Virtual Peers as Partners in Storytelling and Literacy Learning

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ABSTRACT

Literacy learning - learning how to read and write, begins long before children enter school. One of the key skills to reading and writing is the ability to represent thoughts symbolically and share them in language with an audience who may not necessarily share the same temporal and spatial context for the story. Children learn and practice these important language skills everyday, telling stories with the peers and adults around them. In particular, storytelling in the context of peer collaboration provides a key environment for children to learn language skills important for literacy. In light of this, we designed Sam, an embodied conversational agent who tells stories collaboratively with children. Sam was designed to look like a peer for preschool children, but to tell stories in a developmentally advanced way: modeling narrative skills important for literacy. Results demonstrated that children who played with the virtual peer told stories that more closely resembled the virtual peer's linguistically advanced stories: using more quoted speech and temporal and spatial expressions. In addition, children listened to Sam's stories carefully, assisting her and suggesting improvements. The potential benefits of having technology play a social role in young children's literacy learning is discussed.

Keywords

Emergent literacy learning, storytelling, peer collaboration, virtual peer, preschool, primary school, empirical research

INTRODUCTION

As new technologies are increasingly present in classrooms, efforts are being made to prepare children for computer literacy. Yet, the traditional literacy skills – the ability to read and write – remain critical for children's academic success and may also be aided by advances in technology and research. Young children's acquisition of skills leading to literacy begins with everyday interactions in informal settings with both adults and peers, and is not isolated to formal, academic environments. Whether it is for an adult or a child peer, constructing language for *someone* encourages children to practice many skills essential to later literacy.

In this research, we address the specific discourse genre of *storytelling* as a bridge to literacy. Storytelling occurs in the context of peer play and while a fun activity for children, it also involves the kind of linguistic activities that can bridge children's competence and knowledge of oral language with that of written language. We present and discuss a novel approach to supporting children's literacy learning, where technology plays a social role, as a listener of children's stories, thus providing opportunities for children to foster linguistic expressions in an oral mode that are useful for their later literacy skills.

First, we will explain the link between storytelling and literacy, and the importance of social interactions in literacy learning. Then we will introduce Sam, an embodied conversational agent that acts as a peer to children in storytelling play, and finally we will discuss our preliminary findings from our empirical study.

Storytelling and Literacy

Our research on literacy learning and storytelling is based on the theory of emergent literacy (Teal & Sulzby, 1986). Unlike the traditional view of literacy, which presumed children go though fixed and sequenced mastery of skills, emergent literacy is based on the gradual process of children learning skills for reading and writing from infancy (Goodman, 1986). In the emergent literacy view, aspects of language – both oral and written – develop concurrently rather than sequentially. Although children's mastery of literacy skills can be described in terms of generalized stages, children may pass though these stages in a variety of ways and at different ages. According to this view, literacy learning does not happen only in formal classroom settings, but also in informal settings, in both oral and written modes, and in collaboration and interaction with others.

Whitehurst and Lonigan (1998) distinguish between the "inside-out" and "outside-in" skills of literacy. Inside-out skills are concerned with children's phonological and syntactic awareness, and grapheme-phoneme correspondence, thus facilitating children's ability to decode information within a sentence. Outside-in skills are concerned with children's ability to take the meaning of a sentence from the context in which the sentence is placed. For example, when reading the phrase, "Then she ate the poisoned apple," the child must understand who "she" in the phrase refers to and what the speaker means by "the poisoned apple." Therefore, children must bring their knowledge about the world and apply that to the text. Children need both inside-out and outside-in skills for successful literacy learning. However, with development, the outside-in skills become increasingly important to children, as literacy learning is concerned more with comprehending text, and not just with the decoding of letters in the text (Snow, 1983; Whitehurst & Lonigan, 1998). These outside-in skills of literacy – children's knowledge about language and how it works in a given context – are what concern us in our research about the kinds of language activities important for the transition between pre-school to school.

Young children's language is initially limited to concrete here-and-now talk. Early words rely on physically present objects and scaffolding from a familiar conversational partner with whom the child can assume shared knowledge (Ninio & Bruner, Nelson). Thus, the acquisition of outside in skills, which requires gaining independence from physical and temporal context, marks a significant transition in a child's literacy development.

Snow (1983) introduced the term "decontextualized language" to refer to language that is not bound to spatial or historical context. According to her work, children not only have difficulties with reading or writing, but also have trouble dealing with decontextualized language. She hypothesized that language activities involving decontextualization, even oral language activities, would be difficult for children.

Storytelling, then, provides an ideal forum for children to practice decontextualized language since it avoids any laborious writing tasks. Rather than concrete "here-and-now" talk, storytelling encourages the use of "then-and-there" language (Scarlet & Wolf). In order to tell a comprehensible story for the audience, children must be able to hold the audience's perspective in mind and reconstruct the original context (Cameron and Wang, 1998). Children learn these skills through interaction with both adults and peers. We now turn to a discussion of the unique contribution learning partners, both peer and adult, have in literacy learning.

Learning with Adults

Vygotsky defined the zone of proximal development as "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (Vygotsky, 1978, p.86). According to this theory, a child performs at a higher developmental level of abstraction and performance with a knowledgeable and skilled partner than she would achieve independently.

Adults serve as the competent partner in emergent literacy activities to support children's literacy learning. With parents and teachers, children engage in many different kinds of conversations

together: exchanging information, disciplining, socializing, and showing feelings. Within those various types of conversations, children are given opportunities for syntactic planning, careful lexical selection, making explicit cross-utterance relationships, and integrating successive utterances into a particular structure (Nelson, 1996). For lexical selection, the use of rare words during parent-child book reading has been shown to correlate with children's vocabulary acquisition (Snow, 1993). Dickinson, Cote, and Smith (1993) found that preschool teachers' use of rare words during meal time and in free-play settings were positively correlated with story understanding and definitional abilities (such as a cat is a kind of animal) in addition to vocabulary growth.

Another distinctive characteristic of the adult in an adult-child learning situation is the adult's potential control over the child. Adults are mature individuals with more expertise and experience. When interacting with children, these characteristics allow them to assume the dominant role and deliberately manage the shared activity (Daiute & Dalton, 1993). In problem solving, adults not only know strategies, but also know *how* and *when* to use them (Rogoff, 1990).

It is important to note that children are sensitive to the presence of adults. Children pause their activities when they become aware of being watched (Rogoff, 1990). For example, the levels of interaction in 5-year-old and 8-year-old peer dyads were reduced when adult observers were present (Brody, Stoneman, & Wheatley, 1984). As adults usually assume the role of leader or teacher in adult-child interaction, knowledge is passed down from adult to child in a linear fashion rather than co-constructed by the participants who are both seeking answers (Damon & Phelps, 1988).

Learning with Peers

In contrast to adults, a learning companion can be characterized as someone of a similar developmental age who understands the world in similar ways (Damon & Phelps, 1988). For this reason, a peer partner does not bring the sophisticated strategies and knowledge that an adult partner would. Learning with peers is more heuristic than rule-oriented. Children working with peers may settle for an ungrammatical use of language or may not come to a solution or conclusion simply because they forget to do so (Neuman & Roskos, 1990).

Despite these drawbacks, peers offer a unique learning opportunity for children that learning with adults may not. While parents and teachers may not always be available to listen to children's everyday stories, peers are available and can also offer scaffolding to their co-equal status partners. Researchers have observed children's directing and criticizing behaviors in pretend play using puppets in both naturalistic kindergarten environments (Paley, 1984) and experimental conditions (Pellegrini, 1987; Morrow, 1990; Roskos & Neuman, 1993). Neuman and Roskos (1991) investigated how children provide the kind of expert-to-novice scaffolding adults provide in literacy activities. Neuman and Roskos observed children engaged in instructional conversation with their peers – designating, negotiating, and coaching each other's literacy activities. Similarly, Stone and Christie (1996) found that children engaged in collaborative behaviors to help each other in literacy activities. In their mixed-age, K-2 classroom, they found children helping each other by modeling, inviting, assisting, directing, tutoring, negotiating, affirming, and contradicting each other in literacy activities. Results from these studies suggest that the combination of literacy-enriched play environments and older primary-grade children in a mixed age play setting stimulates literacy behaviors. In addition, Christie and Stone (1999) have shown with their studies of multi-age classrooms that even younger children (supposedly less capable ones) sometimes offer assistance to older and more capable ones. Children often took turns being the more capable peer according to the purpose of the play. Peer interactions are more complicated than a one-way transmission of knowledge from an expert to a novice, involving more "multi-directional" interactions (Christie & Stone, 1999). In her study comparing peer-to-peer with adult-child interactions, Daiute confirmed that children directed their peers (e.g. "Do it like this.") 20 times more frequently than they did with adults (Daiute et al., 1993). These behaviors of directing and assisting a peer indicate not only that children can provide scaffolding to their co-equal status partner, but also that peer interactions

offer a forum for the participants to explain and clarify *what they mean*. According to Daiute et al., through such explaining, children linguistically externalize their thoughts and ideas towards their peer, which is key to producing audience-based language.

It is through dialogue with peers that children come to realize the unique functional potential of the various symbol systems in their society, including reading and writing (Vygotsky, 1978). In a comparison of collaborative teacher-child writing with collaborative child-child writing, Daiute et al. (1993) found that generally, teacher-child collaboration produced more classic narrative structures than peer collaboration. However, one pattern of teacher talk that was controlling was negatively correlated with more elaborative narrative. Peer collaboration did not produce a more classic narrative structure than teacher-child collaboration, but did produce more elaborated narrative texts. Moreover, engaging in highly interactive peer conversation was positively correlated with the change toward writing in the third person. Thus, as Daiute et al. concluded, the social nature of the interaction around literacy learning is just as important as the absolute expertise of any partner.

RELATED SYSTEMS

New technologies have been developed and proven to improve both reading fluency and other linguistic skills important for literacy. Mostow et al. (1994) used state-of-the-art speech recognition technology to develop a reading tutor that gave appropriate feedback for children reading storybooks out loud. The reading tutor was found to increase oral reading fluency in children significantly. In contrast to Mostow's intelligent tutor approach, the Cognition and Technology Group at Vanderbilt used a situated learning approach in developing their Young Children's Literacy series (The Cognition and Technology Group at Vanderbilt, 1996). A series of anchored animated video stories challenged children to write a story to save the animals they saw in the video. Interaction with both the teacher and peers was key to literacy learning, as the teacher modeled the story writing activity for the children, and children worked together as a group. The series has produced significant improvements in children's word and sentence fluency and story complexity.

We have designed a series of story listening systems (Cassell, 2001). One of our previous story listening systems, StoryMat (Ryokai & Cassell, 1999) was a technologically enhanced play mat that recorded children's oral stories and movements of stuffed animals made on the mat. Those stories were played back on the mat as animations when the same or another child told a story at the same place. Through listening to peer stories on StoryMat, children told more imaginative and structurally advanced stories. Another earlier story listening system TellTale (Ananny & Cassell, 2001) recorded pieces of children's stories into the body parts of a plastic toy caterpillar. Through deciding how to arrange and segment story sequences, children exhibited more sophisticated use of discourse connectives (e.g., "and," "then," "because") and story event language. These systems led us to questions about the potentially encouraging role of a partner's feedback on children's stories; for instance, could we foster children's storytelling skills in a way more specifically helpful for literacy by incorporating a kind of virtual companion who could be a listener of children's stories?

Chan and Baskin (1988) created "learning companion systems" that employed a set of agents – one as an intelligent tutor and the other as an artificial student that was designed to be at about the same level as the student (both agents were non-embodied). The idea was that a student would learn from an intelligent tutor (in regards to programming LISP), but then was asked to teach the artificial student (learning companion) what he learned. By having the two tasks – learning by being tutored and tutoring, these learning companion systems offer a learning protocol that is similar to "reciprocal teaching" (Palincsar & Brown, 1984) in which children take both the teacher's and learner's role. While their preliminary results did not show significant improvements on problem solving tests, their interviews revealed that the students enjoyed teaching an agent over a real student because they felt it was like a game.

Technology to provide opportunities for children to learn by teaching others was explored further by Brophy and his colleagues in the Teachable Agent project (Brophy et al., 1999). In their system, children learned ecology by teaching it to a naïve cartoon character. Brophy et al. found that children who studied in order to teach the agent did better on the post test than control children who studied just for the subject test, as the students who prepared to teach spent time trying to understand "the why" of the studies.

There seems to be an advantage in making technology play a more social role in supporting children's learning. In literacy learning, such social interactions are important as they provide opportunities for children to gain knowledge about language and communication, and also to test their knowledge about language.

SAM

We created Sam in an attempt to give technology a social role in supporting young children's literacy learning (Cassell, 2001). The Sam system has two parts: the character Sam, an embodied conversational agent who is designed to look like a child around age 6, and a toy castle with a figurine. Sam's androgynous appearance (and accordingly, the name, Sam) was chosen intentionally so that both girls and boys could relate to Sam. For the sake of simplicity, in this article, we will consider 'Sam' a female peer.

Sam is projected on a screen behind the castle, and can both listen to a child's stories and tell her own. The figurine can exist in either the physical world or on the screen, so that Sam and the child can pass it back and forth between their worlds (Cassell et al., 2000). When a child arrives in front of the toy castle, Sam looks at the child and says, "Hi, I'm Sam!" After the child greets Sam, Sam tells a story as she moves the figurine around the castle, occasionally looking up to draw the child in to the story. When Sam finishes her story, she says, "I'll put the toy in the magic tower so you can tell a story," and places the figurine inside the tower. When the child opens the door, she finds the figurine Sam had been playing with and tells her story. While the child does so, Sam watches the child (following where the child is moving the figurine with head and eye movements), nodding, smiling, and prompting, "And then what happens?" When the child is done, she places the figurine back in the castle where Sam can access it.

Sam then starts her story in the same part of the magic castle where the child finished hers. Sam tells stories using more advanced forms of linguistic expressions (quoted speech, and enough temporal and spatial information for the audience to be able to reconstruct the story). In Vygotsky's terms, children learn through their participation in activities that are slightly beyond their competence, with the assistance of adults or more skilled children. Thus, by interacting with a peer who tells stories in a developmentally more advanced form than the child, the child may enter his/her "zone of proximal development" (Vygotsky, 1978). Our hypothesis is that by interacting with precocious Sam and listening to Sam's developmentally advanced stories, children model Sam's linguistic behavior and therefore, perform their storytelling task in a more mature form themselves. However, in addition, Sam's young appearance and playful environment (with the toy castle) may invite children to critique Sam's behavior, giving them an opportunity to externalize their thoughts and communicate their points using language. Our intention is for Sam to provide just the right amount of challenge. Sam's storytelling is more advanced than the child's, but not too advanced, as she is a partner who is just a head taller than the child.

Technical Implementation

The Sam system detects a child's presence through a microphone and a motion detector sensor in front of the castle. When the child is playing with the toys and narrating, the system uses audio threshold detection to determine when to give feedback (backchannels such as "uh-huh" nods, and explicit prompts such as "and then what happens?"). Swatch RFID tag readers are embedded inside of every room in the castle. The tag attached to the figurine tells the system which room in the castle the figurine is at. A switch in the door tells the system whether the figurine is inside of the magic tower and when the magic tower door is opened, so that the child

will never see the physical and virtual instantiations of the toy simultaneously (when the door is opened and Sam has the figurine, it disappears instantly and Sam expresses surprise). In order to make Sam's character believable, Sam's stories and other utterances were recorded from a real child, as the quality of children's synthesized voices is still poor. The software is written in Java and C++ and can run on a single PC with a graphics acceleration card. The animation is displayed on a back-projection screen behind the castle.

SAM STUDY

We designed a study to observe how Sam's presence and behaviors affected a child's use of decontextualized language, compared to children who played without Sam in a similar context.

Twenty-eight children (all female and aged five) volunteered for the study. Five year-old children are at the transition between pre-school and school. In a 2x2 design, eight children played alone with a castle without Sam, eight children played alone with a castle with Sam, six children played with a co-present playmate with a castle but without Sam, and six children played with co-present playmate with a castle and with Sam. The study was done in a "Wizard of Oz" setting where Sam's response was controlled by a researcher behind the screen. All children played for approximately 15 minutes: 5 minutes introduction with an experimenter, and 10 minutes play session on their own. All the children's 10-minute play sessions were transcribed.

Sam as a Capable Partner

First, we looked at Sam's role as a capable partner. In taking turns with Sam and listening to Sam's stories, children seemed to use and explore linguistic expressions important for literacy learning. The following is an example of a child interacting with Sam:

Ann (age 5) is telling stories with Sam by herself

SAM: OK. Let me start. Today I'm going to ride horses in the meadow. My parents said I could ride the big horse named Star. Oh, no. Star has been stolen. I better go tell the sheriff. "Oh, sheriff, my favorite horse Star has been stolen and I don't know where she is." "Oh, no. No need to worry. A kind old lady from the other side of the forest has found her, and she is just coming back home." "Yippee! Thanks. Come on, Star."

SAM: I'll put the toy in the magic tower so you can tell a story.

ANN: Once upon a time there was a little girl and she went downstairs. She looked in the magic mirror. She went downstairs and looked in the mirror. And turned on the lights, and then went back up the stairs. And she looked at her magic, and she looked in the magic mirror, then went back downstairs, and there was her mom and dad. The end. Your turn to tell the story.

SAM: Cool! OK, let me start. I'm going to have a party and I'm going to invite whoever I want. My mom, the queen said I could. Oh look! Here Chris comes. I'm going downstairs to meet him. "Hi Chris, you're the first one here. What do you want to do?" "Well, we can go ask the mirror, who is going to come to your party?" "Oh yeah. Oh, mirror, who is going to come to my party?" "Oh, people from all the way over the land." "Oh yeah. Here, I see Cheryl, Brad, and Sean. Oh, this is going to be a great party." I'll put the toy in the magic tower so you can tell a story.

ANN: Once upon a time, there was a little girl who wanted her mommy and poppy, but she didn't have one so she could do anything she wanted. She hopped downstairs and then she saw the, she went upstairs and told the magic mirror that she wanted a mama and papa. The magic mirror told her that she couldn't get one. So she went back downstairs and she saw a monster. She went back upstairs to the magic mirror and said, "Magic mirror, why there's a monster?" and she went back downstairs and there wasn't a monster anymore. The end!

Ann took turns with Sam, listened to Sam's stories, and in that process, seemed to tell her stories with increased complexity. In her first turn, Ann's sentences were fairly simple. Her speech may be categorized as an eventcast (i.e. the form of "then she went there, and then she went there...") rather than a story with a causal connection between clauses (Labov, 1972).

Sam's stories were designed to involve complicating actions (e.g. losing a horse) and resolution of stories (e.g. finding the horse). They also modeled decontextualized language, such as quoted speech (e.g. "Oh, sheriff..."), temporal expressions (e.g. *today* I'm going to...), and spatial expressions (e.g. a kind old lady from *the other side of the forest*), and relative clauses (e.g. the big horse named Star) that help the audience reconstruct the event. In the example above, hearing Sam's stories seemed to encourage Ann to use such decontextualized language (e.g. "a little girl who wanted her mommy and poppy") and quoted speech (e.g. "she said, 'Magic mirror...'").

A team of two researchers coded the occurrence of spatial expressions, temporal expressions, and quoted speech in the children's stories. Following Peterson, Jesso, and McCabe (1999), a spatial expression was coded as definite information about *where* the event took place (e.g. "then the boy went to the *kitchen*") and temporal expression as explicit information about *when* the event took place (e.g. "he went downstairs *when he heard the noise*"). For the quoted speech, we coded for both direct speech with a framing clause (e.g. then she said, "Oh no!") and indirect speech such as "he said that he wasn't hungry" (Hickmann, 1993). The occurrences were tallied, and the numbers were then normalized with respect to the time each child had to tell her story.

Sam's presence as a storytelling partner dramatically increased the frequency with which children used quoted speech and temporal and spatial expressions. Figure 3 shows the mean frequency (tally of occurrences of expressions by each child / total time that child spent speaking) of spatial expression across the four conditions. Thus, for the dyads, the bar represents the mean frequency for each of the children in dyads. A full-factorial ANOVA revealed a main effect due to the presence or absence of Sam, $F(3, 24) = 68.04$, $p<.01$. There was no main effect for number of children (the one child vs. the dyad condition), nor were there any interactions. Children used significantly more spatial expressions when playing with Sam than they did alone, or with another child. Findings were equally significant for quoted speech ($F(3, 24)=10.58$, $p<.01$) and temporal expressions ($F(3, 24) = 30.52$, $p<.01$). The children in the "dyad with Sam" condition had equally high frequencies of quoted speech and temporal and spatial expressions as in the "one child with Sam" condition. This suggests that Sam succeeds in evoking decontextualized language even in the presence of a real flesh-and-blood playmate.

Were the children's uses of literate expressions attributable to the fact that Sam modeled these behaviors? In order to examine this question, we looked at whether the literate expressions increased over the course of the interaction with Sam. Remember that as the children took turns with Sam, every one of their stories was preceded and followed by a story by Sam. Figure 4 illustrates the mean number of spatial expressions per story produced by the children in the "one child with Sam" condition. The figure illustrates the increased amount of spatial expressions as the children tell their stories with Sam: the first story contained a relatively low number of spatial expressions, yet the number doubles and triples over the course of a child's interactions with Sam. The Pearson product-moment correlation test revealed a significant positive correlation between the chronology of stories and occurrence of spatial expression, $r=.35$, $p<.05$, and of quoted speech ($r=.27$, $p<.06$). No significant correlation was found for temporal expressions ($r=.065$). However, if one looks only at the first three stories, the use of temporal expressions increases significantly successively. This suggests that children may have become tired after the third interaction and were no longer able to push their linguistic behavior to its limits.

The result suggests that Sam did succeed at eliciting more literate language from children over time. However, the duration of the study is not sufficient to conclude that the children actually *learned* these behaviors from Sam. Perhaps, the children already had the ability to use decontextualized language, but did not necessarily know when or why to use it. In that sense, Sam may have helped the children bring out the best of their ability. By telling stories in a developmentally advanced way, Sam modeled the use of literate expressions and provided an opportunity for the children to practice them. A future study will investigate children's interactions with Sam over a longer term in order to determine how repeated interactions with Sam affect children's development.

Conversation vs. Storytelling

Pairs of children who played with the castle without Sam treated each other as conversational partners rather than taking turns being the storyteller and the story listener. In the example below, the two children engage in fantasy/pretend play (i.e. the two children seem to be pretending to be at a house with a ghost) and move seamlessly between talking to one another as characters in a shared story, and as children in shared play:

Wendy and Sarah (both age 5) are playing without Sam

Wendy: You broke this after I had fixed it.
Sarah: Not me.
Wendy: It's probably the ghost.
Sarah: There's no such thing as monsters. Did that door just open, or was it just my imagination?
Wendy: It was just your imagination.
Sarah: No. I think it was just the wind. I'm having nightmares.
Wendy: Me, too.
Sarah: I want to sleep. I want to sleep. I hope I am.

While the two children are engaged in a conversation, instead of storytelling, their speech is more dependent upon contextual cues. For example, the child did not introduce or explain what "this" was in the utterance "You broke this..." because the referred item was immediately shared with her partner and in their conversation. The children who played with Sam also shared the physical context with Sam (e.g. sharing the castle). However, Sam explicitly invited the children to tell stories and modeled decontextualized storytelling behavior. Further, because Sam's method of narration did not rely on contextual cues, the children's narration also became less context-dependent. In a way, the children and Sam shared the same invisible audience. Therefore, Sam's presence as a partner who took turns with children and told stories using diverse linguistic expressions appears to have been important in making the stories more sophisticated, fostering children's use of linguistic expressions in storytelling.

Sam as a Storytelling Partner

As discussed earlier, Sam is an attempt at having technology play a social role in supporting children's storytelling. So how did the children behave toward Sam? As if Sam were a computer or a playmate?

The children regarded Sam as a storytelling partner. This was evident both from how the children took turns with Sam and from various comments directed at Sam. The following example is a typical turn taking behavior between a child and Sam:

Ann (age 5) is playing alone with Sam. Sam finishes her story and gives the turn to Ann.

SAM: I'll put the toy in the magic tower so you can tell a story.
ANN: Once upon a time there was a little girl and she went downstairs. [eye gaze at the toy she is telling her story with] She looked in the magic mirror. She went downstairs and looked in the mirror. And turned on the lights, and then went back up the stairs. And she looked at her magic. And she looked in the magic mirror, then went back downstairs, and there was her mom and dad. The end. Your turn to tell the story. [gaze back at Sam]

After finishing her story, Ann acknowledged Sam's turn by looking at Sam and saying, "Your turn to tell the story." Ann then put the toy back to the magic tower for Sam to take it away. Many children acknowledged Sam's turn by giving similar "Your turn!" acknowledgement. When things were not clear, as in the following example, children seemed to "ask" Sam questions as if to check if Sam was OK:

Simone (age 5) *is playing alone with Sam.*

SAM: Cool! OK, my turn. Today I'm going to ride horses in the meadow. My dad, the king, said I can ride a big horse named Star. Oh, no! Star has been stolen! I better go tell the sheriff. Oh, sheriff, my beautiful Star has been stolen and I don't know where she is.

Oh, no. No need to worry. A kind old lady from the other side of the forest had found her. She is just coming back now. Whee! Thanks. Come on, Star. [pause]

SIMONE: You done, Sam? [pause] OK.

SAM: I'll put the toy in the magic tower so you can tell a story.

SIMONE: What should I tell, Sam? Do you have an idea? [gaze Sam] Hmmmm. [gaze away]

SAM: Tell me what happens next.

SIMONE: Oh, the girl was happy. She came back from, her husband was there, she was very happy. Everyone, I mean everyone knew she was a good girl. She always had fun playing with her sisters.

SAM: Cool.

When Sam finished her story but did not immediately give up her turn, Simone asked Sam, "You done, Sam?" before she took her turn. Simone also seemed to consider Sam as a fellow collaborator. When Simone was thinking about what to tell, she looked at Sam and asked, "What should I tell, Sam? Do you have an idea?" Then, she gazed away while she thought about what to tell, a behavior one might observe from two real peers. Thus the children not only regarded Sam as a fellow narrator, but also treated Sam as if she was a real child. Although we have only preliminary results on eye gaze patterns used by children in the study, our observation leads us to believe that children looked back-and-forth from Sam to the castle in similar ways as they did when they were playing with another child. And, in fact, even with a co-present playmate, children seemed to take Sam into account. The following is an example from two children playing with Sam:

Amy and Beth (both age 5) are playing together with Sam. Beth has already told her story. Now Amy is telling her story.

AMY: And she ran upstairs. And she ran upstairs again. So, they didn't find her. And then they were surprised that it was all messed up. And they didn't even know who it was from. So, then, she came back down. And they said, Annabelle. Did you do this? And she said, no. And she was lying.

BETH: So, her nose went big?

AMY: So, then, the mother and father put her bed.

BETH: Because she lied?

AMY: Because she lied, and because she wasn't supposed to do that.

BETH: OK. My turn.

AMY: Sammy. I want Sammy to do it. I'll put it back. [Amy puts the toy in the magic tower for Sam to take her turn]

The two children seemed to collaboratively tell a story. While Amy is the main storyteller, Beth scaffolded Amy by giving some ideas (e.g. "What about Anna?" "Because she lied?"). When Amy finished, Beth tried to take the turn. However, Amy turned things over to Sam. Thus, even with a co-present playmate, the children seemed to take Sam into account. In everyday storytelling, children become collaborators and facilitators of peer narrations (Preece, 1992). Thinking about Sam's turn and acknowledging Sam's role as a fellow collaborator is similar to what children go through with peers in everyday collaborative storytelling. Literacy learning is more profound in situations where children assist each other or collaboratively engage in activities than it is in parallel or solitary behaviors (Stone & Christie, 1996). In our experiments, Sam seemed to play the role of an engaging peer, and was thus able to elicit linguistic behaviors predictive of future literacy.

Teachable Sam

Unlike the Teachable Agent project (Brophy et al.) in which the agent was specifically designed for students to teach, Sam was not explicitly designed to elicit help from children. However, Sam was designed to appear as a child to the children who play with her. In effect, children not only seemed to regard Sam as a storytelling partner to model after, but also as a peer they can coach. While interacting with Sam, children spontaneously helped her by making various comments about her stories and behaviors. The following is an example of a child "coaching" Sam:

Jane (age 5) *is playing alone with Sam.*

SAM: Now what happens?

CHILD: It's like this. Now it's a girl. Hi. The little girl went, the little prince he went downstairs and he got all dressed and stuff and then he went outside and it was all muddy and rainy but the prince had a rainsuit, but his shoes, no way. Then he went back inside and made it all dirty everywhere. And then when he was playing on the lamp he made the lamp all dirty. Then he realized. He went outside again. He said, that's a wonderful oh-oh. My parents aren't going to like this. So he went in the house, cleaned up. He took his shoes off outside, threw them under the dump, threw them in the dump, cleaned everything. Got to do this before my parents get home. Uh oh. Clean. There! Oo! Uh oh. So he took it up and then he lived happily ever after. Happily. Now it's your turn. And then he went to the farm. And he was like, hmm, good story. Then he comes back down and he gets caught in one of these and then he went back up and he goes, hmm. Then he lived happily ever after. Turned out his light, went to sleep [UNINTELLIGIBLE PHRASE]. And a moth creeped in his room and almost bit at him and he went ahh! ahh! and he used some magic and [UNINTELLIGIBLE PHRASE] and then he went to sleep and his family and everyone lived happily ever after. The End. Now it's your turn.

SAM: Cool. OK, my turn. One day me and my friend were playing around and we heard this loud cry, EEE! We found a bug next to him. We carried the bug outside. We thought Sean was a big brave person and we didn't know he was scared of bugs. Well, my horse Star is scared of cats. And so as Lucky, my dragon. Well, I'm not afraid of anything. I'm pretty tough. [pause] I'll put the toy in the magic tower so you can tell a story.

JANE: [talking to Sam] Try to make a longer story next time. It's like this. The little boy was outside. He flipped all around and he went inside, he did a flip, he whanged and he went ow! and he went ow, ow, ow, ow, ow! [...]

In response to Sam's story, Jane told a relatively long story. After listening to Sam's story, Jane went on to model what she was looking for. "It's like this," she told Sam and then told her own, longer story, thereby coaching and modeling for Sam how to be a better storyteller.

The following is another example of a child correcting Sam:

Ann (age 5) is playing alone with Sam. Sam tells a story which Ann has heard before. Ann interrupts Sam and comments that Sam has already told that story before.

SAM: OK. My turn. I love dancing with the music. [...] They said that the lady from the other side of the forest was going to come, but she didn't show up.
ANN: You already told that story!
SAM: So, many people until my parents said I have to go to bed.
ANN: Sam!
SAM: I could have danced all night. When I grow up, I'm going
ANN: Sam, you already told that story. You can still tell it though. Go ahead. [pause]
SAM: I'll put the toy in the magic tower so you can tell a story.
ANN: OK. Let's see. [pause]
SAM: Why don't you tell me a story?
ANN: Just a minute, Sam.

Ann carefully observed that Sam had already told the story before. Ann acted as a corrector of Sam's storytelling, but did so politely, allowing Sam to finish her story. In everyday storytelling, children become not only collaborators and facilitators, but also active critics and correctors of peer stories (Preece, 1992). Accordingly, Jane and Ann, in the above examples, became critics and correctors of Sam's storytelling. Sam seemed to act as a co-storyteller, but also a peer the children felt responsible to critic and coach. By coaching, not only do peers provide substantive input to one another's learning (Cazden, 1988; Rogoff, 1990; Neuman & Roskos, 1991) but also practice verbalizing their thoughts (Youngblade & Dunn, 1995). Therefore, children's interactions with Sam, both as co-storyteller and as critic, may contribute to them becoming critical thinkers who can evaluate and challenge others' linguistic behaviors while reflecting on their own knowledge.

Sam as a Facilitator of Peer Interactions

Sam does not only play nice with a single child but also facilitates interactions among dyads of children. Using Stone and Christie's labels of collaborative behaviors (1996), we measured the

number of collaborative behaviors the children exhibited towards their partner during their play session. We categorized the collaborative behaviors into two types: *story* and *non-story*. Collaborative behaviors that were labeled as "story" were comments about the on-going story (e.g. "pretend that she was eaten but she escapes"). Collaborative behaviors that were labeled as "non-story" were about any topic except the on-going story (e.g., "I have a toy like this"). Figure 5 summarizes the results.

The children in both the "dyad with Sam" and "dyad without Sam" groups exhibited collaborative behaviors. However, the nature of the collaboration differed between the two groups. The children in the "dyad with Sam" group engaged in more "story" collaborations (M=7.5) than "non-story" collaborations (M=2), $t(5)=3.18$, $p<.05$; that is, they more often helped each other by commenting on one another's stories. The children in the "dyad without Sam" group, on the other hand, engaged in more "non-story" collaborations (M=5.67) than "story" collaborations (M=1), $t(5)=-12.79$, $p<.01$; that is, they more often commented to each other on things not related to the target task of storytelling. With Sam, then, the children talked more *about* storytelling than without Sam. Sam engaged children more fully in collaboration related to storytelling.

Limitations

Sam successfully engaged the children in collaborative storytelling (i.e. taking turns being a listener and a storyteller. However, the primary limitation of the current Sam system arises from Sam's inability to understand the content of the children's speech. Since Sam uses silences to determine when it is her turn to speak, when she does not detect a silence, or incorrectly detects a silence, her feedback can appear inappropriate. Likewise, children may understand Sam's silences as a cue for them to take the turn, and Sam is unable to recover from this and give over the turn gracefully. The following example illustrates some of these misplaced turn cues on the part of both participants:

Simone (age 5) *is playing alone with Sam.*

SAM: Cool! OK, my turn. Today I'm going to ride horses in the meadow. [...] She is just coming back now. Whee! Thanks. Come on, Star. [pause]
SIMONE: You done, Sam? [pause]
SIMONE: OK.
SAM: I'll put the toy in the magic tower so you can tell a story.
SIMONE: What should I tell, Sam? Do you have an idea? [gaze Sam]
SIMONE: Hmmmm. [gaze away]
SAM: Tell me what happens next.
SIMONE: Oh, the girl was happy. She came back from, her husband was there, she was very happy. Everyone, I mean everyone knew she was a good girl. She always had fun playing with her sisters.
SAM: Cool.

Somewhat surprisingly, given Sam's misplaced response behavior, Simone still continued to engage in collaborative behavior with Sam, asking, "What should I tell, Sam? Do you have an idea?" These attempts at conversation with Sam were common occurrences. Sam's very presence behind the castle, and fledging attempts at interaction, appeared to suffice for children to enter into the game of storytelling. Yet, without understanding the child's speech, Sam could not follow up on the children's conversations, nor respond to particular stories that children decided to tell.

In this first study of Sam's interaction with children, we addressed a limited number of research questions. First of all, the study was limited to 5-year-old girls. Would this kind of storytelling play and interaction with Sam and her toy castle engage both girls and boys equally? What age range does this type of storytelling effectively engage? Secondly, the children in the study played with Sam only once and for only fifteen minutes. In order to investigate whether children really learn new linguistic skills from interaction with Sam, we need to prolong children's interactions with Sam in the short and long term.

FUTURE WORK

The results of our study with children revealed a number of possible modifications and improvements. Firstly, we believe Sam's response behavior can be improved. In order to increase the perspicacity of Sam's responses to children's speech, we are investigating keyword spotting speech recognition technology. In addition to speech input, Sam's toy castle is being enhanced with more sensors to follow movements children make while they are narrating. For example, movement of furniture in the castle while children tell their story may be cues for Sam to give feedback to their actions.

Secondly, Sam's modeling behaviors can be pushed further so that Sam models more developmentally appropriate language skills for children. Sam's stories have already been re-written and re-recorded to exhibit more of these skills such as decontextualized language (e.g. spatial and temporal information of stories). A recent study has shown that children's ability to take multiple perspectives in storytelling is positively correlated with their mathematical skills (O'Neill & Pearce, 2001), so Sam's new stories will also include narrative perspective taking. We believe Sam could model such perspective taking by introducing and maintaining different characters in her stories. To encourage such perspective taking, we have now also incorporated multiple figurines so that Sam and children can tell stories with multiple perspectives using the figurines.

To carry out a longitudinal study, Sam's interactions with children also need to evolve over time. For example, Sam cannot simply greet "Hi, I'm Sam!" every time a child plays with her. How could Sam establish a long-term relationship? A study has shown that friends, compared to non-friends, resolved more conflicts and performed better at emergent literacy activities during pretend play (Pellegrini et al., 1998). Can Sam be a friend to a child? We plan to investigate the kind of interactions and relationships Sam could have with children over a longer term.

Finally, we are in the process of evaluating which aspects of Sam contribute to its success as a literacy learning companion: a linguistic model for the children, or a peer who promotes constructive criticism and perspective taking. For example, does Sam's child-like appearance make children more comfortable to critique Sam's stories and behaviors? In order for Sam to produce the positive effect of multi-age collaboration where children learn by both modeling and coaching their peer (Christie & Stone, 1999), we need to have a more explicit model of a peer who could both teach and be criticized. With a more explicit model of Sam as a peer, we plan to further investigate children's literacy learning with Sam.

DISCUSSION

Sam became a partner for children to model their own stories after, as well as a peer in need of didactic coaching. In coaching situations, Sam attracted more directed comments on the topic of storytelling.

By listening to Sam's stories and having Sam as their listener, children became both active storytellers and critics of others' stories. The role of Vygotskian "more capable partner" changed fluidly between Sam and her human playmate, just like it does between real peers. This type of role change resembles a reciprocal model of peer assistance where children take both the teacher's and student's roles (Palincsar & Brown, 1984; Cazden, 1988), beneficial for collaborative learning in general.

Sam was able to model and draw children's attention to linguistic behaviors crucial for literacy. By taking turns with Sam and by listening to Sam's stories, the children's stories became more sophisticated and explicit through the use of quoted speech and spatial and temporal expressions. In effect, children practiced ways of clearly presenting narrative ideas an audience, which is one of keys to literacy learning.

Unlike traditional Computer Assisted Learning, where computers are enlisted to support learning between a teacher and pupils or to support collaborative learning between pupils, this work explored the role of computers as *participants* in collaborative learning. This work contributes to

the field of Computer Assisted Learning as it illustrates how computers could play a more social role in supporting young children's literacy learning by both scaffolding and reproducing social learning environments.

ACKNOWLEDGMENTS

We thank all the children who participated in the study, the administration of the Thompson School (especially the wonderful Vicky Rose), Linda Lin, Elisabeth Sylvan, Dona Tversky, Ian Gouldstone, and the members of the Gesture and Narrative Language group at the MIT Media Lab.

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