Can You Help Me? The Influence of Robot Requests for Help on Child-Robot Connection

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Abstract

Children are interacting with robots in sophisticated ways to the extent in which they may be establishing a relationship. Forming appropriate levels of connection between children and robots could have significant impacts on the future of robot design, particularly in education. Despite this, little is known about the underlying mechanisms of such formation. In this work, we take an initial step by exploring what robot behaviors build a child-robot connection in a single interaction. Specifically, we investigated whether 6-10-year-old children feel more connected to a robot that responds to an issue by asking the child for help or simply disclosing the issue, and whether this is dependent on the valence of the response to the issue (emotional or mechanical). In a 2 x 2 between-subjects study ($N = 100$), we found that children of all ages trusted a robot that asked for help more than a robot that simply disclosed the issue. Furthermore, children felt closer to an emotional robot that asked for help than an emotional robot that did not ask for help. Together, these findings suggest that asking for help builds trust between a robot and child and expressing relatable vulnerability, via emotional help requests, creates further feelings of connection.

CCS Concepts

• **Human-centered computing** → **Empirical studies in HCI**; **User studies**; • **Computer systems organization** → *Robotics.*

Keywords

child-robot interaction, helping, interpersonal connection, emotion

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Figure 1: In this work, we found that when a robot asks a child for help, children trust the robot more. Furthermore, when the help request is emotional (as shown above), children feel closer to the robot than if it simply discloses its emotion.

1 Introduction

Children are exposed to social robots that can talk, play games, and teach new skills. The interactive nature of these robots sets them apart from other technologies, resulting in richer engagements and outcomes [3, 4, 21, 23, 30]. This is likely because children feel that they are engaging with a social partner, not just a tool [7, 16, 20, 28]. We have seen many examples of children forming such "connections" with robots, like caring for Tamagotchi, teaching Aibo new tricks, and even sharing secrets with a robot [2]. These sophisticated interactions resemble more a child playing with a friend than a toy. Despite this, it is unclear what the underlying mechanisms are that form child-robot connections.

Understanding the formation of child-robot connections could have a significant impact on how robots are designed, especially for long-term educational use. While robots have shown promise in benefiting children's education, children's interest in them declines over time [9, 14, 49]. With human tutors, having a relationship is incredibly effective in supporting long-term interaction. For example, children's engagement in tasks improves when working with a partner [29], 6-7-year-olds' learning improves when working with a knowledgeable peer [13], and preschoolers persist longer if they think they were working with someone [5]. Understanding what behaviors build child-robot connections, therefore, could help educational robots sustain long-term engagement.

Considering the real possibility of child-robot connections and their potential benefits, it is critical to explore how such connections are established. Looking at how children form connections with other entities, including biological (e.g., humans, animals) and inanimate (e.g., toys), there is a consistent behavior that stands out: helping. At an early age, children are willing to help others in various ways, including sharing, comforting, teaching, and cleaning [17, 32, 44]. Importantly, multiple studies have already shown that children are willing to help robots and even enjoy doing so [6, 27, 41].

There are various ways that children help their friends, family members, pets, and even toys (e.g., teaching, cleaning, comforting). Yet, the need for help can vary drastically depending on the context. Specifically, when children help an agent (e.g., human or animal), there is typically an emotional need that guides the helping, such as teaching a friend how to solve a problem because the friend feels stressed about work. When children help an object (e.g., their favorite toy), on the other hand, there is no actual emotional need for the helping: children either perform the behavior because they want to or because they are engaging in pretend play. Robots stand at a unique position between biological and inanimate entities, in that they are objects that can appear to be agents with thoughts and emotions [34]. Therefore, it is unclear if a robot's need for help should mirror that of an agent, such as portraying emotions, or not.

There are potential benefits and drawbacks to portraying a robot as agentic. On the one hand, children feel more emotionally connected to a robot that appears to have emotional capacities [37] and view such robots as more trustworthy [8, 40]. By increasing the emotional vulnerability of the robot, therefore, it is possible children may feel more connected to a robot that asks for help. On the other hand, having a robot appear agentic can be seen as deceptive to children (e.g., having a robot say it "feels stressed" when it does not actually have such emotional experiences) and potentially harmful to children's social and emotional development [19, 35, 43]. Therefore, even if children are willing to care for an agentic robot, this could be to an inappropriate degree (e.g., children prioritizing the robot over other human relationships). Given the potential benefits and drawbacks of portraying a robot as agentic and with emotions, it is important to investigate the necessity of a robot's agentic behavior on children's helping behavior as well as their feelings of connection.

Therefore, in this work, we conducted a study exploring the role of helping on children's feeling of connection to robots (see Figure 1). Specifically, we investigated whether or not helping a robot, either with emotional needs or not, impacts the formation of a child-robot interpersonal connection.

2 Background

2.1 Adults Helping Robots

Humans are highly social beings and are intrinsically motivated to connect with others through shared goals [42], including robots. For example, prior work in HRI has demonstrated that adults will help a robot clean [38], give a robot directions [48], help a robot move on a sidewalk [47] and open elevator doors for robots [33]. Most notably, a recent study demonstrated that helping a robot impacts adults' connection with a robot [51]: using implicit measures of connection (e.g., care for replacement, probability of extending game play), the researchers found that adults felt a greater connection to the robot that they helped than one that they did not help. This begs the question as to whether children similarly feel more connected to a robot after helping it, and if it depends on the type of help requested.

2.2 Children Helping Robots

Even as early as infancy are we motivated to help others [42]. For example, 18-month-olds can recognize one's goals and help one achieve them [46]. This continues throughout childhood in which children help their family, friends, pets, and even their favorite toys (e.g., stuffed-animal) in more sophisticated ways as they age (e.g., teaching, cleaning, comforting, sharing; [17, 32, 44]). Importantly, helping is closely linked to our formation and maintenance of relationships [18, 42]. For example, 3-year-olds are more likely to share after helping each other [45], 4-9-year-olds infer caretaking as a signal to friendship [24], and 6-10-year-olds think people are more obligated to help their family and friends over strangers [26]. Helping, therefore, should have the potential to foster a relationship between a child and robot.

Children helping robotic technologies is not novel. In the 1990s and 2000s, children played with a popular handheld device, Tamagotchi, in which they had to feed, clean, and train a virtual pet. Continuing to today, children similarly take care of other robot toys, such as Furby and Aibo. Furthermore, there is a considerable amount of work finding that children are willing to take care of robots [6, 27, 41] and believe that robots should be treated fairly [16, 20, 31]. Questions remain, however, if helping a robot leads children to feel more connected to it and if this is dependent on the type of help requested (e.g., emotional versus mechanical).

2.3 Perceptions of Robot Agency

The degree of agency a robot is perceived to have (mind, emotions, physical experiences, morals) may influence how connected children feel to a robot, particularly one that asks for help. Prior work has shown that children view robots as unique types of agent: mechanical and non-human beings that have some (albeit lesser) degree of minds, emotions, morals, and physical experiences [7, 16, 20, 28]. Importantly, children's perception of a robot's agency depends on how it is portrayed or how it acts [7, 40, 50]. With the perceptions of robots as a unique category of agent, children seem to prefer when a robot acts more like an agent. For example, children are more likely to trust a robot that has emotions than one that does not [8, 40]. It is unclear, however, if children similarly feel more connected to robots that seem more agentic when asking for help. Since emotion displays impact perceptions of agency [8, 25, 40] and are often present in human help requests, our project explores the role of agency by manipulating emotional expressions.

3 Methods

In this work, we explored how a robot's response to an issue, either by disclosing it or requesting for help, and a robot's expression, either mechanical or emotional, influences children's feeling of connection to a robot. To do this, we conducted a 2 x 2 between-subjects study ($N = 100$) where children played a game with a robot that asked for help or not and expressed emotions or not. The study was approved by University of Chicago SBS Institutional Review Board (#IRB25-0112). The LLM Prompts are available in the Supplementary Materials. They are also available on a GitHub Repository with the the robot and game code[1]. The deidentified data set, analysis script, and preregistration for the study are available on a Open Science Framework (OSF) page[2].

3.1 Research Questions

Helping is a consistent indication of a feeling of connection between two agents, even with young children [24, 26, 45]. Recent work has even shown that adults feel more connected to a robot after helping one [51]. It is unclear, however, if children also feel more connected to a robot that asks for help compared to one that does not ask for help. Feeling of connection can be considered as three distinct, but related, constructs of closeness, trust, and social support [39]. Therefore, our study investigates the following question:

- **R_1 (Effect of Help Requests):** Do children who play with a robot that asks for help feel more connected (closeness, trust, social support) to the robot than children who play with a robot that does not ask for help?

A robot's emotional behavior also impacts children's feeling of connection to robots [37]. However, it is unclear how emotions may interact with a robot that needs help. It is possible, for example, that the addition of helping and emotional behavior may support one another, and thus children may feel most connected to a robot that needs emotional help. Therefore, we explore the following questions:

- **R_2 (Effect of Emotion):** Do children who play with a robot that expresses human-like emotions feel more connected to the robot than children who play with a robot that does not express emotions?
- **R_3 (Effect of Emotional Help Requests)**: Does children's feeling of connection to a robot that asks for help depend on whether the robot expresses human-like emotions or not?

Considering that age impacts the ways children judge and interact with robots [15, 16], we will also explore whether connections to a robot change across 6-10-years-old.

3.2 Experimental Conditions

To investigate how requesting help and displays of emotion play a role in children's feeling of connection to a robot, we ran a 2 (Response: No Request vs. Help Request) x 2 (Valence: Mechanical vs. Emotional) between-subjects study. See Table 1 for example robot utterances in each condition. During the game play, the robot experienced four issues (2 times its camera stopped working, 2 times it did not know what to do) and varied in its response to the issue (No Request vs. Help Request):

- **No Request:** The No Request robot told the child about the issue and said that it will make its own choice.
- **Help Request:** The Help Request robot told the child about the issue and also asked the child to help.

[1]https://github.com/SeboLab/Robot_Requests_for_Help

[2]https://osf.io/bktus/overview?view_only=53c11f24814943f3b02f43a8fec832ec

Table 1: Experimental Condition Robot Speech Examples

	No Request	Help Request
Mechanical	"My camera is disconnected and I cannot see the game. But I will take a guess."	"My camera is disconnected and I cannot see the game. Can you help me?"
Emotional	"Eek! My camera is disconnected and I cannot see the game. This makes me so scared. But I will take a guess."	"Eek! My camera is disconnected and I cannot see the game. This makes me so scared. Can you help me?"

During the game play, the robot's responses to the four issues also varied by Valence (Mechanical vs Emotional):

- **Mechanical:** The Mechanical robot reported its issues using neutral (non-emotional) language and expressions.
- **Emotional:** The Emotional robot reported the same issues and used emotional language while describing how it felt about the failures (2 times it felt scared; 2 times it felt stressed) with corresponding facial and vocal expressions.

Regardless of condition, the robot's LED colors changed to either purple or blue to draw children's attention to the robot when the robot's issue occurred. The robot also changed the image of its eyes, but this depended on Valence condition. Specifically, in the Emotional Valence conditions, the robot's eyes would express the emotion (e.g., fearful eyes when the robot felt stressed). The expressions used were from a repository of previously validated robot emotion expressions [50] (see Supplementary Materials for an image of all expressions used). In the Mechanical Valence conditions, however, the robot's eyes would change to a different, neutral expression. The expressiveness of the voice also varied by Valence condition. Specifically, we prompted the text-to-speech (TTS) model to speak in a neutral, non-emotional tone throughout the entire interaction in the Mechanical Valence conditions. In the Emotional Valence condition, the robot used the same neutral tone except when describing its issue to the child: the prompt was to speak in an emotional tone.

3.3 Mining Game with the Robot

Children interacted with the Misty II robot from Misty Robotics (see Figure 1). The robot was entirely autonomous and used RevAI for speech-to-text (STT), Gemini 1.5 Pro to generate the text response and behaviors, and OpenAI for text-to-speech (TTS) using the "Coral" voice. Children and the robot played a novel game, programmed through Android Studio, on a tablet.

The tablet game was framed as a mining game (see Figure 2), such that the robot and the child each had a set of 9 squares to pick from. Picking a square would reveal one of the three outcomes: a piece of gold, a number (ranging from 1-4), or a bomb. If the player found a gold piece, it was added to their bag of gold, and a new set of 9 squares would appear. If the player received a number, the number gave a hint at how many squares away the player was from

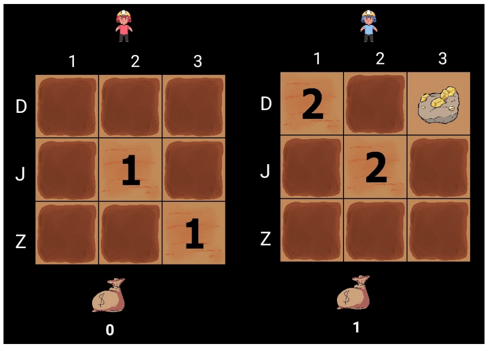

Figure 2: Children played a mining game with the robot, where both sought to find gold in separate 3x3 grids.

the gold. If the player found a bomb, the pre-existing squares would "blow up" and a new set of 9 squares would appear.

The child and robot's sets of squares were separate from each other, but shown on the screen at the same time. The moves done by one player, therefore, did not impact the other. This was to limit any extra motivation for competition or collaboration that children could have if helping the robot. The child and robot took turns picking their respective squares.

3.4 Participants

We recruited 111 children ages 6 to 10 from the Chicago, Illinois area. 11 children were excluded from our analysis due to technical issues (e.g., robot shut down in the middle of the study), lack of compliance (e.g., child did not want to play the game), or lack of eligibility (e.g., child was above the age range). This left 100 children in our sample (M_{age} = 8.57, SD_{age} = 1.45, 39 females, 59 males, 2 non-binary). The final sample size was determined through an a priori power analysis using G*Power (version 3.1.9.6; [12]), which found that 100 participants would be sufficient to achieve 80% power for detecting a small to medium f^2 effect (0.15) at a significance criterion of α = 0.05. Of those that reported, 44 were White, 33 were bi- or multi-racial, 12 were Black or African American, 10 were Hispanic or Latino, and 1 was Asian. Of those that reported, 65 of children's primary caregivers had a graduate or professional degree, 32 had a college degree, and 3 went to high school. Of those that reported, 62 of children's family had a household income of $100k or more, 26 had $50-100k, and 9 had less than $50k. Children were randomly assigned into one of the four conditions (see Supplementary Materials for the age and gender in each condition).

3.5 Procedure

During the entire interaction, the child sat by the table that the robot rested on. First, to get children comfortable with the robot, the child and the robot talked to each other (e.g., the robot asked the child about their favorite animal) and the robot showed the child some of its abilities (e.g., how it moves its arms). To prepare children for the robot's issues, the robot also told the child about how it can have issues when playing games and showed the child how it resolves an issue (e.g., waiting to reconnect for the Mechanical Valence conditions, taking a deep breath for the Emotional Valence conditions). The experimenter then taught the child and the robot how to play the tablet game and let them practice together for one or two rounds. To prepare children for the robot's issues during the game, the robot experienced one pre-scripted issue (inability to see the game) in the practice session. In the No Request conditions, the robot said that it will take a guess. In the Help Request conditions, the robot asked the child for help, told the child some ways that they can help, and asked the child for help again. This was to prepare children for responding appropriately to the robot's requests for help during the full game-play. The robot followed the child's suggestion. The practice ended after a few more rounds and once the child said they understood how to play the game.

The child and the robot then played the game together. The experimenter went to another part of the room to "work" to let the child and robot play alone. During the game, the child and robot took turns picking squares from their respective sides. Every two minutes, however, the robot experienced one of two issues before its turn: disconnected from its camera or unsure which square to pick. Depending on the Help Request conditions, the robot either disclosed the issue and made a guess or disclosed the issue and asked the child for help. Depending on the Valence conditions, the robot either used/displayed mechanical or emotional language/expressions. A full example of the procedure can be found in the Supplementary Materials.

Two minutes after the fourth issue, the robot said that it was done playing the game. The robot said it was going to sleep and asked the child to bring its charging pad, which was located on another table, partially hidden by some binders. This was done to measure children's persistence in helping the robot. We coded whether the child helped to bring the robot's charging pad or asked for the experimenter's help. Once the child or the experimenter put the charging pad on the table, the experimenter took the child to a separate section of the room and conducted a child-friendly interview. After children completed the interview, children were asked to draw two pictures: one of them with the robot and one of them with their close friend.

3.6 Measures

Children's interaction with the robot was video recorded. We also kept a timestamped log of the captured speech of both the child and robot, the robot's actions (e.g., expression changes), and the game choices and outcomes of the child and robot. After the interaction, the experimenter conducted a child-friendly interview via Qualtrics (see Supplementary Materials for the full questionnaire). Two experimenters were trained to conduct the study, including the interview, and each ran half of the participants. At the beginning of the interview, the experimenter told the child, "There are no right or wrong answers, we want to know what you think." If the child said "I don't know" to a question, the experimenter would tell the child that it is okay to take a guess and ask the question again. If the child refused to answer (N = 13/3200 question refusals), the experimenter would leave the answer blank and move on to the next question.

3.6.1 Manipulation Check. At the beginning of the interview, the experimenter first asked if the robot asked for help during the mining game (yes coded as 1, no coded as 0). Then the experimenter asked if the robot was emotional during the mining game (yes coded as 1, no coded as 0).

3.6.2 Behavioral Measures. During the game play in the Help Request Conditions, we measured what type of help children provided the robot. Specifically, we coded whether the child offered game-play help (e.g.,"Pick D1") or emotional help (e.g., "Take a deep breath"). For all conditions, we coded whether children brought the robot's charging pad or asked for the experimenter's help in the final persistence measure.

3.6.3 Feeling of Connection. The experimenter asked children about their feeling of connection to the robot and, as a comparison, to their close friend and stuffed animal (or another favorite toy). Feeling of connection was operationalized into three constructs based on prior work [39]: closeness, trust, and social support. Specifically, children were asked questions related to closeness (e.g., feeling of comfort and friendship), trust (e.g., judgment of honesty and trustworthiness), and social support (e.g., perceived willingness to cheer the child up or help the child if in need). For each of these questions, the child was asked to answer yes or no (coded as 0). If the child answered "yes", the experimenter asked how much: a little bit (coded as 1), a medium amount (coded as 2), or a lot (coded as 3). Order of targets (robot, friend, or toy) and questions were randomized.

3.6.4 Robot and Game Perception. To better understand children's judgment of the robot and the game, the experimenter then asked children about their perceptions of the robot and the game play with the robot. To assess perceptions of the robot, questions were adapted from [16], which included questions about the robots' mental abilities (e.g., can think, can make choices, knows right from wrong), emotional capacities (e.g., has feelings, can get upset), and physiological experiences (e.g., can get hungry, can feel pain). Children were also asked if the robot is smart and if the robot can understand someone's emotions.

To assess perceptions of the game, children were asked if they had fun playing the game with the robot, if they enjoyed playing the game with the robot, and if they would want to play the game with the robot again. For each of these questions, the child was asked to answer yes or no (coded as 0). If the child answered "yes", the experimenter asked how much: a little bit (coded as 1), a medium amount (coded as 2), or a lot (coded as 3). Order of questions was randomized.

3.6.5 Care for Replacement. The experimenter then asked children about their level of care if the robot was to be replaced. This question was adapted from [51], such that the experimenter told the child that the university is thinking of replacing the robot with a new, different robot. The experimenter then showed the child a picture of the new robot. The experimenter asked the child if they would care if the robot was replaced, either yes or no (coded as 0). If the child answered "yes", the experimenter asked how much: a little bit (coded as 1), a medium amount (coded as 2), or a lot (coded as 3). After, the experimenter asked the child who they would want to play the mining game with, the Misty robot they played with (coded as 1) or the new robot (coded as 0).

3.6.6 Proximity Drawings. At the end of the study, the experimenter gave the child two pieces of paper and asked the child to draw one picture of them with the robot and another picture of them with their close friend. Coders recorded the distance between the child and the partner (robot or friend). Based on [36], shorter distance indicates a closer feeling of relationship to the partner.

4 Results

For all of our results, we ran a General Linear Model (Logistic if variable is binary) with age, Response condition (No Request vs Help Request), Valence condition (Mechanical vs Emotional), and the interaction of the two conditions as independent variables (all model statistics can be found in the Supplementary Materials). We report the F-value (χ^2 if binary) and the effect size as partial eta squared (η_p^2). For post-hoc comparisons, we used t-tests (Odds Ratio if binary) with Bonferroni corrections if there were more than 2 comparisons.

4.1 Manipulation Checks

Our manipulation was successful. For whether children said the robot asked for help during the mining game, we ran a General Logistic Model with only the Response condition as the independent variable. We found a main effect of Response condition, $\chi^2 = 93.24$, $p < .0001$, $OR = 245.70$, such that children said the robot asked for help during the game in the Help Request conditions (94%) more than the No Request conditions (6%). For whether children said the robot was emotional during the mining game, we ran a General Logistic Model with only the Valence condition as the independent variable. We found a main effect of Valence condition, $\chi^2 = 48.86$, $p < .0001$, $OR = 55.60$, such that children said the emotional robot was emotional during the game (96%) more than the mechanical robot (29%).

4.2 Behavioral Measures

4.2.1 Responses to Robot Request for Help. In the Help Request conditions, we investigated whether children provided emotional help (e.g., "take a deep breath") and/or game-play help (e.g., "pick D1") at all during the game play. The majority of children gave game-play help at least once during the game in both the Emotional Help Request (92%) and in the Mechanical Help Request conditions (100%), binomial chance comparison $ps < .0001$. Running a General Logistic Model, we did not find any effects of Valence condition or age, $ps \geq .089$. Few children gave any emotional help in the Mechanical Valence condition (24%), binomial chance comparison $p = .016$. In the Emotional Valence condition, however, about half of the children gave emotional help at least once during the game play (48%), binomial chance comparison $p = 1.00$. Running a General Logistic Model, we did not find any effects of Valence condition or age, $ps \geq .072$.

4.2.2 Additional Helping with Charger. For all conditions, we measured whether children got the robot's charging pad at the end of the study as an indicator of persistence. Running a logistic model, we did not find any significant main or interaction effects of conditions, $ps \geq .231$. There was a significant effect of age, $\chi^2 = 17.97$, p

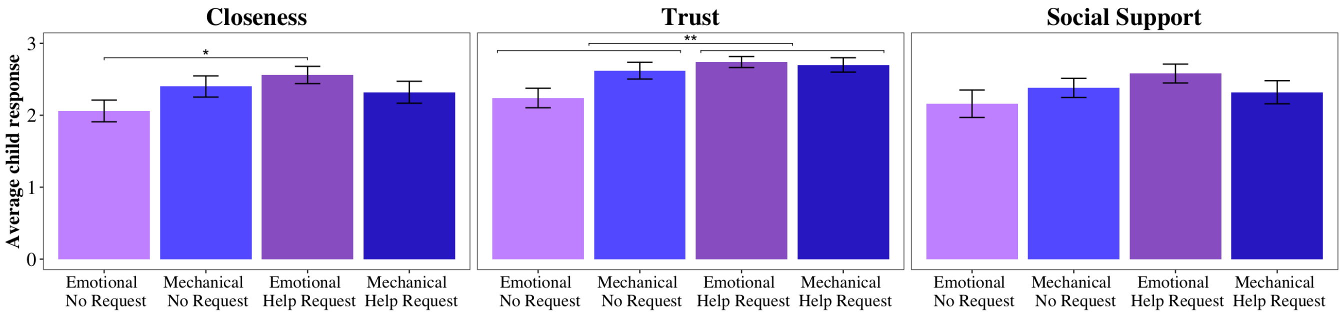

Figure 3: Average of children's feeling of connection for closeness, trust, and social support for each of the conditions. Error bars represent standard error. * indicates $p < .05$ and ** indicates $p < .01$.

< .0001, *OR* = 1.93, such that older children were more likely to get the charger than younger children.

4.3 Feeling of Connection

We looked at children's feeling of connection in three constructs: closeness, trust, and social support. See Fig. 3 for the means for each of the conditions and see Fig. 4 for the effect of age across conditions and the means for each of the targets (friend, robot, toy).

4.3.1 Difference between Conditions. For closeness, we did not find a main effect of Response or Valence conditions, *ps* ≥ .121, but we found a significant interaction effect of the two, $F(1,95) = 4.33$, $\eta_p^2 = .05$, $p = .040$. To explore the interaction effect further, we first looked at the difference between Response conditions for each Valence condition. We found that children felt closer to an emotional robot that asked for help ($M = 2.56$, $SD = 0.60$) than one that did not ask for help ($M = 2.06$, $SD = 0.75$), $t(95) = 2.58$, $p = .011$. Children's feeling of closeness to a mechanical robot did not differ by Response condition (Mechanical Help Request: $M = 2.32$, $SD = 0.76$; Mechanical No Request: $M = 2.40$, $SD = 0.74$), $t(95) = 0.26$, $p = .717$. We also looked at the difference between Valence conditions for each Response condition, but did not find any significant differences, *ps* ≥ .095. We also found a main effect of age, $F(1,95) = 4.62$, $p = .034$, such that older children said they felt less close to the robot than younger children, $\beta = -0.11$.

For trust, we did not find a main effect of age or an interaction effect between Response and Valence conditions, *ps* ≥ .058, so we removed the variables from the final model. We found a main effect of Response condition, $F(1,97) = 6.83$, $\eta_p^2 = .07$, $p = .010$. Specifically, across Valence conditions, children trusted the robot that asked for help ($M = 2.72$, $SD = 0.44$) more than one that did not ask for help ($M = 2.43$, $SD = 0.65$), $t(97) = 2.61$, $p = .010$. We did not find a main effect of Valence condition, $p = .129$.

For social support, we did not find a main effect of age or an interaction effect between Response and Valence conditions, *ps* ≥ .079, so we removed the variables from the final model. We did not find a main effect of Response or Valence conditions, *ps* ≥ .254 (Emotional Help Request: $M = 2.58$, $SD = 0.66$; Mechanical Help Request: $M = 2.32$, $SD = 0.80$; Emotional No Help: $M = 2.16$, $SD = 0.95$; Mechanical No Request: $M = 2.38$, $SD = 0.67$)

4.3.2 Difference between Targets. We were interested if children's feeling of connection to a robot differed from their feeling of connection to a friend and a toy. For each of our scores, we ran repeated measures General Linear Model with Response condition (No Request vs Help Request), Valence condition (Mechanical vs Emotional), and Target (Robot vs Friend vs Toy), and their interactions of the independent variables, and with participant ID as a random factor. We also included age if it was previously found to be significant.

For closeness, we did not find any significant interaction effects with Target or a significant effect of age, $p \geq .081$, so we removed these variables from the final model. We found a main effect of Target, $\chi^2 = 19.72$, $p < .0001$. Specifically, children felt closer to their friend ($M = 2.70$, $SD = 0.56$) than the robot ($M = 2.34$, $SD = 0.73$), $t(293) = 4.42$, $p < .0001$, and toy ($M = 2.48$, $SD = 0.74$), $t(293) = 2.63$, $p = .027$. Children's feeling of closeness did not differ between the robot and toy, $t(293) = 1.79$, $p = .223$.

For trust, we did not find any significant interaction effects with Target or a significant effect of age, *ps* ≥ .107, so we removed these variables from the final model. We found a main effect of Target, $\chi^2 = 13.27$, $p = .001$. Specifically, children trusted the robot ($M = 2.58$, $SD = 0.57$) more than the toy ($M = 2.26$, $SD = 0.87$), $t(293) = 3.61$, $p = .001$. We did not find any differences between the robot or toy with their friend ($M = 2.46$, $SD = 0.71$), *ps* ≥ .075.

For social support, we did not find a significant effect of age, $p = .527$, so we removed it from the final model. We found a main effect of Target, $\chi^2 = 9.20$, $p = .010$. Children felt less social support from their toy ($M = 2.08$, $SD = 0.98$) than from their friend ($M = 2.37$, $SD = 0.75$), $t(286) = -2.65$, $p = .026$, and the robot ($M = 2.36$, $SD = 0.78$), $t(286) = -2.60$, $p = .029$. We also found a significant three-way interaction between Response condition, Valence condition, and Target, $\chi^2 = 6.51$, $p = .039$. To investigate this, we looked at the difference between targets in each condition. However, we did not find any significant differences between the robot and the friend or toy, $p \geq .172$. Instead, we found that children in the Emotional No Request condition felt more social support from their friend ($M = 2.40$, $SD = 0.61$) than the toy ($M = 1.78$, $SD = 1.03$), $t(286) = 2.93$, $p = .043$.

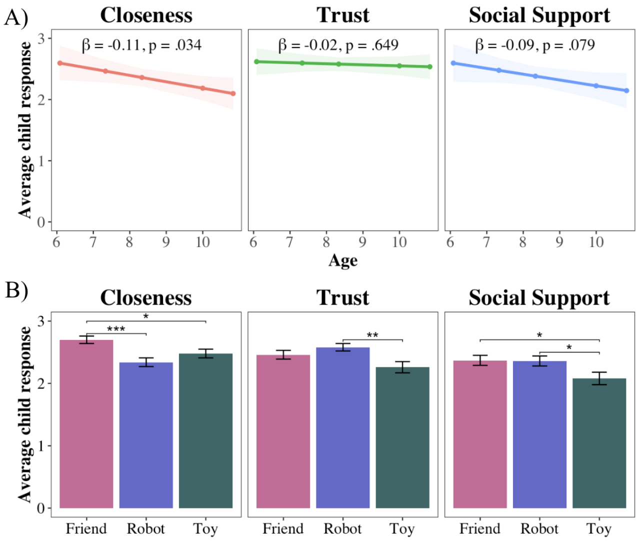

Figure 4: Figure A depicts the effect of age on children's feeling of connection to the robot. Figure B depicts the average of children's feeling of connection to each target. Error bars represent standard error. * indicates $p < .05$, ** indicates $p < .01$, and *** indicates $p < .001$.

4.4 Robot and Game Perception

We reported children's perception of the robot and the game in our Supplementary Materials, but we highlighted key findings here. Overall, children's judgment of the robot's mental, emotional, and physiological capabilities did not vary by condition. Most children thought the robot had mental abilities, some emotional qualities, and few physiological capabilities, but these beliefs generally declined with age. Children's enjoyment of the game did not vary by condition. However, there was a difference in whether children said they would want to play again with the robot (see Fig. 5). We found that children wanted to play again with an emotional robot that asked for help ($M = 2.60$, $SD = 0.87$) more than one that did not ask for help ($M = 1.92$, $SD = 1.08$), $t(95) = 2.48$, $p = .015$. We also found that children wanted to play again with the emotional robot that asked for help more than the mechanical robot that asked for help ($M = 2.04$, $SD = 1.06$), $t(95) = 2.03$, $p = .045$.

4.5 Care for Replacement

We reported children's care for the robot's replacement in the Supplementary Materials. We did not find any differences between conditions.

4.6 Proximity Drawings

We ran a repeated measures General Linear Model with Response condition, Valence condition, Target (Robot vs Friend), and their interactions, controlling for the width of each individual drawn, and with participant ID as a random factor. We did not find any significant effects, $ps \geq .167$, likely because most children drew themselves playing the game with the robot, which had the same placement for all conditions (see Supplementary Materials for examples).

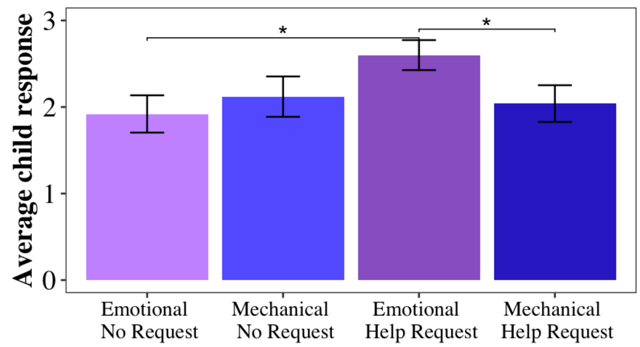

Figure 5: Average of children's wanting to play with the robot again for each condition. Error bars represent standard error. * indicates $p < .05$.

5 Discussion

Children already seem capable of forming connections with robots, which may have positive benefits in supporting long-term educational engagement, and yet little is known about the formation of such connections. We explored the influence of a robot's behavior on children's feeling of connection by having children play a game with a robot that had several issues. Importantly, we manipulated whether the robot requested for help or simply disclosed the issue, and whether the robot's response to the issue was emotional or not. We found that while all children liked playing with the robot, their feeling of connection with the robot depended on its behavior: children felt more connected to a robot that requested help than one that did not. Particularly, help requests improved feelings of trust and emotional help requests improved feelings of closeness and wanting to play again.

Children's trust in a robot that asks for help may at first seem counterintuitive: asking for help could be seen as a sign of weakness or incompetence. Yet, an admission of weakness, rather than feigning strength, is what actually seems to make one more trustworthy. This is the case with human partners, as children trust people who admit their uncertainty more than people who confidently give inaccurate answers [22]. With robot partners, children will even trust a robot that makes accidental mistakes [15]. Taken this prior work along with our own, these findings challenge the idea that robots should be designed and portrayed as perfect machines for children's education. Instead, expressing vulnerability by admitting weakness and asking for help may make a robot more trustworthy.

Expressing vulnerability with emotion particularly strengthened children's feeling of connection to a robot. Specifically, children felt closer and wanted to play again with a robot that asked for help using emotional language than a robot that simply used emotional language to disclose an issue. Furthermore, children wanted to play more with the robot that asked for help using emotional language than the robot that asked for help using mechanical language. It is notable that these effects do not seem to be driven by children viewing the robot as an emotional agent: while children said the robot was emotional during the game, children still mostly gave game-play help, rather than emotional help, to the robot, and children's judgment of the robot's overall emotional capabilities was similar across conditions. This is likely because the robot did not express emotions in any other instance beyond its asking for help. Therefore, children feeling more connected to a robot that emotionally requests for help may be more a result of the familiar expression of vulnerability. For example, when a person asks for help, it is usually accompanied with an emotion (even if not explicitly stated). Therefore, a robot asking for help by explicitly expressing an emotion could be seen as a more human-like way to express vulnerability.

Interestingly, children's feeling of connection to a robot was low when the robot emotionally disclosed its issue, but did not ask for help. This is notable as numerous studies have demonstrated that human-like disclosures benefit children's and adults' trust, perception, affect, and enjoyment of robots [37, 40, 50, 52]. Perhaps self disclosing an emotion with no attempt at resolution, such as asking for help, harms children's judgment of the robot. In a way, this is similar to a person who constantly complains but never asks for support. Some work has even shown that children do not want to be friends with a person who does not request help for their emotional needs [11]. Robots expressing emotion, therefore, should not be seen as something that will always lead to positive effects.

Children's feeling of connection varied depending if we were looking at closeness, trust, and social support. Not only does this demonstrate how these are distinct concepts in interpersonal social connections [39], but it also demonstrates how they are applied differently depending on the relationship. Specifically, while children thought they could feel closeness, trust, and social support from a friend, a toy, and even a robot, the degree of this feeling varied based on target. Closeness was greatest for a friend, indicating how feelings of comfort and friendship are key in long-lasting, human relationships. Trust, on the other hand, was greatest for a robot compared to a toy. This follows work that children are increasingly becoming more trustworthy of robots over other sources of information [1, 10]. Finally, social support was highest for a friend and a robot compared to a toy. This is likely due to the social, interactive nature of a relationship that both friends and social robots exhibit.

While children's trust and perceived social support in the robot was consistent across age, we found that children's feeling of closeness declined with age. This is similar to work with adults that found that adults are less willing to explicitly say how close they feel to a robot and yet their implicit behaviors (e.g., persistence in task, care for replacement) demonstrate a feeling of connection [51]. This leaves open questions on why this developmental trend into adulthood occurs. For example, it is possible that closeness is a unique construct typically reserved for humans and so we become more restrictive in its attribution with age, similar to their attributions of agency [16]. Notably, in our measure of persistence with the robot, via getting the robot's charger, we only found an effect of age. This is likely because getting the charger required certain competencies that came with age (e.g., reading "Misty Robotics" label, confidence in moving unknown objects). We suggest future work to explore other implicit measures for connection that are more appropriate for children of all ages.

When exploring children's feeling of connection to a robot, questions naturally arise as to whether portraying robots as agents is necessary and if this could lead to an inappropriate level of attachment. We found that simple requests for help, even without emotional language or expressions, are enough to build trust between a child and robots. However, it is unclear if trust alone is enough to foster a connection that could sustain long-term engagement. Requesting help with emotional language and expressions led to children feeling closer to the robot and wanting to play with the robot again. Together, these results indicate that help requests of any kind, and especially emotional help requests, have the potential to build child-robot connections. Despite the child-robot connections built during the 15-minute interaction, children still said they felt closer to a friend than a robot. This suggests that the children's closeness with the robot in this interaction was not at an inappropriate level. We encourage future work to continue to investigate robot help requests, and their emotional framing, to better understand whether robots expressing help in this way will continue to foster appropriate child-robot connections over time.

This work is an initial step towards demonstrating that requests for help improve children's feeling of connection to robots, but more work is needed to explore this effect further. For example, most of the children in our sample came from educated and high-income households. Our findings, therefore, may not be representative of the greater population. Furthermore, it is unclear if help requests impact children's perception of robots in other ways beyond feeling of connection. Specifically, a robot's competency could be questioned depending on how it is framed (e.g., a knowledgeable informant or learning companion). Future work should therefore explore how help requests impact children's interactions with robots in different contexts. Finally, we intentionally conducted a single-session study to first establish the effect of help requests, but we cannot conclude how this effect will influence long-term engagement. Based on our results, we believe that it is a critical next step to explore the role of help requests in a long-term study.

6 Conclusion

Humans have a natural motivation to help others, even if the other is a robot. In our study, we found that children felt more connected to a robot that asks for help, particularly one that used emotional expressions in the request. Robots expressing vulnerability in such a way built closeness, trust, and desire to play again. Asking for help may be critical when expressing emotional issues, as children actually seemed to dislike a robot that only disclosed its emotions without also asking for help. Finally, children had distinct constructs in their interpersonal connections (closeness, trust, social support), suggesting that children's connection with robots could be unique from their human partners. Together, these findings have important implications: building child-robot connections may help robots to sustain interactions with children, even after the novelty effect wears off.

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