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Would Children Help a Robot in Need?

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Abstract Just as human-human behavior and interactions are important to study, human-robot interactions will take more prominence in the near future. These interactions will not only be in one direction, robots helping humans, but they will also be bidirectional with humans helping robots. This study examined the interactions between children and robots by observing whether children help a robot complete a task, and the contexts which elicited the most help. Five studies were conducted each consisting of 20 or more children per group with an approximate even number of boys and girls. Visitors to a science centre located in a major Western Canadian city were invited to participate in an experiment set up at the centre. Their behaviors with a robot, a small 5 degree of freedom robot arm programmed with a set of predefined tasks which could be selected during the experiments, were observed. Results of chi-square analyses indicated that children are most likely to help a robot after experiencing a positive introduction to it, $X^2(1) = 4.15$, $p = .04$. Moreover, a positive introduction in combination with permission to help resulted in the vast majority (70%) of children helping. These results suggest that adult instructions about a robot impact children's perceptions and helping behaviors towards it. The generalizability of these results to children's helping behaviors towards people is also discussed.

Keywords Robotics · Children · Prosocial behaviors · Developmental robotics

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1 Introduction

Companies are investing millions of dollars in research and development of service robots (i.e., robots that help humans perform special activities) that are appealing for people, presumably with the intention of mass producing these robots to become social and functional companions [11, 16]. Recent research also suggests that robots could be a viable means to impart skills to children with autism spectrum disorders since these children tend to be fascinated by robots [8]. In response to these and other needs a growing number of studies have been investigating the application of advanced interactive technologies to address core deficits related to autism such as computer technology and robotic systems [20]. However, not much attention has been placed on robot-children interaction (friendship). At a time when robots are being developed at a faster rate than any other time in our history as a civilization combined with our advancement of technology, it is imperative that we also understand how children interact with and perceive robots. In recognition of the synergistic relationship between children and robots, there is a growing area of research called developmental robotics. This involves applying scientific knowledge gained from developmental psychology to the development of robots [28]. Although this research provides the worthwhile opportunity of building robotic models of children's behaviours, we can take these robotic models a step further by examining how they, in-turn, impact children's psycho-social development. The design of social robots is a developing field in which standards are still being developed. In general, a social robot is an autonomous agent that can act in a socially appropriate manner based on its role in an interaction [12], such as interacting with a child. The purpose of this study is to examine if a robot, which is exhibiting searching behaviours (without explicit autonomous capabilities which allows us to be in control of how the tests are performed), elicits helping behaviours in children. Furthermore, we explore the type of context of children's interactions with a robot, to determine which is most likely to elicit children's helping behaviours.

1.1 Children's Prosocial Behaviors

Prosocial behaviours are defined as actions that are intended to help or benefit another person or group of people [10, 27]. A longstanding theory of prosocial behaviours was proposed decades ago. Latané and Darley [23] developed a decision model for bystander helping behaviour that outlines three main decisions. First the situation must be interpreted as one in which help is required (e.g., "Someone is in need of help"). Second, the person who is in a position to offer help must take personal responsibility in doing so (e.g., "It's up to me to help"). Third, the person must decide how to help (e.g., "I can help by...") and then take action. If a bystander responds affirmatively to all of these decisions, then assistance is likely to be offered [9]. The steps in this decision model of bystander helping behaviour have been supported by various empirical studies and applied in current research [7, 15, 17].

1.2 Context

Although it is informative to understand the mechanisms of decision making about whether or not to help, would *children help a robot* and what situational cues might trigger this cognitive process that leads to their helping behaviours? Although no such studies have yet been conducted, there is some related research with adults regarding their aggressive behavior towards a robot. Bartneck and colleagues explored conditions in which participants would turn off a robot it had played a game with [2]. When participants attributed positive traits to the robot, they were hesitant to shut it down. The researchers speculated that people may hold animistic impressions about the robot, making them reluctant to turn it off. Similarly, Bartneck and co-authors demonstrated that adult participants are unlikely to smash a robot with a hammer when it exhibits a high level of intelligence [3]. Although the empathic response to the experimenter's request to destroy a robot was not the primary purpose of the study, and despite several methodological difficulties, they reported some anecdotal evidence of an empathic response in the adult participants. People stated, for example, that the experimenter's request to destroy the robot was 'inhumane' and that, 'the robot is innocent'. Given the participants' reluctance to harm the robot, as shown in these two studies, perhaps people are, rather, inclined to show positive behaviors towards it.

There are two studies, again with adults, that may provide some insights into children's helping behaviors. Ono and Imai tested whether subjects would develop a sympathetic response to a robot, understand its goal, and respond with an action that would help it achieve its goal [26]. Although the researchers argued that people could interpret the robot's intention and responded behaviourally to it, the robot in the study had not actually requested help. Rather, it gave an instruction to move an object from its path. Similarly, Yamamoto and colleagues used a robot who also gave a command to the participant [32]. Rather than a request for help to the participants, the experimental condition examined the likelihood of participants following an instruction from a robot. In this latter study, they found that the robot command was generally ignored. Thus, these two studies provide limited insight into whether people would help a robot. Moreover, these studies examine person-robot interaction, solely, and do not include situational features that may impact whether help will be offered.

One study that does straightforwardly examine helping behaviors towards a robot was conducted by Huttenrauch and Eklundh [18]. They found that adults were likely to help a service robot complete a task that it was clearly unable to do. These researchers draw on Latané and Darley's model of bystander behaviour by examining two characteristics of the environment that may impact helping behaviors, which include preoccupation and role modeling. That is, people were more likely to help when they were not busy with another task, but not more likely to help when another adult modeled the helping behavior towards the robot. This experiment, along with the above two studies, used voice communication from the robot to the participant. It remains to be seen whether people can infer the need for help based solely on the robot's movements.

In summary, there is some limited evidence of helping behaviors towards a robot. Research to date has been conducted with adults, but not with children. Also, studies involved direct robot to human communication directing participants exactly what to do. This can create pressure on the part of the potential help giver to act benevolently, which may inflate helping behaviors. Moreover, there are many situational cues that have yet to be explored to determine their impact on helping behaviors. Our study, therefore, extends previous research in many important ways. We examine whether children, who will become the next generation of responsible citizens and are likely to spend considerably more time with robots than past generations, would be inclined to help a robot. Moreover, we do so without voice cues from the robot to determine the extent to which they initiate helping behaviors independently of the robot's guidance. This will also allow us to determine if children can read some minimal social cues for help exhibited by a robot. Additionally, we explore the situational conditions in which children are most likely to help a robot [13]. Cues may be natural, although difficult to characterize in human interactions; however, robots can be programmed to exhibit cues (e.g., in their motions, appearance) that elicit certain reactions in people [6]. The following series of studies conducted in this vein directly assesses whether various situational cues increase or inhibit children's helping behaviours. The first four conditions introduced characteristics of an authority figure, and the fifth condition introduced a feature of the robot itself. Although important for robot design and development, herein the abilities of the robot and its appearance are ignored when interpreting the results. The reason for this is to focus on the aspects mentioned above without trying to include all the interrelated complexities which would make the data too cumbersome to analyze.

2 Method

2.1 Sample and Procedure

Children for all the studies were visitors at a science centre located in the downtown area of a large city in Western Canada. Each study consisted of 52 or more children, which is an adequate sample size to determine a low to moderate effect size [21]. Data collection occurred over the summer during opening hours from Monday to Sunday. As families walked through the exhibits, an experimenter randomly selected parents to ask if their children would like to visit with a robot. Children between the ages of 5–16 years were approached. If a child agreed then the accompanying parent was informed about the study and asked to sign a consent form. Each child was then escorted into the 'robot exhibit'. Parents and young children were encouraged to sit at a table just outside the robot exhibit to draw pictures of and read facts about robots. Thus, the participating children took part in the experiments on their own.

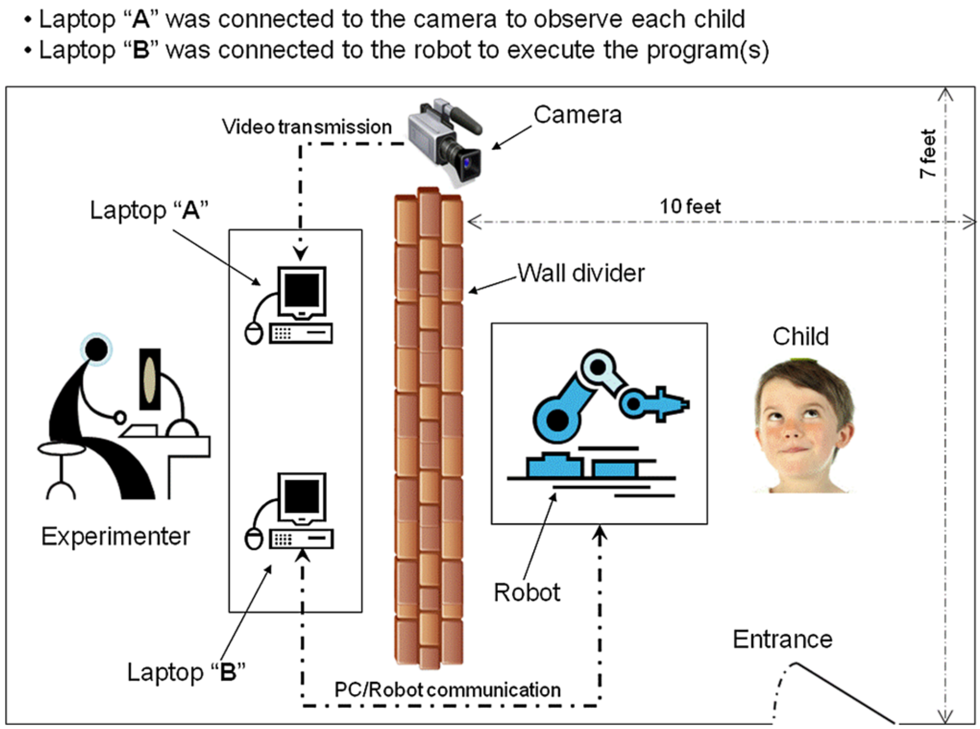
The robot exhibit was enclosed by a heavy curtain that reduced noise and with only one opening prevented people from wandering in. It was 10 feet by 7 feet and consisted of a robotic arm on a platform with a chair facing it (see Fig. 1). For safety reasons, children were positioned outside of the workspace of the robot (i.e., 0.56 meters) at all times but were able to reach over to the robot. There was an adjoining space behind a divider used to situate two laptops. Laptop "A" was connected to a camera mounted on the wall behind and to the side of the robot and facing the child. All observations of children's behaviours were conducted by an experimenter behind the divider on this laptop through this closed circuit camera. Children were not informed that they were being monitored. Laptop "B" issued the commands to execute a desired program within a set of pre-loaded programs to control the robot including a stop button via a serial communication port. Once inside the exhibit, the experimenter instructed the child to sit on the chair in front of the robot. Then an instruction was given to the child and the experimenter left to go behind the divider. The experimenter then initiated commands on laptop "B" for the robot to stack blocks. While the robot performed its actions, the experimenter observed the child's actions on laptop "A" and recorded them on a form. Once the robot stopped, the experimenter returned to the child and asked about some general impressions of the experience. Children were then thanked and escorted back to their families.

2.1.1 Description of Robot

The self-contained electric D.C. servo driven robotic arm used was a CRS-Plus small 5 degree of freedom articulated arm having a base ($\pm 175°$ rotation), shoulder ($+110°$, $0°$ rotation), upper ($0°$, $-130°$ rotation) and lower arm ($\pm 115°$ rotation), and wrist ($\pm 180°$ rotation) motions controlled by a RSC-M1A robot system controller. The robot joints include optical encoders for position feedback and can move at speeds of 180 degrees/second. For this study the robot's speed was limited (both program and hardware) to slower speeds to prevent any potential personal injury. The robotic arm was covered in craft foam and corrugated plastic to appear pleasing to look at (see Fig. 2). Gender neutral colors yellow, white, and black were chosen. The end of the arm (i.e., the gripper) was covered with a head so that its grip was situated in the mouth of the head. Thus, the robot appeared to pick up blocks with its mouth. Its head contained two eyes made of smooth silver buttons. It made a low humming noise when it turned, which was barely audible at the science centre due to white noise created by an overhead fan. The rectangular wooden blocks were 2 cm $\times$ 2 cm $\times$ 4 cm, each weighing a few grams. They were placed in a line to the side of the robot in the craft foam that covered the platform.

An outline of the blocks was cut into this foam to ensure that the blocks were correctly positioned every time for the robot grip to reach them. The arm was initially positioned in the center of the platform with the head raised, appearing

Fig. 1 Design of experiment



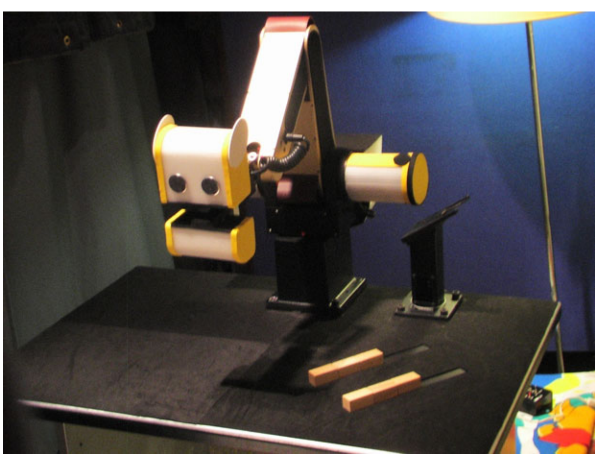


Fig. 2 Five degree of freedom robot arm on platform with blocks

to 'look' at the child (Fig. 2). Once the experimenter issued the command from laptop "B", the arm moved to the side where the blocks were located. The grip closed around the first block, then returned to the center and in a raised position in line with the child. This gave it the appearance of lifting its head to appear to be 'looking' at the child. Then it placed the block on the platform in front of the child. The robot repeated this motion to stack the second block. The arm then moved to the third block, picked it up, but slightly opened its grip as it turned toward the child, thus, appearing to drop the block. The grip then opened wider to make the facial appearance of the mouth opening. The arm then returned to the original location of the blocks and moved back and forth for 25 seconds, appearing to 'look' for the block. It lowered twice, attempting to pick up the block but 'missed' both times. Then the arm returned to the center with the head raised and positioned in front of the child's face. These actions were all pre-programmed into the robot's memory via a set of independent programs that the experimenter had at his/her disposal to command the robot to execute as the experiment progressed. These programs were selected for the robot to execute via a graphical user interface used by the experimenter.

In an attempt to make the need for help unambiguously clear we programmed the grip to open so that the child would see the mouth opening as if in surprise that the block had fallen. In addition, the grip was unable to locate the block and the child was positioned close enough to be able to reach the block. Moreover, the head traveled in a sweeping pattern back and forth for almost half a minute allowing ample time for the child to think through the situation and consider offering help. The head also moved up towards the child's face each time it switched directions to appear as if it was looking to the child for help. These 'deliberate' actions of looking for the dropped block and the social cue of 'looking' up at the child after moving its head in each direction gave the impression that it was acting autonomously (although the robot was simply executing a pre-loaded program selected by the experimenter as the experiment was conducted). Although we did not specifically ask children if they believed the robot was autonomous, after interacting with the robot we asked them, "How did the robot do with the blocks?" All children commented that it dropped and attempted to find the last block. This validity check indicates that they understood the robot's 'deliberate' reaction of searching for the block it 'accidentally' dropped.

2.2 Measures

All children's behaviors were written on a record form, but helping behaviors were recorded only once the robot dropped a block. A behavior was coded as helpful if the child touched or moved the third block. For example, some children tapped the block while looking at the robot, others moved the block closer to the mouth, and still others stacked the final block. There were some children who exhibited all of these behaviors. A child who exhibited any or all of the above behaviours was classified as a helper. No children touched the blocks once the robot stopped.

Other engaging behaviors were recorded. These include waving at the robot as it is stacking blocks, watching it, moving their head to follow its movements, looking underneath the head to see the grip pick up the block, placing their face directly in front of its face, smiling at it, talking to it, placing their hands towards his head as if to catch a block, clapping and nodding as it stacks the blocks, and placing their hands on their face in response to the robot dropping the block. These behaviors suggest that children actively interacted with and enjoyed spending time with the robot, indicating good engagement. They do not, however, demonstrate active assistance in helping it complete the block stacking task.

Off task behaviors were also recorded, which included looking at anything but the robot (e.g., the curtains, ceiling), fidgeting in their seat, and playing with their clothing. No child stood up while the robot was moving. One child began crying when it dropped the block and left. All children watched the robot stack the blocks and saw it drop the block. Children were randomly assigned to each condition within the following studies. According to a logistic regression using age to determine the likelihood of helping, no significant effect was found ($p > .05$); thus, helping behaviors did not differ by age of child.

3 Study 1

The first context tested was *adult introduction*. If children observe an adult give a positive introduction about the robot then they may develop a positive attitude towards the robot and be likely to help it. This tests the assumption that when children observe a positive relationship from an adult towards someone who is later in need of help, they are likely to help the person in need. Indeed, Thornberg [29] showed that children's ownership of personal responsibility toward someone in need of help greatly determines whether they will help.

3.1 Sample and Procedure

In the introduction group 32 children (15 male, 17 female) ranging in age from 5–15 years ($M = 8.31$, $SD = 2.51$) were included. Once seated, these children were greeted by the experimenter who used the following script:

1. Are you enjoying the science centre? What's your favorite part?
2. This is my robot (experimenter touches platform near robot). What do you think?
3. My robot stacks blocks (experimenter runs fingers along blocks).
4. I'll be right back.

As seen in this script, the experimenter attempted to establish some rapport with each child. She then demonstrated a sense of ownership and positive attitude towards the robot. The experimenter then exited to the area behind the divider (see Fig. 1) to operate the robot and record the child's behaviors.

Another 32 children with the same gender proportion between the ages 5–17 years ($M = 8.53$, $SD = 2.38$) were in the no introduction group as they did not experience this exchange. Rather, as soon as each child sat down, the robot began stacking blocks while the experimenter sat behind the divider.

3.2 Results and Discussion

The number of children who helped the robot stack the blocks was compared between the introduction group and the no introduction group. More children in the former ($n = 17, 53.1\%$) compared to the latter group ($n = 9$, 28.1%) helped the robot, $X^2(1) = 4.15$, $p = 0.04$. These results indicate that children are more likely to offer help towards a robot when they experience a positive introduction. Here the children had no introduction to the capabilities of the robot for the reasons mentioned in Sect. 1. Given the significance of the introduction, the next study included this factor with another to see if their combination would further increase the likelihood of helping.

4 Study 2

Given that 53.1% of children in the introduction group offered assistance, we introduced a second context, *permission from authority*, to determine if this would result in a larger number of children offering help. This tests the hypothesis that when given support, or autonomy to help, children, who feel uncertain, may be more willing to do so.

4.1 Sample and Procedure

A total of 36 children (17 male, 19 female) ranging in age from 5–13 years ($M = 7.72, SD = 2.05$) were included in the introduction/permission group. In addition to the instruction in study 1, they were also told: "It's ok to help the robot stack blocks". Such simple sentences were used to prevent misinterpretations due to the young age of some children. The experimenter then said "I'll be right back" before going behind the divider.

4.2 Results and Discussion

The number of children who helped the robot stack the blocks was compared between the introduction/permission group and the two (introduction and no introduction) groups in Study 1. Although another 16.3% of children in the introduction/permission group offered help ($n = 25, 69.4\%$), this was not statistically greater when compared to the introduction group ($n = 17, 53.1\%$), $X^2(1) = 1.91$, $p > 0.05$. However, there was a significant difference between the number of children in the introduction/permission group who helped ($n = 25, 69.4\%$) compared to the no introduction group ($n = 9, 28.1\%$), $X^2(1) = 11.57$, $p = 0.001$.

These results suggest that once a positive introduction is given, providing permission to help the robot does not increase the likelihood of children helping. However, when children have both a positive introduction and permission to help the robot, then children are more likely to help than if they received neither type of information.

5 Study 3

The third context tested was *authority expectation* to see if this would increase the likelihood of helping compared to the introduction condition. Children are often informed about rules in their daily lives as adults inform them of how they are expected to behave. It was predicted that when children understand an authority's expectation about behavior in a specific situation (i.e., when help is needed) that children would be likely to meet this expectation. Thus, it was predicted that an adult's emphasis on the importance of a task being completed with a robot would encourage children to ensure the task was indeed completed.

5.1 Sample and Procedure

A total of 32 children (15 male, 17 female) ranging in age from 5–16 years ($M = 7.84, SD = 2.48$) participated in this introduction/expectation test. They were told that the experimenter expected that a task the robot was performing would be completed. Thus, after receiving the introduction, the experimenter gave the following instruction: "It's *really* important that *all* these blocks are stacked by the time I come back". The experimenter then said "I'll be right back" and went behind the divider.

5.2 Results and Discussion

Chi square analysis revealed that more children in the introduction/expectation group ($n = 21, 65.6\%$) compared to the introduction group ($n = 17, 53.1\%$) helped the robot, but this difference was not significant, $X^2(1) = 0.31$, $p > 0.05$. However, there was a significant difference between the number of children in the introduction/expectation group who helped ($n = 21, 65.6\%$) compared to the no introduction group ($n = 9, 21.0\%$), $X^2(1) = 9.04$, $p = 0.003$.

These results indicate that once children hear a positive introduction, emphasizing the importance of a task being completed does not significantly increase the likelihood of children helping. However, when cues for positive introduction and authority expectation are given to help the robot, then children are more likely to help than if they received neither type of information. Thus, neither permission, nor authority expectation significantly increased the likelihood of helping when compared to the introduction condition. All three contexts, however, do result in more helping compared to when none of these instructions is given.

6 Study 4

The fourth context tested was *warning of consequence*. Specifically, it was examined whether children would be likely to help a robot complete a task when an authority figure suggested it would receive a consequence for not completing a task. It was expected that children would attempt to 'protect' the robot and offer assistance if they were concerned about the consequence to the robot.

6.1 Sample and Procedure

A total of 20 children (10 male, 10 female) ranging in age from 5–13 years ($M = 8.20, SD = 2.74$) were told that the robot would experience a punishing consequence if the blocks were not stacked. After the introduction script they were given the following instruction: "My robot stacks blocks but has been dropping them today. If the robot drops another block I'm going to pull out the plug and put the robot away. I'll be right back". The experimenter then went behind the divider while the robot stacked the blocks.

6.2 Results and Discussion

Results indicate no significant difference in helping behavior between children in the introduction/warning of consequence group ($n = 6, 30.0\%$) compared to the introduction group ($n = 17, 53.1\%$), $X^2(1) = 2.67$, $p > 0.05$. Moreover, there was no significant difference between the number of children in the introduction/threat of consequence group who helped ($n = 6, 30.0\%$) compared to the no introduction group ($n = 9, 21.0\%$), $X^2(1) = 0.02$, $p = 0.88$.

These results indicate that the increase in helping behaviors resulting from experiencing a positive introduction is offset by the warning of a consequence. Thus, suggesting that a robot in need of help will experience a punishing consequence does not encourage children to help it complete a task, even after receiving a positive introduction to it.

7 Study 5

The fifth context tested was *robot capability*. This study examined whether children would be likely to help a robot when it showed it was incapable of completing a task, and, thus, required assistance. If a robot showed a previous failed attempt to stack three blocks, then children may be more willing to help than if the robot showed a previous successful attempt. Children may believe that because the robot successfully performed the task at least once that it should be able to do so again; therefore, it would not require assistance. On the other hand, if the robot was previously unsuccessful at performing the task, then it may not be able to in the future; therefore, it would require assistance. This hypothesis tests whether children are more likely to help someone complete a task when the person demonstrates no capability at this task compared to demonstrating some capability.

7.1 Sample and Procedure

In the robot capability group children observed the robot successfully stack three blocks, then drop the third block when attempting to stack a second set of three blocks. In this condition there were 32 children (15 male, 17 female) ranging in age from 5–15 years ($M = 8.53, SD = 2.38$). In the incapability group, children observed the robot drop the last block when stacking three blocks. Then the robot attempted to stack a second set of three blocks, and again dropped the last block. There were 32 children (14 male, 18 female) in this group ranging in age from 5 to 13 years ($M = 8.53, SD = 2.29$). Neither group was given any instructions or greeted by the experimenter before the robot began stacking blocks.

7.2 Results and Discussion

Results indicate no statistically significant difference in helping behavior between children who saw the robot demonstrating capability of stacking three blocks ($n = 9$, 28.1%) compared to those who saw the robot demonstrating the inability to stack three blocks ($n = 14, 43.8\%$), $X^2(1) = 1.70$, $p = 0.15$. Thus, we cannot conclude that children's helping behaviors towards a robot are influenced by the capability of the robot itself.

8 Discussion

Do children help robots? This question was addressed by examining five conditions which were expected to elicit children's helping behaviors towards a robot. The first four conditions introduced factors inherent to an authority figure, and the fifth condition introduced a characteristic of the robot itself. Many children helped across the five conditions, demonstrating that they did interpret the social cues from the robot as a need to help it, decided they were in a position to be able to offer help, and were able to determine how to help, which, according to Latané and Darley, are implicated in helping behaviors.

Of all the types of contexts, the adult's positive introduction to the robot was the most significant. Combining the introduction with permission or expectation from an adult did not significantly impact helping when compared to the positive introduction alone. When compared to children who received no instructions of any kind, however, those who received a positive introduction and were given permission to help were the most likely to do so (about 70% of children). Thus, we were able to test multiple contexts and determine the combination that attained support from the vast majority of children. We were also able to ascertain that a positive introduction in combination with the warning of a consequence resulted in only about a third of children choosing to assist the robot. This proportion was also found when the robot demonstrated the inability to perform the task.

8.1 Authority Figure

The adult's positive introduction to the robot seemed critical to eliciting helping behaviors for several reasons. First, it may have created a halo effect whereby it sets an expectation for the child that he/she will likely have a positive experience with it. Thus, when the child is alone with it, the pleasant thoughts and feelings experienced at the initial introduction likely carry over into the child's own personal interaction with it. The occurrence of halo effects was established long ago [22, 30]. Witnessing a positive attitude towards the robot may also have allowed children to develop familiarity with it. They had time to examine and, indeed, provide feedback about the physical features of the robot and become accustomed to the idea of it being in close proximity to them. This may have increased their sense of comfort when alone with it to enable them to offer help. Indeed, research suggests that people are more likely to help others who they have had or expect to have contact with than others they do not [14, 32]. Similarly, research has shown that when a robot gives an instruction to adults who had no previous contact with it they were unlikely to follow the request [32]. Another reason why the introduction may have encouraged helping behaviors may be due to the messages it relayed. The robot was introduced as ‘my robot’ by the experimenter. This may create a sense of personal responsibility to and relationship with it. Witnessing an adult’s affiliation with the robot may have invited their own personal reaction in terms of developing responsibility towards and affiliation with it. Research has supported this explanation by showing that people are most likely to help others they have a sense of responsibility towards [24]. A final explanation for why so many children helped a robot after experiencing a positive introduction is that it may have allowed some opportunity for the child to develop rapport towards the robot after seeing the researcher demonstrate rapport towards the robot and themselves. This triangulated link may have been instrumental in facilitating a connection between the child and robot after seeing a connection between the adult and robot. Another interpretation is that children may have intended to directly help the adult, who they felt rapport towards, rather than the robot itself. This issue was raised by researchers when explaining why adults did not help a social robot [18]. They suggested that people were disinclined to help when they believed the robot was helping someone who was ‘too lazy to do it themselves’. However, their results are inconclusive and even suggest that the opposite may be true. We have anecdotal evidence to suggest that children were not directing their helping behaviors towards the experimenter. Upon returning to their families many parents asked their children if they enjoyed seeing the robot. When telling their parents about the robot’s actions, many children spontaneously stated that they helped the robot because it dropped a block. Though various reasons were given for their actions, no child mentioned the role of the researcher in their decision to help. This finding is in contrast to Huttenrauch and Eklundh’s post-experiment results whereby adult participants did state that they believed they were helping another person via the robot [18]. Of course it is possible that our young participants were not aware of or did not articulate this intent.

The remaining conditions inherent to the authority figure did not significantly increase the likelihood of helping once the positive introduction was given. When an adult provided permission or expectations for assistance in combination with the introduction, though, almost ¾ of the children offered assistance. This was the highest across all five studies. Thus, rapport may create a sense of responsibility for helping, and permission and expectation may give children the authorization and duty to act on that responsibility. Perhaps it is this combination that encourages children to demonstrate helping behaviors rather than just thinking about helping. Future research must explore whether permission and expectation without a positive introduction would also influence children’s helping behaviors. Moreover, when an adult suggested that the robot would experience a negative consequence for failure to complete a task, few children helped the robot. Perhaps they became curious to see what the adult would do to the robot. It is also possible that telling them the robot would receive a consequence for failing to complete the task may have suggested that the robot is responsible for the task, and, thus, they are not. If this is the case, then their sense of personal responsibility may have actually decreased. One more consideration is that children did not perceive this consequence as particularly negative.

8.2 Robot Capability

The fifth condition tested was whether the robot’s capability of completing the task would influence children’s helping behaviors. No significant effect was found in this case. Perhaps when children observed the robot dropping the third block in both stacking attempts, they continued to wait, curiously, to see if the robot would be able to do it the next time. It is possible that two failed attempts were not sufficient to demonstrate to the child that the robot was incapable of stacking all of the blocks. Also, the test may simply have not been powerful enough to illicit differential helping behaviors.

In an effort to determine children’s reasons for their decision as to whether to help, after the experiment we asked them the direct question, “Why did you help/not help?” They provided very brief responses and these did not vary systematically according to the context they were in. Many children ($n = 41$, 22.3%) stated they did not know why they helped or not, and four responses (2.2%) could not be coded (e.g., ‘instinct’). A total of 41 children (22.3%) thought the robot did not need help, 24 (13.0%) thought the robot did need help, 10 children (5.4%) did not want to touch the robot or ‘forgot’ to help, 28 children (15.2%) were not aware they were allowed to help,[1] 25 children (13.6%) provided a description of the helping behavior they used, 9 children (4.9%) thought the robot would not respond to help, and two (1.1%) thought their help would not be effective. Thus,

[1] No children in the permission condition stated they were not aware they were allowed to help.

many children were unable to provide reasons for their decision as to whether or not to help, and/or provided vague reasons (e.g., 'forgot'). Also, many children stated they did not recognize the need for help suggesting that they did not recognize the robot's social cues. It is uncertain as to the total number of children who did perceive the need for help because they may simply not have articulated this response to the open-ended question of why they helped or not. Thus, it is recommended in future research that this question be included and responses probed to determine how they understood the robot to show whether it needed help. Similarly, it is unclear as to why a few children stated they thought their help would be ineffective or that the robot would not receive the help, and this should be explored in future research. Given that some children stated they were not aware they were allowed to help, it may be important to include this instruction in all conditions in future research.

8.3 Limitations

There are several factors to consider that may influence our findings. Although conducting an experiment within the science centre afforded us a tremendous opportunity in collecting data at a rapid rate, and resulted in a high response rate from those asked to participate, this location may have impacted children's behaviours towards the robot. Research has shown that when people are in a positive mood they are likely to offer assistance [1, 25]. Presumably, many children who were visiting the science centre found the exhibits enjoyable and, thus, experienced elevated mood at the time they participated. Thus, more children may have helped in our experiment than may be the case outside of the science centre. In addition, children in our study may be unique by virtue of the fact that they are visiting the science centre, and their helping behaviors may not represent those of other children. It is, therefore, important to validate the results with other samples. These samples should be diverse and include people from varying ethnic and geographical backgrounds. In addition, it is important to use varying styles and capabilities of robots such as traditional arms, mobile manipulators and humanoid robots. Perhaps robots that appear more human-like and more sophisticated will illicit more physical helping behaviors. Studies have been conducted in trying to understand what actions of a robot produce a rich, flexible, and dynamic interaction that is affective and social such as the work performed with Kismet (an expressive robotic creature with perceptual and motor modalities tailored to natural human communication channels) [5], but very little work has been conducted on interactions that are more physical.

Regarding the introduction condition, it is uncertain as to the part of the statements that influenced helping behaviors. It is possible that the question about enjoying the science centre created rapport, which affected helping behaviors. Or, perhaps the researcher showing ownership of the robot ("This is my robot") influenced helping behaviors. Our study provides new insights about the relevance of the adult's interaction with the robot, and it is now up to future research to examine the precise nature of the interaction that is critical to children's own interaction with the robot. Moreover, we suggest that researchers conduct a post-experiment interview to determine how participants interpreted the social cues the robot exhibits and the experimental conditions. For example, it is possible that children did not perceive the threat of unplugging the robot to be a punishment (although turning off the robot was construed as a negative consequence to the robot in Bartneck et al.'s study [2]).

Some children noticed the camera on the wall to the side of the robot. This may have created a social desirability effect thereby increasing their likelihood of helping. However, no children stated they thought they were being watched and some children thought it was connected to the robot to control its movements. In addition, the camera was present in all conditions, and, thus, does not explain differences in helping behaviors between conditions.

Regarding the reliability of measured helping behaviors, we could not determine inter-rater reliability because only one observer was present. Also, due to background noise it was not possible to hear children's comments. In some cases, children yelled at the robot expressing their frustration about the proximity of the block and the robot's inability to pick it up. On several occasions the experimenter observed the child's mouth moving but was unable to hear the child's comments. It is recommended that future research include audio capabilities as some children may have offered help in the form of verbal encouragement.

8.4 Implications for the Development of Social Robots and Children's Helping Behaviors

This study suggests that children do respond to the social cues of a robot. In addition to robots being used to help or benefit people, children may reciprocate these behaviours and offer assistance that benefits the robot. Indeed, there is some suggestion that children can develop a collaborative relationship with a robot when playing a game together [31]. Perhaps, then, children may enjoy interaction with a robot that allows give and take. This may enhance a child's sense of altruism and, hence, increase engagement with it. It is, thus, recommended that developers of such robots consider designing them to not only offer help, but be able to receive it.

Our study provides another unique insight into the study of social robotics. Rather than vary the design of the robot to determine differences in children's helping behaviors, we varied the adult's interaction with the robot. Discovering that many children help when an adult provides a positive introduction but that no other instructions about the robot further increased the likelihood of helping suggests that the adult-robot-child interaction is a significant factor when examining children's reactions to a robot. In other words, we must not study children's reactions to robots in isolation, but rather in the context of how people interact with it (much like studying child development in the context of their family and peer relationships). Moreover, this study provides preliminary insights into the importance of the context of children's interaction with a robot suggesting that the situation, not just the design of the robot, must be considered with developing robots to work with children. It is also rather intriguing that children offered help to a fairly simple robot compared to those currently being developed.

This study has inherent value in understanding children's helping behaviors towards robots, given that robots and applications of technology are taking a more prominent role in our lives. In addition, we must ask, are the results relevant to children's helping behaviors towards people? Given that the premise of each hypothesis tested was to determine helping of people, it is important to ask whether the results are generalizable to people. We attempted to determine when children would demonstrate helping behaviors by having a robot sit in as the one needing assistance. This provided the opportunity to control the conditions in which children would offer help. Would these results be replicated if a child had been in need of assistance? Perhaps the answer depends on whether children can develop an affiliation with robots as they would with other children. Indeed, this has been suggested by researchers whereby children and adults seem to hold intrinsic value about robots, engage in social exchanges, enjoy physical contact (e.g., hug), participate in turn taking, and, according to our study, offer assistance to them [4, 6, 19]. Thus, it seems plausible that our results are relevant for children's helping behaviors towards people whereby they are most likely to help others when an adult shows a positive attitude towards them and/or the person needing help. This has strong implications for programs and initiatives designed to promote prosocial behaviors of children in school. Rather than place responsibility exclusively on children for these behaviors, adults must be seen as instrumental in building positive relationships with children as well. Finally, this study demonstrates that a distinct advantage of using a robot in an experiment rather than a person is that it can act as a standardized confederate to test and directly compare controlled conditions. This study points to the exciting new possibilities of using robots in research to provide new insights about human behavior in relation to both humans and robots.

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