“Mentor-Child and Naive-Pupil-Robot” paradigm to study children’s cognitive and social development

Jean Baratgin*
CHArt RNSR 200515259U, Université Paris 8
Saint-Denis, France
& P-A-R-I-S Association
Paris, France
jean.baratgin@univ-paris8.fr

Baptiste Jacquet
CHArt RNSR 200515259U, Université Paris 8
Saint-Denis, France
& P-A-R-I-S Association
Paris, France
baptiste.jacquet@paris-reasoning.eu

Marion Dubois-Sage
CHArt RNSR 200515259U, Université Paris 8
Saint-Denis, France
& P-A-R-I-S Association
Paris, France
marion.dubois-sage@etud.univ-paris8.fr

Frank Jamet
CHArt RNSR 200515259U, Université Paris 8
& CY Cergy-Paris Université
Cergy-Pontoise, France
& P-A-R-I-S Association
Paris, France
frank.jamet@u-cergy.fr

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1 Introduction

In this paper we discuss the “Mentor-Child & Naive-Pupil-Robot paradigm” for the experimental study of the cognitive and social development of the young child in a context in which pragmatic factors are disambiguated. This new methodological framework has a double interest. Firstly, it offers psychologists a relatively simple methodology to study the major notic categories of thinking in young children (number, space, time and causality) but also the acquisition of key concepts of cognitive and social development such as the notions of conservation (liquid, matter, weight and volume) and class inclusion [25–27] or that of understanding the mental states of others about the state of the world [34]. Then, for HRI studies, it provides a context for the natural engagement of the young child in a learning relationship with a robot that allows the study of different interactions.

2 The pragmatic difficulty of the traditional paradigm

Psychological experiments about the child’s cognitive or social development resemble teaching contexts and more generally test situations experienced by the child. An adult experimenter interacts verbally with the participating child by asking a target question following a given statement (i.e., asking for the conclusion of a story, a comparison, a problem-solving situation, etc.). The child is asked to respond by a gesture or an action (e.g., indicating something) or verbally. Several authors have criticised this methodology [i.e. 1, 6, 10–12, 16, 24, 29, 30, 33] emphasising the failure to analyse these experiments as situations of communicative engagement between two physically present interlocutors[1]. In particular, the interpretation of the target question by the child may be different from the one expected by the experimenter for pragmatic reasons. When the question is disambiguated to help the young child make the correct interpretation of what is asked of them they acquire these different concepts much earlier studies made with the traditional paradigm indicate.

The meaning of the question is usually not obvious to the child. They are aware that the question put to them is a “higher order question” [28], i.e. it does not imply that the experimenter does not know how to find the answer, but rather that it is a general question to test their knowledge. The answer must satisfy the expectation of relevance that the child attributes to the experimenter [31]. However, the child’s attribution of the experimenter’s expectations depends on their representation of the task and previous similar experiences, which are often educational in nature. The child uses the simplest procedure of interpretation, which consists of inferring from the communicative stimulus the intention most relevant to their own point of view. However, what is relevant to the child may be different from what the experimenter actually intends to communicate. The experimenter waits for an answer to see if the child is familiar with the concept being investigated. However, if for the child the notion is already perfectly acquired, they may interpret the question as a test on their general knowledge because to them it seems impossible that a “knowing” adult would expect such an “obvious” answer from them. Therefore they assume the expected answer to be different.

*Corresponding author.

[1] This criticism is also true in experimental tasks carried out on adults [i.e. 2, 4, 5].

3 The solution with the "Mentor-Child and Naive-Pupil-Robot" paradigm

The proposed solution to disambiguate the interpretation of the question for the child is to explicitly reverse the knowing status of each of the two interlocutors in the experimental task. The person asking the target question should be perceived by the child as not knowing the answer (as a non-knowing person) while the child should be explicitly put in the role of the mentor, the knowing person. It is also important that the question asked needs to be understood by the child as a request for help from the ignorant person. Indeed, it has been shown that toddlers spontaneously want to help [i.e. 7, 14, 32]).

3.1 The robot as an ignorant person

In order to limit the possible pragmatic implicatures of their utterance, the ignorant person is represented by an iconic robot (NAO) with which the young child has no previous experience or interactions[2]. Moreover, it was shown that children maintain their attraction to help with a robot [i.e. 17, 18, 35]. The robot used in our paradigm is the NAO robot. NAO is 58 centimeters tall (21 in). Its head, arms, fingers, trunk, thighs, legs and feet are mobile. It can grasp but also point objects with its three fingers which allow it to indicate or take objects. It is equipped with a camera and microphone and can be easily operated remotely or controlled autonomously. Its size is not too imposing for a 3 year old child.

3.2 Procedure of the paradigm

The experiment was carried out individually for each child to reinforce the interaction between them and the robot. It is essential that the child is certain that he is alone with the robot, without any other adult in the room. If not, the child may think that they are being tested by the adult observing the interaction and answer the robot's question by attributing it instead to the observing adult. Thus, we recommend the use of the technique of the Wizard of Oz in order to adapt perfectly to the unpredictability of young children's behaviour. First of all, the child's role of being the mentor is explicitely stated as well as the ignorant, naive and slow character of the robot and its need for help. These characteristics will be reinforced during the course of the experiment. The child, robot and experimenters acted according to a didactic contract that we will now explain.

One member of the research team (the companion) fetches the child in the classroom. They explain that they are going to meet a robot NAO who talks but knows nothing at all and that the child's aim is to teach him lots of things. As NAO does not know anything, he often makes mistakes and then the child will have to correct him and explain his mistake to him again. NAO will also be able to ask the child surprising questions, and there again it is normal as NAO is ignorant: he knows nothing. Once in the experimentation room, NAO was already there sitting on a table. The companion then leaves the room to leave the child alone with NAO. NAO presents himself as an ignorant robot and to reinforce this attribution NAO repeats over and over again in the conversation "I don't know anything", "I don't know much". He often explicitly asks for help: "[First name of the child], will you be my teacher?"; "will you help me"; "will you help me understand?". This request for help is in a way contractualized by the child's agreement to the question "Will you be my teacher?". Under the cover of his ignorance it is in fact NAO who is testing the child without saying so. The whole dynamic of the conversation is based on NAO's questions and answers. The objective of the child mentor is to answer the robot, to validate his proposals, to correct him if he makes a mistake, to help him. The child essentially carries out all the prototypical acts of a teacher. This context of learning by teaching is natural [19] and has been very often obtained in the field of robotics: [for a review 13].

4 Conclusion

This new experimental paradigm has been successfully tested with 5-6 years old children in the class inclusion task [13, 21] and in 3-4 years old children in a theory of mind task [3]. These studies also provide two important new insights into child-robot interaction. They seem to confirm that preschoolers attribute beliefs to the robot [8, 9, 15] and that the child behaves like a mentor, with the motivation to help a robot understand a story even if physical interactions are quite limited [17, 18]. However, our paradigm was not conclusive in children under 3 years old who did not accept to be "alone" with NAO. It is possible that the choice of a humanoid robot may confuse young children and that other robots would be more appropriate for them. So far we explored this paradigm with neuro-typical children but we are also convinced that it could be adapted to children with specific needs.

[2] We had previously studied this last point in adults by showing that the neutral social status of a robot made it possible to limit pragmatic implicatures such as those of politeness [20–23].

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