Changing Perspective as A Learning Mechanism

Elmira Yadollahi
GAIPS, INESC-ID, IST
Lisboa, Portugal
CHILI, EPFL, Lausanne, Switzerland
elmira.yadollahi@epfl.ch

Pierre Dillenbourg
CHILI, École Polytechnique Fédérale de Lausanne (EPFL)
Lausanne, Switzerland
pierre.dillenourg@epfl.ch

Ana Paiva
INESC-ID, Instituto Superior Tecnico (IST), University of Lisbon
Lisboa, Portugal
ana.s.paiva@tecnico.ulisboa.pt

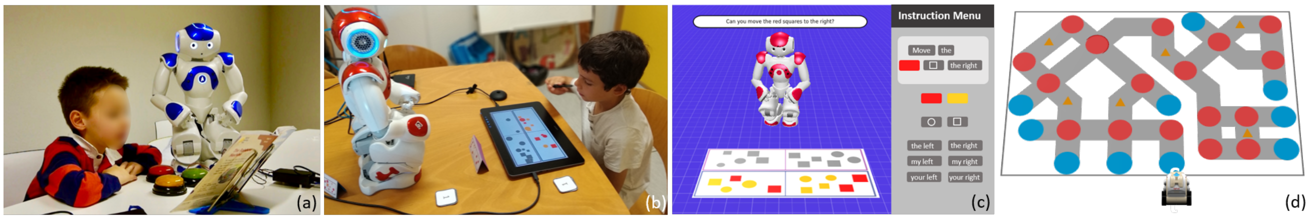

Figure 1: Experimental setups designed for studying perspective taking, (a) CoReader platform with Nao, (b) Object game with Nao, (c) Object game with virtual Nao, (d) Cozmo maze game

ABSTRACT

One of the numerous approaches that increases the interaction quality between two people is having a proper understanding of the other person's perspective. In this doctoral thesis, we aim to understand children's perspective taking behavior, create a perspective taking framework for social robots, and evaluate the framework in educational scenarios and real-life interactions. The research started by designing tasks that allow us to analyze and decompose children's decision-making mechanisms in terms of their perspective taking choices. We collect data from series of studies that capture the dynamic between the child and the robot using different perspective taking tasks and develop a complementary adaptive model for the robot. This article summarizes the perspective taking tasks, experimental studies, and future works for developing a comprehensive model of perspective taking for social robots.

KEYWORDS

Child-Robot Interaction, Perspective taking, Education, Cognitive Framework

ACM Reference Format:
Elmira Yadollahi, Pierre Dillenbourg, and Ana Paiva. 2020. Changing Perspective as A Learning Mechanism. In *Companion of the 2020 ACM/IEEE International Conference on Human-Robot Interaction (HRI '20 Companion), March 23–26, 2020, Cambridge, United Kingdom.* ACM, New York, NY, USA, 3 pages. https://doi.org/10.1145/3371382.3377442

1 INTRODUCTION AND BACKGROUND

Humans are inherently social beings able to carry out fluid and dynamic interactions [2–4]. Understanding our counterpart's perspective or taking it into consideration during interaction is one of human's many efficacious abilities [7, 8, 12]. Correspondingly, to enhance the quality of human-robot interaction, one of the aspects worth consideration is perspective taking [1, 16, 17, 23].

Looking at perspective taking in human-robot interaction scenarios, various questions come to mind with different studies trying to tackle these questions [6, 13, 19]. Here, we are interested in comprehending the dynamics between the robot and the child from perspective taking aspect and supplementing the robot with a framework that facilitates and strengthens its interaction capabilities in educational mediums [13, 20]. To fully comprehend children's decision-making mechanism, several studies in psychology have studied the underlying mechanism of perspective taking [5, 11, 15, 18]. A better understanding of this mechanism; whether it unveils the underlying procedures or decomposes the decision-making process, can help us decode human's behavior. In the following sections, we detail the decomposition of perspective taking mechanisms in child-robot interaction and development of the corresponding cognitive mechanism in the robot.

2 RESEARCH PLAN

We aim to investigate the means of conducting natural human-robot interaction by focusing on perspective taking in collaborative educational tasks. As a result, we need to evaluate the problem from two different angles, the child's angle; understanding their behavioral mechanism, and the robot's angle; developing its complementary cognitive mechanism. To model natural interactions between human and the robot, we plan to: *explore*, *model*, *evaluate*, *remodel*, *reevaluate*, and *integrate* our mechanism in the robot. An adaptive perspective taking model will give the robot the ability to adjust its perspective to the human and to conduct effective interactions. For example, the robot's response to the human's egocentric or exocentric perspective should be addressee-centric or exocentric perspective respectively. To achieve our final goal of developing the model, first we try to focus on the following intermediate goals.

(1) What are the first steps in achieving joint attention in children?
(2) What is children's first perspective choice and how much they are willing to adjust their perspective to their counterpart?

ACM ISBN 978-1-4503-7057-8/20/03.
https://doi.org/10.1145/3371382.3377442

(3) Does a robot with perspective taking ability facilitates the interaction?
(4) Can children learn and practice perspective taking while interacting with a robot equipped with this capability?

3 PREVIOUS WORK

In our previous works, we mainly focused on the first and second goals with the following studies:

A Joint Attention Study with CoReader.
In this study, we have explored the effect of robot's behaviors on children's success in establishing and maintaining joint attention. We have developed a reading platform designed to let children practice reading with a learner robot as shown in Figure 1a. The robot's learner role was a mean to provide learning by teaching opportunity for children. Considering the importance of gaze following in establishing joint attention [10], during the experiment eye-tracking glasses were also used. However, due to some issues, the eye-tracking data was ommited from the final analyses. The findings were twofold, first, understanding children's performance in response to their teacher-learner dynamic. Second, evaluating the effect of robot's movement on children's performance and joint attention [22].

Object Game: Children's Perspective Taking Baseline.
This study analyzes children's choice of perspective in the context of playing a game with the robot. As a result, a two-player game with a focus on understanding the other player's perspective was designed. This study provided valuable insights on developing a perspective taking model for the robot. Children's performance was aligned with some of our initial hypotheses, such as *"children will use egocentric perspective in their first instruction trial"*. While, it was in contrast with some of our other hypotheses, such as *"children will switch to using explicit instructions after realizing the robot's egocentrism"*. Here, we were mainly interested in children's initial perspective selection, their tendency to adapt it in case of encountering conflict with the robot, and how all of these affect the successful completion of the task [21].

Definitions and Behavioral Observations.
As a result of the previous study, we have classified our observations into definitions that help us understand the interaction and design a perspective taking model. For example, we have defined *implicit* and *explicit utterances* based on using possessive adjectives in the sentence. Hence, "Give me the racket on the right" is implicit, while, "give me the racket on your right" is explicit. Implicit utterances are prone to create conflicts as both parties might have either egocentric or addressee-centric interpretation of them. Consequently, we have also defined *speaker perspective* and *listener perspective*, as a result of observing the inconsistency in children's choice of perspective between their speaker and listener roles [14]. Our analyses suggests that children's first choice of perspective is egocentric, they have higher tendency to use *implicit utterances* than *explicit utterances*, and they don't automatically transfer their model of robot's *listener perspective* to the robot's *speaker perspective*.

4 FUTURE WORK

For our future work, we are interested in developing the intelligence behind the robot for adapting its perspective during the interaction. Furthermore, beside modeling the robot's framework, we expect to use the interaction in educational mediums for learning and practicing perspective taking. At this point, by relying on the previous studies, we are able to develop the first version of our adaptive model, which will be tested in our next study.

Object Game: Adaptive Model.
In order to access many participants, we are planning to run a full scale study in Mechanical Turk. We are modifying the setup of our previous study to execute it in an online platform as shown in Figure 1c. The previous study with children allowed us to see whether they select implicit or explicit utterances to compose their instructions. In this study, we are going to separate our participants into two groups, the ones that only have implicit options (test group) and the ones that have both implicit and explicit options (control group). The goal is to test our adaptive model, and collect behavioral data. The findings of this study help us to update our model and evaluate the updated model with a new user study that will be executed in the school.

Cozmo Maze: Perspective Adjustment for Different Angles.
In this study, we are interested in understanding the methods children use to change their perspective under different rotation angles [18]. The study is composed of children guiding Cozmo robot within a maze; which is carefully tailored to position the robot with different angular rotation, to reach a certain goal as shown in Figure 1d. Children navigate the robot in the maze using direction buttons. A failure to consider the robot's perspective can result in a wrong move, that ends in a penalty or losing the game. Currently, we are preparing a version of this game suitable for 6 to 9 years old to be tested in the school. The findings of this study will be twofold, understanding children's strategy when they comprehend and/or take the robot's perspective, and the potential of similar tasks to train children in learning and practicing perspective taking. We expect the result from this study to contribute to our adaptive model.

Task Under Development: Final Integration and Evaluation.
Our final study brings everything together into a comprehensive study. Here, we equip the robot with the final version of our perspective taking model. Then, we test and evaluate the robot's performance and quality of the interaction in two educational scenarios.

5 CONCLUSIONS

In conclusion, this research aims at understanding children's perspective taking behaviour, modeling a perspective taking framework for the robot, and evaluate the framework in educational scenarios and real-life interactions. The design of the framework satisfies two purposes, the first is endowing the robot with adaptive perspective taking abilities in order to enhance the interaction and the second is teaching children different types of perspective taking such as perceptual, cognitive, and even emotional [9].

ACKNOWLEDGMENTS

E. Yadollahi would like to thank Prof. W. Johal and Dr. M. Couto for their insightful discussions and contributions to my PhD research. This work is supported by Fundação para a Ciência e a Tecnologia (FCT) through funding of the scholarship PD/BD/135150/2017 and project UID/CEC/50021/2019, and CHILI laboratory in EPFL.

REFERENCES

[1] Matt Berlin, Jesse Gray, Andrea Lockerd Thomaz, and Cynthia Breazeal. 2006. Perspective taking: An organizing principle for learning in human-robot interaction. In *AAAI*, Vol. 2. 1444–1450.

[2] Richard J Boland Jr and Ramkrishnan V Tenkasi. 1995. Perspective making and perspective taking in communities of knowing. *Organization science* 6, 4 (1995), 350–372.

[3] Herbert H Clark. 1992. *Arenas of language use.* University of Chicago Press.

[4] Herbert H Clark and Catherine R Marshall. 2002. Definite reference and mutual knowledge. *Psycholinguistics: critical concepts in psychology* 414 (2002).

[5] Fruzsina Elekes, Máté Varga, and Ildikó Király. 2017. Level-2 perspectives computed quickly and spontaneously: Evidence from eight-to 9.5-year-old children. *British Journal of Developmental Psychology* 35, 4 (2017), 609–622.

[6] Tobias Fischer. 2018. Perspective taking in robots: A framework and computational model. (2018).

[7] John H Flavell, Frances L Green, and Eleanor R Flavell. 1986. Development of knowledge about the appearance–reality distinction. *Monographs of the society for research in child development* (1986).

[8] Adam D Galinsky and Gordon B Moskowitz. 2000. Perspective-taking: decreasing stereotype expression, stereotype accessibility, and in-group favoritism. *Journal of personality and social psychology* 78, 4 (2000), 708.

[9] Lawrence A Kurdek and Maris M Rodgon. 1975. Perceptual, cognitive, and affective perspective taking in kindergarten through sixth-grade children. *Developmental psychology* 11, 5 (1975), 643.

[10] Andrew N Meltzoff, Rechele Brooks, Aaron P Shon, and Rajesh PN Rao. 2010. "Social" robots are psychological agents for infants: A test of gaze following. *Neural networks* 23, 8-9 (2010), 966–972.

[11] Nora Newcombe. 1989. The development of spatial perspective taking. In *Advances in child development and behavior*. Vol. 22. Elsevier, 203–247.

[12] Jean Piaget, Bärbel Inhelder, and Alina Szeminska. 1960. The child's conception of geometry. (1960).

[13] Ben Robins, Kerstin Dautenhahn, Luke Wood, and Abolfazl Zaraki. 2017. Developing Interaction Scenarios with a Humanoid Robot to Encourage Visual Perspective Taking Skills in Children with Autism–Preliminary Proof of Concept Tests. In *International Conference on Social Robotics*. Springer, 147–155.

[14] Luc Steels and Martin Loetzsch. 2006. Perspective alignment in spatial language. *arXiv preprint cs/0605012* (2006).

[15] Andrew R Todd, C Daryl Cameron, and Austin J Simpson. 2017. Dissociating processes underlying level-1 visual perspective taking in adults. *Cognition* 159 (2017), 97–101.

[16] Cristen Torrey, Susan R Fussell, and Sara Kiesler. 2009. What robots could teach us about perspective-taking. *Expressing oneself/expressing one's self: Communication, cognition, language, and identity* (2009), 93–106.

[17] J Gregory Trafton, Nicholas L Cassimatis, Magdalena D Bugajska, Derek P Brock, Farilee E Mintz, and Alan C Schultz. 2005. Enabling effective human-robot interaction using perspective-taking in robots. *IEEE Transactions on Systems, Man, and Cybernetics-Part A: Systems and Humans* 35, 4 (2005), 460–470.

[18] Karin M Vander Heyden, Mariette Huizinga, Maartje EJ Raijmakers, and Jelle Jolles. 2017. Children's representations of another person's spatial perspective: Different strategies for different viewpoints? *Journal of experimental child psychology* 153 (2017), 57–73.

[19] Mathieu Warnier, Julien Guitton, Séverin Lemaignan, and Rachid Alami. 2012. When the robot puts itself in your shoes. managing and exploiting human and robot beliefs. In *2012 IEEE RO-MAN: The 21st IEEE International Symposium on Robot and Human Interactive Communication*. IEEE, 948–954.

[20] Luke Wood, Kerstin Dautenhahn, Ben Robins, and Abolfazl Zaraki. 2017. Developing child-robot interaction scenarios with a humanoid robot to assist children with autism in developing visual perspective taking skills. In *2017 26th IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN)*. IEEE, 1055–1060.

[21] Elmira Yadollahi, Wafa Johal, Joao Dias, Pierre Dillenbourg, and Ana Paiva. 2019. Studying the Effect of Robot Frustration on Children's Change of Perspective. In *2019 8th International Conference on Affective Computing and Intelligent Interaction Workshops and Demos (ACIIW)*. IEEE, 381–387.

[22] Elmira Yadollahi, Wafa Johal, Ana Paiva, and Pierre Dillenbourg. 2018. When deictic gestures in a robot can harm child-robot collaboration. In *Proceedings of the 17th ACM Conference on Interaction Design and Children*. ACM, 195–206.

[23] Xuan Zhao, Corey Cusimano, and Bertram F Malle. 2016. Do people spontaneously take a robot's visual perspective?. In *2016 11th ACM/IEEE International Conference on Human-Robot Interaction (HRI)*. IEEE, 335–342.