Researchers explore interactions between preschoolers and robotic partners

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Screenshot of one of the videos used in the researchers' experiments, depicting a child and a robot acting out the unexpected transfer story. Credit: Di Dio et al.

The relationship between humans and robots has become the focus of an increasing number of research studies, in light of the approaching integration of robots within a variety of fields, including professional and educational contexts. An international and interdisciplinary team of researchers including psychologists and roboticists at Università Cattolica del Sacro Cuore in Milan (Prof. Antonella Marchetti, Prof. Davide Massaro, Dr. Cinzia Di Dio and Dr. Federico Manzi), Kyoto University (Prof., Shoji Itakura and Prof. Takayuki Kanda), Osaka University (Prof. Hiroshi Ishiguro) and Advanced Telecommunications Research Institute International (ATR) in Kyoto have carried out a study investigating human-robot interactions, which involved five- and six-year-old children playing with other children and robotic partners.

"Human beings are in continuous development, and the most complex phases of change and maturation of psychological processes and competencies, including the development of social skills, occur during the first years of life," the researchers told TechXplore, via email. "If life is a succession of decisions, very soon, we will also be called upon to make decisions with robotic partners. Given the increasing presence and relevance of robotic artifacts in our society, it is fundamental to begin investigating how relational patterns change when relating to a robot and, with specific reference to our experimental study, how decision-making processes are affected by the partner's agency in a lifespan perspective. Connecting developmental psychology to the study of human–robot interactions from a multidisciplinary perspective, Itakura proposed a new research domain named Developmental Cybernetics, which we used in this study."

The authors of the paper, which was published on Springer's International Journal of Social Robotics, are interested in uncovering the psychological mechanisms and processes behind human-robot interactions. Their study particularly focuses on children, as they believe that this could help to define the developmental benchmarks that characterize such relational patterns.

"After all, a five-year-old child would possibly engage in a unique relational modality to a robot as compared to an older child or an adult," the authors said.

In their study, the authors administered a series of tests to 31 Italian kindergarten children, some of which assessed their theory of mind (ToM), which is the human ability to recognize mental states (e.g. thoughts, perceptions, feelings, etc.) in oneself and others. In particular, the experimenters assessed the children' understanding of false belief using the classical Unexpected Transfer Task and a set of videos of the Unexpected Transfer Task in which the characters are either children or robots. This allowed them to assess the children's ability to ascribe a false belief, and so a theory of mind, to another human and to the robot.

The Unexpected Transfer Task, often used to test

young children on ToM, involves a character who puts an object under a box and then leaves the room. While he is away, a second character enters the room and moves the object somewhere else. The first character then comes back into the room looking for the object that he had originally placed under the box.

The experimenters narrated this story using two dolls, a ball, a box and a basket. When they finished telling the story, they asked participants a series of questions that assessed their memory and ToM.

The children were then shown four videos of the same story, but with a robotic agent as one of the characters. The two characters in the videos were either two children, two robots, or a child and a robot, while the displaced object was a teddy bear. Pairings within and between agent-types (human and robot) were to assess the effectiveness of all possible relational and role combinations in evaluating the children's ToM. After watching the videos, the children were asked the same questions that they were asked previously, during the classical ToM task.

The key aim of this experiment was to determine whether the children attributed 'false belief' (i.e. believing that a displaced object is where one last saw it) to both another child and a robotic agent, or whether these attributions were somewhat different. Subsequently, the researchers tested the children on the ultimatum game, evaluating the fairness with which they distributed a 'special object' (i.e. stickers) between themselves and another player (i.e. either another child or a robot).

Screenshot of one of the videos used in the researchers' experiments. Credit: Di Dio et al.

"To study the dynamics underpinning decision-making processes and, more specifically, one's inclination and sensitivity to fairness, we used an interactive game derived from the Theory of Economic Games, the Ultimatum Game, which is broadly used in psychology," the authors explained. "The advantage of this experimental situation is that it can be used across different ages, enabling the experimenter to compare data from early childhood to adulthood in a controlled manner. Likewise, the same protocol can be used transversally to compare sensitivity to fairness when playing with different agents, in our case with a human or a robot."

In the Ultimatum Game, one player (the proposer) divides a sum of money (or goods) with another player (the receiver). Once the proposers communicate their decision, the receiver can either accept or reject it. If she/he accepts, the money is divided as proposed; if she/he doesn't, however, both players receive nothing.

One of the distinctive features of the Ultimatum Game is that it requires reciprocity. In fact, when acting as the proposer, a player needs to consider the other's 'mind,' anticipating her/his response in order to gain a good, as the proposal's rejection would result in no gain whatsoever. The researchers chose this game as it would help them to better understand what children expected a robot's responses to be and how their viewed his 'mind.'

"To evaluate how children perceive the interactive partner in mental and physical terms, we then administered the Attribution of Mental and Physical States (AMPS) questionnaire developed ad hoc and derived from scientific literature," the authors said. "We are increasingly using the AMPS questionnaire because it allows us to investigate the attribution of a 'mind' that subjects of various ages have of robotic agents and compare it with the human agent."

The experiments carried out by the researchers yielded interesting results. While children appeared to recognize robots as distinct entities compared to humans, in the Ultimatum Game, their behavioral responses and reasoning were similar when playing with another child and with a robot.

Furthermore, the results to the ToM tasks showed that all children attribute a false belief to the child independent of whether the task was administered in the form of storyboard or video. Interestingly, all children attributed a false belief to the robot, independent of its role in the game, suggesting that the robot's, like the human's mind, is subject to informational access limits. These data indicate that mechanisms and beliefs associated with human-robot interactions might develop fairly early in our lifespan.

"Children attribute different physical and mental states to the robotic and the human agent," the authors said. "However, they tend to make similar economic decisions when interacting with another child or when interacting with a robot. If the relationship with the robot shows in children behaviors similar to those observed with human partners, then the use of robots in different contexts, from educational to rehabilitative, can be particularly crucial."

The study carried out by this interdisciplinary team of researchers provides valuable insight into how humans, particularly children, relate to robots and how they perceive these 'new entities.' To improve the generalizability of their findings, however, the researchers would need to replicate their study with a bigger group of participants. Further research could also compare how humans interact with robots to how they interact with other non-human entities, such as animals, toys, or other objects.

"Currently, we are expanding both the type of psychological functions and the type of socially relevant situations in which the human partner could be sided by a robotic partner," the authors said.

More information: C. Di Dio et al. It Does Not Matter Who You Are: Fairness in Pre-schoolers Interacting with Human and Robotic Partners, *International Journal of Social Robotics* (2019). DOI: 10.1007/s12369-019-00528-9