He Can Read Your Mind: Perceptions of a Character-Guessing Robot*

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***Abstract*— After playing a five to seven minute character guessing game with a Nao robot, children answered questions about their perceptions of the robot's abilities. Responses from interactions with 30 children, ages eight to twelve, showed that when the robot made an attempt at guessing the participant's character, rather than being stumped and unable to guess, the robot was more likely to be perceived as being able to understand the participant's feelings and able to provide advice. Regardless of their game experience, boys were more likely than girls to feel they could have discussions with the robot about things they could not talk to other people about. This article provides details associated with the implementation of a game used to guess a character the children selected; a twelve question verbally-administered survey that examined their perceptions of the robot; quantitative and qualitative results from the study; and a discussion of the implications, limitations, and future directions of this research.**

I. Introduction

As we continue to explore the uses of social robots in child-centric domains, the development of a thorough understanding of children's perceptions and beliefs about social robots is essential. To gain further insight into this area, we equipped a robot with character guessing abilities, an identifiable skill that is beyond that of most humans, and designed an open-ended verbally-administered survey to understand participants' beliefs, feelings, and potential behaviors related to the robot. This article describes our implementation, results, and future directions related to understanding children's perceptions and beliefs about social robots.

II. Background

Many child-robot interactions have involved playing a game of some type and evaluating the interactions, but few have investigated the broader perceptions children have of the robots as a result of these interactions. The two most relevant areas of prior work involve: (1) child-robot interactions during game play and (2) child perceptions of a robot's abilities.

A. Interactions During Child-Robot Game Playing

A variety of games have been incorporated into child-robot interaction studies. Examples include guessing games [1], [2], information or memory games [3], and more physically engaging games like follow the leader [4].

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Pardo et al. investigated how long children (ages 9-11) looked at the robot during a 20 Questions game with a Nao robot [1].The game was performed in a group setting of up to 10 children. Eye gaze direction toward the robot was high in the first two minutes and then dropped off until the time when the robot attempted to guess the item selected by the children [1]. The research also examined emotional responses, but did not directly explore perceptions of the robot or its level of awareness or intelligence.

Breazeal and colleagues explored whether younger children (ages 3-5) viewed a contingent (engaged interaction) or non-contingent (not engaged in the interaction) robot as an informant in a game about unusual animals [3]. Though the robots were liked at a similar level, children showed a preference toward the contingent robot when they had to ask the robot questions or for information. The study provides insight concerning young children's perceptions of the robots, but did not directly inquire about their perceptions.

Shahid and colleagues explored child-robot interactions across cultures through the use of a card guessing game with children (ages 8-12), who were from Pakistan or the Netherlands, using the iCat robot [2]. The results showed that the children preferred playing the game with the iCat robot over playing alone; however they preferred playing with a friend over playing the game with iCat [2]. The children from Pakistan expressed having more fun playing the game than the children from the Netherlands [2]. Emotional perceptions of the children were analyzed via video coding; however the research did not explore perceptions of awareness or intelligence associated with the iCat robot.

As part of a study examining whether children (ages 4-6) would be more likely to share a secret with a robot than a human, Bethel et al. incorporated a "follow the leader game". Results indicated that children shared the secret at a similar level between the human and robot, and did not further investigate perceptions of the robot [4].

B. Children's Perceptions of Robots

As the use of robots with children has grown, researchers have examined children's perceptions of different robotic platforms in home, school, museum, and hospital settings. Studies have found that children expect humanoid robots, like Nao, to be capable of friendship, conversation, and helpful behavior like helping with homework or cheering them up [5], [6]. Non-humanoid robots have also been examined, and though many children do not report expectations beyond their physical abilities, most still indicate they can befriend

the robot, talk to it, receive comfort from it, and share secrets with it [7].

Nalin et al. [5] asked groups of four to five children (ages 8-11) to determine the robot's capabilities without touching it and then surveyed children about their perceptions of the robot. From this study, 100% of the children perceived the robot could be a friend. Almost 89% of the children perceived the robot to be human and to a lesser extent a computer. Most of the children (88.6%) perceived the robot to have feelings. They felt the robot would work best as a companion, followed by a teacher, and then a coach. All of the participating children reported that the robot could have "helped them if they were feeling down or worried about something" [5].

Fior et al. analyzed the perceptions of 184 children (ages 5-16), who observed a five degree-of-freedom robotic arm engage in a block stacking behavior at a local science center and then participated in a five to ten minute interview with a researcher. Despite the simple form of the robotic arm, most of the children reported that the robot liked them, could potentially be their friend, would be able to help improve their mood, and felt that they could share a secret with the robot [7]. The study found that girls were more likely than boys to talk to the robot or share a secret with the robot, while our results indicated the opposite.

Diaz et al. examined the dynamics of social bonds between children and robots and desired robot functionality through a study of interactions of 49 sixth grade students with the Pleo (animal-like) and Nao (humanoid) robots in a classroom environment at an elementary school. Responses indicated a high level of enthusiasm towards robots and suggestions for functionality were consistent with the platforms' abilities (e.g., the Nao robot was expected to have conversational abilities) [6]. This study did not explore how participants felt about sharing information or obtaining advice from the robots.

To our knowledge, the research presented in this paper is the first investigation in child Human-Robot Interaction (cHRI) to examine how a robot's game playing performance affects perceptions of awareness and intelligence. Specifically examining trust, willingness to take advice from the robot, and the likelihood of sharing information with the robot they could not share with others.

C. Study Design

We implemented a character guessing game that had a duration of five to seven minutes, in which a Nao robot asked each participant a series of questions in an effort to guess the identity of a fictional or non-fictional character the participant selected. This brief interaction encouraged a high level of engagement from participants and typically involved about 40 verbal exchanges between the robot and participant. Additionally, the ability to rapidly deduce an identity based on provided evidence was a skill for which machines seemed well-suited and we were curious about the perceptions children would have toward a robot attempting this type of task.

Fig. 1. A participant playing the character guessing game with the robot.

The game interactions and a structured verbally-administered survey that examined the children's perceptions of the robot, were a single component in a larger study comparing child eyewitness memory accounts provided to robots and humans. Since half of the participants within the larger memory study were randomly assigned to a human interviewer, an additional robot interaction was included at the conclusion of the study so that all participants had an opportunity to interact with the robot. The eyewitness memory aspect of the larger study is not the focus of the research presented in this paper.

Our analyses focused on the children's perceptions of the robot after the character guessing game, and takes into consideration participant factors (e.g., gender), the character guessing game outcomes (e.g., successful guess), and the study condition the participant was assigned to (human or robot interviewer in the main part of the study). The participant's assigned study condition did not alter the game interaction, but those in the robot interviewer condition had interacted with the same robot verbally for five additional minutes in an earlier phase of the study. The character guessing game followed the memory portion of the study.

D. Character Guessing Game

Led by a Nao robot, the character guessing game had a conversational style and required the participant to think of, but not disclose to the robot, a well-known fictional or non-fictional character. The robot then posed a series of increasingly specific questions to the participant, which could be answered with "yes", "no", "I don't know", "probably", or "probably not". For example, *"Is your character female?", "Is your character a famous singer?", "Does your character sing in Bad Blood?"*. Once enough information had been obtained to make a confident guess, the robot guessed the character and asked the participant if it was correct. If a guess could not be formed after approximately 20 questions, the robot told the participant it was stumped and asked the participant for the correct answer.

In our study the Nao robot remained seated in a crouched position on the table directly across from the participant (see Figure 1). The robot did not exhibit any face tracking

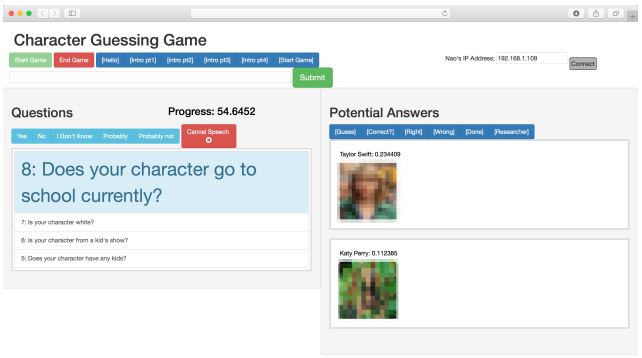

Fig. 2. Web interface for the character guessing game.

behavior or body movements, but demonstrated aliveness through eye blinks via the LED rings surrounding its eyes. The robot was controlled using a Wizard-of-Oz approach [8], with a human robot operator acting as the robot's speech recognizer, updating the game state and administering the robot's speech utterances.

E. Implementation of the Character Guessing Game

The data required for the character game was obtained live during each session via HTTP requests to a third-party created character guessing game, Akinator [9], developed by Elokence. The Akinator game is freely available to play via its website. The game continuously expands its knowledge base and learns from its interactions, allowing it to maintain up to date information about modern fictional and non-fictional characters. Since the game was adept at identifying characters from modern popular culture, it was an ideal candidate for interactions with children in our study. The Akinator web service has been used by other human-robot interaction researchers as a source for dialogue in a study examining empathy via facial mirroring [10].

The Akinator website did not contain a documented API, but an examination of the HTTP requests and responses associated with game play through the website allowed us to develop a module to assist in transferring the game's input and output to and from the robot.

The game module was integrated into our existing web-based Wizard-of-Oz [8] platform used for other portions of the study. An additional interface was developed for the robot wizard to administer game sessions (see Figure 2). The Akinator service included a parameter for a child-mode (helping to eliminate any mature or sensitive content); however as an additional safeguard the robot wizard was required to click on the question before it was spoken by the robot to each child. Additionally, the research team played many rounds of the game and noted any common questions or words that were difficult for the robot to pronounce. Then manually created phonetic versions of these words (e.g., "Pokemon" to "poke e mon") and stored them in a database. These versions of the words were automatically substituted for the original words when encountered in study sessions. The interface also provided the wizard with a count of the number of questions asked, the current best guess at the character with a confidence rating, and an indicator of whether the game was unlikely to find a good guess with further questions. The wizard also had access to several pre-defined utterances via interface buttons and the ability to input text for the robot to speak.

F. Perceptions of the Robot Survey

Immediately following the interactive character guessing game session, a researcher engaged the participant in a structured verbally-administered survey about their perceptions of the robot. This survey included the following twelve questions:

1) What did you think about the robot during the study?
2) Do you think the robot was aware of what was going on around it?
3) How well do you think the robot understood what you said?
4) How well do you think the robot understood how you felt?
5) Do you think that the robot could give you advice if you had a problem? Why or why not?
6) Sometimes people hide how they feel from others. Do you think you could hide how you feel from the robot?
7) Are there things you could talk to the robot about that you could not talk to other people about?
8) How is the robot different from a human?
9) Do you like the robot?
10) Do you think the robot liked you?
11) What would you do if the robot did not listen to you while you were trying to talk to it?
12) What would happen if you did not listen to the robot while it was trying to talk to you?

Participants were free to provide as much or as little detail as they felt necessary and were able to ask clarifying questions if they did not fully understand the question. Due to their closed form ("do" and "are" style), five of the twelve questions usually provoked simple responses of agreement, disagreement, or uncertainty.

Though other questionnaires, interviews, and behavioral observations were part of the larger study in which the character guessing game was situated, they were not focused on the participant's perceptions or interactions with the robot. Consequently, our analyses focuses on the results obtained from administering the *Perceptions of the Robot Survey* following the character guessing game.

III. Results

Responses to each of the twelve questions from the *Perceptions of the Robot Survey* were coded into categories when possible through a collaborative review of video recordings by two of the authors. Most responses were intuitively categorized, for example participants often clearly provided positive, negative, or uncertain responses. Many questions (2, 4-7, 9, 10) were coded into in three categories (yes, no, unsure), while Question 3 was coded into two categories (understood or somewhat understood). Other questions (1, 8, 11, 12) provided more detailed qualitative insights,

which helped to anchor our interpretation of the results. Categorized results were examined as contingency tables of the response category by the study condition (human or robot interviewer), character game performance (correct guesses, incorrect guesses, no guesses), or participant gender (female or male). Since greater than 20% of the cell counts were below 5 observations in all cases, Fisher's exact test was used for statistical comparisons.

A. Participants

A total of 33 participants completed the study, yielding 30 sessions of analyzable data. The three excluded cases included: one session in which wireless network interference disrupted interactions with the robot, one session in which the audio recording system experienced a power interruption resulting in data loss, and one participant who had difficulty providing responses and met exclusion criteria for the study.

The study was approved by the university's institutional review board and participants were recruited from the community surrounding Mississippi State University, and were between the ages of eight and twelve, with a median grade level of 4.5 and $60\%(18/30)$ being female. All participants played the character guessing game with the robot, while half (10 females, 5 males) interacted with the robot earlier in the eyewitness memory portion of the study and the other half (8 females, 7 males) interacted with a human interviewer.

B. Character Game Outcomes

While the target duration for the character game was five minutes (actual median 5 minutes 41 seconds), the number of rounds played depended upon the dynamics of each round and resulted in 30% of participants playing one round of the game, 63% playing two rounds, and 7% playing three rounds.

Over the 53 total rounds played, the robot correctly guessed the participant's character in 45% of the games, was stumped by the participant in 43% of the games, and guessed incorrectly in 12% of the games. The robot guessed correctly in at least one round for 18 of the participants, was unable to confidently guess in any round for 8 of the participants, and made only incorrect guesses for 4 of the participants.

Examples of correct guesses included classic characters like Cinderella, modern celebrities like Taylor Swift, political figures like Barack Obama, and family members (e.g., older brother). Incorrect guesses were often closely related to the correct answer, for example one participant selected Maddie Rooney as her character and the robot incorrectly guessed Olivia Rooney (the characters are twins in a Disney Channel television series and are portrayed by a single actress). Characters for which the robot was unable to confidently make a guess were not of a distinct genre, with the situation typically arising after conflicting or incorrect information was provided in response to several of the robot's prompts.

C. Awareness and Understanding

A majority of participants 73% $(22/30)$ indicated that the robot was aware of what was going on around it, while 6 responded that it was not aware and 2 were unsure. Similarly, 26 participants described the robot as understanding most of their speech and 4 characterized the robot as understanding "some" or "a little bit" of their speech.

Responses to the question *How well do you think the robot understood how you felt?* showed a significant association with the robot making at least one guess (correct or incorrect) during a round of the character guessing game ($p = .014$, Fisher's exact test). Of the participants who experienced at least one guess (correct or incorrect), $67\%(14/21)$ felt the robot understood their feelings, while only $13\%(1/8)$ of those who did not experience any guesses by the robot felt it understood their feelings. A comparison of those who experienced at least one correct guess with those who did not (including those experiencing no guesses) was not significantly associated with perceptions of the robot understanding their feelings. This suggests that the act of guessing is more critical than the correctness of the guess. No significant differences were observed between interviewer conditions or participant genders.

When the children were asked: *Do you think you could hide how you feel from the robot?*, $28\%(8/28)$ indicated they could, $61\%(17/28)$ reported they could not, and $11\%(3/28)$ were unsure. Though not a statistically significant difference ($p = .159$, Fishers exact test), an examination of responses by gender indicated that $81\%(9/11)$ of male participants reported they could not hide their feelings, while females were more divided with $47\%(8/17)$ reporting they could not hide their feelings and $41\%(7/17)$ indicating they could hide their feelings from the robot. No significant associations were found between perceived ability to hide feelings and study condition or game performance.

D. Advice and Confidence

The robot's performance in the character guessing game was significantly associated with responses to the question: *Do you think that the robot could give you advice if you had a problem?* . Of participants who experienced the robot correctly guessing their character in at least one round, $89\%(16/18)$ felt the robot could give them advice, while $50\%(2/4)$ who only experienced incorrect guesses felt the robot could give them advice and $38\%(3/8)$ who experienced no guesses felt the robot could provide advice ($p = .021$, Fisher's exact test). It is notable that the robot's ability to provide advice was also significantly associated with providing any guess (correct or incorrect) during at least one round of the game, with the provision of a guess making it more likely to be rated as able to provide advice ($p = .041$, Fisher's exact test). An examination of the data indicated that the four participants who experienced only incorrect guesses were evenly divided among endorsing and not endorsing the robot as a source of advice, while the participants receiving no guesses were nearly uniformly distributed across response categories.

Furthermore, of those who also interacted with the robot in the interview portion of the main study, $5/15$ felt the robot could not provide advice while $10/15$ felt it could.

In comparison, of the participants who only interacted with the robot in the character guessing game $1/15$ felt it could not provide advice, $3/15$ were unsure, and $11/15$ said it could provide advice ($p = .053$, Fisher's exact test). Though this comparison is not significant at the $p < .05$ level, the absence of any participants in the robot interviewer condition reporting uncertainty is notable.

Participants provided a range of reasons as support for their perceptions about the robot's ability to provide advice. The robot's perceived possession of knowledge was noted in $57\%(17/30)$ of responses, with the robot's game performance specifically mentioned in $30\%(9/30)$ of responses. Example responses included: *"Yes, because I've asked questions unbelievable that he'd answer so I think he would do that.", "He couldn't say the actual name of my character", "Yes, it went yay when it guessed correctly."*. Six participants (20%) emphasized the robot's programmed nature, and lack of human experiences, with responses such as: *"robots are just programs", "robot's haven't had experiences like we have", "robots can't like really understand some stuff"*.

A significant association between participant gender and responses to the question *Are there any things you could talk to the robot about that you couldn't talk to other people about?* was also present ($p = .012$, Fisher's exact test). Female participants were less likely (9 no, 5 unsure, 4 yes) to report being able to confide in the robot in comparison to male participants (1 no, 2 unsure, 9 yes). No significant differences on this question were identified when comparing between interviewer conditions or character game outcomes. Though participants were not prompted for reasoning about their responses, a few included justifications such as: *"I don't think he would tell.", "Yes, because you know a robot like if you're talking to somebody they can judge you, like you know, robot, he– A robot can't judge you about it you know. He can't make you feel– like whenever you talk to an adult you feel– it feels awkward, because you know, you don't know what they'll think, but the robot will only give you, you know, the facts. So there's no judgment.", "If it was smart enough."*.

Although all participants indicated that they liked the robot, $63\%(19/30)$ reported that the robot liked them, $23\%(7/30)$ were unsure, and $13\%(4/30)$ indicated the robot did not like them. No significant differences related to the participant's perception of the robot liking them were found between interviewer conditions, participant gender, or character guessing game outcomes. Participants who expressed doubt that the robot liked them provided reasons such as: *"It doesn't have a mind.", "I don't think it had any emotions programmed in it.", "His voice sounded exactly the same the entire time. Like usually you know you tell people, if people like you by how they act and how their voice sounds whenever they talk to you and their face. The only thing is what he said, which you know isn't anything that would lead me to believe that he liked me."*

E. Human-Robot Differences

In response to the question *How is the robot different from a human?*, $79\%(23/29)$ included descriptions of physical differences in their responses. Responses also addressed the robot's high intelligence, programmed nature, synthetic voice, lack of emotion, and non-judgmental nature.

When asked *What would you do if the robot did not listen to you while you were trying to talk to it?*, $34\%(10/29)$ indicated they would continue to talk until it listened, $24\%(7/29)$ were unsure, $17\%(5/29)$ would ignore the robot, $14\%(4/29)$ reported they would feel some emotion (frustration, anger, nervousness), and the remainder indicated they would ask a researcher for help.

The question *What do you think would happen if you did not listen to the robot while it was trying to talk to you?* was met mostly with responses regarding how such an event would negatively impact the participant's performance in the study $28\%(8/29)$. Others $21\%(6/29)$ responded that the robot would feel some sort of emotion (sad, mad, frustrated), would verbally attempt to gain attention $14\%(4/29)$, or would suffer performance-wise $7\%(2/29)$. The remaining participants either described taking steps to remedy the situation $10\%(3/29)$ or were unsure of what would happen $24\%(7/29)$.

IV. Discussion

While participants uniformly demonstrated positive attitude toward the robot, each supplied unique insights regarding their perceptions of the robot. Though the results of the character guessing game had an impact on evaluations, the more static attribute of the participant's gender also contributed to the statistically identifiable differences in perceptions of the robot.

Though the results of the character guessing game were not systematically manipulable by experimenters, the sample collected covers a range of possible outcomes and raises further questions regarding the impact of robot performance on perceptions. As children who never experienced the robot guessing a character were less likely to identify the robot as understanding how they felt, we posit that interactions in which the robot did not provide a guess may not have induced the same level of emotional arousal as those with correct or incorrect guesses. It is possible that the shared experience of heightened emotional arousal with the robot during the game led participants to perceive the robot as more able to understand their feelings.

Our results also indicated that the robot's performance in the game was associated with whether a participant felt they could receive advice from the robot or not. Though a larger sample would benefit this discussion, the data available in this study indicated that participants who experienced at least one correct guess (18) were likely to endorse the robot as an advice provider, while those who experienced no guesses (8) were nearly uniformly distributed between accepting, rejecting, and being uncertain about accepting the robot's advice. Those who only experienced incorrect answers (4) were evenly divided in feeling the robot could provide advice. The case of a robot, which effectively demonstrated a skill, being trusted for advice appears intuitive, but further study is needed to understand the effects of incorrect guesses

or poor performance on children's perceptions of the robot as an advice giver. This can be achieved in future studies by purposefully injecting incorrect guesses.

In addition to the impact of the robot's performance in the character guessing game, results indicated that male participants were more likely to feel they could discuss topics with the robot, which they could not discuss with other people. Related to this, female participants were evenly divided when asked if they could hide their feelings from the robot, while all but one male participant reported they could not. While reviewing video of the studies, we observed that male participants appeared more enthusiastic about interacting with the robot in comparison to the female participants, which may relate to this effect. It is also possible that the robot was perceived as male and that this congruency contributed to this result. Our future studies involve the use of male and female robots and should be helpful in further characterizing gender differences.

Aside from survey measures, we should convey that in nearly every instance of a correct guess the participant's visible excitement appeared to accelerate as the robot's questions became more specific and relevant. Upon a correct guess some participants congratulated the robot while others appeared to be in a state of disbelief, and yet others were anxious to play another round. When the robot was unable to make a guess many participants were happy to choose an "easier" character or explain their character choice to the robot. It was also a common occurrence for participants to immediately begin describing their experience to the researcher after the session without prompting. These anecdotes characterize the engaging nature of the interaction, which we believe was an essential ingredient for conducting a discussion of perceptions of the robot with the participants.

A. Limitations

This study has identified intriguing trends related to children's perceptions of robots, but they are most useful when considered with regard for the context from which they were provided. First, the character guessing game was not manipulated in any systematic way and the sample size was small given the potential set of outcomes. As a result rigorous statistical analysis is not yet achievable, though these exploratory efforts set the stage for more controlled studies. Second, the interaction examined in this study took place at the end of a one hour memory-related study. Participants were likely to be at least somewhat cognitively taxed from other portions of the study, which may have impacted their engagement in the interaction with the robot. Third, the study took place in the Southern United States and participation required a parent to transport their child to the study location to participate. As a result, these findings may not generalize to children in dissimilar scenarios.

V. Conclusions and Recommendations

The findings from our first use of a character guessing game and *Perceptions of the Robot Survey* indicated that the robot's performance in the guessing game was associated with children's willingness to seek advice from the robot as well as their perceptions of the robot's awareness of their feelings. Additionally, male participants were found to be more likely to feel they could talk to the robot about things they could not talk to a person about. Qualitative feedback represented a variety of viewpoints with some seeing the robot as a potentially beneficial companion or helpful assistant, while others characterized the robot as mindless. Our future work includes refining the survey to better capture the reasoning behind responses and conducting studies with male and female robots across a larger sample of participants.

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