Preschoolers engage in theory of mind differently across cooperative and competitive contexts

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Abstract

Whether people engage in theory of mind (ToM)—the capacity to infer, attribute, and reason about mental states—similarly across different social contexts is unclear. Here, we focus on two fundamental social contexts that encompass much of human behavior: cooperation and competition. Some evolutionary and psychological work suggests that people engage in ToM more for competition than cooperation, while other findings and theories indicate the opposite. We investigate this question by examining the period of development during which explicit ToM emerges. We examined preschool children's abilities to explicitly express an understanding of false beliefs, a key marker of ToM, as observers of cooperative or competitive interactions (Study 1), and also their abilities to apply that understanding in actual cooperative or competitive interactions (Study 2). Our findings reveal that preschool children are better at understanding false beliefs in competitive contexts than cooperative contexts as observers; however, they are better at applying their understanding of false beliefs when actually engaging in cooperative interactions compared to competitive interactions—a pattern that cannot be attributed to differences in executive functioning or memory. Together, this work suggests that preschool children deploy ToM differently across cooperative and competitive contexts, and the extent to which they do depends on age and whether participants are mere observers of others' behaviors or active participants engaged in social interactions.

Introduction

Cooperation and competition comprise two basic forms of social interaction. At first glance, successful cooperative and competitive interactions both appear to require the capacity to infer, attribute, and reason about the contents of people's minds (e.g., thoughts, beliefs, intentions), a capacity often referred to as theory of mind (ToM). Indeed, to successfully help another person, one must understand both that the person needs help and what he or she needs help with. Similarly, to compete effectively against another person, one must understand what one's opponent is thinking in order to oppose him or her effectively.

Although ToM facilitates both cooperation and competition, some evidence suggests that ToM has developed primarily in service of competitive aims. Prior work on the evolutionary origins of ToM provides evidence for rudimentary ToM capacities in non-human primates in the ecologically salient domain of competition (e.g., over scarce resources such as food), as compared to cooperation (e.g., Hare, 2001; Hare, Call, Agnetta, & Tomasello, 2000; Hare, Call, & Tomasello, 2006; Hare & Tomasello, 2004; Lyons & Santos, 2006; Melis, Call, & Tomasello, 2006). The primarily competitive nature of social interactions among non-human primates and environmental pressures such as limited resources (e.g., for food and mating opportunities) may have favored individuals who could represent the perceptions and simple beliefs of conspecifics — an ability that may have been preserved in the hominid lineage. These findings are in line with evolutionary accounts of ToM as having evolved for Machiavellian aims (Byrne & Corp, 2004; Byrne & Whiten, 1988). Even among human children and adults, agents that display negative behavior, as compared to neutral or positive behavior, are particularly strong triggers for ToM in the service of understanding those agents' present and future behaviors (Hamlin &

Baron, 2014; Knobe, 2003; Leslie, Knobe, & Cohen, 2006; Morewedge, 2009; Vaish, Grossmann, & Woodward, 2008; Waytz et al., 2010).

On the other hand, several lines of research suggest that, in humans, ToM may have emerged to facilitate cooperation. Unlike our closest ape relatives, humans are "cooperative breeders": individuals distantly related or unrelated to a child often serve as caregivers ("alloparents"), engaging in active food sharing and providing shelter and protection (Hrdy, 2009). It has been argued that the need to identify individuals in one's environment who are most likely to provide optimal care has facilitated the emergence of advanced ToM in humans. This conclusion is supported by the observation that other cooperative breeders in the primate lineage, most notably callitrichids, are largely deficient when compared to apes and various other non-cooperative breeding primates in general cognitive functioning, but nevertheless have relatively advanced social-cognitive abilities (Burkart, Hrdy, & Van Schaik, 2009; but see Thornton & McAuliffe, 2015). Relatedly, experimental work in human children and adults reveals a greater tendency for people to consider the minds of ingroup members (who are more likely to be cooperators) than outgroup members (or competitors) (Kelman, 1973; Leyens et al., 2000; McLoughlin & Over, 2017; Opotow, 1990; Struch & Schwartz, 1989).

We previously investigated the question of whether ToM is greater for competition than cooperation or vice versa in adults, using overall levels of activity in brain regions implicated in ToM (right and left temporoparietal junction, medial prefrontal cortex, precuneus) as a proxy for the cognitive process of ToM (Tsoi, Dungan, Waytz, & Young, 2016). We found that overall levels of activity within ToM regions were similar for cooperative and competitive interactions, suggesting that adults do not engage in ToM more for cooperation than competition or vice versa. These regions did, however, encode information separating cooperation from competition

in their spatial patterns of activity, as revealed by multi-voxel pattern analyses. Together, this work leaves open the question of whether these effects at the mature state are due to learning and/or socialization. We answer this question by investigating how ToM is deployed in childhood across these fundamental social contexts, when children have not yet been socialized to the same extent as adults.

The approach we take in the current work is to examine the period of development during which explicit ToM comes online. Many developmental studies of ToM have focused on false belief understanding, that is, the understanding that people can have beliefs that contradict reality (Wimmer & Perner, 1983). The ability to understand false beliefs has been shown to emerge during the preschool years, approximately 4 years of age (for a review, Wellman, Cross, & Watson, 2001). At this point in development children start being able to make explicit predictions and inferences about people's false beliefs. While there is growing evidence of implicit false belief understanding in infants (e.g., Onishi & Baillargeon, 2005; Scott & Baillargeon, 2017; but see Crivello & Poulin-Dubois, 2018; Dörrenberg et al., 2018; Powell et al., 2018), the focus of the current studies is on (1) the explicit expression of false belief understanding (Study 1) and (2) the application of that understanding to first-person social interactions (Study 2).

Here, in two studies, we test whether children, at the age during which explicit ToM comes online, are better at understanding false beliefs in competitive contexts than cooperative contexts or vice versa. In Study 1, we build on an extensive body of literature on preschool children's explicit performance on a classic false belief task (Perner & Roessler, 2012; Wellman et al., 2001; Wimmer & Perner, 1983) and test whether preschool children's false belief understanding is better for processing mean (competitive) versus nice (cooperative) interactions.

Prior work shows improvements in false belief tasks framed in terms of deception (Chandler, Fritz, & Hala, 1989; Davis, 2001; Hala, Chandler, & Fritz, 1991; Sullivan & Winner, 1993; Wellman et al., 2001). However, the motives behind the deception in these prior tasks were not always made clear. In particular, deception may not map neatly onto competitive motives (and indeed, Study 2 features a task that involves deception for both competition and cooperation). While some researchers have studied deception as a means of hindering another person (e.g., from getting to a treasure), which maps onto competitive intent (Hala et al., 1991), others have described deception in terms of tricking another person "for fun" (Sullivan & Winner, 1993). Few studies have directly compared competitive with cooperative intent. Study 1 therefore uses a classic ToM task to look specifically at false beliefs across competitive and cooperative contexts. In Study 2, we depart from traditional ways of measuring ToM as in Study 1, that is, in third-party contexts, during which participants observe and assess the behaviors of others (non-interaction partners). Instead, in Study 2, we test ToM during first-person social interactions and use the capacity for deception (i.e., planting a false belief in someone else's mind) as a proxy for ToM (Chandler et al., 1989; Hala et al., 1991; Lee, 2013; Premack & Woodruff, 1978; Woodruff & Premack, 1979). Specifically, we examine whether preschool children are better able to plant a false belief in another's mind to achieve a competitive goal (i.e., to be the sole winner of stickers) versus a cooperative goal (i.e., to be joint winners, together, of stickers) or vice versa. Moreover, we examine whether the difference in ToM across cooperation versus competition is specific to ToM, or whether it can be attributed to a difference in executive functioning or memory across the two conditions, given prior work linking executive functioning and memory with ToM (Carlson et al., 1998; Carlson & Moses, 2001; Carlson et al., 2002; Carlson et al., 2004; Gordon & Olson, 1998; Hughes, 1998). To test this, participants completed a slightly

modified version of the ToM task from Study 2, answered a memory question about the task, and completed a cooperative and competitive version of a child-appropriate Stroop task (Day-Night task; Gerstadt, Hong, & Diamond, 1994).

Study 1

This study examined whether preschool children are better at understanding false beliefs when observing cooperative interactions than competitive interactions or vice versa.

Methods

Participants

The final sample consisted of 537 participants: 147 three-year-olds (74 females), 266 four-year-olds (137 females), and 124 five-year-olds (55 females). Participants were recruited from a community-based science center and tested in a soundproof room dedicated to behavioral science research. A legal guardian provided informed consent for all children. Breakdown of sample size per cell and detailed information on exclusion criteria are reported in Supplementary Material.

Procedure

Participants were introduced to a modified version of the Sally-Anne task (Baron-Cohen, 1985) in the form of a live puppet show. Participants were assigned to either the *Nice Anne* condition or the *Mean Anne* condition (counterbalanced across participants; see complete script in Supplementary Material). In the *Nice Anne* condition, Anne, who is a nice girl, moves Sally's ball from the basket to the closet while Sally is away because she wanted to help Sally. In the *Mean Anne* condition, Anne, who is a mean girl, moves Sally's ball from the basket to the closet while Sally is away because she wanted to trick Sally. After the puppet show, participants are asked the following questions: (1) Where will Sally look?, (2) Where does Sally think her ball

is?, (3) Should Anne and Sally be friends?, (4) Is Anne a nice girl or not a nice girl?, (5) Is Sally a nice girl or not a nice girl?. The order in which Questions 1 and 2 were asked was counterbalanced across participants. The focus of this paper is on responses to Questions 1, 2, and 4; descriptive statistics for responses to the remaining Questions 3 and 5 are provided in Supplementary Material.

Analyses

Analyses were conducted in R (version 3.3.3; R Core Team, 2015). Responses were analyzed using a Generalized Linear Mixed Model (GLMM) with binary response terms (correct [1] or incorrect [0]). We were primarily interested in whether responses (correct versus incorrect) depended on Condition, Question Type, and Age. Thus, our full model included the following predictor variables: Condition (Mean Anne or Nice Anne), Question Type ("Where will Sally look" or "Where does Sally think her ball is?"; manipulated within-participant), Age Category (three, four, or five), and Gender (male or female). Because the standard question ("Where will Sally look?") might be difficult in that it requires integrating a belief about Sally's mental state as well as knowledge of how mental states can affect motor behavior, we also included a question probing just the belief ("Where does Sally think her ball is?")—hence, we included Question Type as a factor. We examined the three-way interaction between Condition, Question Type, and Age Category, the three two-way interactions (Condition x Question Type, Condition x Age Category, and Question Type x Age Category), and the main effects of these variables. Participant was entered as a random effect. To assess the importance of our predictors of interest, we performed likelihood ratio tests (LRTs) and examined whether the model including a given term provided a significantly better fit to the data than the model without that term. For all

analyses with Age Category as a predictor, we also conducted the same analyses with age as a continuous measure.

Results

Overall, we did not see any interactions involving Condition (Mean Anne or Nice Anne). That is, likelihood ratio tests revealed no three-way interaction between Condition, Question Type, and Age Category ($\chi^2(2) = 3.719$, $p = 0.16$), no two-way interaction between Condition and Age Category ($\chi^2(2) = 0.687$, $p = 0.71$), and no two-way interaction between Condition and Question Type ($\chi^2(1) = 2.344$, $p = 0.126$). There was, however, an interaction between Question Type and Age Category ($\chi^2(2) = 10.866$, $p = 0.004$): the effect of Question Type differed across the three age groups (Fig. S2). Pairwise contrasts performed at each age group revealed that the log odds of getting the "Where does Sally think her ball is?" question correct was significantly greater than the log odds of getting the "Where will Sally look?" question correct among 4-year-olds ($z = 4.438$, $p < 0.001$) and 5-year-olds ($z = 3.785$, $p < 0.001$), but not among 3-year-olds ($z = 0.495$, $p = 0.62$).

More critically, we found a significant main effect of Condition ($\chi^2(1) = 7.136$, $p = 0.008$): the log odds of providing a correct response was significantly greater for the *Mean Anne* condition than for the *Nice Anne* condition (Fig. 1). Entering age as a continuous variable revealed a similar pattern of results: a significant main effect of Condition ($\chi^2(1) = 7.2893$, $p = 0.007$; see Supplementary Material for more details). We also restricted our analyses to participants who responded to the question "Is Anne a nice girl or not a nice girl?" in a manner congruent with the condition to which they were assigned; this question served as a comprehension check, but excluding people who did not get this question correct did not change

the general pattern of results ($\chi^2(1) = 13.605$, $p < 0.001$; see Supplementary Material for more details).

Even though the interaction between Condition and Age Category was not significant, we nevertheless performed contrasts examining the difference between conditions at each Age Category and for each Question Type. For the question, "Where does Sally think her ball is?", the difference between *Mean Anne* and *Nice Anne* was significant for 3-year-olds ($z = 1.997$, $p = 0.046$) but not for 4-year-olds ($z = -0.327$, $p = 0.74$) or for 5-year-olds ($z = 0.564$, $p = 0.57$). On the other hand, for the question, "Where will Sally look?", the difference between *Mean Anne* and *Nice Anne* was significant for 4-year-olds ($z = 2.568$, $p = 0.01$) but not for 3-year-olds ($z = 1.069$, $p = 0.29$) or for 5-year-olds ($z = 1.260$, $p = 0.21$). These results reveal that children are more likely to respond correctly to questions about beliefs in competitive contexts than cooperative contexts at age 3 and more difficult questions about beliefs and behavior in competitive contexts than cooperative contexts at age 4.

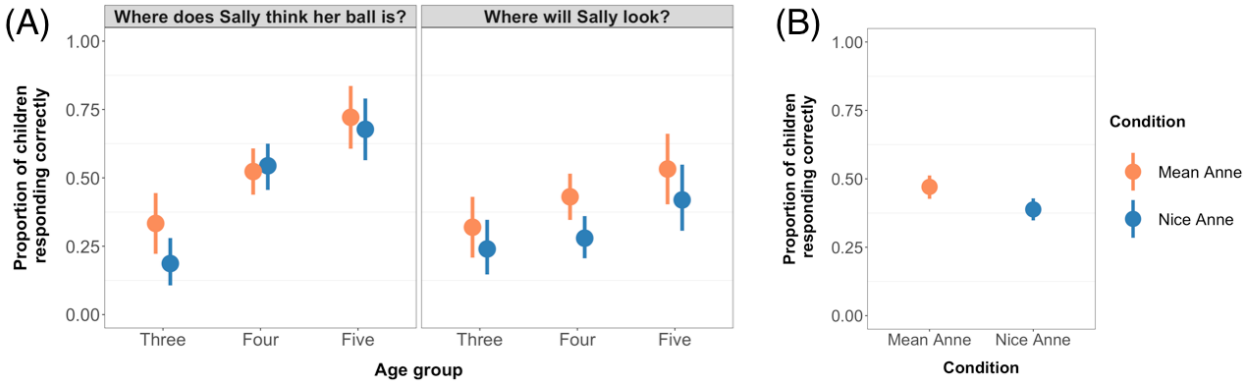

Fig. 1. Proportion of correct responses in the modified Sally-Anne task in Study 1. (A) Proportion of children responding correctly, broken down by Age Category, Condition, and Question Type. (B) Proportion of children responding correctly, across Condition. Error bars denote 95% CIs.

Study 2

In Study 1, we demonstrated that preschool children were better able to understand false beliefs when they observed a competitive behavior than when they observed a cooperative behavior. Study 2 tests whether this pattern extends to actual cooperative and competitive behaviors. That is, we examined whether preschool children are better able to plant false beliefs in another's mind to achieve a cooperative goal versus a competitive goal. Additionally, we examined whether any difference in ToM across cooperation and competition can be attributed to a difference in memory or executive functioning, two cognitive processes known to contribute to ToM. Based on prior testing (see Supplementary Material), we decided to focus on four-year-olds. The pre-registration of this study can be found here: http://aspredicted.org/blind.php?x=xn73hw.

Participants

One hundred and forty-six participants were recruited from public parks in the Boston area. We had a predetermined goal of 60 participants per cell (roughly 30 per gender), based on Study 2. The final sample consisted of 120 participants, 66 of which were female. Breakdown of sample size per cell and detailed information on exclusion criteria are reported in Supplementary Material. A legal guardian provided informed consent for all children. This study was approved by the Boston College Institutional Review Board.

Methods

Procedure

Participants completed two tasks (scripts provided in Supplementary Material): the first task was a two-person game involving stickers, where the goal of the game was to get as many stickers as possible. Each participant was assigned to either the *Competition* condition or the *Cooperation* condition. In the *Competition* condition, participants were instructed to hide a

sticker in one of two cups while a second player (a second experimenter, hereafter referred to as E2) had her eyes closed. The participant was instructed to respond however he or she wanted (e.g., by pointing to either Cup #1 or Cup #2) when E2 opened her eyes and asked the participant where the sticker is. E2 would then make a guess as to where the sticker is solely based on the participant's response. In this condition, only one person could win stickers at a time: if E2 guessed correctly, she kept the sticker, but if she guessed incorrectly, the participant got to keep the sticker. In the *Cooperation* condition, the participant was instructed to hide two stickers, with both stickers going in the same cup. In this condition, both players could win stickers at the same time: if E2 guessed correctly, neither player got any stickers, but if she guessed incorrectly, the participant and E2 each got to keep one of the two stickers. In order to succeed on either task, the participant would have to plant a false belief in E2's mind. Each participant played four rounds of this game; thus, the participant had the opportunity to win up to 4 stickers in either condition. At the end of the game, participants were asked a memory question regarding the last trial: "Which was the last cup that E2 pointed to?" The second task was a variant of the Day-Night task (Gerstadt et al., 1994), a popular task used to measure inhibitory control in children. This children's version of the Stroop task consisted of 16 trials, in which participants were told to say "Day" in response to an image of nighttime and "Night" in response to an image of daytime. We adapted this task by creating a competitive or cooperative version of the task: in the Competition condition, children were told that if they got more trials correct than E2 (who had played the game before), they would receive a sheet of four stickers (the four stickers here match the number of stickers a participant could potentially win in the Stickers task). Otherwise, E2 would win a sheet of 4 stickers. Meanwhile, in the Cooperation condition, children were instructed that if they got more trials correct than E2, they would win a sheet of four stickers for the participant

and a sheet of four stickers for E2; otherwise, no one would win anything. These versions mimicked the structure of the conditions in the Stickers task.

The condition was the same across the two tasks; for instance, if a participant was in the Cooperation condition, that person would complete the cooperative version of the Stickers task and the cooperative version of the Day-Night task. The order of tasks was counterbalanced across participants.

Analyses

Analyses were conducted in R (version 3.3.3; R Core Team, 2015). Responses were analyzed using Generalized Linear Models with proportion data. We were primarily interested in whether the proportion of stickers won depended on age and condition; our full model included the following predictor variables: Condition (cooperation or competition), Age (continuous), and Gender (male or female). We also examined the two-way interaction between Condition and Age. To assess the importance of our predictors of interest, we performed likelihood ratio tests (LRTs) and examined whether the model including a given term provided a significantly better fit to the data than the model without that term. Likewise, we ran the same model but substituting proportion of stickers won with proportion of correct trials in the Day-Night task. For the memory question, we had a binary response (correct or incorrect) and modeled the data accordingly, again with Condition, Age, and Gender as predictors and including the two-way interaction between Condition and Age.

Results

Analyses involving the Stickers game revealed a significant interaction between Condition (cooperation or competition) and Age ($\chi^2(1) = 6.0985$, $p = 0.0135$): the effect of Condition differed across age (Fig. 3). That is, younger children won more stickers in the

Cooperation condition than in the *Competition* condition, whereas older children did not show a difference across the conditions. We also tested whether this pattern could be revealed on a trial-by-trial basis. We found that this interaction was present for trials 2, 3, and 4 (trial 1: $\chi^2(1) = 0.467$, $p = 0.495$; trial 2: $\chi^2(1) = 4.53$, $p = 0.03$; trial 3: $\chi^2(1) = 7.07$, $p = 0.008$; trial 4: $\chi^2(1) = 3.77$, $p = 0.05$). Together, these findings show a pattern that is quite different from Study 2.

Analysis of the memory question at the end of the Stickers game revealed no significant interaction between Condition and Age ($\chi^2(1) = 1.66$, $p = 0.20$) and no significant main effect of Condition ($\chi^2(1) = 1.83$, $p = 0.18$). Similarly, analysis of the Day-Night task reveals no significant interaction between Condition and Age ($\chi^2(1) = 0.284$, $p = 0.59$) and no significant main effect of Condition ($\chi^2(1) = 2.11$, $p = 0.15$). These findings reveal no evidence that memory or response inhibition differs across cooperative and competitive contexts; yet, we find, again, that the extent to which preschool children apply their understanding of false beliefs in live interactions differs across cooperative and competitive contexts.

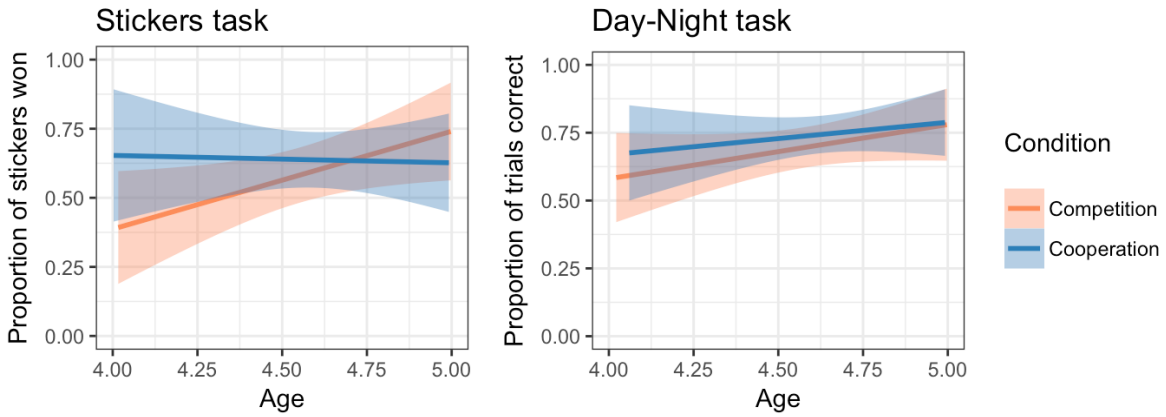

Fig. 3. Performance in Study 3. Proportion of stickers won in the Stickers task (left) and proportion of correct trials on the Day-Night task (right), by Age and Condition. Error bars denote 95% CIs.

The relationships among performance on the Stickers task, memory, and response inhibition are not directly relevant to this study but are reported in Supplementary Material.

General Discussion

Three studies demonstrate differences in preschool children's abilities to understand false beliefs across cooperative and competitive contexts. In Study 1, we tested children's false belief understanding using a novel variant of a classic false belief task, tapping into children's abilities to understand people's mental states from the perspective of a third-party observer. In Study 2, we tested children's abilities to plant false beliefs in another's mind, tapping into children's abilities to use mental state information to guide their own behavior. We also tested whether the difference in ToM across contexts can be due to differences in other cognitive capacities such as memory or executive functioning.

Study 1 revealed better understanding of false beliefs among preschool children in competitive contexts than cooperative contexts. If ToM evolved to support competitive aims, we might predict that people are more attuned to the minds of those they consider to be potential opponents, even if they never actually end up interacting with them. What is interesting about Study 1 is that participants made inferences about the false beliefs of Sally, who was neither a threat nor an opponent. Whether Anne was nice or mean was not relevant to the main questions asked in the task (i.e., Where does Sally think the ball is? Where will Sally look for the ball?); yet, exposure to this information (i.e., about Anne's moral character) was sufficient to drive differences in children's abilities to make inferences about Sally's beliefs. Therefore, an interesting alternative possibility is that competitive contexts may trigger ToM such that people are more likely to reason about all minds related to the specific situation. Though our data don't

speak directly to this possibility, the results of Study 1 support the idea that children may be more generally attuned to minds in competitive contexts and not specifically to the minds of individual competitors, at least when observing cooperative and competitive interactions from a third-party position.

The *Mean Anne* and *Nice Anne* conditions were designed to be quite similar, so that any condition differences could not be due to factors such as word length or story structure. However, we recognize that in doing so we may have inadvertently introduced other features that could potentially drive condition differences. One possibility is that participants in the *Nice Anne* condition were led to focus more on the location corresponding with the wrong answer. That is, children in the *Nice Anne* condition were told that Anne was trying to be nice and so moved the ball to a different location, implicitly indicating that the different location is the correct place for the ball. Meanwhile, there was no implicit indication of a "correct" place for the ball in the *Mean Anne* condition. Thus, perhaps children in the *Nice Anne* condition experienced more difficulty because of this incidental emphasis on the "correct" location, corresponding to the wrong answer for the actual task. Another possibility could be that children performed better in the *Mean Anne* condition than in the *Nice Anne* condition because of associative reasoning rather than ToM. That is, in the *Mean Anne* condition, participants were told "That was not very nice" after describing Anne moving the ball. This phrase may have led children to focus on the likelihood of Anne causing a bad outcome associated with Sally having a false belief about the location of the ball. While it's unclear the extent to which children would think this way, we cannot rule out these possibilities in the current study.

Meanwhile, the results from the Stickers task reveal a difference in ToM performance across cooperation and competition and across age. When younger 4-year-old children show that

they understand the task, they are better able to plant false beliefs in another's mind when meeting a cooperative goal versus a competitive goal; this pattern is not found for older 4-year-olds. Importantly, this difference between cooperation and competition seems to be specific to ToM: this difference across cooperation and competition is not found for executive functioning or memory.

If cooperation boosts ToM performance among younger children engaging in actual interactions, one question that arises is why that might be the case. Human societies display an immense capacity for large-scale cooperation and altruistic social preferences that is uncommon in other species (Warneken & Tomasello, 2009). Infants as young as 14 months of age readily help others to achieve their goals (e.g., helping others get out-of-reach objects) (Warneken & Tomasello, 2006; Warneken & Tomasello, 2007). Not only do infants engage in instrumental helping, but they also engage in emotional helping (e.g., comforting others in distress) (Johnson, 1982; Zahn-Waxler, Radke-Yarrow, Wagner, & Chapman, 1992). Note that in these cases, children are engaging in actual helping behaviors. One possibility is that younger children may have a propensity to help those around them, and they may be more likely to consider the minds of others if doing so improves their ability to actively cooperate with and help others. Indeed, one study showed that prosocial motives boosts early false belief understanding (Matsui & Miura, 2008). We add to this work by revealing the nuances associated with this claim: we demonstrate that a cooperative advantage is present for younger children and not older children, that it is sensitive to task difficulty, that it emerges for live interactions with others, and that it is specific to ToM and not a result of other cognitive processes like memory or response inhibition.

One remaining puzzle is how to reconcile the findings of Study 1 with the current interpretation of Study 2. One plausible explanation could be that cooperative versus competitive

contexts may have differential effects on ToM based on whether people are engaging in actual cooperative versus competitive interactions with real stakes (as in the Stickers task) versus observing others' cooperative versus competitive behaviors with no stakes (as in the Sally-Anne task). We speculate that young children may be more motivated to maintain positive, cooperative relationships with their social partners in real life, and thus would engage in greater ToM for cooperation in real interactions. This idea converges with work showing that children are more likely to maintain positive attributions of people and are reluctant to make negative ones (Boseovski, Chiu, & Marcovitch, 2013). Indeed, recent research demonstrates the costliness of missing the chance for cooperative social partnerships (Siegel, Mathys, Rutledge, & Crockett, 2018). In contrast, these motivations may be less prominent in third-party tasks like the one in Study 1. Future work is needed to test these speculative hypotheses, with a larger set of tasks incorporating both judgment and behavior.

In short, we examined preschool children's abilities to understand false beliefs and apply their understanding of false beliefs across cooperative and competitive contexts. Our findings suggest that preschool children's performance on ToM tasks differs across cooperative and competitive contexts, and that behavioral patterns vary depending on age and whether participants are mere observers of others' cooperative and competitive behaviors or active participants in cooperative and competitive interactions.

Context of the Research

When and how do people consider the thoughts, beliefs, and intentions of others? We test whether people engage in mental state reasoning or "theory of mind" differently across different social contexts, focusing on two major contexts that encompass much of human behavior and

motivation: cooperation and competition. While some prior work suggests that people attribute more mind to those they like and wish to cooperate with and attribute less mind to their opponents in times of conflict or war, other work suggests that people attribute more mind to competitors in service of predicting their future actions and outsmarting them. Since our initial investigations, we have become increasingly interested in understanding how theory of mind may be deployed differently not just across cooperation and competition but whether and how differences across these contexts emerge for judgment and behavior. In past and ongoing work, we have examined this exact question in adults across judgment and behavior, using neuroimaging methods to measure neural activity in brain regions implicated in theory of mind as a proxy for the cognitive process. In the present paper, we used a developmental approach to test whether children, at the point in time during which explicit theory of mind emerges, are better able to deploy their theory of mind capacities during cooperative versus competitive contexts or vice versa. We view these studies together as providing complementary means of understanding the broader phenomenon of when people do and do not consider the minds of those around them.

Author Contributions

L.Y., A.S.B., K.H., and A.W. developed the study concept and contributed to the study design for Study 1. L.T., L.Y., A.S.B., K.H., and A.W. developed the study concept and contributed to the study design for Study 2. Testing and data collection for Study 1 was performed by A.S.B. Testing and data collection for Study 2 was performed by L.T. L.T. analyzed the data and interpreted the results. L.T. drafted the manuscript, and A.S.B., K.H., A.W., and L.Y. provided critical revisions. All authors approved the final version of the manuscript for submission.

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Author Note

We have posted a pre-print of an earlier version of this manuscript on PsyArXiv. This work was presented in several talks by L.T. and L.Y.

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Table of Contents

Script for Study 1

Nice Anne Condition

Hi (child's name)! Let me introduce you to some people.

This is Sally (Sally waves), and this is Anne (Anne waves). Sally is playing with her favourite ball (act playing with ball) when her mom calls her out to lunch. Sally has to go, so she runs off, dropping her ball in the basket on the way out (act dropping ball in basket).

Now Anne sees where Sally put her favourite ball and knows that the ball is supposed to go in the closet, and NOT in the basket. Anne thinks that Sally must have been in such a hurry that she put her ball in the wrong place! Anne is a very nice girl, so she wants to help Sally by moving the ball to the closet. Anne goes and gets the ball out of the basket, and to help Sally, puts it away in the closet. That was very nice. Now Sally comes back after lunch and wants to find her ball.

Where will Sally look?
Where does Sally think her ball is?
Should Anne and Sally be friends?
Is Anne a nice girl or not a nice girl?
Is Sally a nice girl or not a nice girl?

Mean Anne Condition

Hi (child's name)! Let me introduce you to some people.

This is Sally (Sally waves), and this is Anne (Anne waves). Sally is playing with her favourite ball (act playing with ball) when her mom calls her out to lunch. Sally has to go, so she runs off, dropping her ball in the basket on the way out (act dropping ball in basket).

Now Anne sees where Sally put her favourite ball and knows that Sally LOVES to play with it. Anne thinks that Sally must have been in such a hurry that she will definitely come back after lunch to play with her ball again. Anne is not a very nice girl, so she wants to trick Sally by moving the ball to the closet. Anne goes and gets the ball out of the basket, and to trick Sally, puts it away in the closet. That was not very nice. Now Sally comes back after lunch and wants to find her ball.

Where will Sally look?
Where does Sally think her ball is?
Should Anne and Sally be friends?
Is Anne a nice girl or not a nice girl?
Is Sally a nice girl or not a nice girl?

Script for Study 2

Counterbalance order of task: half get Stickers task first, half get Day-Night first

Competition **Condition – 4 stickers**

You like stickers, right? Well, E2 likes stickers, too. Let me tell you about this game. Ok (child's name), here is the game. The goal of the game is to get as MANY stickers as you each can. You try and get as many as you can, and she'll try and get as many as she can. You and E2 both like these stickers, but in this game, only ONE person can win stickers at a time.

To play the game, I'll ask E2 to close her eyes, and then you can hide this sticker in one of these cups. You can put the sticker in this cup or in this cup, in any cup you like! Now, after you hide the sticker while E2 can't see you, I will tell E2 she can open her eyes, and she will ask you a question about where the sticker is, and you can tell her this cup [points left] or this cup [points right], whatever cup you want. Then E2 will guess where the sticker is.

Now here's how the game goes. If E2 guesses the wrong cup, then YOU get to keep the sticker, but if E2 guesses the right cup, then SHE gets to keep the sticker! Get it?

So we'll play the game the same way every time—you always get to hide the sticker and E2 will ask you a question and then guess where the sticker is. Ok, just to make sure you understand the rules: If E2 guesses right, who gets to keep it? If she guesses wrong, who gets to keep it?

Great, ok. Remember, the goal of the game is to win as many stickers as you can! You can take home all the stickers you win.

E1 to E2: Ok E2, close your eyes! No peeking!
E1 to child: ok, hide the sticker! Did you hide it?
E1 to E2: Ok E2, you can open your eyes and ask (child's name) a question!
E2 to child: ok (child's name), now I'm going to ask you, can you show me where the sticker is? [if they don't respond in the expected way] Can you pick one for me?
E2: [ponders] I think the sticker is in this cup [points to the cup that the child pointed at]
If sticker is in the cup, E1: "E2 guessed right! Since she found the sticker, she gets the sticker!" and gives it to E2.
If the sticker is not in the cup, E1: "Huh, no sticker", find the sticker and gives the sticker to the child, "E2 guessed wrong! Since she didn't find the sticker, this time the sticker goes to you!"
E1: Great! Ok, remember, we want to have as many stickers to take home at the end of the game!

Question at the end:

Alright, we are done with this game. I just have one question for you:
[memory] Which was the last cup that E2 pointed to?

***Cooperation* Condition – 4 stickers**

You like stickers, right? Well, E2 likes stickers too. Let me tell you about this game. Ok (child's name), here is the game. The goal of the game is to get as MANY stickers as you each can. You try and get as many as you can, and she'll try and get as many as she can. You and E2 both like these stickers, and in this game, you can BOTH get stickers at the same time.

To play the game, I'll ask E2 to close her eyes, and then you can hide two stickers in one of these cups. You can put the stickers in this cup or in this cup, in any cup you like, but both stickers have to go in the same cup! Now, after you hide the stickers while E2 can't see you, I will tell E2 she can open her eyes, and she will ask you a question about where the stickers are, and you can tell her this cup [points left] or this cup [points right], whatever cup you want. Then E2 will guess where the stickers are.

Now here's how the game goes. If E2 guesses the wrong cup, then each of you gets to keep one sticker! But if E2 guesses the right cup, then NEITHER of you gets any stickers and they go back in the box! Get it?

So we'll play the game the same way every time—you always get to hide the stickers and E2 will ask you a question and then guess where they are. Ok, just to make sure you understand the rules. If E2 guesses right, who gets to keep them? If she guesses wrong, who gets to keep them?

Great, ok. Remember, the goal of the game is to win as many stickers as you can! You can take home all the stickers you win.

E1 to E2: Ok E2, close your eyes! No peeking!
E1 to child: ok, hide the stickers! Did you hide them?
E1 to E2: Ok E2, you can open your eyes and ask (child's name) a question!
E2 to child: ok (child's name), now I'm going to ask you, can you show me where the stickers are?
[if they don't respond in the expected way] Can you pick one for me?
E2: [ponders] I think the sticker is in this cup [points to the cup that the child pointed at]
If stickers are in the cup, E1: "E2 guessed right! Since she found the stickers, no one gets any stickers!"
If the stickers are not in the cup, E1 "Huh, no stickers", find the stickers and give stickers to the child and E2, "E2 guessed wrong! Since E2 didn't find the stickers, this time you both get a sticker!"
E1: Great! Ok, remember, we want to have as many stickers to take home at the end of the game!

Question at the end:

Alright, we are done with this game. I just have one question for you:
[memory] Which was the last cup that E2 pointed to?

***Competition* Condition – Day-Night**

OK, (child's name)! Let's play a game where you try to get as many of these cards as you can! Your goal is to get more cards than E2, who already played this game before! At the end of the game, if you get *more* than E2, *you* get to keep a sheet of 4 stickers! If you get *less* than E2, *E2* gets to keep a sheet of 4 stickers!

Here are the rules!
When you see this card [night], I want you to say 'day'. Can you say 'day'?
When you see this card [day], I want you to say 'night'. Can you say 'night'?

[For the rest of the task, do NOT say the words 'night' or 'day']

Practice trials:

Alright, let's do some practice so we can make sure you understand the rules!

[There are two practice trials: one for day and one for night. Show the day card and then the night card (counterbalance the order). For each card, show without instructions. If child hesitates, say "What do you say for this one?"]

[If correct] Great!

[If child gets any of them incorrect] Remember the rules! When you see this card [night], I want you to say 'day', and when you see this card [day], I want you to say 'night'!

[If child gets 3rd set of practice trials wrong, end task and mark data for this task as unusable]

Test trials:

OK, let's play the game!

[16 trials with no feedback]
[If child hesitates, say "What do you say for this one?"]

End:

[if child receives equal to or greater than 8 cards] You got more than E2! That means you get a sheet of 4 stickers!
[if child receives less than 8 cards] You got less than E2! That means E2 gets a sheet of 4 stickers.

***Cooperation* Condition – Day-Night**

OK, (child's name)! Let's play a game where you try to get as many of these cards as you can! Your goal is to get more cards than E2, who already played this game before! At the end of the game, if you get *more* cards than E2, *you* get a sheet of 4 stickers and E2 will *also* get a sheet of 4 stickers! If you get *less* than E2, no one gets anything!

Here are the rules!
When you see this card [night], I want you to say 'day'. Can you say 'day'?
When you see this card [day], I want you to say 'night'. Can you say 'night'?

[For the rest of the task, do NOT say the words 'night' or 'day']

Practice trials:

Alright, let's do some practice so we can make sure you understand the rules!

[There are two practice trials: one for day and one for night. Show the day card and then the night card (counterbalance the order). For each card, show without instructions. If child hesitates, say "What do you say for this one?"]

[If correct] Great!

[If child gets any of them incorrect] Remember the rules! When you see this card [night], I want you to say 'day', and when you see this card [day], I want you to say 'night'!

[If child gets 3rd set of practice trials wrong, end task and mark data for this task as unusable]

Test trials:

OK, let's play the game!

[16 trials with no feedback]
[If child hesitates, say "What do you say for this one?"]

End:

OK, that's the end of the game! Let's count the number of cards you got!

[if child receives equal to or greater than 8 cards] You got more than E2! That means you each get a sheet of 4 stickers!
[if child receives less than 8 cards] You got less than E2. That means you don't get *any* stickers.

Participant Information

Study 1:

The final sample consisted of 537 participants (Table S1). Of the 643 participants that were recruited for Study 1, 106 were excluded due to: participant's age being outside our age range of interest (31), incompletion of the task or declining to do the task (12), insufficient understanding of English (10), parental/other interference (9), being a part of experimenter pilot/training (8), lack of attention to the task (6), experimenter error (4), not understanding the task (4), having previously seen or completed the task (3), improper consent forms (2), having a developmental disorder (2), fussing out (2), or having data noted by the experimenter as unusable (12).

Table S1. Final sample breakdown by age, gender, and condition for Study 1

	Female	Male	Total
Mean Anne			
three	37	35	**72**
four	66	64	**130**
five	26	36	**62**
Nice Anne			
three	37	38	**75**
four	71	65	**136**
five	29	33	**62**
Grand Total	**266**	**271**	**537**

Study 2:

The final sample consisted of 120 participants (Table S2). Of the 146 participants that were recruited for Study 2, 26 were excluded due to: participant not wanting to continue (10), parental interference (5), participant not understanding the rules (3), experimenter error (3), participant having a hearing disability (1), participant having a neurodevelopmental disorder (1), participant not paying attention to the task (1), participant being too shy to respond (1), and rain, which cut the test session short (1).

Table S2. Final sample breakdown by age, gender, and condition for Study 2

	Female	Male	Total
Cooperation	37	23	60
Competition	29	31	60
Grand Total	**66**	**54**	**120**

Table S3. Participant age summary statistics by study, condition, and age group

Study 1	**Mean**	**Minimum**	**Maximum**
Competition	4.47	3.02	5.99
three	3.58	3.02	3.99
four	4.47	4.00	4.99
five	5.49	5.00	5.99
Cooperation	4.44	3.04	5.98
three	3.53	3.04	3.99
four	4.46	4.00	4.99
five	5.48	5.00	5.98
Total	**4.45**	**3.02**	**5.99**
Study 2	**Mean**	**Minimum**	**Maximum**
Competition	4.56	4.02	4.99
Cooperation	4.59	4.00	4.99
Total	**4.58**	**4.00**	**4.99**

Table S4. Comparing ages across Cooperation and Competition conditions for each age group in each Study

Study 1	**t**	**df**	**p**
three	0.982	140.46	0.328
four	0.461	263.56	0.646
five	0.200	121.93	0.842
Study 2			
four	-0.710	116.84	0.479

Table S5. Exclusions broken down by criteria and condition

Study 1	Total Excluded	Competition	Cooperation
Age outside of age of interest	31	11	18
Incompletion or declining to do the task	12	7	5
Insufficient understanding of English	10	1	9
Parental / other interference	9	2	7
Part of experimenter pilot/training	8	1	7
Lack of attention to the task	6	2	4
Experimenter error	4	3	1
Lack of understanding of the task	4	2	2
Previously saw or completed the task	3	3	0
Improper consent forms	2	1	1
Has developmental disorder	2	0	1

Fussed out	2	2	0
Data marked as unusable but reason was unspecified	12	5	7
Total	**106**	**41**	**62**

Note: The sum of the Competition and Cooperation columns does not equal Total Excluded because 3 participants were not put in a condition since they did not meet our criteria beforehand but wanted to experience a sample of the task anyway. 2 were excluded because of age outside the age of interest; 1 was excluded because of a developmental disorder.

Study 2	Excluded	Competition	Cooperation
Did not want to continue	10	4	6
Did not understand the rules	3	1	2
Has hearing disability	1	0	1
Has neurodevelopmental disorder	1	1	0
Experimenter error	3	1	2
Parental interference	5	3	2
Did not pay attention to the task	1	0	1
Was too shy and didn't respond	1	0	1
Weather-related	1	0	1
Total	**26**	**10**	**16**

Study 1: Additional Analyses

Descriptive statistics for responses to questions in Study 1

In addition to the two main questions, "Where will Sally look?" and "Where does Sally think her ball is?", we asked, "Should Anne and Sally be friends?", "Is Anne a nice girl or not a nice girl?", and "Is Sally a nice girl or not a nice girl?". Proportion data for the latter three questions are depicted below (Fig. S1).

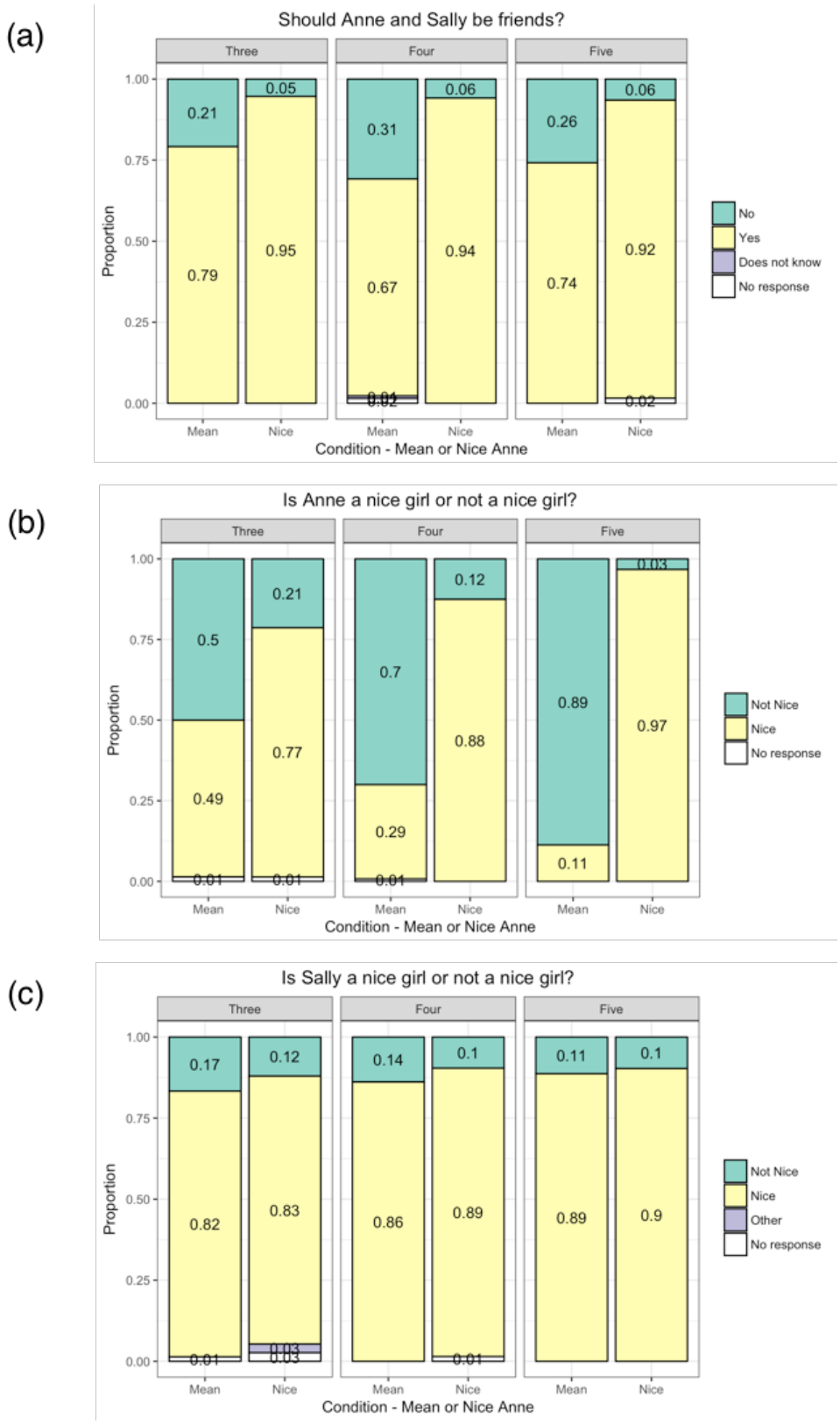

Fig. S1. Proportion of participants by response to auxiliary questions in Study 1, broken down by Condition and Age Category.

Breakdown of performance by Age Category and Question Type

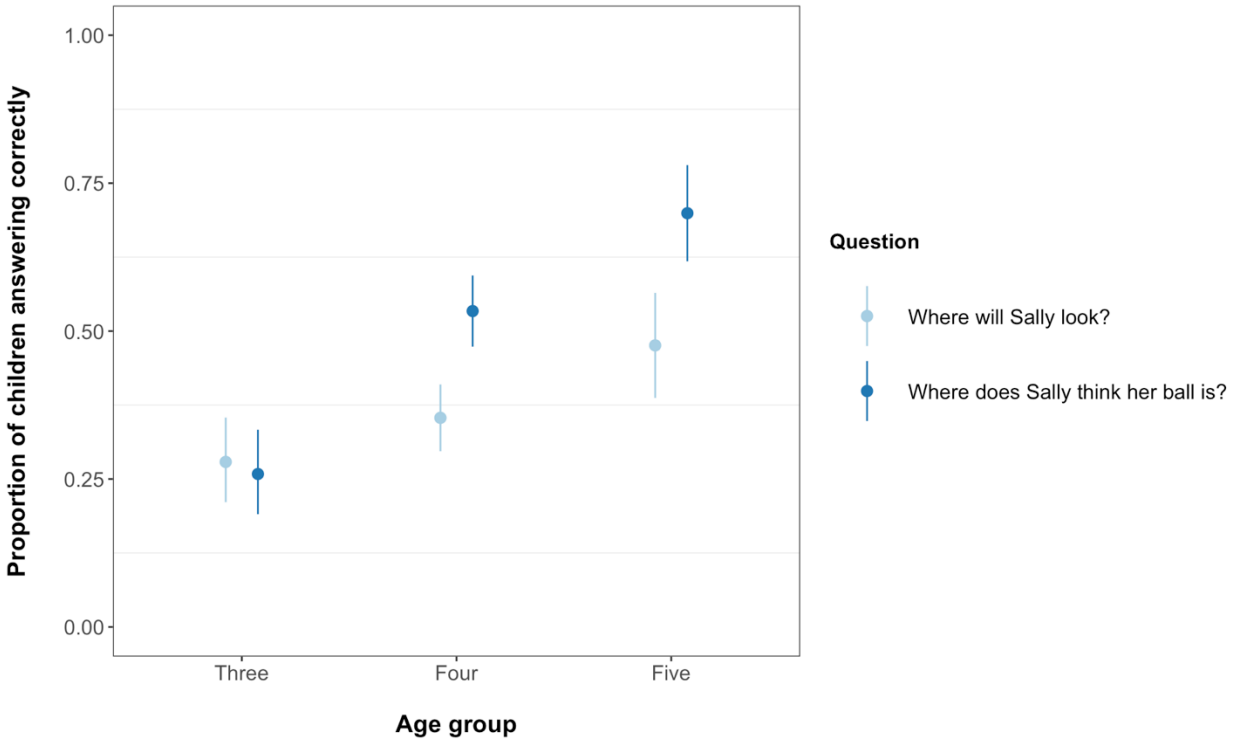

Figure S2. Proportion of participants answering correctly by age group and question. Results are reported in the main text. Bars denote 95% CI.

Analyses limited to participants who responded in a congruent manner

The following analyses restricted the data to those who responded to the question "Is Anne a nice girl or not a nice girl?" in a manner congruent to the condition to which they were assigned. This question acted as a comprehension check, but excluding people who did not get this question correct did not change the general pattern of results.

Results were similar to those found in the main text with all usable data. Likelihood ratio tests revealed no significant three-way interaction between Condition, Question Type, and Age Category ($\chi^2(2) = 2.0941$, $p = 0.351$), no significant two-way interaction between Condition and Age Category ($\chi^2(2) = 2.0691$, $p = 0.3554$), a marginally significant two-way interaction between Condition and Question Type ($\chi^2(1) = 3.1647$, $p = 0.075$), and a marginally significant interaction between Question Type and Age Category ($\chi^2(2) = 5.4554$, $p = 0.065$).

More importantly for our hypotheses, the main effect of Condition remained significant ($\chi^2(1) = 13.717$, $p < 0.001$): the log odds of providing a correct response was significantly greater for the *Mean Anne* condition than for the *Nice Anne* condition.

Entering age as a continuous variable provided a similar pattern of results, revealing, once again, a significant main effect of Condition (see Supplementary section on Analyses with age as a

continuous variable).

Analyses with age as a continuous variable

Because some models failed to converge, we dropped participant as a random effect from analyses using age as a continuous variable and analyzed the data using Generalized Linear Models instead of Generalized Linear Mixed Models.

With all usable data (data reported in the main text):

Entering age as a continuous variable did not affect the pattern of results found in the main text. Similar to results reported in the main text, likelihood ratio tests revealed no significant three-way interaction between Condition, Question Type, and Age ($\chi^2(1) = 1.0116$, $p = 0.3145$), no significant two-way interaction between Condition and Age ($\chi^2(1) = 0.682$, $p = 0.409$), and no significant two-way interaction between Condition and Question Type ($\chi^2(1) = 2.3335$, $p = 0.1266$). There was, again, a significant interaction between Question Type and Age Category ($\chi^2(1) = 8.8752$, $p = 0.003$): the effect of Question Type differed by age. Importantly, the main effect of Condition remained significant ($\chi^2(1) = 7.2893$, $p = 0.007$): the log odds of providing a correct response was significantly greater for the *Mean Anne* condition than for the *Nice Anne* condition.

With data limited to participants responding in a congruent manner:

Similar to results reported in the main text, likelihood ratio tests revealed no significant three-way interaction between Condition, Question Type, and Age ($\chi^2(1) = 0.73388$, $p = 0.3916$) and no significant two-way interaction between Condition and Age ($\chi^2(1) = 1.3816$, $p = 0.2398$). There was a marginally significant two-way interaction between Condition and Question Type ($\chi^2(1) = 3.1597$, $p = 0.07548$). There was, again, a significant interaction between Question Type and Age ($\chi^2(1) = 4.4642$, $p = 0.0346$): the effect of Question Type differed by age. Importantly, the main effect of Condition remained significant ($\chi^2(1) = 13.605$, $p < 0.001$): the log odds of providing a correct response was significantly greater for the *Mean Anne* condition than for the *Nice Anne* condition.

Study 2: Additional Analyses

Correlations between the three measures (Stickers task, Day-Night task, memory question)

We tested how well performance on the memory question and on the Day-Night task could predict performance on the Stickers task. Neither were significant predictors (Day-Night: $\chi^2(1) = 0.057$, $p = 0.81$; memory: $\chi^2(1) = 0.052$, $p = 0.82$).

Earlier version of Study 2

We conducted an earlier version of Study 2 with three-, four-, and five-year-olds. One large limitation of this study was that we could not rule out the possibility that participants in this study had greater difficulty understanding the instructions for the Cooperation condition. Because of this large flaw, we made the decision to not include this study in the main text. For full disclosure, we included details of the study here.

Methods

Participants were recruited from a community-based science center and tested in a soundproof room dedicated to behavioral science research. A legal guardian provided informed consent for all children.

The final sample consisted of 541 participants: 166 three-year-olds (89 females), 251 four-year-olds (130 females), and 124 five-year-olds (54 females). Of the 662 participants that were recruited for Study 2, 121 were excluded due to: age outside our age range of interest (30), incompletion of the task or declining to do the task (21), parental/other interference (11), insufficient understanding of English (9), lack of understanding of the task (9), lack of attention to the task (6), experimenter error (6), indications of not following task instructions (5), participant having previously seen or completed the task (3), invalid consent forms (2), participant having a developmental disorder (2), fussing out (2), being a part of experimenter pilot/training (2), or having data noted by the experimenter as unusable (13).

Table S6. Final sample breakdown by age, gender, and condition for the earlier version of Study 2

	Female	Male	Total
Competition			
three	48	38	**86**
four – 4 stickers	26	26	**52**
four – 8 stickers	39	30	**69**
five	27	34	**61**
Cooperation			
three	41	39	**80**
four – 4 stickers	35	30	**65**
four – 8 stickers	30	35	**65**
five	27	36	**63**
Grand Total	**273**	**268**	**541**

Table S7. Participant age summary statistics by condition and age group for the earlier version of Study 2

Study 2	Mean	Minimum	Maximum
Competition	4.40	3.02	5.99
three	3.56	3.02	3.99
four	4.46	4.00	4.99
five	5.46	5.00	5.99
Cooperation	4.45	3.00	5.98
three	3.56	3.00	3.99
four	4.48	4.00	4.99
five	5.51	5.00	5.98
Total	**4.42**	**3.00**	**6.00**

Table S8. Comparing ages across Cooperation and Competition conditions for each age group in the earlier version of Study 2

	t	df	p
three	-0.013	161.96	0.990
four	-0.557	248.99	0.578
five	-0.900	121.95	0.370

Table S9. Exclusions broken down by criteria and condition for the earlier version of Study 2

Earlier version of Study 2	Total Excluded	Competition	Cooperation
Age outside of age of interest	30	9	21
Incompletion or declining to do the task	21	9	12
Insufficient understanding of English	9	7	2
Parental / other interference	11	4	7
Lack of understanding of the task	9	3	6
Lack of attention to the task	6	3	3
Experimenter error	6	2	4
Indications of not following task instructions	5	5	0
Participant previously saw or completed the task	3	1	2
Invalid consent forms	2	1	1
Has a developmental disorder	2	2	0
Fussed out	2	1	1
Part of experimenter pilot/training	2	2	0
Data marked as unusable but reason was unspecified	13	3	10
Total	**121**	**52**	**69**

Procedure

In the earlier version of Study 2, participants were introduced to a two-person game involving stickers, where the goal of the game was to get as many stickers as possible. Each participant was assigned to either the *Competition* condition or the *Cooperation* condition (see complete script in Supplementary Material). For both conditions, the participant was instructed to hide two stickers in one of two cups while a second player (a second experimenter, hereafter referred to as E2) had her eyes closed. The participant was instructed to respond however he or she wanted (e.g., by pointing to either Cup #1 or Cup #2) when E2 opened her eyes and asked the participant where the stickers were. E2 would then make a guess as to where the stickers were solely based on the participant's response. In the *Competition* condition, only one person won stickers at a time: if E2 guessed correctly, she kept both stickers, but if she guessed incorrectly, the participant got to keep both stickers. In the *Cooperation* condition, both players could win stickers at the same time: if E2 guessed correctly, neither player got any stickers, but if she guessed incorrectly, the participant and E2 each got to keep one of the two stickers. In order to succeed on either task, the participant would have to plant a false belief in E2's mind. Each participant played four rounds of this game; thus, the participant had the opportunity to win up to 8 stickers in the *Competition* condition and up to 4 stickers in the *Cooperation* condition.

We included two additional conditions for the 4-year-old group to address a potential concern: that any difference in performance between the *Competition* and *Cooperation* conditions could be driven by the difference in the maximum number of stickers that could be won (8 stickers in the *Competition* condition versus 4 stickers in the *Cooperation* condition). Participants could be more motivated to do well (to plant a false belief in another's mind), with a larger possible prize on the line (in this case, more stickers). Thus, we included a condition in which participants had the opportunity to win up to 4 stickers in the *Competition* condition and another in which participants could win up to 8 stickers in the *Cooperation* condition. In total, we had 4 conditions: *Competition-8 stickers*, *Cooperation-8 stickers*, *Competition-4 stickers*, and *Cooperation-4 stickers* (see scripts in Supplementary Material). Because we expected any potential difference to emerge around 4 years of age, as predicted by prior work, we recruited only 4-year-olds for these two additional conditions.

For the 3-year-olds, we introduced an additional control condition (*Pompom* condition) to address the concern that poor performance on this task among this age group could be attributed to difficulties with pointing. In this condition, 3-year-olds were instructed to place pompoms in front of one of the two cups (in lieu of pointing to the cup) when responding to E2's question of where the stickers were (see script in Supplementary Material). No difference in performance was found for the pompom versus non-pompom condition ($\chi^2(1) = 0.140$, $p = 0.71$), indicating that the added step of pointing does not negatively affect performance on this task. In our main analyses, we include data from both the *Pompom* and *Non-Pompom* conditions.

Analyses

Analyses were conducted in R (version 3.3.3; R Core Team, 2015). Responses were analyzed using Generalized Linear Models with proportion data. We were primarily interested in whether the proportion of stickers won depended on age and condition; our full model included the

following predictor variables: Condition (cooperation or competition), Age Category (three, four, or five), and Gender (male or female). We also examined the two-way interaction between Condition and Age Category. To assess the importance of our predictors of interest, we performed likelihood ratio tests (LRTs) and examined whether the model including a given term provided a significantly better fit to the data than the model without that term.

Results

Analyses revealed no interaction between Condition (cooperation or competition) and Age Category ($\chi^2(2) = 3.5864$, $p = 0.1664$), suggesting that the effect of Condition did not vary across age group. Unsurprisingly, there was a significant main effect of Age Category ($\chi^2(2) = 242.25$, $p < 0.001$): the log odds of winning stickers were greater among older versus younger age groups. More importantly, and central to the present hypotheses, we found a significant main effect of Condition ($\chi^2(1) = 4.4441$, $p = 0.035$): the log odds of winning stickers were greater for the *Competition* condition than for the *Cooperation* condition. Entering age as a continuous variable revealed the same pattern of results: significant main effects of Condition ($\chi^2(1) = 6.2352$, $p = 0.013$) and Age ($\chi^2(1) = 233.08$, $p < 0.001$).

Even though the interaction between Condition and Age Category was not significant, we nevertheless performed contrasts examining the difference between Conditions at each Age Category. These preplanned contrasts revealed a greater difference for competition versus cooperation among 4-year-olds ($z = 2.489$, $p = 0.0128$), but no difference between cooperation and competition among 3-year-olds ($z = 1.299$, $p = 0.1940$) or 5-year-olds ($z = 0.031$, $p = 0.9753$) (Fig. 2a). To examine whether performance in the task among 4-year-olds could be predicted by alternative factors such as the total possible number of stickers a participant could win (4 versus 8), we examined the effects of Condition and Total Number of Possible Stickers by analyzing just the data with 4-year-olds (Fig. 2b). We did not see a significant effect of total possible number of stickers ($\chi^2(1) = 2.4572$, $p = 0.117$), and, more importantly, we still found a marginal effect of Condition after controlling for Total Number of Possible Stickers ($\chi^2(1) = 3.3141$, $p = 0.069$).

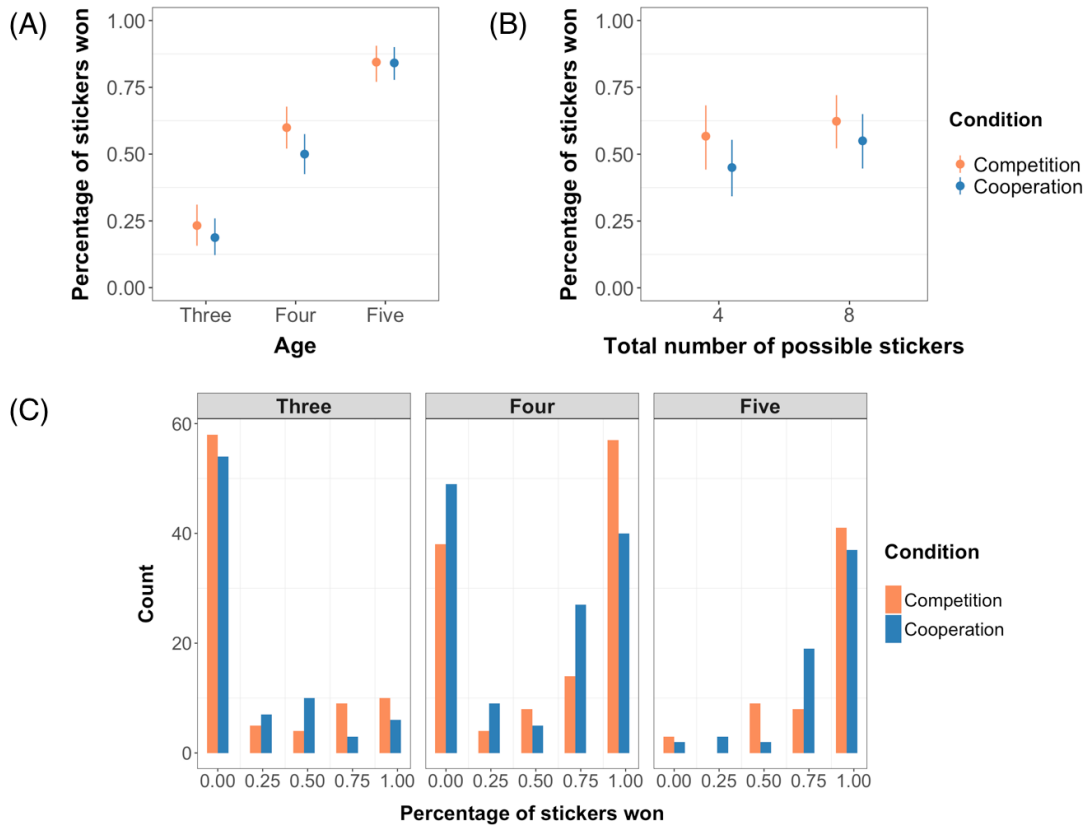

Figure S3. Performance on the Stickers game in Study 2. Proportion of stickers won, (A) broken down by Age Category and Condition, (B) broken down by Condition and Total Number of Possible Stickers for the 4-year-old age group, and (C) depicted as a histogram broken down by Age Category and Condition. Note that the sample size of 4-year-olds is much larger than other groups due to the inclusion of two additional conditions, which makes it difficult to compare bar sizes across age groups. Error bars denote 95% CIs.

Discussion

This study demonstrated that preschool children were better able to apply their understanding of false beliefs in competitive interactions than cooperative interactions. The two conditions were designed to be very similar in wording and in structure. However, this study had one large flaw: the rules for the *Cooperation* condition ("If E2 guesses wrong, then each of you gets to keep one sticker! But if E2 guesses right, then NEITHER of you gets any stickers and they go back in the box!") may have been more difficult to understand than the rules for the *Competition* condition ("If E2 guesses wrong, then YOU get to keep both the stickers, but if E2 guesses right, then SHE gets to keep both the stickers!"). While deception for benign or cooperative reasons does exist and children demonstrate the ability to understand it (e.g., masking true feelings so that others' feelings don't get hurt, telling white lies or throwing surprise parties; Davis, 2001; Hadwin & Perner, 1991; MacLaren & Olson, 1993; Wellman & Banerjee, 1991), deception for cooperative reasons may still occur less frequently than deception for competitive reasons. Planting a false belief in someone's mind for cooperative reasons may have been unintuitive and unrealistic for our participants. One way of addressing this concern is to examine the number of excluded

participants who did not complete or declined to complete the task, did not pay attention, or did not understand the task. These numbers did not systematically differ across conditions; nevertheless, we cannot rule out the possibility that participants who completed the task did not entirely understand the rules of the game, given the relatively unintuitive nature of deception in the name of cooperation. If so, by ensuring that participants understood the rules with comprehension checks we can reduce the concern that participants performed worse in the *Cooperation* condition because they had more difficulty understanding the rules for the *Cooperation* condition.

We made five main changes to Study 2 based on this earlier version: (1) We added comprehension checks to make sure that participants understood the rules of the game before continuing on with the task. We did this to address one major concern: that children may have performed worse in the *Cooperation* condition because the instructions for the *Cooperation* condition were more difficult to understand. That is, the rules for the *Competition* condition were relatively straightforward: "If E2 guesses wrong, then YOU get to keep both the stickers, but if E2 guesses right, then SHE gets to keep both the stickers!". In contrast, the rules for the *Cooperation* condition may have been less intuitive and hence more difficult to understand: "If E2 guesses wrong, then each of you gets to keep one sticker! But if E2 guesses right, then NEITHER of you gets any stickers and they go back in the box!" In earlier version, no systematic check of rule comprehension was provided for the task, and so, in Study 2, we added this component. (2) We fixed the number of stickers that participants could potentially win to be four stickers for both the *Cooperation* and *Competition* conditions. (3) We focused solely on 4-year-olds, given that this age group showed the biggest difference in ToM between cooperation and competition in the earlier version of the study. (4) We added the Day-Night task (Gerstadt et al., 1994), which assesses response inhibition in children. (5) We added a memory question to the Stickers task. We included the Day-Night task and memory question to test the possibility that the difference in ToM across cooperation and competition could be due to a difference in executive functioning or memory, respectively, across the two conditions, given prior work showing contributions of executive functioning and memory to ToM (Carlson et al., 1998; Carlson & Moses, 2001; Carlson et al., 2002; Carlson et al., 2004; Gordon & Olson, 1998; Hughes, 1998). A positive finding for ToM and a negative finding for memory and executive functioning would provide initial evidence that any difference in ToM across cooperation and competition may be specific to ToM.

Script for the earlier version of Study 2

***Competition* Condition – 8 stickers**

You like stickers right? Well, E2 likes stickers too. Let me tell you about this game. Ok (child's name), here is the game. The goal of the game is to get as MANY stickers as you each can. You try and get as many as you can, and she'll try and get as many as she can. You and E2 both like these stickers, but in this game, only ONE person can win stickers at a time.

To play the game, I'll ask E2 to close her eyes, and then you can hide two stickers in one of these cups. You can put the stickers in this cup, in this cup or in this cup, in any cup you like, but both stickers have to go in the same cup! Now, after you hide the stickers while E2 can't see you, I will tell E2 she can open her eyes, and she will ask you a question about where the stickers are, and you can tell her whatever you want to. Then E2 will guess where the stickers are.

Now here's how the game goes. If E2 guesses wrong, then YOU get to keep both the stickers, but if E2 guesses right, then SHE gets to keep both the stickers! Get it? If SHE finds the stickers, SHE gets to keep them, but is she DOESN'T find the stickers, then YOU get to keep them!
So we'll play the game the say way every time- you always get to hide the stickers and E2 will ask you a question and then guess where they are. Ok, just to make sure you understand the rules. If E2 finds the stickers, who gets to keep them? If she doesn't find the stickers, who gets to keep them?

Great, ok. Remember, the goal of the game is to win as many stickers as you can! You can take home all the stickers you win.

E1 to E2: Ok E2, close your eyes! No peeking!
E1 to child: ok, hide the stickers! Did you hide them?
E1 to E2: Ok E2, you can open your eyes and ask (child's name) a question!
E2 to child: ok (child's name), now I'm going to ask you, can you show me where the stickers are?
If stickers are in the cup, E1: "there are the stickers!" and gives them to E2. "This time the stickers go to E2!"
If the stickers are not in the cup, E1: "Huh, no stickers", find the stickers and give stickers to the child, "This time the stickers go to you!"
E1: Great! Ok, remember, we want to have as many stickers to take home at the end of the game!

***Cooperation* Condition – 4 stickers**

You like stickers right? Well, E2 likes stickers too. Let me tell you about this game. Ok (child's name), here is the game. The goal of the game is to get as MANY stickers as you each can. You try and get as many as you can, and she'll try and get as many as she can. You and E2 both like these stickers, and in this game, you can BOTH get stickers at the same time.

To play the game, I'll ask E2 to close her eyes, and then you can hide two stickers in one of these cups. You can put the stickers in this cup, in this cup or in this cup, in any cup you like, but both

stickers have to go in the same cup! Now, after you hide the stickers while E2 can't see you, I will tell E2 she can open her eyes, and she will ask you a question about where the stickers are, and you can tell her whatever you want to. Then E2 will guess where the stickers are.

Now here's how the game goes. If E2 guesses wrong, then each of you gets to keep one sticker! But if E2 guesses right, then NEITHER of you gets any stickers and they go back in the box! Get it? If SHE finds the stickers, no one gets ANY stickers, but if she DOESN'T find the stickers, then you EACH get to keep one!

So we'll play the game the say way every time- you always get to hide the stickers and E2 will ask you a question and then guess where they are. Ok, just to make sure you understand the rules. If E2 finds the stickers, who gets to keep them? If she doesn't find the stickers, who gets to keep them?

Great, ok. Remember, the goal of the game is to win as many stickers as you can! You can take home all the stickers you win.

E1 to E2: Ok E2, close your eyes! No peeking!
E1 to child: ok, hide the stickers! Did you hide them?
E1 to E2: Ok E2, you can open your eyes and ask (child's name) a question!
E2 to child: ok (child's name), now I'm going to ask you, can you show me where the stickers are?
If stickers are in the cup, E1: "there are the stickers! This time no one gets any stickers!"
If the stickers are not in the cup, E1 "Huh, no stickers", find the stickers and give stickers to the child and E2, "This time you both get a sticker!"
E1: Great! Ok, remember, we want to have as many stickers to take home at the end of the game!

Cooperation-Sheet **condition for 4-year-olds – 8 stickers**
In the *Cooperation* condition, participants could win at most 4 stickers, whereas in the *Competition* condition, participants could win at most 8 stickers. To address the concern that the number of total stickers that a participant could win may influence how well participants performed in the game, we added a different version of the *Cooperation* condition in which the total number of stickers one could possibly win matches the total number of stickers one could possibly win in the *Competition* condition (8 stickers).

Do you like stickers? Can I please get you to pick out 8 sticker sheets from this box?

You like stickers right? Well, E2 likes stickers too. Let me tell you about this game. Ok (child's name), here is the game. The goal of the game is to get as MANY sheets of stickers as you each can. You try and get as many as you can, and she'll try and get as many as she can. You and E2 both like these sheets of stickers, and in this game, you can BOTH get sticker sheets at the same time.

To play the game, I'll ask E2 to close her eyes, and then you can hide two sheets of stickers in one of these cups. You can put the sticker sheets in this cup, in this cup or in this cup, in any cup you like, but both sticker sheets have to go in the same cup! Now, after you hide the sticker

sheets while E2 can't see you, I will tell E2 she can open her eyes, and she will ask you a question about where the stickers sheets are, and you can tell her whatever you want to. Then E2 will guess where the stickers sheets are.

Now here's how the game goes. If E2 guesses wrong, then each of you gets to keep one sticker sheet! But if E2 guesses right, then NEITHER of you gets any sticker sheets and they go back in the box! Get it? If SHE finds the sticker sheets, no one gets ANY sticker sheets, but if she DOESN'T find the sticker sheets, then you EACH get to keep one!

So we'll play the game the say way every time- you always get to hide the sticker sheets and E2 will ask you a question and then guess where they are. Ok, just to make sure you understand the rules. If E2 finds the sticker sheets, who gets to keep them? If she doesn't find the sticker sheets, who gets to keep them?

Great, ok. Remember, the goal of the game is to win as many sticker sheets as you can! You can take home all the sticker sheets you win.

E1 to E2: Ok E2, close your eyes! No peeking!
E1 to child: ok, hide the stickers sheets! Did you hide them?
E1 to E2: Ok E2, you can open your eyes and ask (child's name) a question!
E2 to child: ok (child's name), now I'm going to ask you, can you show me where the sticker sheets are?

If stickers are in the cup, E1: "there are the stickers! This time no one gets any sticker sheets!"
If the stickers are not in the cup, E1 "Huh, no sticker sheets", find the stickers and give stickers to the child and E2, "This time you both get a sticker sheet!"

Competition-Four Stickers **condition for 4-year-olds – 4 stickers**
In the *Cooperation* condition, participants could win at most 4 stickers, whereas in the *Competition* condition, participants could win at most 8 stickers. To address the concern that the number of total stickers that a participant could win may influence how well participants performed in the game, we added a different version of the *Competition* condition in which the total number of stickers one could possibly win matches the total number of stickers one could possibly win in the *Cooperation* condition (4 stickers).

The script was the same as the one for *Competition* condition – 8 stickers, but instead of facing the possibility of earning 2 stickers per round, participants faced the possibility of earning 1 sticker per round.

Pompom **condition for 3-year-olds**
Because we were concerned that difficulties with pointing among 3-year-olds could have affected their performance on the task, we introduced a control condition (*Pompom* condition) to a subset of 3-year-olds. Instead of pointing to the cup of their choosing, participants in this condition placed a pompom in front of the cup.

E1 to E2: Ok E2, close your eyes! No peeking!

E1 to child: ok, hide the stickers! Did you hide them?
E1 to E2: Ok E2, you can open your eyes and ask (child's name) a question!
E2 to child: ok (child's name), now I'm going to ask you, can you show me where the stickers are by placing the pompom in front of the cup where the stickers are?
If stickers are in the cup, E1: "there are the stickers! This time no one gets any stickers!"
If the stickers are not in the cup, E1 "Huh, no stickers", find the stickers and give stickers to the child and E2, "This time you both get a sticker!"
E1: Great! Ok, remember, we want to have as many stickers to take home at the end of the game!