Enhancing child-robot tutoring interactions with appropriate feedback

Mirjam de Haas[1], Paul Vogt[1] and Emiel Krahmer[1]

Abstract— **The use of social robots for teaching children a second language is a promising field. This paper describes an ongoing experiment in which we explore how children engage with a robot after receiving feedback in a tutoring session. We created three scenarios in which the robot performed peer-like, adult-like feedback or was withholding feedback. A group of 85 preschool children are investigated. We will compare how the children experience interaction with the robot and their responses to the different types of the robot's feedback. The purpose is to explore the possibilities of peer interaction between robot and child for long-term tutoring.**

I. Introduction

Robots are starting to enter the classroom and more and more children are interacting with robots. Studies have shown that robots can have effective interactions with children with regards to educational settings [1]. Children are less stressed when interacting with robots and are more readily engaged with tasks that are otherwise considered boring. Robots are able to teach children different school subjects, one of these is second language [2], [3]. This can be tutoring a popular second language such as English or tutoring the official school language to children from immigrant families. Teaching immigrant children the school language is crucial in early stages of development, as later educational success builds on that [4].

In educational settings, children are expected to maintain long-term relationships with a tutoring robot. To achieve successful long-term relationships, natural and varied interactions between the robot and children are crucial. One of the challenges is to keep the child interested. For establishing long-term relations, a robot should engage users over extended periods of time and this can be achieved through an understanding of interactions between peers [5]. In most educational settings, the robot acts as a teacher (see for example [6]). However, younger children prefer robots to behave as peers and, within language, they prefer a tutoring style [7]. A child would perceive a peer tutor as a friend with more advanced language skills, would interact with the peer tutor as a friend and would receive feedback from the peer tutor as a friend. Observations of peer interactions between children [9] showed that children provide less feedback than adults and they produce different feedback when their peers make mistakes. However, in interactions between native and non-native children's interactions, non-native children receive significantly more feedback than the native children. Therefore, to create a robot behaving as a peer and a tutor we expect that children respond to the robot as a peer and the robot would also respond to the children as a peer. Moreover, a robot that gives appropriate feedback is expected to support the child's language development best. Question is: How should a robot provide feedback to make the interaction both pleasant and educational?

Klugel and DeNisi mention that no feedback is sometimes better [10]. In a meta-analysis of 131 studies they found one third of these studies show that there are negative effects of feedback compared to no feedback at all. However, they did not investigate the type of feedback, only the amount. Negative feedback might have more impact on learning efficacy, although positive feedback can give some reassurance to the learner [11]. Older people showed a higher user compliance and performance when a robot gave feedback during their workout [12], [13]. Moreover, robots giving positive feedback is widely used within therapy when children have Autism Spectrum Disorder (ASD) [14]. In addition, children with ASD tend to be more motivated when the robot gives a reward after a correct behavior. When a robot reacts to our actions it makes us more confident in the robot's behavior.

We want to investigate whether these results can be extended to typically developing preschool children learning a second language. In child-child interactions, Long [15] found that there was a clear advantage in learning for explicit feedback (e.g. by saying "no, that's wrong, you need past tense") when compared to recasting feedback (the learner says "he runned" and the teacher reacts with "he ran"). The explicitness of the feedback is also an important determinant of children's responses to feedback. In a free-play situation where four-year old children could play, observations revealed that children responded much more often to specific questions than for implicit nonverbal feedback, or implicit verbal feedback [16], [17].

Mazzoni [18], explored feedback of a humanoid robot in language learning of young children. Children were asked to play with either the robot or another child, and work together to understand the meaning of an English word. The robot did not give explicit feedback, but it introduced a doubt (for example, "ahh, your suggestion is interesting … but are we sure that it is correct?"). If children did not respond, the robot would ask them for suggestions. The children showed in both conditions (one in interaction with the robot and one with another child) improvement in their Engels vocabulary. The authors, however, did not provide information on how children reacted on the robot and whether the children considered the robot as a peer or else.

*Research supported by European Union's Horizon 2020 and innovation programme under grant No 688014.

[1]Tilburg center for Cognition and Communication, Tilburg University, PO Box 90153, 5000 LE Tilburg, The Netherlands
{mirjam.dehaas, p.a.vogt, e.j.krahmer}@tilburguniversity.edu

The objective of this study is to answer the question whether the type of feedback (more explicit such as peers or implicit such as adults) that the robot gives to children will influence their engagement with the robot, and compare this with a robot that gives no feedback at all.

Mashburn et al. [20] found that peer interactions have a positive effect on language development. However, children with relative poor language abilities benefited less from peer interactions, because they had less opportunity to engage with other children. One-to-one interactions in which a robot provides opportunities to engage more, might be less intimidating than an actual peer and can have a positive effect on the children's language abilities. Other than adults, children are more focused on constructing their own personal meaning, and, therefore, use less negotiation techniques that focus on their peers' understanding. Furthermore, Mackey et al. [9] investigated patterns of negotiation in child interactions and found that the children use three different forms of negotiation: clarification (what do you mean?), confirmation (do you mean this?) and comprehension (do you understand?).

This research is part of the L2TOR project, which focuses, among others, on teaching native Dutch children English as a second language, and on teaching Dutch to native speakers of Turkish living in the Netherlands [19]. The general idea is that the robot will support all children in both their native language and the second language.

The remainder of this paper describes an experiment that investigates the influence of providing peer-like or adult-like feedback by the robot, aged 3 to 4 years on the child's engagement with the robot. The experiment was carried out in various preschools in the Netherlands. We created a scenario in which the children interact with a humanoid robot either giving one of the feedback types or withholding feedback and study the effect of the robot on the children's engagement in the activity and their relationship with the robot.

II. Experimental Design

This experimental design will describe an experiment in which a robot will teach Dutch speaking children English. We will explore the children's reactions on the robot's feedback.

A. Participants

Approximately 85 preschool children of 3 to 4 years old will take part in this experiment. These children attend a preschool in Tilburg and are normally instructed in Dutch. For all children the parents sign an informed consent form.

B. Task

The task is a collaborative game with blocks. The robot uses the blocks to teach the children to count from 1 to 4 in English. During the interaction the robot instructs all children in Dutch and only names the different numbers in English. Each child sits on the ground in front of the robot that is approximately 40 cm from the participant (see Fig. 1). The experimenter explains the children that the robot is going to teach the children some words in English. The duration of the interaction is around 10 to 15 minutes, depending on how much feedback the children need. Prior to the experiment the children practice counting in Dutch together with the experimenter and the blocks and their knowledge of the English counting words will be tested before and after the experiment. The children were not given any feedback during the pre and posttest.

Fig. 1. Experimental setup

C. Robot

The robot used during this experiment is the Nao robot, which is a small humanoid robot produced by Aldebaran. This robot has already been used in many studies with children. The advantage of using Nao is that this robot can use gestures to explain the children the words. Children are more engaged when the speech is accompanied by gestures, their joint attention increases the interactions are longer and they look more at the robot during its turn [21], [14]. The robot points and gazes at the blocks that are used in this experiment. Moreover, it gazes at the children during interactions. The children were already introduced to the robot prior to the experiment and were explained how the robot shows emotions and they were familiar with the behaviors of the robot. Furthermore, the robot speaks with a synthesized Dutch and English voice. Most of the sentences will be in Dutch; only the target words for the children are in English. While we plan to use automatic speech recognition in the near future, we use the Wizard of Oz method [22], because of the imperfections in the automatic speech recognition of child speech. This way, it appears for the children as if the robot is responding on their questions and actions.

D. Experimental Conditions

In this study we want to test the impact of different types of feedback. All conditions are tested with a between subject design. The children are randomly assigned in one of the feedback conditions. The behavior and movements of the robot remain identical between all conditions, except for the robot's feedback.

We use two types of feedback; the first one uses explicit feedback that children often use during peer interactions and the second one uses implicit recasting feedback that adults most often use while interacting with children and compare these to a condition without feedback. Prior research has

shown that children react more often to explicit specific questions [16] and we, therefore, included explicit egocentric feedback in the peer-feedback condition. The other type of feedback is based on how adults respond to children and how they interact with them. Adults use recasting feedback and tend to praise the children for their work. This adult-feedback condition contains of implicit (recasting) feedback and giving praise to the child whenever they did something correct.

In the examples below, the text said in English is indicated in Italics, the rest of the text is said in Dutch.

1) No Feedback condition

This condition is the baseline condition for this experiment, wherein the robot only serves as a language instructor and playmate for this game. The robot does not explicitly motivate the child by giving feedback. All motivations come from the other instructions and the child's own intrinsic motivation. When the experimenter notices that the child does something completely wrong with the result that interaction does not continue, she corrects the mistake of the child after the interaction with the robot.

Example of no feedback after correct and incorrect child response:
Robot: "Can you show me *three* blocks?"
Learner: shows robot three blocks.
Robot: "Put all the blocks back. Can you show me *two* blocks?"

2) Peer-Feedback condition

In this condition the scenario sequence is the same as in the no feedback condition, with an addition that the robot gives explicit feedback whenever the child does something wrong. The verbal feedback changes every time, only the non-verbal feedback stays the same during the task itself.

Example of feedback after correct child response:
Robot: "Can you show me *three* blocks?"
Learner: shows robot three blocks.
Robot: "Put all the blocks back. Can you show me *two* blocks?"

Example of feedback after incorrect child response:
Robot: "Can you show me *three* blocks?"
Learner: shows robot two blocks.
Robot: "That's wrong! You should take three blocks."

3) Adult-Feedback condition

In this condition the scenario sequence is the same as in the other two conditions, except that the robot gives feedback when the child responds either correctly or incorrectly. When the child responds correctly, the robot gives positive feedback both verbally and non-verbally by showing the child that it is happy by blinking its eyes in different colors. When the child makes a mistake, implicit negative feedback is provided, which is less strong as in the peer-feedback condition.

Example of feedback after correct child response:
Robot: "Can you show me *three* blocks?"
Learner: shows robot three blocks.
Robot: "Well done! *Three* means three in English."

Example of feedback after incorrect child response:
Robot: "Can you show me *three* blocks?"
Learner: shows robot two blocks.
Robot: "*Three* means three, you should take three blocks."
Learner: shows robot three blocks
Robot: "Well done! *Three* means three in English."

E. Hypotheses

The main purpose of our experiment is to investigate how the children are engaged with the robot in all conditions, while the effectiveness of the language tutoring is of secondary importance in this experiment. We therefore have the following three hypotheses:

H1. We expect that the robot that gives feedback will engage the children more than the robot that gives no feedback. Mackey explored feedback with children and also found these results, although they did not test this with a robot, we still expect this will be true for the robot and a child [9].
H2. We expect that the children will be more motivated to continue when the robot gives positive feedback.
H3. We expect that the children will learn more target words in the peer-feedback condition due to the explicit negative feedback.

F. Evaluations

The experiments, which are concluded at the moment of writing this paper, have been recorded on video. These recordings will be analyzed for the child's engagement with the robot using a coding scheme adapted from [23]. In particular, we will measure children's reaction to having feedback or not in a perception study. To this aim, short video fragments, displaying children's responses to the feedback of the robot or the absence thereof, will be shown in random order to naive observers. These observers are asked to indicate for each snippet whether the child displays positive or negative emotions, which will indicate how children are engaged with the robot after a certain type of feedback.

Second, we will measure the proportion of time children are engaged with the robot. For this, we will adopt the coding scheme of Mastin and Vogt [24] to assess the amount of time children are engaged with the robot and whether the engagement concerns episodes of joint attention or not.

Finally, we will measure whether there is any learning effect from interacting with the robot. To this aim, we will carry out a short pre-test and a short post-test to test the children's ability to count from 1 to 4 in Dutch and in English.

III. CONCLUSION

This paper described an experiment in which a robot is used to teach children a second language. The experiment described explores how children react to feedback of the robot. The experiment has taken place in June and is

concluded at the moment of writing, so we expect to present some preliminarily results during the workshop in August.

REFERENCES

[1] G. Castellano, I. Leite, A. Pereira, C. Martinho, A. Paiva, and P. W. Mcowan, "Multimodal Affect Modeling and Recognition for Empathic Robot Companions," *Int. J. Humanoid Robot.*, vol. 10, no. 01, p. 1350010, 2013.

[2] J. Kennedy, P. Baxter, and T. Belpaeme, "The Robot Who Tried Too Hard: Social Behaviour of a Robot Tutor Can Negatively Affect Child Learning," *Proc. ACM/IEEE Int. Conf. Human-Robot Interact.*, no. January 2016, pp. 67–74, 2015.

[3] M. Fridin, "Storytelling by a kindergarten social assistive robot: A tool for constructive learning in preschool education," *Comput. Educ.*, vol. 70, pp. 53–64, 2014.

[4] P. P. M. Leseman, "Effects of Quantity and Quality of Home Proximal Processes on Dutch , Surinamese – Dutch and Turkish – Dutch Pre - schoolers ' Cognitive Development," vol. 38, no. January 1998, pp. 19–38, 1999.

[5] R. Gockley, A. Bruce, J. Forlizzi, M. Michalowski, A. Mundell, S. Rosenthal, B. Sellner, R. Simmons, K. Snipes, A. C. Schultz, and J. Wang, "Designing Robots for Long-Term Social Interaction," in *International Conference on Intelligent Robots and Systems*, 2005, pp. 2199–2204.

[6] T. Kanda, T. Hirano, D. Eaton, and H. Ishiguro, "Interactive Robots as Social Partners and Peer Tutors for children: A field trial," *Human-computer Interact.*, vol. 19, pp. 61–84, 2004.

[7] M. Saerbeck, T. Schut, C. Bartneck, and M. D. Janse, "Expressive robots in education: varying the degree of social supportive behavior of a robotic tutor," in *Proceedings of the 28th international conference on Human factors in computing systems - CHI '10*, 2010, pp. 1613–1622.

[8] N. Shin and S. Kim, "Learning about, from, and with robots: Students' perspectives," in *Proceedings - IEEE International Workshop on Robot and Human Interactive Communication*, 2007, pp. 1040–1045.

[9] A. Mackey and J. Leeman, "Interactional input and the incorporation of feedback an exploration of NS-NNS and NNSNNS adult and child dyads.," *Lang. Learn.*, vol. 53, no. 1, pp. 35–66, 2003.

[10] A. N. Kluger and A. DeNisi, "Feedback Interventions: Toward the Understanding of a Double-Edged Sword.," *Am. Psychol. Soc.*, vol. 7, no. 3, pp. 67–72, 1998.

[11] S. Y. Okita and D. L. Schwartz, "Learning by Teaching Human Pupils and Teachable Agents: The Importance of Recursive Feedback," *J. Learn. Sci.*, vol. 22, no. 3, pp. 375–412, 2013.

[12] J. Fasola and M. J. Mataric, "Robot motivator: Improving user performance on a physical/mental task," in *Proceedings of the 4th ACM/IEEE international conference on Human robot interaction*, 2009, pp. 295–296.

[13] B. J. Fasola and M. J. Mataric, "Using Socially Assistive Human – Robot Interaction to Motivate Physical Exercise for Older Adults," in *Proceedings of the IEEE*, 2012, vol. 100, no. 8, pp. 2512–2526.

[14] E. I. Barakova, P. Bajracharya, M. Willemsen, T. Lourens, and B. Huskens, "Long-term LEGO therapy with humanoid robot for children with ASD," *Expert Syst.*, vol. 32, no. 6, pp. 698–709, 2015.

[15] Long. M. H., "Recasts in SLA: The story so far," in *Problems in SLA. Second Language Acquisition Research Series.*, Mahwah, NJ: Lawrence Erlbaum Associates., 2006, pp. 75–116.

[16] C. L. Petersen, F. W. Danner, and J. H. Flavell, "Developmental Changes in Children ' s Response to Three Indications of Communicative Failure," *Soc. Res. Child Dev.*, vol. 43, no. 4, pp. 1463–1468, 1972.

[17] D. Spilton and L. C. Lee, "Some Determinants of Effective Communication in Four-Year-Olds," *Soc. Res. Child Dev.*, vol. 48, no. 3, pp. 968–977, 1977.

[18] E. Mazzoni and M. Benvenuti, "A Robot-Partner for Preschool Children Learning English Using Socio-Cognitive Conflict," *Educ. Technol. Soc.*, vol. 18, no. 4, pp. 474–485, 2015.

[19] J. Kennedy, P. Baxter, E. Senft, and T. Belpaeme, "Social Robot Tutoring for Child Second Language Learning," 2016, pp. 231–238.

[20] A. J. Mashburn, L. M. Justice, J. T. Downer, and R. C. Pianta, "Peer effects on children's language achievement during pre-kindergarten," *Child Dev*, vol. 80, no. 3, pp. 686–702, 2009.

[21] C. L. Sidner, C. Lee, C. D. Kidd, N. Lesh, and C. Rich, "Explorations in engagement for humans and robots," *Artif. Intell.*, vol. 166, pp. 140–164, 2005.

[22] L. D. Riek, "Wizard of Oz Studies in HRI: A Systematic Review and New Reporting Guidelines," *J. Human-Robot Interact.*, vol. 1, no. 1, pp. 119–136, 2012.

[23] S. Shahid, E. Krahmer, and M. Swerts, "Child-robot interaction across cultures: How does playing a game with a social robot compare to playing a game alone or with a friend?," *Comput. Human Behav.*, vol. 40, pp. 86–100, 2014.

[24] J. D. Mastin and P. Vogt, "Infant engagement and early vocabulary development: a naturalistic observation study of Mozambican infants from 1;1 to 2;1," *J. Child Lang.*, pp. 1–30, 2016.