperation in an iterated Prisoner's Dilemma is associated with justifications and expectations about the other's actions and immediate experience, whereby the child adjusts their behavior based on what the partner does or what they expect in this regard (Blake et al., 2015; Prétôt et al., 2020; Riar et al., 2024). In this study, the interactions and expectations have impacted how children behaved meanwhile neither the presence nor the absence of an observer have not of how the child behaved. This finding contrasts with previous studies suggesting that social pressure or the pursuit of a positive reputation would lead children to decide in a socially desirable manner when observed (Bradley et al., 2018; Dutra et al., 2018; Tricoche et al., 2023).

It was also observed that, despite the similarity in cooperation rates between the games in CR1, the NPC's initial move impacted subsequent behavior: in SC, the NPC's initial non-cooperation resulted in a decrease in cooperation rates in CR2, aligned with the win-stay, lose-shift (WSLS) strategy, which maintains successful actions and alternates after an unfavorable response (Nowak & Sigmund, 1993). Also, the children responded to non-cooperation with defection, an expected pattern of "tit for tat" (Hermes et al., 2020), where the player replicates the partner's previous action to inform their next decision (Winke & Stevens, 2017).

The second strategy is considered here because cooperative behavior was re-established in later rounds, although it did not return to the level observed under the SM. It is worth noting that in SM there is no impossibility of anticipating the partner's decision in each round and it may have increased the immediate risk of retaliation for defection, possibly inhibiting it. This suggests that children actively process the concrete elements of the

situation, that is, they formulate hypotheses about the consequences of their actions. Such a pattern is common in games with alternating decisions, in which cooperation tends to be more unstable and less robust compared to games with simultaneous decisions (McAvoy & Hauert, 2017; Park et al., 2022).

The correlation between the first round cooperation with the cooperation throughout the game reinforces the initial choice as an important factor for establishing cooperation. These results demonstrate that the early establishment of a cooperative relationship is crucial, since trust and aligned expectations between partners constitute the foundation for enduring relationships, which tend to strengthen in a positive manner over time. Specifically in SM, those who cooperated in CR1 maintained higher cooperation rates in subsequent rounds compared to those who started by defecting.

The trajectory of cooperation recovery in the third round observed in SC indicates that although the decision to cooperate in the first round is a strong predictor of cooperation, children demonstrate the capacity to adjust their behavior towards cooperation after initial experiences of defection (Blake et al., 2015; Hermes et al., 2020; Prétôt & McAuliffe, 2020; Suarez et al., 2021; Yamamoto & Goto, 2024). However, this involves lower engagement in cooperation, as those who retaliated against the initial defection showed a tendency to maintain lower levels of cooperation. Conversely, individuals who chose to re-establish cooperation exhibited a gradual increase in their cooperative behavior over time (Yamamoto & Goto, 2024).

Beyond the immediate game dynamics, children's behavior is also influenced by their expectations of the partner. The categories derived from the verbal responses indicated a consistency pattern in the SM, suggesting that children's cooperative decisions are influenced by social evaluations, expectations, and justifications, which in turn lead to behaviors aligned with these predictions (Corbit et al., 2023; Prétôt et al., 2020). In SC, initial expectations of

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cooperation were not associated with final cooperative behavior. However, the children's verbal report about how they played, that is, whether they cooperated or not, proved consistent with their actual behavior. Furthermore, two associations were significant: (1) expectations of cooperation and strategic expectations about the partner, and (2) strategic expectations and adoption of strategic behavior. This result suggests that in this game, the relationships were less consistent between expectations and actual cooperative behavior. Thus, even when expectations indicated an initial disposition to cooperate, the actual behavior was different and modulated by the interaction with the partner.

This behavior is attributable to the NPC's scripted defection in the initial round. This action presumably contradicted the children's prior expectations, thereby eliciting an adaptive shift in strategy to counter the non-cooperation. Furthermore, even with the expectation disrupted by the NPC, the children accurately reported their actual behavior. This suggests that, beyond beliefs about partners' intentions (Fiedler et al., 2024; Hermes et al., 2020), children take into account the immediate context of the game; that is, they adjust their decisions based on how the other plays, indicating that children not only react to the partner's actions but also evaluate and interpret the situation in an integrated manner within their decision-making process (Riar et al., 2024).

Experiences in cooperative environments favor the development of intuitive cooperative responses, especially during childhood, a critical period for the formation of complex social skills (Castro & Siqueira, 2022; Corbit et al., 2023; Nava et al., 2023). More specifically, the manipulation of NPC strategies enabled the analysis of distinct response patterns, from immediate retaliation to subsequent recovery of cooperation. Taken together, these findings provide a novel contribution through a unified analysis of three key elements: children's initial expectations of their partner, their behavioral choices during the cooperative game, and their post-game justifications. This integrated approach uniquely allows for the

identification of robust associations between self-reported expectations and justifications and observed behavioral choices.

While previous studies have identified age-related patterns associated with principles such as equality, equity, and inequity aversion (Blake & Rand, 2010), and recent studies highlight the interaction between reasoning modes (intuitive vs. deliberative) and internalized norms (Corbit et al., 2023), our data present a perspective that complements traditional models of distributive development in childhood by demonstrating that, within the same age range, children actively adjust their choices based on social expectations and the ongoing interaction dynamics. Thus, these results underscore that children's cooperative decision-making process is dynamic and adaptive to the immediate interactional context, in which children integrate their expectations with a continuous evaluation of the partner and the interactive context. This view emphasizes the processual, flexible, and socially situated nature of children's decision-making and suggests a promising line for future investigations.

The findings should be considered in light of some limitations, such as the sample size and the distinct initial programming of the NPC, which precludes a direct and equivalent comparison between the games. Future research could isolate the effect of game design (simultaneous vs. alternating) by using the same initial NPC strategy in both. Furthermore, interacting with a simulated partner instead of another child may have simplified the dynamics; in this sense, it would be interesting to explore situations with two children playing with each other. Moreover, it would be relevant to explore to what extent tolerance of defection is maintained after consecutive interactions and at what point children would begin to respond reciprocally with higher rates of defection (Corbit et al., 2023; Fahimur & Kabir, 2024).

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Research Data Availability

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

Conflict of interest

The authors have no conflicts of interest to declare.

Declaration of Use of Artificial Intelligence

The authors declare that no artificial intelligence tools were used in the writing or editing of this manuscript.

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Authors' Contribution:

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