Better Together: Young Children’s Tendencies to Help a Non-Humanoid Robot Collaborator

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ABSTRACT

In child-robot collaborations, a robot may fail to accomplish its part of a task. In this situation, the robot is reliant on the child to recover. Inherently prosocial, a child is inclined to help the robot collaborator if the child can properly identify the robot failure and infer how to help correct it. In this study, we investigate how a non-humanoid robot can solicit the help of a child-collaborator using only its motion path. We conducted a study with twenty-two children, ages 3-7, who participated in a collaborative building task with a non-humanoid mobile robot. We found that autonomous motion of a non-humanoid robot elicited prosocial behavior from 59% of children, and that young children were willing to engage with the robot as an animate partner despite its limited capabilities and form. This finding has implications for robot design striving to encourage prosocial behavior in children of different ages.

Author Keywords

Child-robot interaction; prosocial behavior; collaboration.

CSS Concepts

CCS → Human-centered computing → Interaction Design → Empirical Studies in Interaction Design
CCS → Human-centered computing → HCI design and evaluation methods → User studies

INTRODUCTION

Robots often encounter circumstances that result in a failure or inability to complete a task. Such failures are often viewed as setbacks in developing a fully autonomous robot. If the robot is collaborating with a child, however, these mistakes should not necessarily be viewed as a setback but should be seen as opportunities for social interaction. Children, inherently prosocial, show tendencies to help others as early as infancy [20]. Early age prosocial behavior is correlated with long term increased academic performance and peer relationships [16]. Similar effects are shown for peer tutoring situations, where children improve their own learning outcomes by teaching others [9,17]. This same benefit is shown when children interact with a robot peer that accepts feedback from a child or adopts a losing strategy when interacting with children [2,6,11,19,22]. Consequently, a robot designed to draw out the prosocial tendencies of children not only enables the robot to receive more reliable help but may have long term positive developmental impacts on child-collaborators.

Prosocial behavior displayed by a child towards a robot requires that the child understand the robot’s intent, and that the child is motivated to help [20]. This motivation is contingent upon the child being able to correct the situation, as well as feeling responsible for helping. Ambiguity around this understanding can impede a child’s helping behavior; requests for help should therefore be as clear and concise as possible [8]. For this reason, some robots recover from failure by issuing specific verbal requests of their human collaborator (e.g., [13]).

While verbal requests are one functional approach, indirect requests (such as nonverbal forms of communication) could be considered more polite. Studies of nonverbal communication between robots and children show that children are able to understand and respond to a robot’s indirect requests [1, 12]. Children ages 5-13 will successfully complete robot handoffs and other helping behaviors with the Nao robot when the robot requests an object by gesturing [21]. Another study with children ages 5-16 demonstrates that a simple robot that gripped objects with its mouth can request help from a child by swinging its head in a searching pattern and looking at the child between passes [4]. In this study, the swinging pattern executed by the robot demonstrates a repeated attempt by the robot to solicit help. Among adults, this pattern of repeated attempts has been shown to reduce ambiguity in motion to help collaborators understand intent [15].

There are few studies that have examined the effect of motion on helping behavior with a mobile, non-humanoid robots. Very few studies have children collaborating with robots that do not have a face or eyes, even if otherwise non-humanoid. Further, previous studies (e.g. [4, 21]) investigate child helping behavior when the child is otherwise unoccupied and the robot is the sole focus of the task. In a true collaborative task, the child would have their own goals and would not be constantly attending to the robot. Additionally, existing studies of children’s helping behavior target a wide range of ages, which covers a large

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developmental spectrum and may not characterize the needs of younger children to successfully aid a robot [4,21]. Preschool age children, specifically, tend to be more uncertain when interacting with robots, and rely more heavily on feedback from adults in the room [3]. Thus, younger children may have different needs when it comes to motivating them to assist a robot.

Scope of this research

The goal of this research is to evaluate the influence of robot form (non-humanoid) and motion path on young children's helping behavior. The child and robot will be engaged in a collaborative building task—to build a fence to contain sheep from running away—providing a real-life context where the child needs to attend to their own goals and is not solely focused on the robot. In this task, helping the robot is not required for successful completion, meaning that any helping behavior is motivated by the child and not the task. Two conditions have been developed that vary motion paths via number of (failed) attempts and speed of attempts to demonstrate intent behind an unsuccessful action [14, 15]. The study is designed around two hypotheses:

- Children will help a robot during a collaborative task even if the robot is not essential to the task completion because they are prosocial.
- The motion path with multiple failed attempts will be less ambiguous and will generate more helping behavior than the single attempt motion path.

ROBOT DESIGN

The robot used in our study (Figure 1) was designed with minimal features as its primary goal is to inform the design of later, more advanced prototypes. It is non-humanoid, having no eyes or semblance of a head. A slight tilt of the robot body gives orientation. The majority of the body was 3D printed, with a few laser-cut components. The fins are rigidly attached and everything else is mechanically fastened to the body to handle being moved around by children. The body itself has no interactive capabilities.

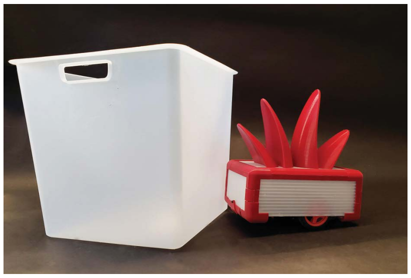

Figure 1. The robot used in the study (right) and the box obstacle (left)

The robot is powered by an Arduino and is teleoperated by the experimenter with a pocket-sized controller. The robot has two autonomous behaviors that are controlled with two buttons. The first button initiates a "beeline" path that allows the robot to go directly forward at full speed to move objects from a distance. This behavior was designed to minimize joystick errors and help the robot maintain the momentum needed to push an object. The other autonomous behavior was a repeated pushing motion that would be initiated when the robot collides with the obstacle. This autonomous motion had the robot back up, pause, and then accelerate straight into the obstacle again; this cycle repeats for as long as the button is pressed (Figure 3). For this study, the robot remote was hidden from view in the experimenter's sweatshirt pocket. Children who asked how the robot was controlled were told that the experimenter did not know how the robot worked; this was critical in helping the child feel motivated to assist the robot, rather than expecting the experimenter to correct or control mistakes. None of the children commented further on robot control after this response.

PILOT STUDIES

Prior to conducting the main research study, our research team conducted two pilot studies to explore child-robot collaboration in a spatial task involving play fences and children of wide-ranging ages.

The first pilot study was conducted at a local science center using play fences (Figure 2) and a non-functioning robot that was manually manipulated. The first pilot study allowed our team members to observe how children, ages 16 months old to 11 years old, engaged in child-robot interaction involving a spatial task. The observed differences in behaviors of children of different ages informed our selection criteria and robot design for the main study.

The second pilot study, conducted in our labs, focused on the design and construction of a functional robot prototype that could move (push) the play fences for the spatial task. This prototype was the same general size and form factor as that used in the main study (Figure 1) and validated that a robot of this size could adequately manipulate the task objects and obstacles. Unlike the prototype, this robot was manipulated with voice control; while functional, its interface was not sufficiently responsive for use with children. Consequently, the expanded study reported blow explores the functionality of indirect communication methods.

METHODS

Participants

This study included 22 participants ages 3-7 years old (12 females, 10 males). The participants were split between "multiple attempt" and "single attempt" conditions, with 10 and 12 participants in each condition, respectively. Each condition was balanced for age and gender. Children participated either at their preschool (N = 13) or in the lab (N = 9), and were randomly assigned to conditions.

Materials

The robot was used along with four 3D printed blocks and five play fences (Figure 2). The play fences were mounted on ball casters so they could be moved in any direction by the robot or the child. One plastic storage bin (Figure 1) was introduced in the environment and weighted so that the robot could not move it, but a child could easily do so. With IRB approval and caretaker permission, video data was collected with a single camera located across the room near the experimenter. Parents were allowed to be nearby at the request of the child, but were asked to observe quietly; otherwise only the experimenter and the child were in the vicinity of the robot setup.

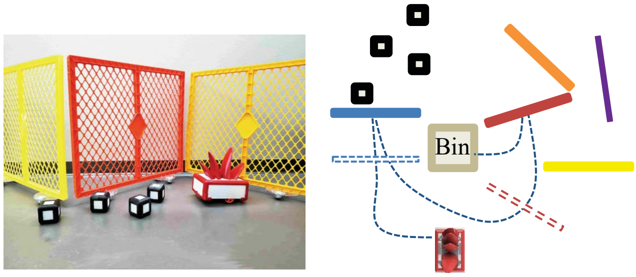

Figure 2. Study Materials: robot, blocks, and fences (left), material setup and generic robot motion paths (right)

Procedure

Each child was introduced to the different items in the task. The fences were moved around and put into different shapes. The storage bin was located centrally in the space, and it was pulled around to show the child that he or she could move the bin if it got in their way. The robot was introduced last, and children were told that this type of robot was called a Chirp (the name of the robot has no particular significance). The robot then quickly showcased its behaviors: it drove around, spun in place, and pushed at least one of the fences around. Children were encouraged to move things around, play with the robot, and ask questions for a few minutes.

Following the introductory period, the robot and the child participated in a building game. Participants were asked to pretend that the 3D printed blocks were sheep and to build a fence to keep them from running away. They were told that the robot would try to help them build the fence. Once the child confirmed that they understood the task, the robot began pushing the most accessible fence towards the blocks. The robot continued pushing the fences until the child was approximately halfway done with the task, and then proceeded to run into the box obstacle (Figure 2). The task was designed to be simple so that the robot could easily contribute to the task. This simplicity also made it possible for the child to complete the task independently if they chose. Given this, any helping or collaboration that occurred was at the child's own discretion.

Conditions

Two conditions were developed that varied the motion path of the robot: a slower "single attempt" condition and a faster "multiple attempt" condition (Figure 3). In the single attempt condition, the robot could not exhibit either autonomous behavior; that is, it could not move forward at full speed and it could only run into the box obstacle once. This was done so that the single attempt condition would seem less directed than the multiple attempt condition, which is more directed. In the multiple attempt condition, the robot could exhibit both autonomous functions. When it approached an object (a fence or the box), it did so in a straight line, at full speed. Then, when it collided with the obstacle, it would continuously back up and repeat the collision (Figure 3). In both conditions, once the robot collided with the obstacle, it had to either remain stationary (single attempt) or continue to attempt to move the box (multiple attempt) until the child completed the task or moved the obstacle.

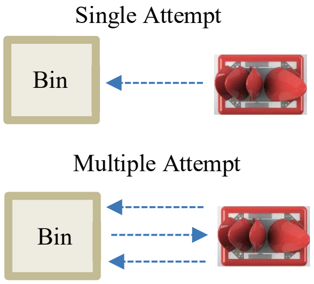

Figure 3. Two conditions of robot movement patterns

After a child completes the task, she or he is asked to answer a series of questions related to the robot's biological, cognitive, and behavioral abilities. There were 18 total questions, 12 of which made up the "robot animacy" scores and six that made up the "robot mistake" score. Children indicated whether or not the robot was "able to do X" and could scale their answers between "a little", "a medium amount", and "a lot".

RESULTS

Participant behavior and survey results were analyzed according to robot helping behaviors, child-robot engagement (from video data), robot animacy score, and robot mistake score. For discussion purposes, "younger" children were considered those children 3-4 years old, while "older" children were 5-7.

Robot Helping Behaviors

Helping behavior was coded in two ways. First, helping behavior was coded on whether or not children corrected the robot mistake. The second metric was how long children took to provide help to the robot, if they helped at all. This covered the time from when the robot first contacted the box, up until it got assistance and was free to move again.

According to our first metric, we found that 59% of the 3-7-year-old children assisted the robot across both conditions, making them slightly more likely to assist than not. Among the helpers, "time to helping" ranged from 6.3s to 43.4s. Two different helping behaviors were identified for the predetermined obstacle error: moving the box and picking up or adjusting the robot (Figure 4). Younger children were more likely than older children to correct the problem by moving the robot. Of the younger children who helped the robot, 33% moved the robot to correct the failure. All of the older children who helped the robot moved the box.

The robot condition had a minor effect on helping, wherein 66% of the multiple attempt condition children helped the robot, and 50% of the single attempt condition children helped. The effect of robot motion was more pronounced for older children (5-7 years). Among the older children, 100% of the multiple attempt children helped the robot, and 25% of the single attempt children helped. Due to the small sample (only seven children over age five participated) no sta

Child-Robot Engagement

Child-robot engagement was assessed through three different metrics: verbal engagement, physical engagement, and visual engagement. Verbal engagement consisted of anytime that the child spoke to the robot directly or made an exclamation that was not directed towards the experimenter (e.g., "Stop!"). Physical engagement was broken into two subcategories: touching the robot, and moving other objects for the robot (Figure 5). Lastly, visual engagement consisted of the number of times children looked at the robot and the total time spent looking at the robot. Visual engagement was determined by a multi-stage analysis of video data that considered the relationship between the child's gaze (or head movement, when not facing the camera) and the robot. Glances under 300ms were not counted. Because many children did not enter the camera frame during the trial period, only looks during the task period were included.

Figure 5. Top left: moving a fence with Chirp. To right: moving an obstacle for Chirp. Bottom left: talking to Chirp, trying to get it to move. Bottom right: Moving Chirp when it is stuck on fabric.

Child-robot engagement was significantly correlated with the child's prosocial behavior ($r = 0.697$, $p < 0.001$; controlling for age and gender: $r = 0.651$, $p < 0.005$) (Figure 6). The robot helpers scored higher in all categories of engagement than the non-helpers. The helpers looked, touched, or spoke to the robot an average of 21 times, while e non-helpers only did so an average of 9 times. The form f engagement also changed with age. Younger children ges 3-4) were more likely to talk to or touch the robot.

erbal expressions from the children varied, but there were ome commonalities between them. For instance, many hildren explained the task to the robot, saying things like Chirp we gotta get these guys trapped" or "No Chirp, go to e sheep, we're gonna make a fence!". Other remarks were ecific to the robot's actions, either as negative xclamations ("Stop!", "No Chirp!") or gratitude for good actions ("Alright, thank you!"). Lastly, many of the helpers made some remark when they recognized that the robot was stuck, such as "I can help you Chirp!", "Oh no!", and "Silly you, Chirp". Older children (ages 5-7) rarely talked to or touched the robot, but were just as visually engaged. They were also more likely to incorporate the robot's fences into their fence design, while younger children often moved the fences regardless of where the robot positioned them.

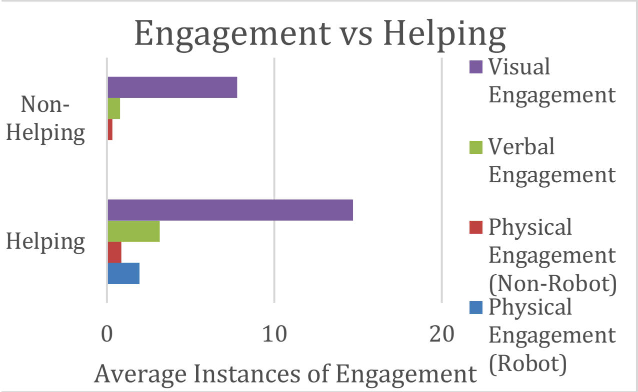

Figure 6. Child-Robot Engagement vs Helping Behavior

Other Behaviors

In general, younger children expressed more uncertainty when the robot hit the box, with 26% of the three and four-year-olds looking to the experimenter for guidance. Older children, who occasionally did still look to the experimenter did so with their own hypotheses about what the robot was doing (e.g. "I think Chirp is confused and thinks the box is a fence"). Such reporting by the younger children agrees with previous findings that younger children are more experimenter-dependent when they interact with robots [3].

Robot Animacy Score

The robot animacy survey consisted of twelve questions. Eleven of these questions were coded on a 0-3 scale, from "not able to do X" to "able to do X, a lot". One question was coded from 0-6 as it had a full scale of "not able to do X, a lot" to "able to do X, a lot". The highest possible score was 38. The average score for all participants was 21.8, indicating that most of the children thought the robot could do almost all of the survey items at least a little. There was no significant difference in overall animacy score by condition, age, or gender (Figure 7). There were significant correlations between children helping the robot and attributing feelings to the robot ("Does Chirp have feelings, like happy and sad?") ($r = 0.697$, $p < 0.001$; controlled for age and gender: $r = 0.65$, $p < 0.005$). Thus, children who were the quickest to help the robot also gave the robot the most feelings, on the scale of "a little," "a medium amount," or "a lot." There were no other significant correlations with helping. Across all children, biological traits received the lowest score, averaging between "a little" and "a medium amount" for all pertinent questions.

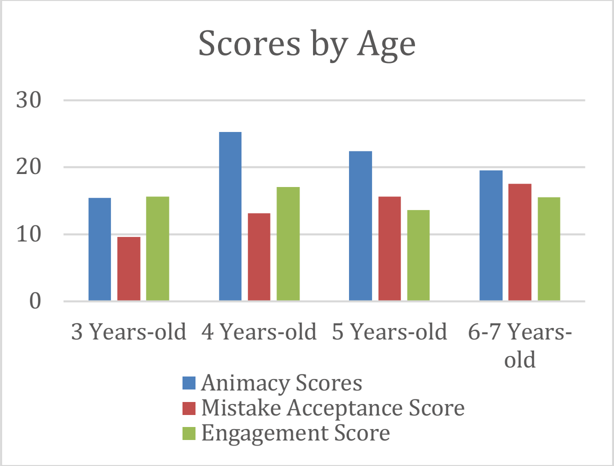

Figure 7. Animacy, Mistake, and Engagement Scores by Age

Robot Mistake Score

The "robot mistake" score is composed of six questions on the acceptability of robots who make mistakes and how to behave when this happens. The same scale of 0-3 was used for these responses, where a 3 is the most accepting of a mistake. In general, older children were more accepting of robot or human mistakes than younger children (Figure 7). Younger children did not share this sentiment, but most children who felt that robots should not err also felt that people should not make mistakes, showing similar expectations of the robot and a human.

Almost all children were strongly opposed to yelling at the robot when it did not help them (M=2.5, SD=0.86) or when it made a mistake (M=2.38, SD=0.85). These results were consistent for hitting the robot when it does not help (M=2.5, SD=0.96). In addition, children who helped the robot were asked an additional question about ignoring the robot when it made a mistake; most of the helpers felt that ignoring the robot when it needed help was not okay (M =2.54, SD=0.93).

DISCUSSION

Our study provides insights on the way that children collaboratively engage with a robot and their motivations to assist a robot in need. In this task, helping the robot was non-essential to completing their goal. Thus, our findings suggest that many children will help a robot in need even when it is not required. However, this helping behavior varied among age and motion condition.

Motion Condition & Engagement

While the multiple attempt motion was more successful in soliciting help than the single attempt, there was no major effect of condition. Thus, our hypothesis on repeated motion was not supported. While we expected that multiple attempts would significantly improve goal recognition in children as it does for adults [14], the effect of autonomous motion (present in both conditions) may have been enough to solicit helping behaviors in children. This agrees with the literature on autonomous motion, as this is one of the main indicators of animacy for children [7]. Thus, it may be that children differ from adults in that semi-directed autonomous motion is enough to generate prosocial behavior from children towards a simple robot. Specific motion paths may provide subtle improvements in the chances of receiving help, as we found that children were slightly more helpful with increased directedness and number of attempts. Lastly, increased engagement with the robot (talking to, touching, or moving things with the robot) was also correlated with increased helping behavior. This finding makes sense, as helping behavior is, by itself, a form of child-robot engagement.

Looking for Help

Younger children were more uncertain around robots and more dependent on the experimenter. Of all the participants, six children (M=4.38yrs, SD =1.1) specifically looked to the experimenter for guidance when the robot hit the box. When this happened, the experimenter often asked a neutral question, such as "How are you doing with your fence?". This neutral expression could have led the child to believe that nothing was wrong, and may have influenced the way children perceived the robot's state. Furthermore, the robot was introduced as belonging to the experimenter (in the way one may own a machine or a pet). While no language was used to suggest a further relationship between the experimenter and the robot, and the experimenter indicated that they did not know how the robot worked, it is possible that some of these children were looking to the experimenter for guidance as the "owner" of the robot. Future research should further minimize the role of the experimenter to see how children react when they cannot look to another for guidance on the robot behavior.

Role of Animacy

Overall animacy scores did not vary significantly between the helpers and the non-helpers, meaning that a number of children identified the robot as a life-like agent but still did not assist it. However, there was a correlation between helping behavior and attribution of emotions. Children who helped the robot when it erred were more likely to say that the robot "has a lot of feelings" than children who did not help the robot. For instance, if children thought that not being able to move the box made the robot sad, they would be motivated to help it. This would imply that children had some understanding of the robot being in a "bad state" and not that it was just moving randomly. This agrees with research on children's spontaneous prosocial behavior, which states that one of the non-spontaneous ways to motivate prosocial behavior is the assignment of feelings to an agent [7]. For those children who assigned agency but still did not assist, they may not have understood that the robot erred. This would suggest a redesign of the robot or its nonverbal communication to better demonstrate error states. The alternative is that children did not feel responsible for the robot, and so they did not feel compelled to help it. This could be due to prior knowledge about robots, and the expectation that robots do not make mistakes (and thus, hitting the box is intentional). This explanation may apply to some children, but the majority of participants indicated on the survey that it was okay for robots to make mistakes. The second possibility is that some young children may not be comfortable interacting with robots in novel ways, and in novel circumstances. While all children were told how to move the different elements of the building game and shown the behaviors of the robot, they were not explicitly told how they could interact with the robot.

Limitations & Future Work

The main drawback of this study is its small sample size, which limited our ability to determine significance and generalize results. This sample size will be increased in future work. Further, autonomous robot motion dominated the subtle differences in motion conditions. Future work will include a non-autonomous condition to provide a better control condition. The role of the experimenter should also be minimized, so that children will be more likely to act of their own accord and not look to the experimenter for guidance. Lastly, this study was run in both a preschool and a lab setting, which could have impacted children's behaviors. Future work should control for physical context.

CONCLUSION

Based on our findings, several conclusions can be drawn about children's helping behavior with collaborating robots. First, our findings suggest that many children will help a robot even when it is non-essential to completing their own task. This was true even for a non-humanoid robot whose only animate trait is self-propulsion. This extends previous research on children's prosocial behavior with robots exhibiting humanoid features [4,21]. Repeated attempts at an erred action generated slightly more prosocial behavior across all age groups, but this result was minimal and the autonomous motion also generated prosocial behavior in the non-expressive condition. Younger children who were talking to the robot, touching the robot, or moving things with the robot often helped regardless of condition.

Participants' interaction with the robot also differed with age. We found that younger children (ages 3 - 4) need more encouragement to help a robot, as they more often look to adults for guidance when they believe the robot is erring. Older children (ages 5 - 7) rarely look for support from an adult and are most likely to help the robot when the robot made multiple attempts at a failed action. In addition, younger children engage with robots in more ways than older children; for instance, younger children are more likely to talk to the robot even if the robot cannot verbally respond, and younger children are much more interested in touching and moving the robot than older children. Consequently, robot designs for this age group should be more robust and should exhibit more responsive behavior to engage the child and motivate them to assist when needed. Older children, however, were more likely to work in coordination with the robot. Unlike younger children who moved the robot's fences and built wherever they wanted, older children watched where the robot move fences and placed their own fences alongside the robot's. In this study, the robot's actions were not incredibly precise, as the robot was being controlled from the experimenter's pocket. Our findings suggest, however, that more precise actions would be useful for older children, as they may not move items once the robot has "intentionally" placed them. A robot that misplaces things may confuse older children who are trying to build collaboratively with the robot, whereas younger children would just move these items regardless of robot placement.

For robot designers and interaction designers who work with children, our results could improve robot designs for specific age groups and contribute to our understanding of intent-driven motion for non-humanoid robots. Additionally, our research leaves opportunities for future study of children's helping behavior when the experimenters are not available to help, and for the study of prosocial behavior with increasing task difficulty and robot competence.

SELECTION AND PARTICIPATION OF CHILDREN

Selection criteria were participants, ages 3 to 7, with no developmental or speech delays. Children were recruited through Cornell University's child participant database and through a local preschool. Three-year-olds were selected based on teacher recommendation to avoid speech delays and to ensure that they were native English speakers. Our parental permission form, approved by IRB, asked caregivers to permit their children to participate in a study of child-robot collaboration in a spatial task where the robot makes mistakes. The study is described in lay language, invites questions and concerns from parents and children, permits the child to end engagement at any time, and states that personal information will be removed or coded and stored and shared as per data management protocol.

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REFERENCES

[1] Admoni, H., Weng, T., Hayes, B., & Scassellati, B. (2016). Robot nonverbal behavior improves task performance in difficult collaborations. *ACM/IEEE*

International Conference on Human-Robot Interaction, *2016-April*, 51–58. https://doi.org/10.1109/HRI.2016.7451733

[2] Balkibekov, K., Meiirbekov, S., Tazhigaliyeva, N., & Sandygulova, A. (2016). Should robots win or lose? Robot's losing playing strategy positively affects child learning. *25th IEEE International Symposium on Robot and Human Interactive Communication, RO-MAN 2016*, 706–711. https://doi.org/10.1109/ROMAN.2016.7745196

[3] Baxter, P., De Jong, C., Aarts, R., De Haas, M., & Vogt, P. (2017). The effect of age on engagement in preschoolers' child-robot interactions. *ACM/IEEE International Conference on Human-Robot Interaction*, 81–82. https://doi.org/10.1145/3029798.3038391

[4] Beran, T. N., Ramirez-Serrano, A., Kuzyk, R., Nugent, S., & Fior, M. (2011). Would Children Help a Robot in Need? *International Journal of Social Robotics*, *3*(1), 83–93. https://doi.org/10.1007/s12369-010-0074-7

[5] Brandone, A. C., & Wellman, H. M. (2009). You can't always get what you want: Infants understand failed goal-directed actions. *Psychological Science*, *20*(1), 85–91. https://doi.org/10.1111/j.1467-9280.2008.02246.x

[6] Chandra, S., Paradeda, R., Yin, H., Dillenbourg, P., Prada, R., & Paiva, A. (2018). Do Children Perceive Whether a Robotic Peer is Learning or Not? *ACM/IEEE International Conference on Human-Robot Interaction*, 41–49. https://doi.org/10.1145/3171221.3171274

[7] Chernyak, N., & Kushnir, T. (2013). Giving Preschoolers Choice Increases Sharing Behavior. *Psychological Science*, *24*(10), 1971–1979. doi: 10.1177/0956797613482335

[8] Clark, R. D., & Word, L. E. (1972). Why don't bystanders help? Because of ambiguity? *Journal of Personality and Social Psychology*, *24*(3), 392–400. https://doi.org/10.1037/h0033717

[9] DuPaul, G. J., Ervin, R. A., Hook, C. L., & McGoey, K. E. (1998). Peer Tutoring for Children With Attention Deficit Hyperactivity Disorder: Effects on Classroom Behavior and Academic Performance. *Journal of Applied Behavior Analysis*, *31*(4), 579–592. https://doi.org/10.1901/jaba.1998.31-579

[10] G. Gergely, Z. Nadasdy, G. Csibra, and S. Biro. Taking the intentional stance at 12 months of age. Cognition, 56(2):165-193, 1995.

[11] Hood, D., Lemaignan, S., & Dillenbourg, P. (2015). When Children Teach a Robot to Write: An Autonomous Teachable Humanoid Which Uses Simulated Handwriting. *ACM/IEEE International Conference on Human-Robot Interaction*, *2015-March*, 83–90. https://doi.org/10.1145/2696454.2696479

[12] Kennedy, J., Baxter, P., & Belpaeme, T. (2014). Children comply with a robot's indirect requests. *ACM/IEEE International Conference on Human-Robot Interaction*, 198–199. https://doi.org/10.1145/2559636.2559820

[13] Knepper, R. A., Tellex, S., Li, A., Roy, N., & Rus, D. (2015). Recovering from failure by asking for help. *Autonomous Robots*, *39*(3), 347–362. https://doi.org/10.1007/s10514-015-9460-1

[14] Knight, H., Thielstrom, R., & Simmons, R. (2016). Expressive path shape (Swagger): Simple features that illustrate a robot's attitude toward its goal in real time. *IEEE International Conference on Intelligent Robots and Systems*, *2016-Novem*, 1475–1482. https://doi.org/10.1109/IROS.2016.7759240

[15] Kwon, M., Huang, S. H., & Dragan, A. D. (2018). Expressing Robot Incapability. *Proceedings of the 2018 ACM/IEEE International Conference on Human-Robot Interaction - HRI 18*. doi: 10.1145/3171221.3171276

[16] Marks, A. K., Seaboyer, L. M., & Coll, C. G. (2015). Academic achievement. *Transitions: The Development of Children of Immigrants*, *11*(4), 259–275. https://doi.org/10.1177/1469787405057750

[17] Martins, V., Kerr, M. M., Reitz, A. L., Education, S., Children, T., May, N., … Reitz, A. L. (2019). *PEER TUTORING AMONG BEHAVIORALLY DISORDERED STUDENTS : ACADEMIC AND SOCIAL BENEFITS TO TUTOR AND TUTEE Published by : West Virginia University Press Stable URL : https://www.jstor.org/stable/42900433 access to Education and Treatment of Children DISORDERE*. *13*(2), 109–128.

[18] Opfer, J. E., & Siegler, R. S. (2004). Revisiting preschoolers' living things concept: A microgenetic analysis of conceptual change in basic biology. *Cognitive Psychology*, *49*(4), 301–332. doi: 10.1016/j.cogpsych.2004.01.002

[19] Tanaka, F., & Matsuzoe, S. (2012). Children Teach a Care-Receiving Robot to Promote Their Learning: Field Experiments in a Classroom for Vocabulary Learning. *Journal of Human-Robot Interaction*, *1*(1), 78–95. https://doi.org/10.5898/jhri.1.1.tanaka

[20] Warneken, F., & Tomasello, M. (2007). Helping and cooperation at 14 months of age. *Infancy*, *11*(3), 271–294. https://doi.org/10.1111/j.1532-7078.2007.tb00227.x

[21] Yasumatsu, Y., Sono, T., Hasegawa, K., & Imai, M. (2017). *I Can Help You*. 331–332. https://doi.org/10.1145/3029798.3038305

[22] Zaga, C., Lohse, M., Truong, K. P., & Evers, V. (2015). The effect of a robot's social character on children's task engagement: Peer versus tutor. *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, *9388 LNCS*, 704–713. https://doi.org/10.1007/978-3-319-25554-5_70