# Children's Relationships with Robots: Robot is Child's New Friend

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*Abstract*— **The purpose of this study was to examine how children think about and attribute features of friendship to a robot after a brief interaction with one. Children visiting a science centre located in a major Western Canadian city were randomly selected to participate in an experiment set up at the centre. A total of 184 children ages 5 to 16 years (M = 8.18 years) with an approximate even number of boys and girls participated. Children were interviewed after observing a traditional robot, a small 5 degree of freedom robot arm, perform a block stacking task. Content analysis was used to examine responses to nine open-ended questions. Results indicate that the majority of children were willing to engage in friendship with the robot by showing positive affiliation and social support towards it, as well as sharing activities, and communicating with it.**

**Significant sex differences in how children ascribe characteristics of friendship to a robot were also found.**

*Index Terms*— **Robotics, Developmental Psychology, Friendships, Human-Machine Relationships.**

## I. Introduction

CHILDREN are becoming increasingly adept at operating computers and spend considerable time doing so. According to Statistics Canada [1], in 2000, 82% of parents reported that their children (aged 5 to 18 years) use computers [2]. Because of the increase in computer access among youth, studies have investigated the implications of this usage on their physical and psychological well-being [3-5]. Results are mixed with studies documenting adverse and positive outcomes, as well as no effects [6-8]. While it remains unclear as to how computer use is related to children's social development, research has also to examine how children's interactions with robots affect their development. With robots being built to mimic human expression and behavior it is possible that when children interact with a robot they may develop feelings of friendship towards it. The development of friendships in childhood is crucial to subsequent mental and physical health [9-11]. Thus, it is important to understand children's perceptions of friendship they may have in relation to a robot. The focus on the present study involves investigating what constitutes children's friendships and examining whether such patterns transfer to child-robot interactions.

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## II. Related Work

### A. Human-Robot interactions

In recent years, the course of development of robots has moved away from creating machines to work independently from humans to now creating robots for the purposes of interacting with humans in daily life [12]. In today's society, some robots function as physical aids for elderly people [13], as museum tour guides [14, 15], or as peer tutors and educational tools [16, 17]. With such a trend toward social robots, questions arise as to the extent of children's knowledge and understanding of humanistic versus robotic characteristics and how this may impact children's social relationships. According to Turkle [18] children who regularly use electronic devices (e.g., computers, video games, electronic toys) are more likely to attribute psychological characteristics to such devices, such as having the ability to talk, sing, or do activities. A recent study by Melson and colleagues [19] examined children's understanding of robotic versus living animals by comparing Sony's AIBO robotic dog to a living dog. The authors found that although more children (aged 7 to 15 years) attributed physical characteristics (i.e., mental states, sociality, and moral standing) to the live dog, the majority of children also ascribed these attributes to the robotic dog. In addition, children were as likely to give commands to the robotic dog as to the living dog. This suggests that children may treat technological devices as if they were social beings, which suggests the existence of a child-robot companionship.

### B. Children's social relationships

Friendships are undoubtedly important for childhood development, and, as such, set the stage for the development of communication skills, emotional regulation, and emotional understanding [20]. Friendships that are considered to be of high quality include many prosocial behaviours and deep intimacy [21]. Several additional characteristics shared between friends include a sense of caring or fondness, emotional support, and enjoyment of activities [21, 22]. Moreover, meaningful friendships between children are based on openness, affection, mutual support and trust, as well as a willingness to share

thoughts, feelings, stories, and secrets [23]. With friends children display a higher frequency of play behaviour and positive affect such as smiling and laughing [22, 24, 25]. From the aforementioned studies the primary characteristics of friendships can be summarized as a sense of positive affiliation, social support, shared activities, and communication between friends. In addition, sharing secrets plays an integral role to developing and maintaining friendships [26, 27].

Robots are under development for a wide variety of purposes that will become commercialized and available to children as toys and companions. It is important to understand children's receptivity to a robot, their thoughts/feelings towards it, and their social responsiveness towards it. This, in combination with the significance of friendship for children's healthy development, compels us to examine their perceptions of friendship with a robot. Specifically, the question concerning the present study is whether children would attribute some of the features of friendships documented in previous research, to relationships children may experience with a robot that exhibits some minimal social cues. Friendship can be characterized as demonstrating positive affiliation, social support, shared activities, and communication (including sharing secrets). We examine whether children would ascribe these same characteristics to a robot after briefly interacting with it. Also, we selected a relatively simple robot, assuming that if children provide positive responses about a robot of this type, that they would also do so with more sophisticated ones. The advantage of such assumption was to eliminate from the study a number of variables such as the robot's physical appearance and its communication skills (e.g., Aibo, NAO and Wowwee robots). By doing so we were able to focus on the intended study and provided more definite conclusions. Given that friendship is exhibited from each child to the other, we asked children about their perceptions of friendship behaviors towards the robot and from the robot.

## III. METHOD

### A. Sample and procedure

A total of 184 children (n = 98 female, n = 86 male) between the ages of 5 to 16 years (M = 8.18, SD = 2.37 years) were included in the study. Participants were visitors to a science centre located in the downtown area of a large city in Western Canada. Data collection occurred in the summer during opening hours from Monday to Sunday. Families with a child in the specified age range, who were visiting the science centre, were approached by a researcher and asked if their children would like to visit with a robot. Then the accompanying guardian was informed about the study and asked to sign a consent form. The researcher then escorted the child independently into the robot exhibit while the family waited at an adjacent exhibit. The response rate was approximately 95%.

The robot exhibit was a small booth 10 by 7 feet located in a quiet area of the science centre. It was built with heavy curtains and dividers designed to reduce noise and discourage interruptions by visitors. The booth contained a robotic arm on a platform with a chair facing it for the child to sit and observe the robot completing a task. There was also an adjoining space behind a divider serving as the testing booth and contained two laptops. One laptop produced diverse task commands for the researcher to control the robotic arm while performing the task. The second laptop was connected to a camera mounted on the wall behind and to the side of the robot and facing the child. This allowed researchers to observe the child on the laptop from behind the divider. Children were not informed that they were being watched through the camera, and most children did not look at it. Of those who did, some thought the camera was used to control the robot and not necessarily monitor them. Based on these observations we believe that children did not know that they were being watched because almost no one looked at, or seem to notice, the camera. We believe that this aspect of how the tests were conducted is relevant because children seem to be comfortable and natural while interacting with the robot (which was one of the intentions while conducting the study).

The researcher escorted the child behind the curtain and gave the request to be seated on the chair in front of the robot. The child was then informed that the researcher would be right back and then went behind the divider. The researcher then executed the command on the laptop to run the robot on a specific task and observed the child on the second laptop. The child's behaviours were recorded on a record form. The robot was programmed to stack blocks, and once the robot stopped, the researcher returned to the child and conducted an interview. Children were then thanked and guided back to their families.

The block stacking task was selected because children recognize this as a familiar play behavior. There is no existing research to suggest that having the robot engage in a different activity would result in a different outcome, so there was no basis to believe that this was the case. The questions were asked at the end of the sequence of movements to allow children an opportunity to focus on the robot, and then afterwards focus on the questions.

### B. 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 (±175˚ rotation), shoulder (+110˚, 0˚ rotation), upper (0˚, -130˚ rotation) and lower arm (±115˚ rotation), and wrist (±180˚ rotation) motions controlled by a RSC-M1A robot system controller. During the experiment the robot moved objects weighing only a few grams (i.e., small rectangular wood pieces). The robot joints include optical encoders for position feedback and a speed setting (both program and hardware) set to slower speeds for safety purposes. For added safety, children were positioned outside of the workspace of the robot (i.e., 0.56 meters) at all times.

The robotic arm was covered in craft foam and corrugated plastic to appear pleasing to look at (see figure 1). Gender neutral colors yellow, white, and black were chosen. To ensure that the robot appeared to pick up blocks with its mouth, the

two finger gripper of the arm was covered with a head so that its grip was situated in the mouth. The head contained two eyes made of smooth silver buttons. Due to its design and construction, the robotic arm made a low humming noise when turned, but this was barely audible.

The rectangular blocks that the robot picked up were 2 cm x 2 cm x 4 cm. They were placed in a line to the side of the robot in the craft foam that covered the platform (see Figure 1). An outline of the blocks was cut into this foam to ensure that the blocks were correctly positioned every time for the robot grip. The arm was positioned in the center of the platform with the head raised to the height of the child, appearing to 'look' at the child.

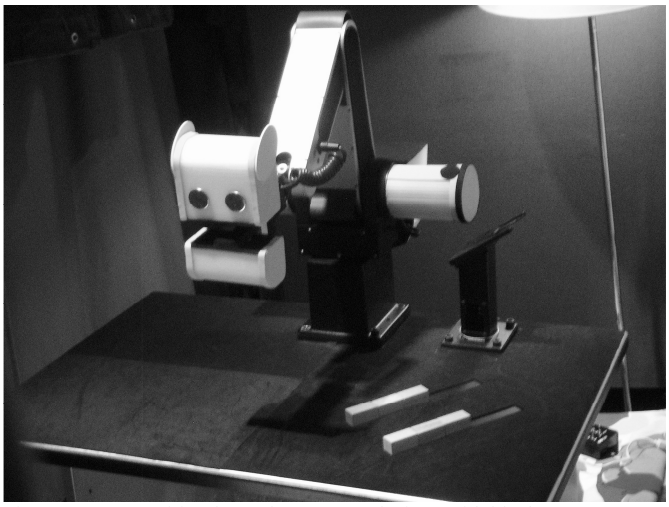

Fig. 1. 5 Degree of freedom robot arm on platform with blocks

### C. Robot's Task

The robot was pre-programmed at the university and then controlled at the science centre by a researcher via a graphical user interface. The first movement of the arm was to the side where the blocks were positioned and to pick up the first block. Then the arm returned to the center with its head opposite the child's face so as to appear to be 'looking' at the child. The robot then lowered the block, placing it on the platform in front of the child. These actions were repeated with the second block to stack it on the first block. The robot grasped the third block, picked it up, but slightly opened its grip as it turned toward the child, thus, dropping it. The grip opened wider while facing the child to make the facial appearance of the mouth opening and appearing surprised at dropping the block. The arm then returned to the original location and moved back and forth for 25 seconds, to 'look' for the block it dropped. 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 movements were programmed to be smooth so as not to appear as machine movements.

### D. Measure

A total of nine questions were asked during a 5-10 minute interview, which took place once the robot stopped. The first three were about children's use of electronic devices at home. These include whether they watched TV or played on a computer at home, as well as whether they owned electronic toys. Responses were coded as 'yes' or 'no'. The following six questions about children's affiliation with the robot were then asked. Positive affiliation was measured by two questions: "Does the robot like you?" and "Can the robot be your friend?" Social support was assessed with one question: "If you were sad would the robot make you feel better?" Shared activities were measured by asking children: "Would you play with the robot?" Finally, communication was assessed through two questions: "Would you talk to the robot?", and "Would you tell the robot secrets?" The first three questions ask about the robot's friendship behaviors towards the child, and the latter three questions ask about the child's friendship behaviors towards the robot. After each question they were asked to explain why they indicated "yes" or "no". These responses were coded according to guidelines recommended for qualitative data [28]. One researcher on the project and a research assistant examined the responses for themes, then a coding scheme was developed, which was used to code the responses. The intraclass correlations for two raters, who coded separately, ranges from .92 to .96 across the six questions, indicating very good inter-rater reliability.

## IV. Results

### A. Use of electronic devices

A total of 95.5% of children (n = 169, n = 7 missing) stated they watch television, 81.9% of children (n = 145, n = 7 missing) reported playing on a computer at home, and 84.5% (n = 147, n = 10 missing) indicated they had electronic toys (e.g., robotic dog, remote control cars). Thus, the majority of children demonstrated familiarity with electronic devices.

To identify if there are any differences between children of different ages and the attitude to the robot (as would be normally expected) children were grouped by age into three groups. Each group (5-6 yrs, 7-9 yrs and 10-16 yrs) consisted of approximately of 50 children. There were no significant chi square results for age and any of the six questions about friendship characteristics.

### B. Positive affiliation

More than half of the children (64.0%) stated the robot liked them (see Table 1). A frequently stated explanation for this belief is that the robot looked at them and appeared friendly (e.g., "his mouth looks like he is smiling at me"). Other children thought the robot had positive intentions (e.g., "he wanted me to know my numbers by counting blocks"). Absence of harm was another reason for thinking the robot liked them (e.g., "never tried to bite me"), and their kind actions towards the robot led them to believe the robot would like them (e.g., "I was encouraging the robot"). Few children (8.7%) stated the robot did not like them, citing reasons such as it not having the ability to think or feel, or that it ignored them by stacking the blocks and not allowing them to help it. Many children did not

know if the robot liked them or were unable to explain why. Some children provided a response that did not address the question (e.g., "hard to tell with robots"). There was no significant difference between the number of girls (n = 60) compared to boys (n = 58) who thought the robot like them, $X2(1) = 0.28$, $p > 0.05$.

In addition to feeling liked, the majority of children (85.9%) believed that the robot could be their friend and provided a variety of explanations (see Table 1). Most of these children stated they could be friends pending the robot's actions. For example, it would depend on whether the robot was nice, helpful, or engaged in conversation. Many other children thought that friendship was based on spending time together or participating in activities together (e.g., "watching a movie together", "teaching me something"). The robot assisting the child or vice versa was also often mentioned, as was a sense of familiarity with (e.g., "robot knows me") and kindness towards the child (e.g., "can hand me things"). In addition, characteristics of the robot for friendship include children's perceptions of it being friendly and likeable. Some children also judged their friendship with a robot based on their friendly acts towards it (e.g., "saying hi to the robot"). One child made a poignant statement about friendships with robots, "Man's best friend is a dog so a robot can be child's best friend". Few children (10.3%) indicated that a robot could not be their friend and explained that the robot has limited ability to move, communicate, or understand their thoughts or feelings. Some children stated they did not know if or why the robot could be their friend, and some responses did not answer the question (e.g., "every robot is my friend"). There was a significant difference found with more girls (n = 90) than boys (n = 68) saying the robot could be their friend, $X2(1) = 4.40$, $p < 0.05$, effect size ($\Phi$) = 0.15.

TABLE I
NUMBER AND PERCENTAGE OF CHILDREN REPORTING POSITIVE AFFILIATION WITH ROBOT (N = 184)

| Robot likes you | | Robot can be your friend | |
|---|---|---|---|
| Yes | 118 (64.0%) | Yes | 158 (85.9%) |
| Looks/smiles at me, friendly | 38 | Conditional | 31 |
| I was nice/did something nice | 20 | Being or doing things together | 30 |
| Did not hurt me | 13 | | |
| It had positive intentions | 9 | Helpful | 17 |
| | | Knows me | 12 |
| Do not know why | 33 | Kind | 11 |
| Not coded | 5 | Friendly | 6 |
| No | 16 (8.7%) | Likeable | 7 |
| No thoughts/feelings | 4 | Friend to robot | 4 |
| Ignored me/didn't let me help | 10 | Do not know why | 28 |
| Do not know why | 2 | Not coded | 12 |
| Not coded | 0 | No | 19 (10.3%) |
| Do not know | 50 (27.3%) | Limited mobility | 3 |
| | | Limited communication | 2 |
| | | No familiarity | 3 |
| | | No brain, feelings | 4 |
| | | Do not know why | 4 |
| | | Not coded | 3 |
| | | Do not know | 7 (3.8%) |

### C. Social support

In regards to social support, a large majority of children (78.8%) indicated that the robot could improve their mood (see Table 2). The most frequent explanation was to perform an action for them such as stacking blocks in a funny shape, or any other type of action (e.g., "making me laugh by doing something weird"). Other children stated the robot could perform an action with them such as playing together (e.g., playing games together). Many children thought the robot appeared cheerful (e.g., "gives me a smile"), and many stated it could emotionally connect with them (e.g., "be beside me", "understands me"). Some children also stated that the robot could help them (e.g., "helping me if I'm hurt"). Fewer children (14.7%) stated the robot could not improve their mood, with most of them explaining that it has limited abilities (e.g., "can't talk", "only stacks blocks", "no brain"). One boy stated the robot did not like him and so would not cheer him up. Some children did not know if the robot could cheer them up and another 25 children did not know why the robot could or could not cheer them up. Ten responses did not address the question (e.g., "just mom"). There was a significant difference found with more girls (n = 86) than boys (n = 59) saying the robot would cheer them up, $X2(1) = 8.09$, $p < 0.05$, effect size ($\Phi$) = .21.

### D. Shared activities

Similarly, the vast majority of children (83.7%) stated they would play with the robot and provided a variety of ideas about how they would play together (see Table 2). Most often mentioned were games of construction such as building towers and castles with toy building blocks. Several active types of games were also suggested by many children including playing catch or fetch with a ball, and running. Less physically inten-

TABLE II
NUMBER AND PERCENTAGE OF CHILDREN REPORTING SUPPORT AND ACTIVITIES WITH ROBOT (N = 184)

| Robot can cheer you up | | Play with robot* | |
|---|---|---|---|
| Yes | 145 (78.8%) | Yes | 154 (83.7%) |
| Perform action for me | 61 | Construction | 103 |
| Perform action with me | 12 | Ball game | 26 |
| Cheerful appearance | 20 | Running game | 12 |
| Connects with me | 20 | Board game | 12 |
| Help me | 7 | Other | 17 |
| Do not know why | 17 | Do not know why | 5 |
| Not coded | 8 | Not coded | 5 |
| No | 27 (14.7%) | No | 25 (13.6%) |
| Limited abilities | 16 | Physical limitation | 11 |
| Does not like me | 1 | Other | 4 |
| Do not know why | 8 | Do not know why | 6 |
| Not coded | 2 | Not coded | 4 |
| Do not know | 12 (6.5%) | Do not know | 5 (2.7%) |

TABLE III
NUMBER AND PERCENTAGE OF CHILDREN REPORTING COMMUNICATION WITH ROBOT (N = 184)

| Talk to robot | | Tell robot secrets | |
|---|---|---|---|
| Yes | 124 (67.4%) | Yes | 84 (45.7%) |
| I like the robot | 16 | Robot will keep secret | 30 |
| To get to know each other | 6 | Friendship with robot | 13 |
| Robot has mouth | 6 | Positive response to secret | 7 |
| If robot could talk | 22 | Other | 4 |
| Gave examples | 30 | | |
| Do not know why | 37 | Do not know why | 22 |
| Not coded | 7 | Not coded | 8 |
| No* | 53 (28.8%) | No | 92 (50.0%) |
| Robot cannot talk | 20 | Secrets are wrong | 24 |
| Robot cannot hear | 6 | Robot has limitations | 18 |
| Not human | 5 | Robot not trustworthy | 24 |
| Looks unfriendly | 9 | Robot is not alive | 9 |
| Do not know why | 11 | Do not know why | 12 |
| Not coded | 4 | Not coded | 5 |
| Do not know | 7 (3.8%) | Do not know | 8 (4.3%) |

*Some children provided more than one reason

sive games were also identified such as playing board games. Several other suggestions were provided such as video games, coloring, hand games, or riding on the robot. Few children (13.6%) stated they would not play with the robot with most of them stating it was because it had a limitation such as no legs or arms. Other reasons include "not one of my interests", and "not this one". Some answers did not address the question (e.g., "can be best friend"), and some children did not know how to answer the question. There was no significant difference between the number of girls (n = 80) and boys (n = 74) who stated they would play with the robot, $X2(1) = 0.88$, $p > 0.05$.

### *E. Communication*

More than half of the respondents (67.4%) indicated they would talk to the robot (see Table 3). Many stated they would do so because they like the robot (e.g., "it looks friendly"), or to become acquainted with it (e.g., "so get to know me better"). Some children believed that its physical appearance of a mouth would be reason to talk with it (e.g., "he has a mouth and me too and we can talk"). Many children stated the condition that if the robot could talk, then they would talk. Other children who stated they would talk to the robot provided examples (e.g., "you're good at building blocks", "how's it going?"). More than a quarter of the children (28.8%) stated they would not talk to the robot. Many stated that it is because the robot cannot talk (e.g., "doesn't speak English, speaks robot talk"), or hear. Some children stated that it is not human or alive, and others stated that it does not look friendly. Several children stated they did not know if or why they would or would not talk to the robot, and several provided a response that did not address the question (e.g., "most robots talk"). There was a significant difference found with more girls (n =

70) than boys (n = 54) saying they would talk to the robot, $X2(1) = 18.56$, $p < 0.05$, effect size ($\Phi$) = 0.32.

### F. Secrets

Almost half of the children (45.7%) stated that they would tell the robot secrets and provided a variety of reasons (see Table 3). Most of them thought the robot would not tell the secret or could not because of the inability to speak. Other children provided a reason that indicated an affiliation with the robot (e.g., "he's friendly", "he's my friend"). Some children thought the robot would respond positively to the secrets (e.g., "robot would remember them", or "robot would forget them so would not repeat them", "the robot will tell me some secrets"). Other responses include telling the robot secrets if they had no other friends, and that it feels good to tell secrets. Half of the children (50.0%) stated they would not tell the robot secrets. Several of them stated it is wrong to tell secrets, that they should be kept private. Others stated that the robot has limitations preventing them from sharing secrets (e.g., "robot can't listen or understand"), or that the robot is not trustworthy (e.g., "can't trust robot, robot might tell"). Some children stated the robot is not alive or that it does not care about secrets. Several children did not know why they would or would not tell the robot secrets or did not provide an applicable response (e.g., "depends on type of secret"). There was a significant sex difference showing that more girls (n = 59) than boys (n = 25) would tell the robot secrets, $X2(1) = 19.52$, $p < 0.05$, effect size ($\Phi$) = 0.33. Given that 24 children stated they would not tell secrets to anyone, we examined whether most of them were boys, as a possible explanation for why more girls would tell the robot secrets. There was no significant difference in the number of boys compared to girls who thought secrets should not be told, $X2(1) = 1.49$, $p > 0.05$.

To determine the extent to which the different types of relationship characteristics are related, Pearson's Product Moment Correlation analyses were conducted (see Table 4). Children who thought the robot could be their friend were also likely to report that they would play with it, talk to it, tell it secrets, and that the robot could cheer them up and likes them. Many of these variables were low to moderately inter-correlated. Moreover, these results suggest that children who stated they would engage in these behaviors towards a robot, were also likely to state that robots could engage in these behaviors towards them. Thinking that the robot liked them was not significantly related to whether they would talk to the robot or that it could improve their mood.

TABLE IV
SPEARMAN'S RANK CORRELATION COEFFICIENTS OF FRIENDSHIP CHARACTERISTICS (N = 184)

| | 1. | 2. | 3. | 4. | 5. | 6. |
|---|---|---|---|---|---|---|
| 1. Likes you | 1.00 | | | | | |
| 2. Friend | .34** | 1.00 | | | | |
| 3. Cheer up | .16 | .49** | 1.00 | | | |
| 4. Play | .20* | .36** | .16* | 1.00 | | |
| 5. Talk | .09 | .35** | .40** | .23** | 1.00 | |
| 6. Tell secrets | .17* | .31* | .31** | .20** | .34** | 1.00 |

## V. Discussion

It is plausible that in the future people will spend a significant amount of time with robots. These robots, moreover, will likely emanate various social cues that are familiar to people, which may facilitate people-robot interactions [29]. This raises numerous complex questions about the nature of the interactions people will have with these robots. We foray into this topic by examining children's perceptions of friendship with a robot that displays minimal social cues. We asked them if they would engage in friendship-type behaviors with one. The majority of children responded affirmatively to questions about exhibiting friendship towards the robot in the form of sharing activities (playing with the robot), and communicating (talking to the robot and sharing secrets). Moreover, more than half of the children would recognize friendship characteristics about the robot that include a sense of affiliation (robot likes them and could be their friend) and support (robot would cheer them up). The extent to which these characteristics are related to friendship was also examined: children who thought the robot could be their friend were also likely to report that they would play with it, talk to it, tell it secrets, and that the robot could cheer them up and likes them.

### A. Positive affiliation

In regards to a positive affiliation with the robot, almost two thirds of the children thought the robot liked them. The predominant reason for this belief was that the robot appeared friendly. For example, some children stated it appeared to look at and smile at them. This may suggest interest and curiosity in the child, which, according to Kohn and Rosman [30] is a characteristic of friendship. In addition, the child's own positive behaviors towards the child (e.g., helping stack the third block) and absence of harmful behaviors may have directly impacted children's perceptions of liking the robot - "I helped the robot, therefore, I must like the robot.", as suggested by Gambrill [31]. That children ascribed positive intentions to the robot was rather surprising. This suggests that many children believed the robot was autonomous and deliberately showing kindness towards them even though it executed all tasks via a specific prerecorded set of programs.

In addition to thinking the robot liked them, more than three quarters of the children stated the robot could be their friend. This could be interpreted in two ways. It may suggest that children believe the robot was capable of being their friend. It is also possible that children believed that they would be or are capable of being friends with the robot. This latter possibility

is suggested by the response given by four children that they would be a friend to the robot. It is interesting that many reasons children articulated for friendship with the robot are those that were asked in the interview (after they stated why the robot could be their friend). These reasons include doing activities together, helping each other, kindness, likeability, and shared understanding ("robot knows me"). Interestingly, some children who believed the robot could be their friend stated that they thought the robot did not like them or that they did not know if the robot liked them. This suggests that how children define their friendships is not solely dependent on feeling liked but on other friendship characteristics as well. Future research could also explore whether children who viewed the robot as a friend had a greater propensity towards friendships with others than those who did not view it as a friend. There was also a significant sex difference whereby more girls than boys thought the robot could be their friend. This effect size was small, however, and research on peer friendships does not suggest that girls have more friends than boys [32]. Perhaps girls have a greater interest in the robot, suggesting greater curiosity or inclination to explore friendship possibilities.

### *B. Social support*

Children were asked if the robot could provide support in the form of improving their mood if they felt sad. This type of prosocial behavior is typically seen in friendships [21]. More than three quarters of the children did believe that the robot could improve their mood. The most often mentioned means of doing so is by the robot doing something for them such as stacking blocks. This action may provide distraction from negative feelings [33]. Some children identified that its friendly appearance, emotional connection or physical proximity would improve their mood. These have been shown to improve health outcomes [34]. More girls than boys believed the robot could improve their mood. This result is consistent with research on child-child friendships. That is, girls tend to be more prosocial in their friendships than are boys [35, 36].

### *C. Shared activities*

More than three quarters of the children believed that they could play with the robot, and provided a variety of ideas of what they could play together. The most commonly mentioned type of game involved construction most likely due to the nature of the task the robot was performing. That so many children in our study believed the robot could play with them and proposed means of play with the robot, suggests that they are willing to include robots in their world of imagination and social-emotional expression, which play activities are known to provide [37-39]. Furthermore, play is a cornerstone of children's friendships which shows that they have friendship aspirations for the robot to include them in this world.

### *D. Communication*

The final aspect of friendship that was examined was talking to the robot and sharing secrets. About two thirds of the children stated they would talk to the robot. Their explanations generally involved sharing examples of what they would say to it ("How's it going?), and liking the robot or wanting to become better acquainted, which again shows an interest in friendship. Indeed, these are types of social behaviors expected among friends [21]. When asked if children would tell the robot secrets, more than a third said that they would. Those who would share a secret said they would do so because they believed that the robot would not share the secret since it cannot speak. This is a very practical response and is likely a direct result of their observation of the robot not speaking. Several other children, however, mentioned they would share a secret with the robot because it seemed friendly or was their friend. This suggests that children may be willing and desire to share secrets with the robot as a means of creating a social bond with it. Of those who would not share a secret, many replied that it is wrong to tell secrets and that they should be kept private. Not surprising was the finding that more girls than boys would talk to the robot and tell it secrets. Research has shown that girls generally tend to talk more with their friends than do boys and engage in sharing secrets with their peers as a means of bonding [26, 27, 40, 41].

Although the majority of children responded affirmatively to the questions about friendship, some children responded to the contrary. The most frequent reason was because of the robot's limitations such as the absence of thoughts or feelings. This suggests that these children consider the robot to be a machine rather than human and recognize its true abilities. Reasons for these different perceptions of the robot have not yet been explored in the research but may plausibly include variation in children's knowledge of the mechanics of robots.

Across all questions about friendship a significant proportion of children provided ambiguous or uncertain responses. For example, some stated they did not know how to respond to the question or could not explain why they answered affirmatively or negatively to the question. Moreover, many children provided conditional responses based on the robot's abilities and behaviors. This may reflect the perplexity between understanding the robot as a machine, and recognizing its social behaviors such as "looking at the child", performing a task for the child, and appearing to need help for stacking the blocks. Perhaps some children neither have a well developed understanding of how robots function and the concept of programming. Rather, they may simply project their own understanding of people's behaviors based on their experiences of interacting with people. Over time, and as a result of interactions with robots, children may develop a new system or schema of understanding, and subsequent vocabulary to articulate their sense of friendship with a robot, that is likely distinct from their friendships with children.

### *E. Limitations*

Although our exploratory study provides evidence of characteristics of children's friendships applicable to child-robot relationships, there are some limitations. First, children experienced a brief interaction with the robot which may have created some initial excitement that may not be maintained

over a longer period, which more accurately reflects a friendship. Related to this is the inconsistency in the research as to a definition and description of what constitutes friendship. Indeed, Fabes, Martin, and Hanish [42] describe measurement of friendship as consisting of "a diverse array of conceptually and empirically based constructs designed to measure what they [researchers] consider to be key components of children's peer behaviors and interactions" (p. 48). Thus, alternate characteristics other than those used in the present study should be explored in future research. Moreover, the maintenance and regulation of friendship was outside the scope of this study and are interesting topics for future research. Second, it is possible that earlier questions may have influenced answers to later questions. For example, after children were asked if the robot liked them, some children stated that the robot was their friend because it appeared to like them. Thus, replicating a study with a different order of questions that are less leading could strengthen our findings. Third, results of our study are based on children's own reports of their sense of friendship with a robot. Although this is the predominant means of researching friendship, these results must be substantiated with observations of children friendship-based behaviors towards a robot [43]. Also, it is possible that a social desirability effect occurred whereby children felt compelled to respond favorably to the questions about the robot. It would be worthwhile in future research to determine if children would respond similarly about the robot to someone who was seemingly unrelated to the robot exhibit. Fourth, children observed a robot conduct a task unsuccessfully, thereby eliciting a possible need for assistance from the child. This type of engagement, although prevalent in child-child relationships, may have created a sense of vulnerability and inclination towards friendship with the robot. Replication with other robots, differing tasks, and in a context outside of the science centre is needed. Our robot was not as sophisticated as more recently developed and more expensive robots, so it is rather remarkable that children held thoughts in favor of friendship towards it.

The method of our study is based on the premise that a willingness to engage in activities together with a robot, communicate including sharing secrets, and feeling a sense of affiliation with a robot suggest that children would befriend one. Perhaps children can have these perceptions about a robot without having feelings of friendship. To explore this possibility we examined the degree of association between children's willingness to have a robot as a friend and the aforementioned friendship-type characteristics. We found a low to moderate relationship whereby children who thought the robot could be their friend were also likely to state they believed the robot liked them and could cheer them up, and that they would play, talk, and share secrets with the robot. Moreover, the majority of children did state they thought the robot could be their friend. Thus, we conclude that many children may befriend a robot given the large number of children who responded affirmatively to our questions, while future research must examine whether children actually do befriend a robot. In addition, we cannot conclude from these results that children's experiences of friendship with a robot are similar to those with another child. Research has yet to explore similarities/differences between child-robot and child-child friendships. Moreover, friendships are reciprocal [21]. Although we included questions about the child's friendship behaviors towards the robot, and the robot's friendship behaviors towards the child, this complex bi-directional relationship warrants considerable research. Moreover, we wonder if dyadic friendships [44] between children can somehow be experienced in the future as a reciprocal emotional commitment with a robot that creates a sense of interdependence and provides a source of security. Our preliminary study into this massive issue suggests that the answer is possibly.

Our study demonstrates that children are willing to perceive themselves as befriending robots – that is, as social beings. The majority of children believed that the robot liked them and could be their friend. Furthermore, most children stated they would engage in friendship-like activities with the robot such as play and telling secrets. Overall, the children in our study held the belief that robots are friendly entities that will not only provide entertainment and support, but are worthy of children's affection and communication. Robotic devices sold to children are becoming more technologically and socially advanced. Our study suggests that children will readily accept these types of devices as companions or friends even when they exhibit minimal social cues.

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