Learning A Second Language with a Socially Assistive Robot

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Abstract. We created a socially assistive robotic learning companion to support English-speaking children's acquisition of a new language (Spanish). In a two-month microgenetic study, 34 preschool children will play an interactive game with a fully autonomous robot and the robot's virtual sidekick, a Toucan shown on a tablet screen. Two aspects of the interaction were personalized to each child: (1) the content of the game (i.e., which words were presented), and (2) the robot's affective responses to the child's emotional state and performance. We will evaluate whether personalization leads to greater engagement and learning.

Keywords. Education; children; language learning; long-term interaction; play; social assistive robots.

INTRODUCTION

Preschool (3-5 years) is a critical time for children to learn language. Not only can early language ability greatly impact later educational success (e.g., [1], [2]), but also, learning the pronunciation and accent for a new language is age-sensitive [3]. This may be especially important for children who are newcomers to a country – the earlier they master the new language, the better.

For many children, the main problem faced in mastering a new language is a lack of resources in their homes and schools. Technological interventions can supplement children's language education by providing additional instruction, support, and practice. However, passive media, like videos, can help children learn vocabulary, but not language structure [4]. Many of the interactive games available require reading or writing skills – fine for older children, but not for preschoolers who are generally still learning how to read. Very young children learn language best through social interaction.

To this end, we have created a social robot that can supplement children's early language education. Social robots combine the unique advantages of technology – such as being easily customizable, adaptive to individual learners, and being deployable – with the necessary social cues and "human" behaviors that are crucial for language learning [5]. This robot is accompanied by a virtual sidekick, who appears on a tablet. Prior work has shown that young children will readily learn words from both mobile devices [6] and robots (e.g., [7], [8]). Furthermore, because children learn at different paces and in different ways, the robot will adapt both its affective responses and the material to be learned to each individual child. We ask whether this personalization will increase learning gains and overall engagement.

METHODS

Participants. Thirty-four children ages 3-5 (19 male, 15 female) from a "special start" preschool in the Greater Boston area have signed up for the study. Of these, 15 are classified as special needs and 19 as typically-developing.

Conditions. The study follows a 2x2 design of *Development* (Typical vs. Special) x *Personalization* (Personalized affective responding vs. no personalization).

Hypotheses. We expect that nearly all children will enjoy playing with the robot and will stay engaged over time. We expect that children who receive personalized affective feedback will exhibit greater learning gains overall.

Procedure. Each child will participate in eight 10min sessions with the robot. During each session, children will play with the robot and with a virtual character, a Toucan, who is shown on a tablet screen (Figure 1). The robot and child are situated as peer learners, while the Toucan speaks Spanish and supplies information about new Spanish words. The rest of the tablet screen contains the shared context for the games the robot, Toucan, and child play together. In each session, they play three games: (1) a review of the previous session, (2) a game "directed" by the robot in English, during which the Toucan introduces new Spanish words by saying, e.g., "Did you know that *blue ball* is *pelota azul* in Spanish?", and (3) a game "directed" by the Toucan in Spanish, during which the robot supplies hints in English to help the child along.

The eight play sessions have content revolving around a trip to Spain: packing for the trip, visiting a zoo, having a picnic, and so forth. Each session provides the opportunity to both learn new words and review. For example, at the zoo, children can learn names of animals. The animals appear in later sessions as the Toucan's friends, providing review.

All the speech in the interaction was pre-recorded, which allowed for more emotional expressivity, and pitch-shifted to make the voices sound more child-like. The robot's voice was recorded by a native English speaker and the Toucan's voice was recorded by a native Spanish speaker.

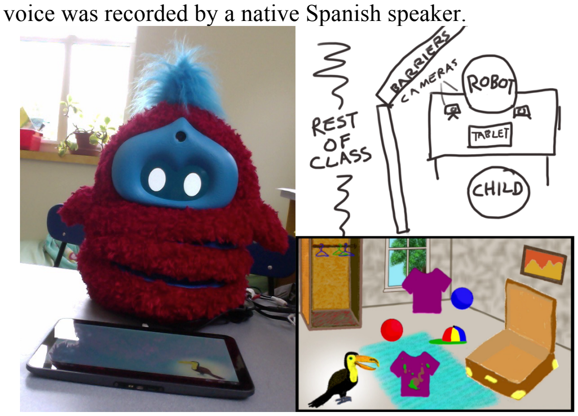

Figure 1: Children played with the robot Tega and the tablet, which featured a virtual toucan.

Robot. We are using the Tega robot (Figure 1), which was designed and built by members of the Personal Robots Group at the MIT Media Lab and their collaborators. An android phone runs the robot's motor control software and displays the robot's animated face. The robot is fully autonomous. Control software coordinates the robot's behavior and the tablet game via ROS. This software follows a general script of the interaction flow, and receives sensory input from the tablet (such as when a child taps or drags an object on the screen) and from the Affdex emotion classifier from Affectiva [9] (including valence and engagement).

Personalization. The interaction is personalized in two dimensions. For all children, the content of the game – i.e., which Spanish words are taught – is personalized based on children's recognition of Spanish words in previous sessions, using an algorithm based on that described in [10]. The goal is to keep children in the zone of proximal development [11], such that they have a 50% change of knowing the words used in a session.

For half the children, the robot's affective responses will be personalized to the child's performance and emotional state. Measurements of the child's engagement (high/low) and valence (positive/neutral/negative) from Affdex, on-off task (measured by whether the child interacts with the tablet) and right/wrong (in the last task) are combined into a reward signal for an online reinforcement learning algorithm (SARSA), with the goal of maximizing high engagement and positive valence. This personalized a policy governing both the robot's non-verbal (e.g., facial expressions) and verbal responses to each child following specific tasks in the game (e.g., if the child performed a task correctly, the robot would respond both with the game-related response, such as "good job," and an appropriate affective response).

Measures. Before the session 1, after session 4, and after session 8, we will ask each child a set of questions about how they perceive the robot (e.g., whether they think the robot is more similar to a person or a tablet on various dimensions). Children will also perform an Anomalous Picture Task, in which they view two pictures of animals in strange situations (e.g., a giraffe in a dining room) with an experimenter (before session 1, as a baseline) and with the robot (after session 1 and after session 8). The child's interlocutor comments once after 10 seconds (e.g, "That's so silly!"). The goal is to see how many spontaneous questions, comments, and laughs children produce, which gives us insight into how they construe the robot as a social other (e.g., since people laugh most in social scenarios [12], do children laugh as much with the robot as with the person?).

In addition, we will give children an initial Spanish vocabulary assessment based on the Peabody Picture Vocabulary Task (PPVT) [13] before session 1 and after session 8. Children will also perform a curiosity task that allows them to freely explore a graphical scene on a tablet, giving insight into how curious they are. Each child's parents and teacher will fill out a questionnaire on the child's learning preferences. Finally, teachers will be asked to fill out a questionnaire probing their perception of and attitudes toward robots in the classroom, first before session 1 and then after session 8 to see if their opinions had changed.

We will also record audio and video of each session, as well as logging Affdex data and actions taken on the tablet.

PROGRESS

This work adds to the growing body of literature on socially assistive robots in education. We are performing one of the first microgenetic studies with a fully autonomous, adaptive robotic learning companion for preschool children and for preschool children with special needs. Data collection is currently ongoing at the preschool.

We expect that the results of this work will inform the design of future robotic learning companions. We hope to understand how personalizing the robot's affective feedback and the game's content can affect children's motivation and learning, with the ultimate goal of developing more effective educational tools that can engage children as peers and leverage the social and playful nature of children's natural early learning environments.

ACKNOWLEDGMENTS

We would like to thank the Personal Robots Group for their support. We would also like to thank Vicky for recording her voice for the Toucan's speech. This research was supported by the National Science Foundation (NSF) under Grant CCF-1138986 and Graduate Research Fellowship Grant No. 1122374. Any opinions, findings and conclusions, or recommendations expressed in this paper are those of the authors and do not represent the views of the NSF.

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