Playing with Virtual Peers: Bootstrapping Contingent Discourse in Children with Autism

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Abstract: In this paper, we describe an intervention for children with social and communication deficits, such as autism, based on the use of a virtual peer that can engage in tightly collaborative narrative. We present a study in which children with autism engage in collaborative narrative with both a virtual and a human peer, and the use of contingent discourse is compared. Our findings suggest that contingent discourse increased over the course of interaction with a virtual peer, but not a human peer. Furthermore, topic management, such as introducing new topics or maintaining the current topic, was more likely to occur with the virtual peer than with the human peer. We discuss general implications of our work for understanding the role of peer interactions in learning.

Introduction

It is well documented in the learning sciences that students can benefit from productive interactions with their peers. Increasingly, research has sought to understand how individuals learn in social interaction, aiming to leverage these interactions to improve learning outcomes. Theorists have argued that students can most effectively learn from their peers in a variety of capacities; a more capable peer can provide guidance, a less capable peer can be taught, or a collaborative partner can negotiate (Rogoff, 1990). Researchers have also examined the advantage of peer interactions in school disciplines such as math and science (Cobb et al., 2001) and language learning (Blum-Kulka et al., 2004). Finally, a number of learning technologies have been designed to take advantage of the benefits of peer interaction for learning, including computer-supported collaborative learning environments (Koschmann, 1994), pedagogical agents (Baylor, 2002) and virtual peers (Cassell et al., 2000).

What these different research programs all have in common, however, is an underlying reliance on students' ability to interact with each other and learn through these interactions. However, for some children, such as those with autism spectrum disorders (ASD), social and communicative deficits make it difficult for the children to learn through peer social interactions. These children are not only missing out on valuable learning opportunities, but their social skills deficits affect their personal relationships, education and future employment opportunities (Webb et al., 2004). Peer relationships are found to be particularly challenging for individuals with ASD (Travis & Sigman, 1998); both adolescents and adults with ASD report fewer friendships with peers (Orsmond et al., 2004). Indeed, finding ways to develop peer social interaction skills is critical to the success and well-being of individuals with ASD.

Productive interaction with peers requires the abilities to make oneself understood to another person and to behave in ways that demonstrate reciprocity, mutuality and common goals in conversation. Productive interactions therefore rely on *contingency,* the ability to maintain a conversation such that what a person says follows from what was previously said. Previous research has shown that when children with ASD interact with adults, they are less contingent and show differential use of contingent discourse compared with other children (Tager-Flusberg & Anderson, 1991). The current study introduces a new type of technological tool to support the development of exactly these aspects of peer social interaction skills. We describe a study that evaluates virtual peers (Cassell et al., 2000) – life-sized computer-animated, interactive children – as a way of facilitating contingent discourse.

In what follows, we describe autism spectrum disorders and how previous research uses peers, narrative and technology to support children with ASD. On the basis of this prior work, we claim that collaborative narrative with a virtual peer should be a promising task for addressing the communication and social deficits of autism. We describe a study that compares children telling stories with a human peer and a virtual peer to apply this hypothesis to a specific skill: contingent discourse. Finally, we discuss the more general implications of our work for an understanding of peer interaction and learning.

Autism Spectrum Disorders

Autism is a developmental disorder characterized by a triad of impairments in communication, social interaction, and repetitive behaviors and interests. These impairments translate to difficulty understanding and conveying meaning, expressing and reading emotions, using nonverbal behaviors, and participating in interpersonal imaginative play. Levels of functioning vary greatly among individuals with ASD. While some children have no functioning language, our focus is on children with high-functioning ASD and other related developmental disorders, such as Asperger syndrome. These children have verbal abilities, but have difficulty with pragmatics – using language to convey meaning in a communicative context. These pragmatic abilities are critical for initiating and sustaining peer reciprocal social interaction.

In this study, we are specifically focusing on *contingency* – a vital aspect of pragmatics and a skill that underlies any social communication (Tager-Flusberg & Anderson, 1991). Children with ASD tend to maintain conversations using repetition, non-contingent responses, and routinized, often odd, scripts (Capps et al., 1998). However, research suggests that features of the linguistic environment can promote contingency. Curcio and Paccia (1987) found that contingency of four boys with ASD (ages 7-12) increased as adults in the interaction incorporated "facilitating features" such as yes/no questions or conceptually-simple questions. An important theoretical perspective in autism research is a theory which posits that the deficits of autism reflect an underlying deficit in Theory of Mind (ToM). That is, individuals with ASD have difficulty recognizing that others have beliefs, desires and intentions that are different from one's own (Baron-Cohen, 1995). This view of autism is able to explain a unique pattern of impairments in autism, including the production of contingent discourse (Capps et al., 1998). For that reason, our research relies on a ToM assessment.

Virtual Peers for Children with ASD

Past peer interventions for children with ASD include social skills groups (Kalyva & Avramidis, 2005), peer partnerships with typically-developing (TD) children (Thiemann & Goldstein, 2004) or formal social skills training programs (Webb et al., 2004). TD children are often used in these programs to model or scaffold appropriate behaviors for children with ASD (Kalyva & Avramidis, 2005). Other research describes narrative interventions that use pictures and short narratives to describe relevant clues in social situations and appropriate responses, such as social stories (Gray & Garand, 1993), comic strip conversations (Gray, 1994) and social skills picture stories (Baker, 2001). Collaborative narrative combines the benefits of these two types of tasks by using a peer and telling a story together.

We hypothesize that participating in a collaborative narrative task with a virtual peer will be an effective way to facilitate contingent discourse among children with ASD. Collaborative narrative requires children to work together to tell a story. Children must take turns, listen and respond to their peer's contributions, and make their own contributions to the story. Collaborative narrative is therefore a useful structured task for facilitating interaction between children with ASD and their peers. Storytelling between children with ASD and TD children is, however, difficult because TD children don't have a lot of patience for it, and ASD children avoid it. Yet, while children with ASD avoid social interaction, they appear to enjoy interacting with computers. In fact, technology is often used in instructional interventions for children with ASD. Research has investigated using robot therapies to motivate interactions between children and adults (Dautenhahn & Weery, 2004), virtual tutors for teaching language and literacy skills (Bosseler & Massaro, 2003) and virtual environments for practicing social interactions (Parsons et al., 2004). However, none of these projects engage the children in social interactions *with* the technology as a way of rehearsing these skills. And, none of these technologies are specifically modeled after the kinds of learning that occur during peer social interactions.

Virtual peers leverage the appeal of computer technology while providing a peer context for collaborative narrative. Previous research on virtual peers has demonstrated that TD children can engage in storytelling play with a virtual peer (Cassell et al., 2000). In fact storytelling interaction with virtual peers significantly increases children's literacy and social behaviors (Cassell, 2004). It has also been shown that virtual peers can scaffold learner motivation (Kim et al., 2006). The present work combines what we know about the important role peers play in children's learning with the power of indefatigable technology, to create an instructional tool that harnesses the potential of collaborative storytelling to facilitate contingent discourse in children with ASD. Specifically, we are asking three questions about storytelling, peer social interaction and virtual peers and how they relate to contingency:

1. How do children with ASD engage in collaborative narrative with a TD peer?
2. How do children with ASD engage in collaborative narrative with a virtual peer?
3. Do children with ASD demonstrate different abilities for engaging in contingent discourse with a TD peer and a virtual peer?

While previous work looks at conversation abilities and narrative in children with ASD (Losh, 2003) the focus of that research is mainly children's interactions with an adult, such as a parent, a therapist or the experimenter. Our contribution is an examination of how peers interact and how narrative is co-constructed.

Methods

To address these questions, we used a within-subjects, counter-balanced design that compared children's interactions with a TD peer (the peer task) to their interactions with a virtual peer (the VP task). We analyzed this data for quantitative and qualitative aspects of contingent social interaction, and looked at the *form* as well as the *content* of contingent discourse.

Participants

Data were collected from six children with high-functioning ASD, ages 7-11. Following Ochs and colleagues (2004), we define high-functioning ASD as children with an autism spectrum diagnosis without mental retardation (full scale IQ above 70). All of our participants have phrase language (producing phrases of three or more words, including a verb). These criteria resulted in a group of children with a wide range of abilities, however all participants attend general education classrooms (some children receive special services for part of their day). The children participated at our on-campus lab or at their local schools. Children were matched with a TD peer whom they knew, within one year of their age. Those who came to campus brought a familiar peer with them, and those who participated in their local school were matched with a familiar classmate by their teachers and school psychologists.

Materials

The virtual peer used in the study, Sam, is a life-sized, animated child designed to look around eight-years-old and gender ambiguous (Sam will be referred to as "she" here). One of the virtual peer's unique features is its ability to engage with the child to tell a story. Instead of exchanging complete stories with the child, Sam starts a story and then takes turns with the child to continue the story. Sam is projected on a large screen with a wooden dollhouse and figurines set up in front (Figure 1). A virtual castle appears to extend the physical castle into Sam's virtual world. Sam uses pre-recorded speech and scripted gestures during the storytelling. For this study a "Wizard of Oz" methodology was used, where an experimenter watched the interaction between Sam and the child from a second room, and selected responses from a panel of options. When the child is telling stories with a TD peer, the toy house and figurines are set up in the same manner, but Sam does not appear on the screen. We used four cameras to capture several angles of the interaction.

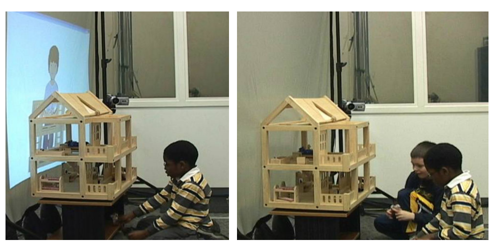


Figure 1: Experimental setup.

Procedures

Children were given a Theory of Mind (ToM) test that consisted of the five questions used to evaluate ToM development of children with ASD (Peterson et al., 2005). The ToM assessment was followed by either the VP task or the peer task, which was then followed by the other task in a counter-balanced design. In the VP task, the children were introduced to Sam and told "Sam loves to tell and hear stories. You can use these toys while you tell stories with Sam. Do you have any questions before you start? … Sam will start the story first." Children told up to four stories with Sam. In the peer task, the children were shown the castle and toys and told, "You can make up stories using these toys. Do you have any questions?" We gave children up to fifteen minutes to tell stories, and then asked if they wanted five more minutes. The instructions in both the VP task and the peer task were intentionally minimal to allow participants to structure the interactions as they chose.

Analysis

The data was transcribed and segmented into utterances. We then annotated the data for two aspects of contingent discourse. The first measure used the contingency annotation scheme from Tager-Flusberg and Anderson's (1991) study of children with ASD. This scheme not only codes for contingent versus non-contingent utterances, but also looks at the *form* of their contingency – how an utterance follows from the previous utterance. For example, are children maintaining the topic simply by recoding what has already been said, or are they adding new information to the conversation through expansions or even opposing what their partner says. Two raters applied the coding scheme. Thirty percent of the data was coded by both raters, and interrater reliability was calculated by dyad using Cohen's Kappa. Kappa ranged from 0.77-0.96.

The second analysis used a measure of appropriate topic management – introducing and maintaining topics in a way that is comprehensible within the context of the prior discourse – to examine the *content* of the discourse in more detail. By examining the topic of the conversation and the function each utterance plays in managing this topic, we are more closely investigating the content of each utterance and how it connects to the content of previous utterances. The annotation scheme is derived from a combination of Brinton and colleagues' (1997) and Edmonds and Haynes' (1988) studies of topic manipulation in children with language impairments. We labeled each utterance as: (1) Topic introduction: initiating a new topic not in the previous discourse; (2) Topic maintenance: matching, acknowledging or incorporating the current topic by adding new information or asking a question; (3) Topic reintroduction: reintroducing a topic that has previously been discussed; or (4) Topic shading: maintaining a portion of the current topic but shifting it to a new direction. Utterances that were purely interactional or backchannel were labeled as such but not included in the analysis. Each utterance labeled with one of the four topic management codes was then labeled as appropriate (comprehensible, socially appropriate and contains referents that are clear within the context of the current discourse) or inappropriate. Thirty percent of the data was coded by two raters, and interrater reliability was calculated by dyad using Cohen's Kappa. Kappa ranged from 0.72-0.94. Unintelligible and incomplete utterances were excluded from the analysis. We used nominal logistic regression to analyze predictors of contingent utterances.

Results

Theory of Mind

For the six participants, a higher score on the ToM test increased the probability of producing some kind of contingent responses (Effect Likelihood Ratio Test: X^2=28.00; p<.0001; nominal logistic regression on 1158 utterances (ASD child with TD peer: 711; ASD child with VP: 447) with factors ToM, relative position of the current utterance, and participant; Whole Model Test: X^2=48.13; p<.0001). These findings support Capps and colleagues (1998) suggestion that ToM ability may be specifically tied to contingency.

Contingency

To analyze predictors of utterances that are contingent, we ran a nominal logistic regression on 2102 utterances (TD child with ASD peer: 944; ASD child with TD peer: 711; ASD child with VP: 447) to evaluate the probability of an utterance being contingent based on a number of factors (Whole Model Test: X^2=121.51; p<.0001), including:

- Speaker: the child with ASD or the TD child
- Partner: for the child with ASD – the human peer or the virtual peer
- Utterance: the relative position of the current utterance (starting at the beginning of the interaction)
- Participant: to control for multiple data points for each participant. This is especially important for children with ASD because of the large variance of abilities among this group.
- Interaction of partner and utterance

We found a significant effect due to speaker (Effect Likelihood Ratio Test: X^2=5.38; p<.03), with a higher probability of an utterance being non-contingent if the speaker was the child with ASD. As expected, this suggests that the children with ASD were less contingent overall (independent of who their partner was). The main effect of partner was not significant, suggesting contingency was not statistically different overall when the child with ASD was telling stories with their human peer or the virtual peer. However, we found an interaction between utterance and partner that was significant only for children with ASD with the virtual peer (X^2=6.02; p<.02) suggesting that contingency increased over the course of the interaction with the virtual peer. We also found a main effect due to utterance (X^2=7.64; p<.03) indicating a difference in the relative position of an utterance within the interaction.

To investigate the interaction between the relative position of an utterance within the child's interaction and who she is speaking to in more detail, we ran a nominal logistic regression by participant and partner, producing a model for each pair: the TD children with their ASD partner (Whole Model Test: X^2=30.82; p<.0001), the children with ASD with their TD peer partner (X^2=35.45; p<.0001), and the children with ASD with the virtual peer partner (X^2=54.47; p<.0001). The factors were utterance and participant. We found that when the children with ASD interacted with the virtual peer, the probability of a contingent response was predicted by how many utterances the child had spoken (Effect Likelihood Ratio Test: X^2=9.72; p<.002). Utterance was only a significant factor in the model for the children with ASD with the virtual peer partner, demonstrating that as children with ASD interact with a virtual peer their contingency improves over the course of the interaction. The predicted values of the model illustrating this increase in contingent responses are shown in Figure 2.

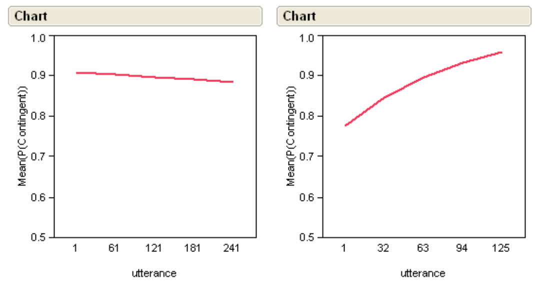


Figure 2: Predicted probability for an utterance being contingent with a peer (left) and with Sam.

Example

Claire[2], a seven-year-old girl with ASD, illustrates this phenomenon. Claire barely speaks during her fifteen minute interaction with her peer. Her peer tells a long story about the day in the life of a brother and sister. Claire does not pick up on the subtle turn-taking cues, such as long pauses where she could take over the story, eg. “So what happened then (pause) was (pause),” until one point where the peer asks her directly for her input:

Peer: Guess what happened then.
Claire: She put on her pajamas.
Peer: No.
Claire: Oops.

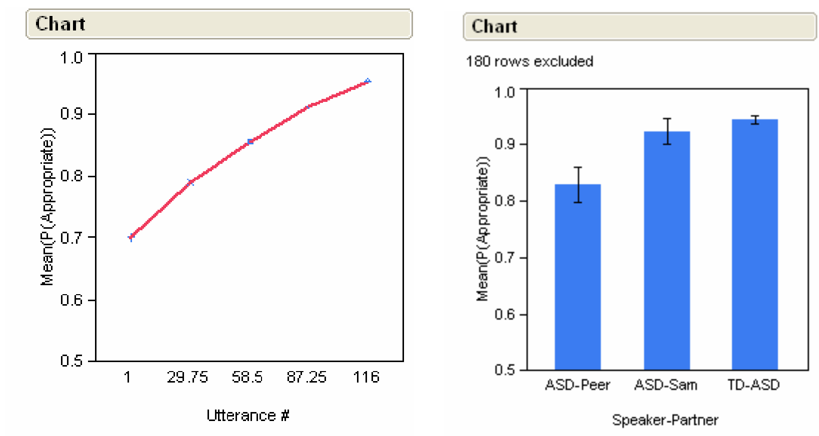
Although her peer is not able to consistently elicit responses, Claire contributes utterances throughout her interaction with Sam, and her responses become increasingly contingent over the course of the interaction. At the beginning of the interaction, Sam starts a story about two children playing hide-and-seek. Sam trails off part way into the story indicating she isn’t sure what happens next. Claire does not at first pick up the trail of the story, but when Sam says, “Then what happens,” Claire begins listing items, “Then, they saw a tree. (Sam: Uh-huh.) And a fence.”

With some prompting from Sam through backchannel and directed questions, Claire begins participating in the interaction, but her utterances are not contingent with the content of Sam’s story. Over the course of the interaction, her responses increasingly make sense within the context of the story. In her last story, she helps Sam tell a story about a boy and a girl baking cookies for the boy’s grandmother who is sick in the hospital. She says “They got the ingredients… And the recipe book… Baked chocolate chip cookies… Grandma’s cookies.” With the virtual peer, Claire is able to use contingent discourse in a way that contrasts with the difficulty she had contributing anything with her TD peer.

Topic Management

To analyze predictors of utterances that correctly manage introduction and maintenance of topics, we ran a nominal logistic regression on 1872 utterances that were labeled as a topic introduction, topic maintenance, topic reintroduction or topic shaded (TD child with ASD peer: 882; ASD child with TD peer: 653; ASD child with VP: 337). We evaluated the probability of an utterance being appropriate based on the same factors tested above, including speaker, partner, utterance, participant, and interaction of partner and utterance (Whole Model Test: X^2=269.48; p<.0001).

Similar to the contingency results above, for topic management we also we found an interaction between utterance and partner (Effect Likelihood Ratio Test: X^2=27.95; p<.0001), and a main effect due to utterance (X^2=14.24; p<.001). The effect of utterance was only significant for children with ASD with the virtual peer partner, when we created separate models for each speaker-partner pair (Whole Model Test: X^2=163.15; p<.0001; Effect Likelihood Ratio Test: X^2=25.87; p<.0001; see Figure 3a). Thus, as with our previous results, children’s use of appropriate topic management increased over the course of the interaction with the virtual peer, but not with the TD peer. Furthermore, we found a significant effect due to partner (X^2=5.21; p<.03). These results demonstrate that children with ASD used more appropriate topic management *overall* in their interactions with the virtual peer than with the TD peer (see Figure 3b), and that their appropriate use of topic management increased over the course of the interaction with the virtual peer (see Figure 3a).



(a) (b)

Figure 3: Probability of an appropriate response: (a) for children with ASD with VP partner over the course of the interaction; (b) for children with ASD with a TD peer partner, children with ASD with the VP partner, and TD children with the ASD peer partner;

Example

Nine-year-old Dan and his TD peer begin their conversation talking about sports. Dan's peer initiates the conversation by asking about favorite teams and players, to which Dan contributes mostly single word answers. These short exchanges are interspersed with extended periods of parallel play with the toys where no one talks. At one point while playing with one of the toys, Dan says, "Walking down the stairs. And he trips." While this content could potentially be part of a narrative, Dan does not introduce the characters and situation in such a way that his partner understands the context and can contribute to create a narrative.

Although Dan's peer attempts to engage Dan by asking questions about sports, Sam sets up narrative situations. Instead of contributing narrative content that is not situated within the same topic, Dan maintains the topic of these conversations with the virtual peer by adding new information, such as, (during a story about two children following a treasure map) "they found the treasure in the basement" or (during the story about two friends making cookies for grandma) "they packed the cookies and drove to grandma's."

Discussion and Conclusion

This study set out to answer three questions: (1) How do children with ASD engage in collaborative narrative with a TD peer? (2) How do children with ASD engage in collaborative narrative with a virtual peer? (3) Do children with ASD demonstrate different abilities for engaging in contingent discourse with a TD peer and a virtual peer? The participants were able to interact with both a TD peer and a virtual peer in a collaborative task that employs contingent discourse skills. Moreover, our results contribute to what we know about both the form and content of contingency in children with ASD and its relationship to theory of mind. Finally, we offer evidence that virtual peers may be a useful intervention for children with autism.

First, previous research has shown that children with ASD are less contingent than other children (Tager-Flusberg & Anderson, 1991) and that the deficits of autism may reflect an underlying deficit in Theory of Mind that may be tied specifically to contingency (Capps et al., 1998). However, previous research focuses on interactions with adults; we extended this work to peer interactions. We found that in interactions between children with ASD and TD children, children with ASD were less contingent. Discourse contingency of the children with ASD was significantly related to their Theory of Mind ability.

While theory of mind remains a predictor of contingency, this study also offers evidence for an intervention approach based on the use of a virtual peer that can engage in collaborative narrative with real children. Previous work with children with ASD leverages the appeal of technology to address social and language deficits, and studies of TD children have used technology to take advantage of the benefits of peer interaction for learning. Our research demonstrates that a virtual peer can engage children with ASD in social interactions *with* the technology to facilitate contingent discourse. We found that over the course of an interaction with a virtual peer, the form and content of contingency of children with ASD increased. This increase could reflect a learning effect of children familiarizing themselves with the technology. In other words, at the beginning of the interaction, Sam is unfamiliar to the participants. Over the course of the interaction they may become more familiar with how Sam works and the types of responses Sam is looking for. The results could also reflect strategies the virtual peer uses to elicit responses from the child. In any case, however, that the fact that contingency increased with the virtual peer, combined with the opportunity for increased consistency, availability and willingness of virtual peers to interact with children with ASD, offers promise for a long term intervention for these children. In addition, and importantly, the content of children's utterances demonstrated more appropriate topic management with the virtual peer than with the TD peer, thus revealing topic management skills that children may not be using in their day-to-day interactions.

Taken together, these findings suggest that collaborative narrative with a virtual peer may offer a structured setting for using contingent discourse. Over the course of multiple sessions, children could rehearse contingent interactions so that they become more familiar. A comprehensive intervention could then look at whether and how children generalize this skill to a natural environment. Future research should investigate the mechanisms by which the intervention improved contingency. These mechanisms may include the narrative context of the task or scaffolding, praise and backchannel feedback from the peers. Our own recent work is investigating exactly these questions, as we design virtual peers to help children flexibly acquire pragmatic skills.

In this paper, we describe the virtual peer, and how it engages children with ASD in collaborative narrative, with abundant opportunities to produce contingent discourse. We compare the interactions of children with ASD with their peers to those with virtual peers, and discover that aspects of contingency are more likely to occur with virtual peers, and more likely to increase over time with virtual peer. The ultimate goal of this research is to help children with ASD access all of the valuable learning opportunities offered up by peer interaction, by improving their ability to engage in contingent discourse. In this context our research contributes to an improved understanding of peer interaction in the learning sciences by discussing a population where the benefits of peer interaction in learning are difficult to access: children with Autism Spectrum Disorder.

Endnotes

(1) To launch our research with children with ASD, we relied on existing diagnoses and assessments (including school individualized education plans) to characterize our participants. In current research, we are using the ADOS and ADI-R assessment tools to correlate results with specific diagnoses.
(2) All names have been fictionalized.

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