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Child–robot interaction across cultures: How does playing a game with a social robot compare to playing a game alone or with a friend?

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ABSTRACT

The present study investigates how children from two different cultural backgrounds (Pakistani, Dutch) and two different age groups (8 and 12 year olds) experience interacting with a social robot (iCat) during collaborative game play. We propose a new method to evaluate children's interaction with such a robot, by asking whether playing a game with a state-of-the-art social robot like the iCat is more similar to playing this game alone or with a friend. A combination of self-report scores, perception test results and behavioral analyses indicate that child–robot interaction in game playing situations is highly appreciated by children, although more by Pakistani and younger children than by Dutch and older children. Results also suggest that children enjoyed playing with the robot more than playing alone, but enjoyed playing with a friend even more. In a similar vein, we found that children were more expressive in their nonverbal behavior when playing with the robot than when they were playing alone, but less expressive than when playing with a friend. Our results not only stress the importance of using new benchmarks for evaluating child–robot interaction but also highlight the significance of cultural differences for the design of social robots.

1. Introduction

In the last decade, there has been an increased interest in designing robots that have the ability to build an interpersonal relationship with humans by exchanging social and emotional cues (Breazeal, 2002). Unlike traditional research on service robotics, where humans were sometimes seen as obstacles and robots were supposed to avoid them while performing their tasks, the new breed of robots is deliberately designed to interact and cooperate with humans, both for serious and entertaining purposes (Kim, Kwak, & Kim, 2013). These robots are called social robots and are used increasingly, not only in entertainment and education, but also in rehabilitation and therapy.

Social robots may have a particularly strong impact for specific user groups. For example, it has been suggested that children are likely to have substantial benefits from robotic devices in many ways (Woods, 2006). Child–Robot Interaction (CRI) is currently emerging as a research area and researchers are motivated by the possibilities of letting children interact and collaborate with a robot in a social and intuitive way, which ideally could be highly similar to how children would interact with their peers. The relationship and type of interaction between children and robots is fundamentally social and it has been argued that children are likely to view robots as more than just a tool used in a task-oriented manner (Salter, Michaud, & Larouche, 2010).

Keeping in mind the social nature of child–robot interaction, researchers have started asking key questions about the societal consequences and acceptance of robots, especially when focusing on younger users. How do children perceive and interact with these robots? How do they establish a social bond with them? Can these social robots provide children with similar psychological outcomes and levels of interaction as human partners do (Salter, Werry, & Michaud, 2008)? A complication is that norms of social behavior differ from culture to culture, and as a consequence it is conceivable that different forms and social behaviors of robots may generate different responses across cultures (Nomura et al., 2007). Given that the market for robots is rapidly expanding and they are starting to reach diverse cultures and user groups, it is crucial to investigate how children with different cultural backgrounds respond to a social robot.

Existing research on how children perceive and interact with robots, particularly across cultures, is inconclusive. A few studies have shown that children like robots as companions and that certain elements of human–human communication are replicated

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in human–robot communication, but others have shown that there are differences in how people collaborate with human and human-like (i.e., robotic) partners (Castellano et al., 2010). Only a limited number of prior studies have looked at human–robot interaction from a cross-cultural perspective, and these studies suggest that the type and richness of social relations that people have with robots vary considerably across cultures. In general, it seems fair to say that in the area of human–robot interaction, and CRI in particular, most of the research is conducted in developed countries, with hardly any studies paying attention to the cultures of developing countries (with Bartneck, Nomura, Kanda, Suzuki, and Kennsuke (2005), a notable exception). Finally, CRI as a research area is still in its infancy and previously most of the research in HRI has focused on adult participants who mainly interacted with robots in a task-oriented manner. Children are different from adults in many ways. In fact, even children of different age groups are different from each other, and little research exists on how children of different age groups (and different cultural backgrounds) interpret and interact with robots in playful settings.

To address these issues, we developed a new experimental paradigm in which children of different age groups (young vs. old) and cultures (Pakistani vs. Dutch) play the same game either alone, with a friend or with a social robot as their game partner. We are interested in whether playing a game with a modern social robot is more similar to playing this game alone or with a friend, and in how children of different cultures establish a social bond with a robot and exchange (non)verbal cues during playful interactions.

1.1. Child–robot interaction

Child–robot interaction is increasingly seen as an important application area for robotic research, and the number of robots and range of applications specifically designed for children is rapidly increasing. A key research question addressed in this field is whether and how a robot can be used as a medium for social interaction. The fundamental challenge is to identify means by which children interact with robots and design the overall child–robot interaction experience in such a way that it closely resembles the human–human interaction experience (Francois, 2009).

Robot technology is being used for children, for example, in the education sector where robots not only act as assistants to teachers but also as autonomous agents in a school environment (Kanda, Hirano, Eaton, & Ishiguro, 2004). Various studies have looked at robots in education, and the results of these studies are mixed (e.g., Han, Jo, Jones, & Jo, 2008; Oh & Kim, 2010). In general, it has been shown that children are able to develop a social bond with educational robots over time and also report a positive learning experience, but factors like participants' age, cultural backgrounds and duration of interaction can have a large influence on the results. Another important application area for robot technology is in child development, rehabilitation and healthcare (Kozima, Nakagawa, & Yasuda, 2007). Studies in this area show that robot technology can assist children with physical disabilities to move and play, and can help children with autism learn about communication and emotions (Conn, Sarkar, & Stone, 2008). Studies such as these also confirm that the success of learning and rehabilitation technologies largely depend on individual differences (including age and mental capacity) and the context in which these technologies are used (Francois, 2009; Salter et al., 2008).

Robots are also being designed for purely entertaining and playful purposes, and different studies have investigated children's attitudes toward this application of robots. Sony's AIBO is an example of an autonomous entertaining home robot, which is often used in HRI and CRI studies (Bartneck, Suzuki, Kanda, & Nomura, 2007; Kerepesi, Kubinyi, Jonsson, Magnusson, & Miklósi, 2006). It is designed to elicit socio-emotional responses and shows learning and growth abilities. The iCat is another animal-like robot frequently used in HRI and CRI studies, developed for in-home usage (Castellano et al., 2010). It is designed to show six basic emotions and elicit rich socio-emotional responses.

Evaluating how social or entertaining robots are is a challenging issue in human–robot interaction research and it is even more difficult when special user groups, such as children are involved. A well-known finding from the HCI literature is that, in many situations, humans treat computers as social actors (Reeves & Nass, 1996). Unlike traditional computers, which exhibit relatively few cues that could be seen as socially intelligent, social robots are "borderline objects" that explicitly mimic many properties of living beings. It seems plausible that the findings of Reeves and Nass apply even stronger to social robots. If this is the case, then an interesting question is to what extent this applies to children and how children of different age groups treat a social robot during an interactive game play.

For investigating the social aspects of child–robot interaction, different evaluation methodologies have been used. In one type of experimental setup, child–robot interaction was compared with child–animal and child–toy interactions (Pepe, Ellis, Sims, & Chin, 2008; Ribi, Yokoyama, & Turner, 2008). Such investigations are uncommon but indeed help in identifying where on the "social" continuum these 'borderline objects' fall in terms of interaction.

For example, in one study, Kahn, Friedman, Perez-Granados, and Freier (2006) looked at the differences in children's responses to a stuffed dog and a robotic dog. They reported that the children engaged in imaginary play with the robotic dog in a similar fashion to how they engaged with the stuffed dog. However, based on a behavioral analysis, they reported that the quality and type of interactions with these two artifacts varied. Children showed more reciprocal and apprehensive behavior toward the robotic dog, and displayed less cautious behavior to the stuffed dog, which also included more mistreatment. In another study, Melson et al. (2005) investigated the interactions of children with a robotic dog (AIBO) in comparison to a live dog (an Australian shepherd). The results showed that children preferred to stay in closer proximity to the live dog than to the robotic dog, and were more inclined to associate sociality, morality and mental states to the live dog. They also touched and engaged in physical activity more with the live dog than with the robotic dog. In yet another study, Kerepesi et al. (2006) compared the interaction of children and adults with a real and with a robotic dog and showed that the robot was appreciated as an equally affective playing partner as the dog puppy. In another type of experimental setup, researchers compared different types of robots (e.g., iCat vs. Nao, a full-body robot), robots with virtual agents (Looije, Neerincx, & Lange, 2008), or different attributes of the same robot e.g., aggressive vs. polite (Fussell, Kiesler, Setlock, & Yew, 2008).

Taken together, these various studies present an unclear picture. On the one hand children are able to differentiate a robot from a toy and a pet, but on the other hand, they have mixed responses and attitudes toward robots. Furthermore, in surveys and questionnaires children indicate that a robot is like a companion or a family member, but behavioral analyses show that children clearly respond differently to living objects, such as a pet dog, than to a robot (Mitchell & Hamm, 1997). In general, differences between the various studies in methodology and set-up make it difficult to draw general conclusions.

For our study, we relied on a comparable paradigm, but crucially, we focus on a human partner instead of an animal partner or a toy. In particular, we focus on young children of different age groups in a game-playing context and investigate how they play collaborative games and establish a bond with a social robot. Games are a popular method to investigate human–robot interaction (Castellano et al., 2010; Short, Hart, Vu, & Scassellati, 2010).