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Research Report

How do typically developing children and children with autism perceive different social robots?

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ABSTRACT

This study investigates the way children categorize different robots and their preferences for certain robots. For this aim, a matching pictures game in which 6 social robots are to be matched to one of the categories: machines, humans, animals and toys, was developed and implemented on a tablet device. A mixed factorial design with one within-subjects variable (type of robots) and two between-subjects variables (type of development and gender) was used. The data suggest that both TD and ASD children perceive robots mainly as toys, while children with ASD also perceive robots as machines. A high diversity of preferences for different robots was revealed, but also a high preference for simplified designs, with exaggerated facial features. This study provides an innovative instrument for studying children's perception about social robots, and offers valuable information, with implications on the design of social robots.

1. Introduction

1.1. Overview

As socially assistive robots have been shown to have promise as therapeutic tools for children, the elderly, stroke patients, and other special-needs populations requiring personalized care (A Roadmap for U.S. Robotics "From Internet to Robotics", 2013), new ways to increase the social acceptance of robots by users should be examined. Different variables such as the appearance of the robot, its manner of movement and its manner of expression fundamentally influences the manner in which people engage the robot (Breazeal, 2002). In order to improve the quality of the human–robot interaction, it has become extremely important to investigate how people perceive and conceptualize different social robots, and what embodiment they prefer. Questions like: How anthropomorphic should the robot appear? What size should it be? Should it be covered in artificial skin, or should robotic components be visible? (Scassellati, Admoni, & Matarić, 2012) are waiting for empirically supported answers. As robots are to be included into educational or therapeutic curriculum activities, children's perceptions and preferences should be investigated and should influence the design of these robots. This paper discusses the impact of physical design of social robots on the perceptions and preferences of children, both typical developing (TD) and children with autism spectrum disorders (ASD). Children represent an extremely valuable source of information regarding the appearance of robots, since their perception is less influenced by preconceptions and much more influenced by the physical features of the robots. For this aim, we have developed a new and child-friendly method, namely, a robot categorization game, implemented on a tablet device. This picture matching game is a nonverbal, implicit measure of perception; therefore, it is a method adapted to the abilities of ASD children and pleasant for TD children, in order to have a single standardized method for both groups. The implications of this research are then discussed, stressing the fact that children should play an active role in the process of designing social robots.

1.2. Robot appearance

Fong, Nourbakhsh, and Dautenhahn (2003) proposed the following taxonomies for categorizing robots based on appearance: anthropomorphic, zoomorphic, and caricatured robots. The argument that support the anthropomorphic design is that an agent

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must be structurally and functionally similar to humans in order to have a meaningful social interaction (Breazeal, 2002). Some examples or robots with anthropomorphic design are: Nao (Aldebaran Robotics), Kaspar (University of Herdfortshire) or iCub (RobotCub Consortium, Italian Institute of Technology). On the other hand, Masahiro Mori (1970) observed that robots seem more familiar as they come to look more human-like, until a point is reached at which subtle deviations from human norms cause them to look creepy (MacDorman, 2006), a phenomenon known as "the uncanny valley". The most plausible explanation for this phenomenon is a mismatch between the human expectations and the robot's behavior. Consequently, caricatured representations may prevent the appearance of this phenomenon, since there is no exact similarity with a well-known creature, and therefore, there are no specific expectations towards their behavior (Saldien, Goris, Vanderborght, Vanderfaeillie, & Lefeber, 2010). Moreover, by incorporating baby features in robots, people tend to treat robots as young creatures, expect less performance and become more willing to adapt their behavior to the possibilities of the robot. These features have been identified by Eibl-Eibelsfeldt (1970) as facial characteristics that cross-culturally trigger nurturing responses from adults. These include a large head with respect to the body, large eyes with respect to the face, a high forehead, and lips that suggest the ability to suck (Breazeal, 2002). Caricatured robots such as: Probo (Vrije Univerisiteit Brusell, Belgium) or Keepon (NICT, Japan) incorporate these kinds of features. The third category proposed by Fong et al. (2003), zoomorphic robots, facilitate the development of an owner–pet relationship and may also prevent the "uncanny valley" effect, since our expectations of what constitutes a realistic animal morphology tends to be lower (Fong et al., 2003). Robots such as Aibo (Sony's Computer Science Laboratory), Pleo (Innvo Lab) or Paro (AIST) incorporate zoomorphic features.

1.3. Studies investigating the perception of robots

As one can notice by reviewing the literature, most studies investigating people's attitudes and preferences about robots, use adult subjects and are based on explicit measures such as questionnaires and interviews. The studies of Cerqui and Arras (2003) and Ray, Mondada, and Siegwart (2008), both performed in Europe, suggest that adults prefer a machine-like appearance to a humanoid one. The preliminary results of an appearance questionnaire, developed by our research team, and completed by 220 Romanians, Belgians and Dutch, reveal a preference for animal-like features to machine-like or human-like features. When it comes to other characteristics, the respondents consider that the robot should be neutral relative to gender, should be responsive, mobile, and should elicit emotional states. But can we expect similar preferences when it comes to children? The study of Scopelliti, Giuliani, D'Amico, and Fornara (2004), investigating how different generations perceive robots, suggests that younger people are more positive towards robots, have different representations, do not express anxiety towards robots and are more open to humanoid features. Children's perceptions and evaluations of different robot designs remains an important unexplored area within robotics research, considering the fact that the domain of educational robotics is gaining more attention, and many robots are designed specifically for children. To ensure the suitability of the robot's design, several research studies have been conducted to identify the characteristics of the robots which are the most appealing for children. In a study by Woods, Dautenhahn, and Schulz (2006), 159 children evaluated 4 images of robots by completing a questionnaire. The conclusions revealed that children judged machine-like robots and human-like robots as aggressive and angry, while the animal-like and human–machine robots were judged as friendly. Based on the empirical data obtained, Woods et al. (2006), summarized a set of recommendations for the design of robots for children: "(1) Robots should have cartoon-like features, exaggerated facial features, a female gender and be brightly coloured for positive behaviours, (2) Robots should have realistic features, less clear facial features, and be dully coloured to depict negative behaviours, (3) The whole appearance of a robot should be considered at the outset of the design phase rather than focusing on specific aspects such as the face, (4) Robots for children should not be designed to look completely human-like, unless they are perfect replicas, indistinguishable of humans". To our knowledge, the study of Woods et al. (2006) is one of the few ones that has directly investigated children's perceptions and attitudes towards the appearance of different robots. Also, we did not find any study comparing the perceptions or preferences of typically developing (TD) and of children with autism spectrum disorders (ASD), although Cabibihan, Javed, and Ang (2013) suggest that the methodology used by Woods et al. (2006) should be applied to ASD children for a comparison.

1.4. Searching for the optimal robot appearance for autism

Research has shown that robots can provide a safe and predictable environment for children with ASD (Dautenhahn & Werry, 2004), can engage them in playful interactions and provide help in developing social skills (Ferrari, Robins, & Dautenhahn, 2009). Different designs of social robots have been involved in research studies with children with ASD. The robots are either intended to possess anthropomorphic features: Robota (Robins, Dickerson, Stribling, & Dautenhahn, 2004), Kaspar (Robins, Dautenhahn, & Dickerson, 2009a, 2009b), Tito (Michaud et al., 2007), or Nao (Tapus et al., 2012), they are designed as animals: Paro (Marti, Pollini, Rullo, & Shibata, 2005), Pleo (Kim et al., 2013), cartoon-like toys: Keepon (Kozima, Michalowski, & Nakagawa, 2009), Probo (Pop, Pintea, Vanderborght, & David, 2014; Vanderborght et al., 2012), or they are designed not to resemble any biological species: Labo-I (Dautenhahn, 2007). Several research studies have been conducted to elicit design requirements that make ASD children more likely to engage with robots. Until now, ASD child's impairments in communication have been a barrier to research investigating perceptions and preferences, and the requirements for the design of robots for autism come either from theoretical inferences based on autism processing style, either from studies that use adult's reports about this issue. The lack of consensus regarding the optimal design for autism has led to a wide range of physical appearances (Scassellati et al., 2012). On one hand, the fact that children with ASD have difficulties generalizing learned social skills outside the context in which they are learned, should justify the choice for an anthropomorphic appearance. On the other hand, a simplified agent with exaggerated social cues may help children with ASD focus attention on the relevant social information. In an attempt to solve the problem of the optimal appearance for ASD, Ferrari et al. (2009) have used feedbacks by experts, therapists, parents and teachers, in order to collect information related to the needs, abilities and preferences of children with ASD. Based on the information collected, they have developed the IROMEC robot. Another attempt was made by Cabibihan et al. (2013), who synthesized the information from studies on a variety of robots used for autism therapy and identified the robot design requirements regarding appearance such as: the robot should be visually engaging (Michaud, Duquette, & Nadeau, 2003; Giullian et al., 2010; Robins, Otero, Ferrari, & Dautenhahn cited in Cabibihan et al., 2013), should have colored body-parts to grab attention (Michaud, Duquette, & Nadeau, 2003; Hoa & Cabibihan, 2013, cited in Cabibihan et al., 2013), simplified features, combine human