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Preschoolers' Reactions to a Social Robot in their First Encounter: A Pilot Study

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Abstract: *Social robots have led to a growing body of research, and continued to demonstrate potential benefits for education, rehabilitation, and special education. The main research questions of this study were: what are preschool children's questions to the social robot? What are preschool children's reactions to activities led by the social robot? Zenbo, developed by a Taiwanese company, was chosen as the experimental social robot. Sixty-nine children aged 5–6 were recruited from preschools for this study. The researcher used an observational method to collect data regarding the children's questions and responses to Zenbo. Data analysis included two parts: (1) questions raised by children to Zenbo; (2) children's attention rate among the three activities—questioning, story-telling and rhyme movement. The result showed that children's questions to Zenbo can be categorized as follows: questions similar to daily conversations among human beings, questions related to Zenbo's functions and abilities, and questions to test Zenbo's purported omniscience. This study demonstrated that the overall attention rate of children was high (above 95%) for the different activities. Based on the findings, recommendations were made by the researcher.*

Keywords: *Social Robot; Preschool; Social Communication; Early Childhood Education, Child-Robot Interaction*

1. INTRODUCTION

Social robots have led to a growing body of research, and continued to demonstrate potential benefits for education, rehabilitation, and special education (Fernández-Llamas, Conde, Rodríguez-Lera, Rodríguez-Sedano, & García, 2017; Lee & Hyun, 2015).The literature suggests that social robots have considerable potential to support children's education. Studies have indicated that educational robots can exert positive effects on learning, in subjects such as science, mathematics, and engineering (Toh, et al., 2016). Thus, developing social robots as tutors and learning companions for young children has received considerable interest. In educational settings, a robot can be used as a teaching assistant, a child's companion, or an assessment tool. Teachers can use robots to guide children's learning tasks, and robots can keep children company during play time. In addition, robots can record the learning process and send photos to parents, making them useful for evaluating and assessing children (Benitti, 2012). Regardless of the roles of social robots, they have achieved promising results in assisting children with special needs, promoting children's socio emotional development, problem solving skills, cognitive flexibility, and mega cognition in early and late childhood (Fridin, 2014; Keren, &Fridin, 2014).

Bers and colleagues discussed the applicability of robotic activities in early childhood settings (Bers, Flannery, Kazaoff, & Sullivan, 2014). Prior research has demonstrated that young children not only treat social robots as companions and guides (Toh, Causo, Tzuo, Chen, & Yeo, 2016), but also learn new information from them (Breazeal et al., 2016). When educators consider integrating social robots in early childhood settings, the perceptions of and reactions to social robots by young children should be analyzed for the design of related activities. Children's various perceptions of and reactions to robots may lead to different learning effects.

Previously, most of the research in human interaction with robot has focus on older children or adults. Young children are different from these groups of participants in many ways (Francois, 2009). If robots are planned to be implemented in early childhood settings, educators require better understanding the actual mechanisms and responses of children-to-robot interactive behaviors. In addition, understanding child-robot interaction can contribute to the design of robot to resemble human interactions to simulate children's communicative and interactive desires with robots (Holmquist & Forlizzi, 2014).

1.1. Literature Review

"Cognitive script" is a term described as an individual's mental representations of real-world events to make decisions about future actions. Cognitive script helps define the activities that an individual perform repeatedly and habitually without awareness in a given context (Kollar, Fischer, & Hesse, 2006).The research paradigm of ''Computers Are Social Actors (CASA)'' has indicated that individuals automatically apply social rules in their interaction with computers as if they are interacting with real human beings. Kramer, von der Pütten, and Eimler (2012) indicated that as long as an entity appeared to be sufficiently social, people would engage in communicative behaviors consistent with human-human interactions. In other words, when young children encounter a social robot, children are likely to apply their cognitive scripts on their interaction with the robot as long as the robot appears to be social.

Therefore, to enact a particular cognitive script, priming plays an important role (Edwards, Edwards, Spence &Westerman, 2016). Nass and Moon (2000) found that primary cues that appeared to be important for eliciting social responses included words for output, interactivity, and human-like characteristics (e.g., face, voice, ethnicity, gender, and personality) (Nass & Moon, 2000). These kinds of cues can automatically invoke schemata or scripts associated with human–human interactions (Nass & Moon, 2000). For example, Oh and Kim (2010) found that children became more engaged with robots that were operated remotely because these robots were perceived as more humanlike and interactive. In addition, research has shown that robot's social characteristics (e.g., recognize others' emotions, communicate with dialogue, etc.) werecritical for robots to become socially interactive with individuals (Goodrich& Schultz, 2007).In addition, Fernández-Llamas et al., (2017) suggested that individuals' personality and gender also influenced how individuals perceived and interacted with robots. For example, Lee, Peng, Jin, and Yan, (2006) found that participants enjoyed interacting with a robot more when the robot's personality was complementary to their own personalities than when the robot's personality was similar to their own personalities.

Based upon above theories and research, this study expects that young children will interact with a social robot in a similar manner to which they communicate with human. Furthermore, this study assumes that young children will be more interested in interacting with social robot than with human due to their fresh feelings of the robot. To explore children's first encounter with a social robot, children's questions to the robot were analyzed. By exploring the questions children asked about the robot, insight can be gained into the characteristics children consider fundamental to a conceptual categorization of the robot. In addition, in this study, children's reactions to the robot were observed while the robot was telling them a story and leading a dancing activity. As the first meeting is critical in creating the foundation for the success of a subsequent child–robot interaction (Fridin, 2014), understanding children's initial reactions to robots is important for further research.

Therefore, the main research questions of this study were: what are preschool children's questions to the social robot? What are preschool children's reactions to activities led by the social robot? In the existing literature, few studies have offered protocols for introducing a social robot to preschool children (Fridin, 2014). The results of this study can help educators design a procedure for preschool children's initial encounters with social robots. In addition, the result of this study can provide a basis for the design of a social robot for subsequent use in preschool settings. Finally, this study was conducted in a natural classroom environment where educators could obtain spontaneous feedback from children about the social robot; therefore, the information provided was completely different from that derived from a laboratory experiment or questionnaire.

2. Methods

The purpose of this section is to describe the research design and procedure and to explain how the children's responses were measured and analyzed.

2.1. Reasons for Selecting Zenbo

Zenbo was developed by Asus, a Taiwanese company. Zenbo has a child like appearance, but without hands and feet, speaks with a 4-year-old boy's voice, and uses proper vocabulary. The robot can express different emotions and is capable of moving freely and independently around a classroom. It has a built-in camera with facial recognition that can take photos and videos, make video calls, and function as a remote-controlled camera monitor. Zenbo can also hear and respond to natural language voice commands. Additionally, Zenbo can play music over its high-quality stereo system. Other functions of Zenbo include telling an interactive story, performing audio visual motions, reading a recipe as a person cooks, and spotting an emergency and subsequently making a phone call or sending a message to a prepared list of people. Moreover, Zenbo can control media, thermostats, and other smart facilities through voice commands.

Zenbo was selected as the experimental robot for the following reasons: (1) Affordability: Zenbo costs approximately US$ 750dollars, which is affordable for most preschools and families. (2) Appearance: as the appearance of a robot is known to have a positive impact on child–robot interaction (Fridin&Yaakobi, 2011), the experimental robot was required to look attractive and nonthreatening to children. Zenbo is a small robot that looks like a toy, and is perceived as a smart, nonthreatening educational tool. (3) Functions: in this study, the experimental robot was assigned to act as a teacher's assistant. Thus, the experimental robot was not required to have many complicated functions. The basic functions of Zenbo, including taking pictures, playing music, telling an interactive story, and dancing with music are sufficient for this research. Due to the aforementioned reasons, Zenbo was chosen as the main research instrument.

2.2. Participants

Sixty-nine children aged 5–6 (Mean (M) = 5.56, standard deviation (SD) = 0.49) were recruited from preschools for this study. All parents signed consent forms for their children and all children verbally assented to participate.All children from two preschools participated in the experiment, and all of the children were Taiwanese. One group of children (A,B, and C classes) lived in urban residences in Pingtung city, and the other group of children (D class) livedin rural mountain areas. Except for children whose parents did not consent to their participation in this study, the entire class of children attended the study activities. Participating preschoolers were at different cognitive, emotional, and developmental levels. To avoid subjecting them to a stressful situation, the researcher asked children if they would like to play a game with Zenbo. Only children who agreed were invited to take part in the procedure.

2.3. Experimental Room

The experimental rooms were the preschool classrooms in which the educational staff typically held classes for small group discussions and learning center activities. For the experiment setup, Zenbo was placed approximately 1m in front of the children. A group of 10–20 children sat in front of Zenbo for each experiment. One teacher was seated approximately 0.5 m from the imaginary line connecting the robot with the children. Two cameras positioned behind the robot captured the experiment. One teacher was seated approximately 0.8 m from the robot to lead children's questions to and interactions with Zenbo.

2.4. Procedure of Introducing Zenbo for the First Time

The time slot chosen for the experiment was between 9 a.m. and 11 a.m., a period typically used in preschools for small group discussions. The researcher made sure that the design of the behavior of Zenbo was in the best interests of children, and avoided causing any harm to children.

Introducing Zenbo: the teacher briefly introduced Zenbo to children through a question-and-answer session. The conversation is described below:

- T: Hi Zenbo, what is your name? Zenbo: My name is Zenbo
- T: Hi Zenbo, how old are you? Zenbo: I am 2 years old
- T: Hi Zenbo, are you a boy or a girl? Zenbo: I am a boy
- Raising questions to Zenbo: the teacher asked children to raise their questions to Zenbo. The teacher asked the children: "Do you have questions that you want to ask Zenbo? Please raise your hands."Children who raised questions could touch Zenbo's head to provide feedback. While touching, Zenbo would react to children by demonstrating an embarrassed movement and posture. Children's questions were recorded to analyze the question types.

- Zenbo telling a story: the teacher asked Zenbo to tell a story. The story was "A Big Wolf and Seven Sheep", which was familiar for young children. This story was designed to be interactive, with Zenbo moving around and asking children to act upon or touch the screen along with the story plot. Children's attention span and reaction to Zenbo's storytelling was observed.
- Rhythmic movement led by Zenbo: the teacher played a song called "A Smiling Face," which is popular in preschools. Zenbo led children to dance with the music. Children's attention spans and physical reactions to Zenbo's leading of the dance were observed.

2.5. Data Collection

The researcher used an observational method to collect data regarding the children's questions and responses to Zenbo. The observations were conducted by using a video recording to record the questions and reactions of children through the entire lesson through two fixed cameras. Video recording has the advantage of capturing subconscious behaviors and responses, such as natural behavior, facial expressions, and nonverbal cues of the physical body.

3. Data Analysis

Question type: questions raised by children were recorded verbatim. Then, question texts were coded and categorized, and the essential meanings of children's questions were analyzed. After the data had been analyzed, the types of children's questions began to emerge.

Attention rate: (1) Time sampling: The time sampling method used was a closed observation method that allowed the observer to gather information about a group of children at the same time (Fawcett & Watson, 2016). The observer selected a time interval of 5 minutes, then scanned the room at these intervals and made notes of children's attention traits or behavior. The researcher recorded the attention ratio of the whole class every 5 minutes; (2) Attention checklist: The observer employed a checklist to identify the attention behaviors. In previous research, direct eye-contact with robots, coupled with positive facial expression (e.g., smiling) and physical reaction have often been measured and interpreted as a sign of engagement and attention (Anzalone, Boucenna, Ivaldi, &Chetouani, 2014). Thus, this study adopted Fridin's definitions of attention behaviors, which included: (1) eye contact; (2) emotional engagement; and (3) verbal or physical interaction (Fridin, 2014). Before observing the children, observers reviewed the checklist thoroughly to assure it captured the target behaviours comprehensively. Then, the researcher recorded children's attention rates in questioning, storytelling, and rhyme movement activities. The attention rate was calculated as follows:

Attention rate= the number of children paying attention /the number of children in the whole group

The attention rate was calculated by two trained coders who watched the videos separately to determine the attention rate. An inter-rater reliability of0.9 (Spearman's correlation)was obtained. The final attention rate of each section was calculated using the average scores of the two trained coders.

4. Results

4.1. Questions Raised by Children to Zenbo

Some children asked Zenbo questions that were related to general daily conversations among people. The questions raised by children were:

"Who are your family members? Who is in your family?"

"Where do you live?" "How old are you?" "What do you want to eat?"

"What is your favorite book?"

Some children asked questions about Zenbo's functions and abilities. The questions raised by these children were:

"Why do you walk with wheels?""Can you tell a story?" "Can you dance?" "Can you play with me?" "Can you attend the class?" "Can you cook?"

A group of children asked "difficult questions" to test whether the robot can answer their questions. These questions included:

"Why is there a moon in outer space?" "Why do mosquitoes suck blood?"

"Why do geckos eat mosquitoes?"

Because these questions were beyond the researcher' expectations, the researcher asked these children: "why do you ask these questions?" Children answered: "Because a robot is supposed to know everything. Robots are omniscient!"

4.2. Attention Rate

The researcher calculated the children's attention rates, which are presented in Table 1:

Table1. *Children's attention rates in different activity sections*

Class activity	Questioning	Story-telling	Rhyme movement
R class	89%	94%	100%
J class	96%	100%	100%
L class	97%	99%	100%
D class	93%	97%	83%
Average	93.8%	97.5%	95.8%

As Table 1reveals, the children had high attention rates (the total average was above 95%) during these three activities. In other words, the activities led by Zenbo can effectively draw children's attention. Among the three activities, storytelling elicited the highest attention rate, rhyme movement had the second highest attention rate, and questioning had the third. Among the four classes of students, the D class had the lowest attention rate compared with the other three classes of children.

5. Conclusion

5.1. Children Tend to Interact with Zenbo in a Way Resembles to Human

Mills, Legare, Grant, and Landrum (2011) indicated that children ask questions as a method of building their understanding of objects. In this study, the questions raised by children toward Zenbo revealed valuable information about children's perceptions of Zenbo. Children's questions to Zenbo can be categorized as follows: questions similar to daily conversations among human beings, questions related to Zenbo's functions and abilities, and questions to test Zenbo'spurported omniscience. As previous studies have demonstrated that children have a propensity to attribute animate characteristics to social robots (Beran, Ramirez-Serrano, Kuzyk, Fior,& Nugent, 2011) and to interact with social robots in a way resembles to human-human interaction (Kramer, et al., 2012) , the children tended to echo the similar findings. Children tended to view Zenbo as a living human being because their questions to Zenbo resembled conversations among human beings. Moreover, children were eager to learn about Zenbo's functions and skills, as they asked some function-related questions. In addition, some children viewed Zenbo as an effectively omniscient creature who knew many different things. Thus, certain children asked some difficult questions; those children expected Zenbo to be capable of answering because they expected Zenbo to be practically omniscient. Educators can use these questions to design children's first encounters with social robots; first encounters are essential for children to clarify their concepts of robots and to build relationships with robots.

5.2. Children's Attention Rates were High toward the Activities Led by Zenbo

This study demonstrated that the overall attention rate of children was high (above 95%) for the different activities. In other words, Zenbo can draw children's attention toward the activities of questioning, storytelling, and rhyme movements. Most previous research has indicated that social robots have a positive influence on the lives of children with autism and other autism spectrum disorders through a combination of piquing their attention and interest in learning (Warren et al., 2015). This study consistently demonstrated the unique potential of social robots for eliciting young children's attention in general classrooms.

Based on the findings, the following recommendations can be made: First, investigating the influence of the social context and living environment on children's perceptions of social robots. Children's questions and perceptions of social robots are strongly influenced by children's ages and experiences with robots (Chernyak& Gary, 2016). In the D class, the children lived in rural areas and had responses to Zenbo that differed from the responses of children from urban areas. More children in the D class were observed as being timid; they asked more questions related to daily conversations. Also, children in the D class had a lower overall attention rate compared with the other three classes. Thus, the researcher suggests further research should be conducted to study the influences of social contexts and living environments on children's perceptions and reactions to social robots.

Moreover, the conclusion that social robots can draw children's attention should be interpreted with caution, because the children's increased attention was probably due to the novelty of Zenbo. Children's attention spans may decline as children become familiar with Zenbo. Therefore, it is suggested that future research should observe the long-term effects of a social robot in preschool settings. Furthermore, many researchers have raised concerns about the possible negative psychological and emotional effects caused by social robots in a childcare setting (Sharkey & Sharkey, 2010). How to utilize social robots in such a way as to prevent possible negative effects on young children should be carefully scrutinized. Young children often have fears of novel things. The robot's appearance and how the educator first introduces the robot both play crucial roles in establishing a positive relationship between children and a social robot(Tung, 2016). Therefore, the appearance of a robot designed for preschoolers should be cute, appealing, and not threatening. Finally, social robots should be designed to be socially responsive. In this study, it was determined that Zenbois not adequately designed to react to children's spontaneous questions and individual needs. Thus, Zenbocan only play a limited assisting role in guiding or teaching in preschool settings. With more sensitivity in social interactions, social robots can assist children in more activities and function more effectively in preschool settings.

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