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Preschoolers appropriately allocate roles based on relative ability in a cooperative interaction

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Abstract

In cooperative activities, all parties have a shared goal but may not have the same set of skills. The current study considers whether preschoolers are sensitive to probable differences in individuals' competence when allocating roles. We found that 3.5- to 5.5-year-olds use relative competence, as indexed by the age of their intended partner, to determine who should do the harder and easier of two tasks in a cooperative interaction. A second experiment demonstrated that children allocate roles differently in a competitive context. Young children infer differences in others' ability and can divide labor efficiently to achieve their goals.

Keywords: cooperation; self/other knowledge; planning.

Introduction

Cooperation is a foundation of human culture, observed in activities as diverse as governing, hunting, fishing, building, and playing (Tomasello, 1999). Young children begin cooperating in problem-solving tasks and social games by their first birthday, and the sophistication of their cooperative interactions increases over the first few years of life (Brownell & Carriger, 1990; Cooper, 1980; Warneken, Chen, & Tomasello, 2006). Children cooperate by sharing food and toys (Brownell, Svetlova, & Nichols, 2009; Hay, 1979), pointing to inform others (Liszkowski, Carpenter, Striano, & Tomasello, 2006; Liszkowski, Carpenter, & Tomasello 2008), and assisting in goal-directed actions (Warneken & Tomasello, 2007). Children also appear to expect cooperation: when adults disengage from cooperative interactions, they protest (Ross & Lollis, 1987).

Across species, the most sophisticated forms of cooperation involve collaboration: cases in which individuals flexibly adjust their behavior to accomplish a goal – as in when some individuals pursue prey and others block its escape (Boesch & Boesch, 1989). In laboratory tasks, children as young as 3.5 engage in this kind of collaboration, flexibly dividing labor, reversing roles when necessary, and coordinating on tasks involving different sub-goals (e.g., as when one child lifts a lever and another pulls a handle to achieve a joint goal; Ashley & Tomasello, 1998; Fletcher, Warneken, & Tomasello, 2012). Moreover, older preschoolers divide labor appropriately with respect to available resources: when the participant has both the tools needed to achieve a joint goal while their partner has only one, five-year-olds (though not 3-year-olds) appropriately delegate to their partner the task corresponding to their partner's tool (Warneken, Steinwender, Hamann, & Tomasello, 2014). Preschoolers also collaborate to achieve goals by considering what action the other partner has already selected (Warneken et al., 2014).

Critically, previous research has focused on cases in which both partners are, in principle, equally capable of performing both roles. However, people differ not just with respect to the availability of external resources, but also with respect to their physical, cognitive, and emotional resources. This is advantageous for living in social groups, given that collaboration among individuals with different skills might lead to more efficient and effective actions, and better problem-solving (e.g., Azmitia, 1988; Dyer & Singh, 1998). However, to capitalize on diverse skills, role allocation should correspond to individuals' differing capabilities.

Dividing labor in this way requires integrating several pieces of information. Even in simple two-participant scenarios, the individual must represent both her own and her partner's ability to perform the different tasks or components of the task, compare the two, and allocate roles so the person relatively more capable of each task performs it. Thus an adept collaborator should take on a relatively easier task when partnered with someone she regards as more capable than she is, and a relatively more difficult task when partnered with someone she believes is less capable than she is. Here we ask whether preschoolers effectively allocate roles in collaborative tasks by considering their own abilities relative to a partner's.

Previous research, in addition to the work reviewed above, provides grounds for believing that children might succeed at this kind of division of labor. Three and four-year-olds acknowledge and comment on the fact that different people have different abilities (Mostache & Bragonier, 1981), and are sensitive to differences in others' knowledge, competence and reliability (e.g., Jara-Ettinger, Tenenbaum, & Schulz, 2015; Koenig, Clément, & Harris, 2004; Sobel & Kushnir, 2013). Such evaluations influence children's helping behavior; children as young as 3 who master a problem-solving task spontaneously tutor learners they

know are naïve (Johnson, Pynn & Nisbet, 2002).

Preschoolers' ability to accurately represent their own strengths and weaknesses is somewhat more controversial. Some work suggests that preschoolers are (excessively) optimistic about their abilities (Cimpian, 2010; Smiley & Dweck, 1994; Schneider, 1998), and thus resilient in the face of negative feedback (Boseovski, 2010; Droege & Stipek, 1993; Ruble, Parsons, & Ross, 1976). To the degree that children misjudge their own abilities, they would be relatively incapable of efficient division of labor.

However, other work suggests that children begin to regard themselves as good or bad at tasks even in very early childhood (e.g., Gunderson et al., 2013; Heyman, Dweck, & Cain, 1992; Smiley & Dweck, 1994). Moreover, children begin to evaluate their own performance relative to their peers as young as 3 (Butler, 1988; Cimpian, 2010; Magid & Schulz, 2015; Rhodes & Brickman, 2008). For the current purposes, note that even if children are relatively poor judges of their abilities in an absolute sense, they might be able to judge whether one task is easier for them than another, and whether they are more or less capable than a peer. If so, children might recognize that they should take the easier task if they believe their partner is more capable than they are, and the harder task if they believe their partner is less capable.

Experiment 1

In the current study, we test this by introducing children to two carnival style games: a ring toss and ball toss. Each game had an easy and a hard version. (See Figure 1.) Any individual child got the easy version of one game and the hard version of the other (counterbalanced across participants). Children were not told that one game was "easy" and the other was "hard" but they were allowed to try each game four times to get a sense of their own ability to succeed on each task. Children were then told that another child was going to come to play with them. They were told that they should choose one game for their partner, and one game for themselves, and that if they both succeeded – so that a ring went on a pole and a ball went in the box— a special machine would light up.

How might children infer others' capabilities on a novel task? Considerable work suggests that children play differently with peers of different ages (Brody, Stoneman, & MacKinnon, 1982; Edwards & Lewis, 1979; French, 1984) thus here we manipulated the age of the (fictitious) peer to see whether children would use this to infer their peers' competence relative to their own and allocate roles accordingly. In one condition, children were told that the partner would be younger (*Younger Other condition*); in the other condition they were told that their partner would be older than the participant (*Older Other condition*).

There are a number of possible results. If children are poor judges of task difficulty, they should choose at chance. If children judge the tasks accurately, but try only to maximize their own chances of success (and ignore the joint, collaborative nature of the task) they should always choose the easy task for themselves and the hard task for their partner. Alternatively, if children tend to overestimate themselves (or underestimate their partners) they should always choose the hard task for themselves and the easy task for their partner. However, if children's role allocation in cooperative tasks is sensitive to relative ability (as indexed by age), they should choose the easier game for their partner if their partner is younger, and the easier game to themselves if their partner is older.

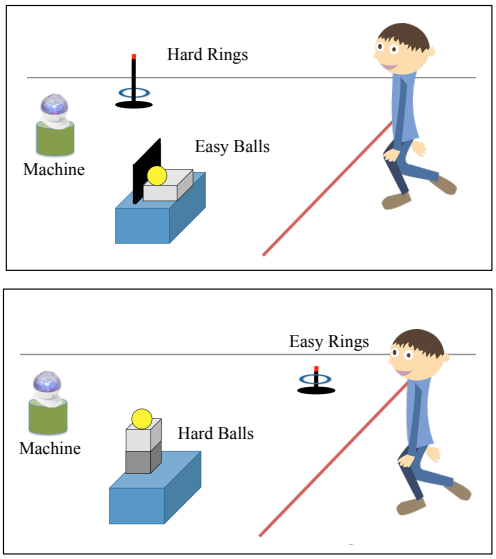

Figure 1: Each participant saw only one setup (top or bottom). Participants practiced each game before allocating roles.

Method

Participants and Materials. All procedures and the analysis plan for this study were pre-registered on the Open Science Framework (osf.io/aq246). Assuming a large effect size (Cramer's V=.50), a power analysis indicated that 44 participants were required to reach a power of .90. All participants were recruited from an urban children's museum and randomly assigned to one of two conditions: Younger Other or Older Other. Forty-four children (mean age = 54 months; range 43-66 months) were included in the final sample (n=22 per condition). Ten additional children did not pass the inclusion criteria. (See Procedure for details). An additional five children were tested but excluded due to parental interference (n=3) or failing to provide a response to the test question (n=2).

A felt mat (132x94 cm) was placed on the floor for game play. The mat was marked with three tape Xs and a line (16cm in front of the Xs) to indicate where participants should stand. Participants stood on the left and right Xs to play games and the center X to answer questions. Children played two games: a ring toss and a ball toss. Each game had two versions—one easier (Easy Rings, Easy Balls) and one harder (Hard Rings, Hard Balls). The ring toss used a plastic pole on a black circular plastic base. The easier version used a shorter pole (22cm with a 5cm red tip) and was closer to the tape line (13 cm away); and the harder version used a taller pole (40cm with a 5cm red tip) and was farther from the tape line (65cm away). The ring toss game was played with blue rings (16cm diameter). Each ball toss game used a gray fabric box placed on top of a blue plastic crate (24x24x41cm) and was played with yellow plastic balls (26cm circumference). The easier version used a larger box (29x14x10cm) with a cardboard backboard (17x28cm) and was placed at the front of the crate, closer to the tape line (53cm). The harder version used a smaller box (14x14x10cm) elevated on a black box of the same size, and was placed at the back of the crate, farther from the tape line (77cm). Half the participants played the Easy Rings and Hard Balls; half the Hard Rings and Easy Balls. Laminated cards (23x6cm) showed photographs of Older Other or Younger Other children. Children depicted in the photographs were either two-year-olds (10cm tall) or six-year-olds (15cm tall), based on the condition. A laminated card of the same size had the word "YOU" printed in the center and was used to represent the participant. A remote-controlled LED light machine (12x13x12cm) was used for the joint task.

Procedure. All children were tested individually in a quiet room at a children's museum. Children were shown two games (either Easy Rings and Hard Balls, or Hard Rings and Easy Balls) and given the chance to practice each game four times. The game played first (rings or balls), the location of each game (right or left), and the version of each game (easy or hard) were counterbalanced across children. After children practiced, the experimenter introduced the light machine and explained that players of the two games could work together to achieve a single joint goal: if the ball went in the box and a ring went on the pole at the same time, then the machine would light up. The experimenter introduced the participant to the fictional Other child, named Jamie, by explaining that she had talked with the other child earlier that day and that s/he wanted to come play the games together with the participant. The experimenter then showed children a card with a picture of the Other child and said that they were either a toddler (Younger Other) or a first-grader (Older Other). The experimenter then asked children their own age, specifying that the Other child was younger or older, by condition. The Other child was matched by gender to the participant. For each category (Younger boy, Older boy, Younger girl, Older girl) two pictures were used to reduce the possibility that ancillary features of any picture might influence children's choices or perceptions of the Other child's abilities. The photographs represented a diversity of races and ethnicities. The experimenter then asked children to allocate roles by choosing which game the Other child should play, placing the Other child's picture next to the game chosen for them and a card with "YOU" written on it next to the game the participant chose for themselves. One game was designed to be easier than the other, however differences in motor skills or experience might lead different children to different conclusions, thus to ensure that the role allocation matched children's judgment of the relative difficulty of the two games, we asked children "Which game was easier?" As a follow-up, children were asked why they chose the game they picked for the Other child. Finally, we asked children if the Other child was older or younger to ensure that they had understood the task. This last question was used as an inclusion criterion: children who did not answer correctly were not included in the analysis.[1] Following these questions, the experimenter left the room briefly (15-30 seconds) and returned saying that she couldn't find the Other child. The experimenter then played the games with the child to turn on the light machine.

Results

In response to, "Which game was easier?" 37 of the 44 children (84%) responded that the game we had designed to be easier was easier for them. Children's self-reported judgment was used in all analyses (consistent with the pre-registered design).

As predicted, children's role assignments differed by condition $\chi^2(1)=7.62$, $p=.006$, $V=.462$. In the Younger Other condition, 64% of children assigned their partner the Easy Game. In the Older Other condition, only 18% of children assigned their partner the Easy Game. Collapsing across conditions, 73% of children assigned roles in a way corresponding to the difficulty of fulfilling each role in the joint task, $p=.004$ by binomial

[1] It might seem surprising that any children failed to remember whether the Other child was older or younger. However, recall that the photos of the Other child used in the study reflected a range of ethnicities. Anecdotally (given the small number of excluded children) children who missed this question tended to miscategorize the age of a photo of a child of another race than themselves, possibly reflecting an own-race bias in processing faces (Anastasi & Rhodes, 2005).

test. Children allocated roles in a way most likely to their joint success. Given previous work showing that five-year-olds, but not 3-year-olds allocate roles based on available resources (Warneken et al., 2014), we also asked whether the likelihood of participants allocating roles based on ability increased with age. We found no evidence of an age effect in the present task, β=-.004(.75), p=.995, suggesting that even children as young as 3.5 years can allocate roles in a cooperative interaction given inferred differences in ability.

Although there was no significant difference in children's ability to allocate roles effectively in each condition, Fisher's Exact Test, p=.31, it is intriguing that twice as many children (eight) in the Younger Other condition misallocated the hard game to the toddler whereas only four children in the Older Other condition misallocated the hard game to themselves. Both the Easy Game and the Hard Game were fairly difficult for the preschoolers. Children scored a zero out of four practice trials 32% of the time across both games. As such, the decision of some children in the Younger Other condition to allocate the Easy Game to themselves may make sense: given that a toddler is unlikely to do better, and the joint goal may thus seem out of reach, it is reasonable for children to choose the game at which they themselves are more likely to succeed. Indeed, when partnered with a younger child, the majority of preschoolers opted for a game that, while increasing the probability of achieving the joint goal, decreased the probability of their own success.

Discussion

Results from Experiment 1 suggest that children appropriately consider their own and their partner's relative abilities in allocating roles in a cooperative interaction. However, the results raise questions about the extent to which preschoolers simply assign harder games to older children and easier games to younger children without regard for context in which they are making this decision. Here children's explanations provide some insight. Recall that we asked children why they chose one of the games for the Other child and the other for themselves. Nine children did not answer, and eleven gave uninformative answers. However, 24 children referred to the difficulty of the activities and/or alluded to relative ability (e.g., "She is older and can get the balls in"; "Because it's easier for him (in context, this meant "than the other game" rather than "easier for him than me"). Anecdotally, children's spontaneous behavior also provided some evidence that children think about role allocation dynamically: one child in the Younger Other condition who had assigned the Easy game to her partner asked to switch roles when she learned that the Experimenter, not a toddler, would be her partner in the interaction.

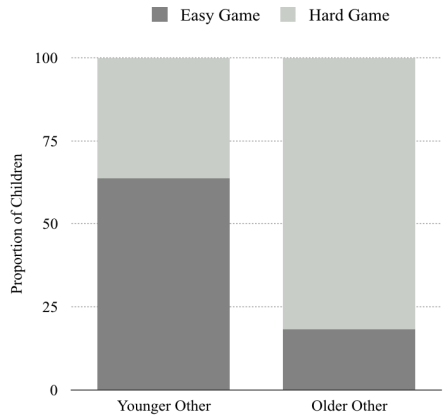

Figure 2: Proportion of children who chose the Easy Game or Hard Game for their partner by condition in Experiment 1: Joint Goal Context.

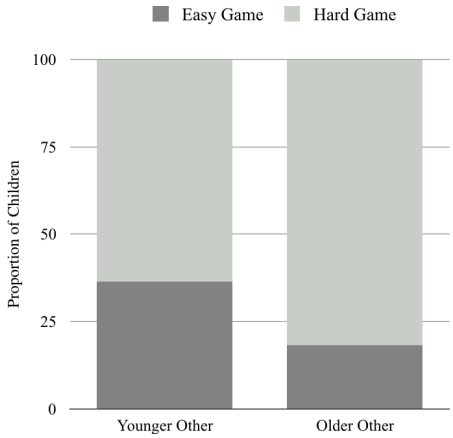

Figure 3: Proportion of children who chose the Easy Game or Hard Game for their partner by condition in Experiment 2: Competitive Context.

Experiment 2

Testing the sophistication of children's role allocation requires seeing if children allocate the roles differently if they are not in a cooperative context. In Experiment 2, we tested children in a competitive condition: in this context, children should assign their partner the harder game regardless of the other child's ability.

Method

All participants were recruited from an urban children's museum and randomly assigned to one of two conditions: Younger Other or Older Other. Forty-four children (mean age = 54 months; range 42-65 months) were included in the final sample (n=22 per condition). Seven additional children did not pass the inclusion criteria. (See Experiment 1 for details). Two additional

children were tested but excluded due to parental interference. Materials were the same as Experiment 1.

Children were introduced to and practiced the two games as in Experiment 1. After children practiced, the experimenter introduced the light machine and explained that the person who gets a ball in the box or a ring on the pole before the other person wins and gets to turn on the machine to establish a competitive context. The introduction of other child, Jamie, and the questions (asking children which game Jamie should play, which game was easier, and how old Jamie is) were identical to Experiment 1.

Results

In response to, "Which game was easier?" 34 of the 44 children (77%) responded that the game we had designed to be easier was easier for them. As predicted, children's role assignments did not differ by condition $\chi^2(1)=1.03$, $p=.31$, $V=.204$. In the Younger Other condition, 64% of children assigned their partner the Hard Game, see Figure 3. In the Older Other condition, only 82% of children assigned their partner the Hard Game. Collapsing across conditions, 73% of children assigned the harder game to the Other child, $p=.004$ by binomial test. These results suggest that children do not allocate the harder game to the older child and the easier game to the younger child independent of context. Instead, participants took into account the competitive context of the interaction and assigned roles accordingly.

Conclusions

In the current study we found that young children allocate roles appropriately in 1) a cooperative interaction, deciding that the less competent partner should take on the easier task while the more competent partner takes on the harder task and 2) a competitive interaction, deciding that the partner should take on the harder task. Note that we did not label the tasks as easy or difficult prior to when children allocated roles.

Past work looking at children's ability to use social comparison information has focused on how children compare themselves to others to evaluate their abilities, or to plan future actions (Butler, 1998; Magid & Schulz, 2015; Rhodes & Brickman 2008; Ruble, et al., 1994). The current study shows that relative ability appraisals are also involved in planning joint interactions. Although one could imagine that preschoolers would simply choose which games to play based on how much they like playing each game, these results suggest they consider the games as sub-goals in a cooperative task and consider their own and others' competence in allocating roles. In future work, we plan to ask how other contexts affect role allocation. Consider for instance that one goal of an interaction might be to allow the other partner to develop her skills. In this case, less competent, and younger individuals might be asked to do harder parts of a task. Note also that the current study asks a single child to allocate roles for herself and one other child, and to plan for a task occurring immediately. How children allocate roles among multiple individuals, in real time requires negotiating myriad other factors that influence successful cooperation. Additionally, we note that age is a coarse proxy of ability: younger individuals can be more skilled than older ones and in some contexts, most likely are. Moreover, individuals of exactly the same age may have special competencies and expertise in particular areas. Studies suggest that children are sensitive to these differences in ability and know who to ask for help for particular kinds of tasks (Koenig & Jaswal, 2011; Kushnir, Vredenburgh, & Schneider, 2013; Lutz & Keil, 2002). Future work might ask whether children also use such knowledge to allocate roles appropriately. However, these results suggest that at least some of the core skills underlying teamwork and collaborative problem-solving are in place in early childhood.

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References

Ashley, J., & Tomasello, M. (1998). Cooperative problem-solving and teaching in preschoolers. *Social Development*, *7*, 143-163.

Azmitia, M. (1988). Peer interaction and problem solving: When are two heads better than one? *Child Development*, 87-96.

Boesch, C., & Boesch, H. (1989). Hunting behavior of wild chimpanzees in the Tai National Park. American *Journal of Physical Anthropology*, *78*, 547-573.

Boseovski, J. J. (2010). Evidence for "rose-colored glasses": An examination of the positivity bias in young children's personality judgments. *Child Development Perspectives*, *4*, 212-218.

Anastasi, J. S., & Rhodes, M. G. (2005). An own-age bias in face recognition for children and older adults. *Psychonomic Bulletin & Review*, *12*, 1043-1047.

Brody, G. H., Stoneman, Z., & MacKinnon, C. E. (1982). Role asymmetries in interactions among school-aged children, their younger siblings, and their friends. *Child Development*, *53*, 1364-1370.

Brownell, C. A., & Carriger, M. S. (1990). Changes in cooperation and self-other differentiation during the second year. *Child Development*, *61*, 1164-1174.

Brownell, C., Nichols, S. R., & Svetlova, M. (2013). Converging developments in prosocial behavior and self-other understanding in the second year of life: the second social-cognitive revolution. Navigating the Social World: What Infants, Children, and Other Species Teach Us, 385-390.

Butler, R. (1998). Age trends in the use of social and temporal comparison for self-evaluation: Examination of a novel developmental hypothesis. *Child Development, 69,* 1054-1073.

Cimpian, A. (2010). The impact of generic language about ability on children's achievement motivation. *Developmental psychology*, *46*, 1333-1340.

Cooper, C. R. (1980). Development of collaborative problem solving among preschool children. *Developmental Psychology*, *16*, 433-440.

Droege, K. L., & Stipek, D. J. (1993). Children's use of dispositions to predict classmates' behavior. *Developmental Psychology*, *29*, 646-654.

Dyer, J. H., & Singh, H. (1998). The relational view: Cooperative strategy and sources of interorganizational competitive advantage. *Academy of Management Review*, *23*, 660-679.

Edwards, C. P., & Lewis, M. (1979). Young children's concepts of social relations: Social functions and social objects. In M. Lewis et al., (Eds.) *The child and its family* (pp. 245-266). New York, NY: Springer US.

Fletcher, G. E., Warneken, F., & Tomasello, M. (2012). Differences in cognitive processes underlying the collaborative activities of children and chimpanzees. *Cognitive Development*, *27*, 136-153.

Frey, K. S., & Ruble, D. N. (1985). What children say when the teacher is not around: Conflicting goals in social comparison and performance assessment in the classroom. *Journal of Personality and Social Psychology*, *48*, 550.

Gunderson, E. A., Gripshover, S. J., Romero, C., Dweck, C. S., Goldin-Meadow, S., & Levine, S. C. (2013). Parent praise to 1-to 3-year-olds predicts children's motivational frameworks 5 years later. *Child Development*, *84*, 1526-1541.

French, D. C. (1984). Children's knowledge of the social functions of younger, older, and same-age peers. *Child Development*, *55*, 1429-1433.

Heyman, G. D., Dweck, C. S., & Cain, K. M. (1992). Young children's vulnerability to self-blame and helplessness: Relationship to beliefs about goodness. *Child Development*, *63,* 401-415.

Johnson-Pynn, J. S., & Nisbet, V. S. (2002). Preschoolers effectively tutor novice classmates in a block construction task. *Child Study Journal*, *32*, 241-256.

Koenig, M. A., & Jaswal, V. K. (2011). Characterizing children's expectations about expertise and incompetence: Halo or pitchfork effects? *Child Development*, *82*, 1634-1647.

Kushnir, T., Vredenburgh, C., & Schneider, L. A. (2013). "Who can help me fix this toy?" The distinction between causal knowledge and word knowledge guides preschoolers' selective requests for information. *Developmental Psychology*, *49*, 446-453.

Liszkowski, U., Carpenter, M., Striano, T., & Tomasello, M. (2006). 12-and 18-month-olds point to provide information for others. *Journal of Cognition and Development*, *7*, 173-187.

Liszkowski, U., Carpenter, M., & Tomasello, M. (2008). Twelve-month-olds communicate helpfully and appropriately for knowledgeable and ignorant partners. *Cognition*, *108*, 732-739.

Lutz, D. J., & Keil, F. C. (2002). Early understanding of the division of cognitive labor. *Child Development*, *73*, 1073-1084.

Magid & Schulz (2015). Quit while you're ahead: Preschoolers persistence and willingness to accept challenges are affected by social comparison. *In Proceedings of the Thirty-Fourth Annual Conference of the Cognitive Science Society.*

Rhodes, M., & Brickman, D. (2008). Preschoolers' responses to social comparisons involving relative failure. *Psychological Science*, *19*, 968-972.

Ruble, D. N., Parsons, J. E., & Ross, J. (1976). Self-evaluative responses of children in an achievement setting. *Child Development*, 990-997.

Schneider, W. (1998). Performance prediction in young children: Effects of skill, metacognition and wishful thinking. *Developmental Science*, *1*, 291-297.

Smiley, P. A., & Dweck, C. S. (1994). Individual differences in achievement goals among young children. *Child development*, *65*, 1723-1743.

Tomasello, M. (2009). *The cultural origins of human cognition*. Cambridge, MA: Harvard University Press.

Tomasello, M. (2010). *Origins of human communication*. Cambridge, MA: MIT Press.

Warneken, F., Chen, F., & Tomasello, M. (2006). Cooperative activities in young children and chimpanzees. *Child Development*, *77*, 640-663.

Warneken, F., Steinwender, J., Hamann, K., & Tomasello, M. (2014). Young children's planning in a collaborative problem-solving task. *Cognitive Development*, *31*, 48-58.