Attentive Robot Listener Engages Children in Language Learning

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***Abstract*— Socially assistive robots have been used successfully to attract childrens attention, stimulate sustainable interactions and improve communication skills in young children. Many recent research studies propose various approaches for increasing the interaction effectiveness of such robots. Our research objective is to develop an autonomous social robot learning companion that, through contingent backchannel feedback, can successfully foster the development of early language skills of preschoolers over long-term interaction in an educational storytelling context. In this study we used Tega and we investigated the effect of the robot nonverbal behaviors during storytelling activities of young children. The findings of this study contribute to the effective use of interactive robots in education. Our results suggest we can build models that capture individual differences in backchannel style, captivate children's attention and enhance the whole storytelling and learning experience. In the near future we will possibly identify individual traits from observations of backchannel behavior and create autonomous and personalized activities so as to increase the children's curriculum in a social and engaging venue.**

I. INTRODUCTION

Early language ability (such as vocabulary skills and oral language knowledge during preschool) is one important predictor of children's academic success throughout their school years. Children who lack a rich vocabulary-building curricula suffer from language differences that may negatively affect the childs entire academic career [1]. The importance of social context to language learning is also well-established and just being surrounded by complex language does not seem to produce positive lexical growth [2]. Extensive research in young children and infants has verified the importance of social cues like backchanneling (BC), joint attention and shared gaze for language acquisition, thereby emphasizing the importance of the cooperative effort of the learner. Storytelling has been widely used as an effective means of improving language skills, (e.g., vocabulary, grammatical level, etc.), as well as cognitive and social understanding [3]. Furthermore, children enjoy telling stories they make up from their own imagination. Self-created stories provide a longer and richer speech sample than asking children questions about stories and children feel more relaxed when engaged in story-telling acts which promotes learning [4].

Social robot learning companions hold great promise in augmenting the language learning experience with parents and teachers. Such robots offer unique opportunities of guided, personalized, and controlled social interaction and delivery of a desired curriculum. Differently from tablets and smartphones, robots can play, learn and engage with children in the real world – physically, socially and emotionally. However, in order to serve as an effective long-term companion, social robots need to be far more autonomous, adaptive, personalized and able to model the corresponding cognitive capacities and language behaviors of child learners.

Still, no studies focus on developing an autonomous personalized social robot companion and assess its efficacy on the language development of pre-school children in the context of storytelling tasks. For this purpose, we developed a rule-based backchannel (BC) prediction model that will push the envelope of our understanding of childrens free form storytelling and eventually foster the development of early language skills in pre-school aged children. The objective of this study is to understand whether the type of feedback that the robot gives to children will influence their engagement and experience with the robot, and compare this with a robot that gives only random feedbacks.

II. RELATED WORK

A long-term interaction with social robots has been shown to have a positive effect on learning and behavioral outcomes for both adults and children beyond mere novelty effects [5]. The use of social robots as peers and tutors for children in educational settings has also been increasingly explored in recent years with promising results. Children have learned vocabulary from a tele-operated storytelling robot [6] and fostered curiosity-relevant behaviors [7]. Socially assistive robots have also been introduced in Kindergarten settings as teacher assistants to foster storytelling activities [8]. Taken together, findings such as these are highly suggestive of the ability of social robots to be perceived as engaging peers or to serve as instructors in learning.

Backchanneling (BC) is a component of conversation and verbalization that is naturally embedded in our everyday interaction and is the part a listener plays in a conversation. There are both verbal and nonverbal BC signals. Throughout a conversation, the listener may nod their head (nonverbal) periodically to show that they are paying attention and/or verbally acknowledge using fillers, such as *yeah, ok, uh huh, mhmm*. BC has been studied as a form of feedback, acknowledgment, and turn-taking in both the psychology field as well as in human-robot interaction.

III. OUR BACKCHANNELING MODEL

Since listener BC are generated rapidly and seem elicited by a variety of speaker verbal and nonverbal cues, generating appropriate BC is a difficult problem. There is evidence that people can generate such feedback without necessarily attending to the content of speech [9], and this has motivated

Fig. 1. Child and mum interacting with contingent Tega (left) and non-contingent Tega (right)

diverse approaches that generate BC using different features that are available in real-time (e.g. energy, prosody, pitch).

We generated autonomous nonverbal behaviors by using a broad range of real-time features. Based on the analysis of our existing corpus of child-robot tele-operated storytelling sessions from our prior study, we created a rule-based BC prediction model for children which, to our knowledge, does not exist at the moment. Commercial tools to extract prosody and timing in speech will be used to find differences in BC style and predict BC opportunities, which is an important milestone for building engaging [9] and natural [10] experiences.

IV. THE STUDY

The effects of our model were explored with 20 children (age $M = 6.25$, $SD = 1.33$; 45% female) who participated in a storytelling activity. Two Tega robots (Fig. 1) were randomly placed in front of the child. One of the robot provided contingent BC feedback with audio and gaze using our algorithm and the other robot provided random non-contingent BC feedback every 5 ± 1.5 seconds. Due to lack of space we can only share few results. Analysis of face expressiveness showed that children were more calm towards the contingent robot and felt the robot more attentive towards them (15 out of 20).

V. CONCLUSION

The proposed project can have a broad impact on bringing social robots into schools and peoples homes for the benefit of childrens development. In the past, the lack of affordable and commercially available social robot platforms had limited real-world impact of this kind of research. But this is no longer the case with recent commercial initiatives in social robotics [11]. By incorporating automatic assessment and personalized language into the child-robot interaction, autonomous social robots can become more believable, engaging, and efficacious to foster the positive development of children. The development of affordable personalized, autonomous social robots that can promote childrens vocabulary and language skills is an invaluable tool across many domains especially for children in under-served communities and with special needs [12], [13]. Having such robots in homes, community centers, and schools can augment parents, teachers and educators in facilitating an effective learning environment for children. As noted above, language is the basis for other cognitive, emotional and social skills, thus promoting it in an engaging and personalized interaction can have far reaching positive effects.

We will soon conduct a 6-month longitudinal study at multiple preschool sites to evaluate the impact of long-term interactions with the storytelling robot on childrens engagement and language skill development. The future work will increase our understanding of the impact of longitudinal interactions with social robot companions on childrens language development. This could inspire new tools and practices for early pre-literacy and language education (as well as other domains such as STEM) in the home, classroom, and beyond. Parenting groups and educators shall be engaged to facilitate the learning activities as well as to provide input and feedback.

Our dream is that these cumulative effects of the projects outcomes with social robots (and others like it) can lead to a more expressive, intelligent and pro-social oriented society.

REFERENCES

[1] B. Hart and T. R. Risley, *Meaningful differences in the everyday experience of young American children.* Paul H Brookes Publishing, 1995.

[2] M. M. Páez, P. O. Tabors, and L. M. López, "Dual language and literacy development of spanish-speaking preschool children," *Journal of applied developmental psychology*, vol. 28, no. 2, pp. 85–102, 2007.

[3] R. C. Schank, *Tell me a story: A new look at real and artificial memory.* Charles Scribner's Sons, 1990.

[4] S. Engel, *The stories children tell: Making sense of the narratives of childhood*. Macmillan, 1995.

[5] E. Short, K. Swift-Spong, J. Greczek, A. Ramachandran, A. Litoiu, E. C. Grigore, D. Feil-Seifer, S. Shuster, J. J. Lee, S. Huang *et al.*, "How to train your dragonbot: Socially assistive robots for teaching children about nutrition through play," in *The 23rd IEEE International Symposium on Robot and Human Interactive Communication*. IEEE, 2014, pp. 924–929.

[6] J. J. M. Kory, "Storytelling with robots: Effects of robot language level on children's language learning," Ph.D. dissertation, Massachusetts Institute of Technology, 2014.

[7] G. Gordon, C. Breazeal, and S. Engel, "Can children catch curiosity from a social robot?" in *Proceedings of the Tenth Annual ACM/IEEE International Conference on Human-Robot Interaction*. ACM, 2015, pp. 91–98.

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

[9] L.-P. Morency, I. de Kok, and J. Gratch, "A probabilistic multimodal approach for predicting listener backchannels," *Autonomous Agents and Multi-Agent Systems*, vol. 20, no. 1, pp. 70–84, 2010.

[10] R. Poppe, K. P. Truong, D. Reidsma, and D. Heylen, "Backchannel strategies for artificial listeners," in *International Conference on Intelligent Virtual Agents*. Springer, 2010, pp. 146–158.

[11] E. Guizzo, "Cynthia breazeal unveils jibo, a social robot for the home," *IEEE Spectrum*, 2014.

[12] A. Bonarini, F. Clasadonte, F. Garzotto, and M. Gelsomini, "Blending robots and full-body interaction with large screens for children with intellectual disability," in *Proceedings of IDC2015*. ACM, 2015, pp. 351–354.

[13] L. Bartoli, F. Garzotto, M. Gelsomini, and M. Valoriani, "Designing and evaluating touchless playful interaction for asd children," in *Proceedings of IDC2014*. ACM, 2014, pp. 17–26.