CHILDREN'S PLAY, PRETENSE, AND STORY

STUDIES IN CULTURE, CONTEXT, AND AUTISM SPECTRUM DISORDER

Edited by Susan Douglas and Lesley Stirling

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Edited by
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DEVELOPING RECIPROCITY WITH TECHNOLOGY AND STORYTELLING

The Design of an Authorable Virtual Peer for Children With Autism Spectrum Disorder

Andrea Tartaro and Justine Cassell

Introduction

Storytelling and pretend play characterize many children's interactions with their peers and are integral to children's development. While these interactions are natural for typically developing children, difficulties with social communication directly affect the kinds of interaction children with autism spectrum and related disorders (ASD) have with their peers, as well as their use of storytelling and pretend play (Douglas & Stirling, this volume). Children's play and storytelling rely on reciprocity—language that engages another person in an interactive exchange. Children with autism have difficulty engaging in reciprocal social interactions (American Psychiatric Association, 2013), and these difficulties could be a component of the trouble they have telling stories and playing with peers.

Our research looks at how technology, specifically a virtual peer, could be used to support children with ASD in engaging in storytelling and other peer interactions (Tartaro & Cassell, 2008; Tartaro, Cassell, Ratz, Lira, & Nanclares-Nogués, 2015). A virtual peer is a computer-animated child that is projected life sized on a screen and interacts with children by telling stories (Cassell et al., 2000). Our previous research suggested that children with ASD increased their use of specific forms of language used in interactive exchanges over the course of an interaction telling stories with a virtual peer but not with their human peers (Tartaro & Cassell, 2008). This chapter asks: How can we leverage this ability to interact with a virtual peer to design tasks and a technology system for learning about reciprocity?[1]

To address this question, we apply constructionist theory in education, which suggests that building artifacts supports learning by engaging metacognitive skills,

including planning, taking the perspective of others, and reflection (Bers & Cassell, 1998; Robertson & Nicholson, 2007). We describe how we applied constructionist theory to learning about social interaction by developing constructionist tasks for virtual peer technology. Our goal is to create tools that allow children to create stories and social behaviors for a virtual peer and then operate the virtual peer in the manner of a puppet while it interacts with another person. We argue that these tasks, which we call *authoring* the virtual peer, engage metacognitive skills, including planning, monitoring, and revising a social interaction. We illustrate that authoring encourages children to employ targeted reciprocity skills and reveals behaviors that may be affecting those skills.

The research presented here is part of a multiple-phase project to develop and evaluate a social group–based intervention incorporating technology that targets the difficulties children with ASD have with peer social interaction (Tartaro, 2011; Tartaro & Cassell, 2008; Tartaro et al., 2015). This chapter specifically describes the design stage of the project. While our goal is to design technology that supports children in developing reciprocity skills they can use in interactions with peers, both the theoretical basis of the research and the technology design process could be applied to the design of technologies and interventions for other skills. In what follows, we first provide background on ASD, research on interventions for autism that motivates our approach, and details of the theories and methods this work is based on. We then describe the study we conducted to design the intervention tasks and technology, including methods for working with children with ASD. We conclude by discussing knowledge gained about the social behaviors of children with ASD, as suggested by their use of the system.

Background

ASD is a developmental disorder characterized by two main features: (a) "persistent deficits in social communication and social interaction" and (b) "restrictive, repetitive patterns of behavior, interests, or activities" (American Psychiatric Association, 2013, p. 50). Language ability varies widely: Some individuals with ASD have little to no intelligible speech; others can only speak in simple sentences, while others can communicate in full sentences (American Psychiatric Association, 2013). Even for those with functional language, social communication difficulties translate to a number of specific deficits in reciprocity affecting peer interactions, such as "failure to initiate or respond to social interactions," "difficulties sharing in imaginative play," and "absence of interest in peers" (American Psychiatric Association, 2013, p. 50). Given that successful interactions rely on these reciprocity components, increasing children's ability to effectively use reciprocal language forms, such as asking and responding to questions or initiating and expanding on topics of conversation, may improve their ability to engage with peers.

Intervention Approaches and Innovative Technologies for Autism

Numerous interventions are currently used to support children with ASD in developing social communication skills. Our research builds on the success of three approaches that are used to address reciprocity skills and peer interaction: social skills groups, narrative approaches, and technological approaches. Social skills groups are an evidence-based approach (Reichow & Volkmar, 2010), where groups of individuals with autism learn and practice social interaction skills. Groups are frequently comprised of children of similar ages and abilities to facilitate age-appropriate interactions. Group programs often include didactic instruction on specific social skills; modeling of social skills by therapists or typically developing group participants; role-play exercises where participants practice new skills; and unstructured activities, such as board games, where contextualized use of social skills can be practiced as appropriate situations arise (e.g., Baker, 2003; Jackson, Jackson, Bennett, Bynum, & Faryna, 1991; McGinnis & Goldstein, 1984, 1990; Webb, Miller, Pierce, Strawser, & Jones, 2004). While recent studies and metareviews support the efficacy of social skills groups (Cappadocia & Weiss, 2011; Reichow & Volkmar, 2010; Wang & Spillane, 2009), limitations exist. For example, conversational skills are difficult to target (Barry et al., 2003), and many evaluations demonstrate limited generalization of skills outside the group setting (e.g., Barry et al., 2003; Castorina & Negri, 2011; White, Koenig, & Scahill, 2010). Thus, additional research is needed to address these limitations.

Another common approach uses narrative and pictures to illustrate social situations and appropriate responses—for example, Social Stories (Gray, 1994b), comic strip conversations (Gray, 1994a), and social skills picture stories (Baker, 2001). Across these approaches, stories describe and illustrate social situations and contrast inappropriate behaviors with acceptable responses. These stories are typically individualized to the situations and behaviors that a particular child faces. Research offers evidence of the effectiveness of Social Stories and related approaches (e.g., Adams, Gouvousis, VanLue, & Waldron, 2004; Barry & Burlew, 2004), which are often used in conjunction with other therapies (Reichow & Volkmar, 2010).

Recent research is demonstrating that a variety of technological solutions, including personal computers, the Internet, video and multimedia, mobile devices, shared active surfaces, virtual and augmented reality, sensors and wearables, robotics, and natural inputs (e.g., speech, eye tracking, etc.; Kientz, Goodwin, Hayes, & Abowd, 2014) can provide unique opportunities for enhancing intervention, increasing our understanding of autism, and improving the diagnosis of autism. Kientz et al. (2014) provide a review of different technologies for autism to date, along with a classification scheme useful for understanding the different approaches. In our own work, we found that the technology of virtual peers—life-sized, computer-animated children that interact using speech and

gestures (Cassell et al., 2000)—may provide a context for developing social interaction skills (Tartaro & Cassell, 2008) by using technology to combine and build on the benefits of peer and narrative interventions. A virtual peer is projected on a large screen, as illustrated in Figure 4.1. Children have physical toys, a dollhouse, and various figurines to play with, and the virtual peer has virtual counterparts

FIGURE 4.1 Virtual peer displayed life sized.

to these toys. The intention of this setup is to create a "shared reality" space in the physical world rather than a virtual reality on the screen (Cassell et al., 2000). Children work together with the virtual peer to develop a story—the virtual peer starts the story and then takes turns with the child to finish the story. Behind the scenes, an experimenter is watching the interaction and selecting prerecorded story continuations when it is the virtual peer's turn. The interaction is based on how children collaborate to tell stories, and the virtual peer's speech acts and behaviors are designed to follow a detailed model of those that children use in interactions with each other (Wang & Cassell, 2003).

This collaborative narrative task requires those same reciprocity skills that are difficult for children with ASD. To tell stories together, children must listen and respond to their peer's story contributions and add to the development of the story. We conducted a study to examine how specific social skills are used when children with ASD co-construct a narrative during peer social interactions and how these behaviors manifest in interactions with virtual peers (Tartaro & Cassell, 2008). Using a within-subjects, counterbalanced design, we compared the stories children with ASD told with the virtual peer to those they told with a same-aged, typically developing peer using the same toys and environment. Our findings suggest that when children interacted with virtual peers, their appropriate use of language forms that maintain a conversation increased. This increase did not occur with their typically developing peers. In addition, the content of their utterances was more appropriate overall in interactions with the virtual peer versus their typically developing peer. We concluded that these findings, taken together with the availability and willingness of virtual peers to engage in interactions, support the use of collaborative narratives with a virtual peer as a context for developing social interaction skills. However, the study does not provide the mechanisms through which learning reciprocity skills occur—we do not know how children can use the virtual peer to learn these skills in a way that translates to them using the skills in interaction with their (human) peers.

Constructionism and Metalinguistic Reflection

To help children develop reciprocity skills that transfer to interactions with their peers, our research proposes that we can apply an educational theory of learning through building artifacts, called *constructionism* (Harel & Papert, 1991), to virtual peer technology. In learning environments based on constructionist theory, children design and build artifacts, such as computer games, and through these tasks build an understanding of disciplines such as math (e.g., Kafai, 1995) or creative writing (Howland, Good, & Robertson, 2007; Kafai, 1995). Theorists believe that by constructing artifacts, children reflect on what they are learning in new ways (Kafai, 1995) to become better learners (Resnick, Bruckman, & Martin, 1996; Resnick & Silverman, 2005) and use metacognitive skills, including planning,

taking the perspective of others, and reflection (Bers & Cassell, 1998; Robertson & Nicholson, 2007). For example, Steiner, Kaplan, & Moulthrop (2006) specifically looked at how reflecting on others' experiences affected children's design of artifacts in a study that asked children to create games. Their findings suggest that testing creations with players led children to restructure their games and focus more on their audience's experiences rather than their own stories (Steiner et al., 2006). Similarly, Bers and Cassell (1998) found that story-authoring interactions on their system, SAGE, allowed children to both explore their own identities and engaged them in *decentering*—taking the point of view of others. Our research focuses on developing language and social interaction skills; therefore, our goal is to engage children in metacognitive activities related to language. We call metacognitive skills related to language, such as reflecting on or monitoring language use, *metalinguistic skills* (Gombert, 1992).

Design-Based Research

Thus, our goal is to design a system based on virtual peer technology that supports children with ASD in developing peer social interaction skills by engaging constructionist learning mechanisms of planning, reflecting, and taking the perspective of others. We used a research method called design-based research (DBR) that develops and tests theories on how learning occurs in its natural context. Design-based researchers iteratively develop and evaluate a system focused on *embodying* and testing *conjectures* on mechanisms of learning (Sandoval, 2004). In other words, the design-based researcher develops a conjecture (Sandoval, 2004) about how learning occurs and designs a system that reflects that idea so that the theory behind the conjecture is built into the design of the system. That theory is then evaluated by testing and refining the system in the educational context in which it will be used (Sandoval, 2004). This iterative process involves continually testing and refining a design (Barab & Squire, 2004). Designers create a learning tool, test it, determine what works and what doesn't, revise the tool, and test it again.

DBR emphasizes the theoretical contributions made possible by the methodology. Barab and Squire (2004) argue that:

> Design-based research requires more than simply showing a particular design works but demands that the research move beyond a particular design exemplar to generate evidence-based claims about learning that address contemporary theoretical issues and further the theoretical knowledge in the field.
>
> *(pp. 5–6)*

In other words, a DBR project is aimed at not only achieving the intervention goals of the project but also at exploring theories of learning.

Design Study

In this study, we focus on designing an interface and tasks that children with ASD can use to develop peer social interaction. We specifically aim at designing a system that encourages children with ASD to develop reciprocity skills through metalinguistic reflection.

The Design Conjecture

Following the DBR methods described previously, we designed a system by developing a design conjecture (Sandoval, 2004) about the potential mechanisms of a virtual peer intervention. The conjecture is based on principles of constructionist theory and mechanisms of learning that occur by engaging metacognitive skills, including planning, reflection, and perspective taking (Bers & Cassell, 1998; Robertson & Nicholson, 2007). The conjecture we propose is:

Constructing (planning), reflecting on (engaging in and observing), and revising storytelling interactions will increase use of reciprocity skills in children with ASD.

Method

DBR often requires that learners expose their thinking through visual and verbal descriptions of ideas (Collins, Joseph, & Bielaczyc, 2004). A design research method called participatory design (PD) is often used to support this process, where end users and developers collaborate throughout the design process. While PD has been used with children (Druin, 2002) as well as individuals with disabilities (Cohene, Baecker, & Marziali, 2005; Cole, Dehdashti, Petti, & Angert, 1994; Fischer & Sullivan, 2002; McGrenere et al., 2003; Moffatt, McGrenere, Purves, & Klawe, 2004; Wu, Richards, & Baecker, 2004), PD with children with social impairments poses new challenges. Specifically, (a) children with ASD have difficulty communicating the types of feedback needed for PD and (b) the diverse abilities of children with ASD challenge generalization from one child to the next. Using typical evaluation tools, such as questionnaires and interview questions, with children with ASD may not yield reliable results. For example, topics or stories that appeal to a child's interests may increase engagement with the system. However, when we asked one child, "What else would you like Sam [the virtual peer] to talk about?" he simply repeated back the things the virtual peer could already say. However, while using the system, the same child developed new stories that were only tangentially related to things the virtual peer could already say. Thus, applying methods for drawing themes from observational data is particularly important with this population. In addition, specific language abilities and other skills vary. Therefore, working with this population requires careful planning and the application of design methods. We developed a three-step process to address these challenges.

1. Individual design sessions with familiar children: Prior to beginning this study, we worked with the children in a weekly social skills group for approximately a year and a half. Children with autism have unique means of communicating their likes and dislikes, when they are frustrated, etc. Thus, getting to know the individual children was critical. Focusing on a familiar child independently allowed us to adapt to the child's needs in terms of the pace of the session, the kinds of questions we asked, and the behaviors that suggest emotions such as engagement or dislike.
2. Iterative sessions and introduction of participants: Children with autism are a challenging population to work with because diverse abilities within the population are combined with limited access to researchers (particularly for researchers who do not work in a clinical setting). To address this challenge, we used a process of iterative sessions with individual children and iterative introduction of new participants to the study as details were ironed out with each child. The study began as individual case studies and eventually developed into three phases of research: (a) developing the task, (b) designing the interface, and (c) generalizing with children of varying abilities. The phases are described below.
3. Assessment of relevant abilities to inform generalization: Finally, a diagnosis of autism or other social impairment provides very little information about the abilities and challenges an individual child has. To choose and evaluate successful interventions, it is critical to understand specific behaviors of individual children. Therefore, assessing relevant abilities, along with narrative descriptions of participants, is critical for discussion of generalization and estimating children for whom virtual peers may be beneficial. Relevant characteristics for the virtual peer tasks include expressive and receptive language and the severity of social impairment. The measures we chose by which to evaluate these abilities are described below. Finally, narrative descriptions of the participants demonstrate the diversity of behaviors in children with high-functioning autism, such as echolalia, shyness, verbosity in nonreciprocal interactions, etc.

Because the iterative nature of DBR differs from traditional experimental processes, Collins et al. (2004) propose that reports present a study in five sections: (a) design goals, (b) setting of the study, (c) description of each phase, (d) outcomes found, and (e) lessons learned.

Design Goals

Based on the design conjecture above, our design goal is to create technology tools for

- planning and creating storytelling interactions;
- engaging in storytelling interactions in ways that enable children to take on the perspective of others and reflect on the interaction; and
- revising the interactions.

These tools aim to allow children to not only engage in face-to-face storytelling with a virtual peer, as in our previous studies, but to also create new behaviors and stories for the virtual peer and use the virtual peer as a puppet while it interacts with another person by selecting the stories and behaviors they created. We call these latter activities authoring the virtual peer.

Setting and Participants

The research was conducted at a local after-school social skills program for children with ASD. We worked with two classes: six children from one class and one from another class. The study lasted approximately eight months, though holidays and other conflicts (such as children's absences) meant that the study did not occur every week. The classes each met once a week for 1.5 hours and began with children practicing greeting each other and some group discussion. The group discussion was usually focused around a monthly theme, such as back to school in September or holidays in December. During this time, the group leader would encourage participation from the children by asking questions about the topic, such as "Who is your teacher this year?" The group then broke into smaller group "table activities" such as games or art projects. Children practiced social interactions and turn taking during these activities. The group also included several "buddies"—typically developing children or teens who helped facilitate interaction with the children with ASD.

Participants With ASD[2]

Seven children aged 8–12 with existing ASD diagnoses participated in the study. Table 4.1 summarizes the basic characteristics of the participants and provides a brief description of each.

We administered several tests to characterize the language abilities and severity of social impairment of the participants:

- Test of Nonverbal Intelligence—3 (TONI–3; Brown, Sherbenou, & Johnsen, 1997). The TONI–3 is a brief screening of nonverbal IQ that is administered without the use of any language. It was used to screen participants for a nonverbal intelligence score of 75 or above.
- Peabody Picture Vocabulary Test—IV (PPVT–IV; Dunn & Dunn, 2007). The PPVT–IV is a language ability scale that measures children's receptive

TABLE 4.1 Summary of Participants

Fictional name	*Gender*	*Age (start of study)*	*Grade in school*	*Description*
Mikey	Male	9	4	Mikey is very verbal and interacts well with adults. However, he seems shy and uninterested around his friends. His language ability appears to be at the middle level of the group, which is reflected in his Peabody Picture Vocabulary Test—IV (PPVT–IV) and Expressive Vocabulary Test (EVT–2) scores. One of Mikey's autistic behaviors is that he doesn't like change in routine, which made scheduling research sessions with him difficult.
Cindy	Female	9	4	Cindy has good expressive and receptive language skills and is often talkative. However, her interactions are often nonreciprocal—she enjoys sharing with the group during greeting time, for example, but often does not engage other children by asking questions.
Chris	Male	8	3	Chris uses the least amount of expressive language of the group. Although he is capable of phrase speech, he rarely says anything complex. His contributions to both conversations in the group program and in the intervention storytelling tasks are often echolaic and noncontingent.
Peter	Male	9	4	Peter is often outgoing and affectionate with adults and older "buddies." Although he uses a lot of language, his expressive and receptive language are at a kindergarten level according to PPVT and EVT scores. Peter's stories were all retellings of various fairy tales that he insisted go the way he knew the stories.
Tony	Male	10	4	Tony is very high functioning and interacts well with adults. He is also particularly friendly with another boy in the group, Chuck. However, like all children with social impairments, their interactions with each other are often awkward. Tony was selected as the first user for the system. Though mainly

(*Continued*)

TABLE 4.1 (Continued)

Fictional name	*Gender*	*Age (start of study)*	*Grade in school*	*Description*
				selected as the first participant because he was one of the higher functioning children available, he made a particularly good first user because he was able to understand not only the task but also his role as someone using the system to help make it better for others to use. He understood, for example, not to talk to other children about the virtual peer (VP) and often asked if Chuck had met the VP yet.
Paul	Male	11	6	Paul is clearly bright and in many ways advanced for his age (his expressive and receptive language skills are above his chronological age), and he, too, interacts well with adults. However, his speech is hard to understand, and he has a clear tendency to focus on particular topics. For example, Paul was very interested in scary stories; thus, his stories often carried this theme. Interestingly, Paul was also very creative in his storytelling. He seemed to come up with original ideas and was able to expand on them. One particular problem he had was eliciting and incorporating information from others.
Chuck	Male	10	4	Although Chuck comes across as shy, sometimes speaks very softly, and avoids eye contact, he has good receptive and expressive language skills. He is often interested in engaging with peers despite his challenges with it. He is particularly friendly with Tony.

language. Children's standardized scores ranged from 70 to 104, with age equivalents ranging from 6 years 2 months to 12 years 11 months.

- Expressive Vocabulary Test (EVT–2; Williams, 2007). The EVT–2 is a language ability scale that measures children's expressive language. Children's standardized scores ranged from 74 to 112, with age equivalents ranging

from 5 years 7 months to 12 years 5 months. Language ability (receptive and expressive) will be discussed with regards to qualitative performance with the authorable virtual peer.

- Social Responsiveness Scale (SRS; Constantino & Gruber, 2005). The SRS is a measure of the severity of autistic social impairment that yields an overall standardized (T) score as well as scores on five treatment subscales: social awareness, social cognition, social communication, social motivation, and autistic mannerisms. The test is used to characterize the severity of social impairment in each of the children. All T scores were clinically significant: in the moderate range (60–75) for three children and severe range (above 75) for four children. Scores in the moderate range "indicate deficiencies in reciprocal behavior that are clinically significant and are resulting in mild to moderate interference in everyday social interactions." Scores in the severe range are "strongly associated with a clinical diagnosis of" ASD and "suggest a severe interference in everyday social interactions" (Constantino & Gruber, 2005, Score Form). The SRS is particularly well suited for this research because of its focus on reciprocity skills.

Table 4.2 summarizes the characteristics of the children. Chronological ages are included, as well as age equivalents on the language measures.

Typically Developing Participants

This study also included nine typically developing children, ages 8–12. One child was a buddy in the clinical social group—the only one in the group within the age range of participants in the study. He occasionally participated in the technology design sessions with a child with autism. The other eight typically developing participants were used to model typical behavior on a new narrative task developed for the system (described below).

TABLE 4.2 Participant Characteristics

Fictional name	*Gender*	*Age*[a]	*TONI–3 standard score*	*PPVT–IV standard score*	*EVT–2 standard score*	*SRS T score*
Mikey	Male	9	91	80	97	117
Cindy	Female	9	105	99	112	72
Chris	Male	8	97	88	75	78
Peter	Male	9	88	70	74	61
Tony	Male	10	96	101	97	65
Paul	Male	11	118	104	102	78
Chuck	Male	10	100	78	92	78

[a]At start of study.

Research Phases

The design study evolved in three main phases: (a) task development, (b) designing the interface, and (c) generalizing with children of varying abilities. This section will describe each phase.

Phase 1: Task Development

To implement the design conjecture, we hypothesized that we could make a virtual peer that could not only engage in face-to-face storytelling, as in our previous studies, but also be authorable by the children, as described in the design goals above. Using this authorable virtual peer (AVP), users should be able to create new behaviors and stories for the virtual peer and use the virtual peer in the manner of a puppet while it interacts with another person by selecting prerecorded story segments. We developed an initial system composed of four tasks in author mode: (a) select buttons that represent speech and nonverbal actions, (b) organize the buttons into groups so as to allow actions to be quickly located, (c) provide a name for each group, and (d) order the groups on the panel. We conducted an initial evaluation of this system with typically developing children that suggests that children employ metalinguistic skills while authoring and operating the AVP (Tartaro, 2011). However, it is not clear whether the single panel of groups is ideal for children to find utterances they need during an interaction and that the concept of creating meaningful groups is intuitive. Moreover, feedback on previous studies from researchers and caretakers of children with ASD indicated that there were doubts about the age and gender appropriateness of the storytelling task, which asked children to make up a story using a dollhouse and figures. This task also may not be ideal for targeting reciprocity skills. Finally, the existing task required the virtual peer to take a long turn to set up the context of the story—we needed a task that was more interactive and required shorter turns on the part of the child and virtual peer. In what follows, we describe the requirements, process, and results for developing a new task.

Task Requirements

The task requirements include:

1. Narrative: The narrative aspect of the intervention is motivated by previous interventions using narrative.
2. Age- and gender-appropriate: The task needs to be appropriate for children 8–12 years old and take into account the gender ratio of autism, which affects boys 4 times more often than girls.
3. Dyadic and collaborative: The task should encourage the virtual peer and child to work together cooperatively.

4. Interactive: The task should provide a lot of opportunity for back and forth in short turns.
5. Reveals a number of relevant skills: The task should apply to situations beyond the current skills focus (reciprocity) so it can be applied in future research on skills such as turn taking, initiating an interaction, imaginative use of objects, functional use of objects, and creativity.
6. Physical objects: The task should incorporate physical objects to encourage interaction and increase the sense of a shared reality with the virtual peer. Physical objects can also be used to target nonverbal behaviors such as shared attention.
7. Narrow context: To allow for prerecorded responses, the context should be narrow enough to predict possible things to say. This is particularly important since children create the stories.

Task Development Process

In DBR, not only is the final solution important, but also the initial, unsuccessful approaches, as well as why they were not chosen, are valuable (Collins et al., 2004) and can provide guidance for others designing interventions. Therefore, in this section we describe different tasks we considered leading up to the final task.

Our first attempt at developing a new task modified the dollhouse into a school. The motivation behind this change was threefold: (a) The physical setup could remain essentially the same, with a house that extends into the virtual peer's space, and only the furniture needed to change; (b) the organizing theme of the social skills group when the study was initiated was back to school, so this would integrate with the group program; and (c) the school theme could be used to elicit personal narratives of the children's day. Moreover, the context was controlled, and short contributions from the virtual peer could yield somewhat predictable responses—for example, talking about a project in art class.

We found that this task had several drawbacks: It did not seem to elicit functional or imaginative play with the props, it involved little creativity on the part of the children and limited application of the data to future projects because of the narrow scope of the props, and it did not apply any existent research on autism.

To make the task more applicable to current research in children with ASD, we turned to the tasks used in a standardized autism observation test, the Autism Diagnostic Observation Schedule (ADOS; Lord, Rutter, DiLavore, & Risi, 2002). Several tasks on the ADOS incorporate similar skills to those targeted by this intervention: the free play task; telling a story from a wordless picture book; repeating back the story in a cartoon; and the "make a story" task. In the free play task, children are given dolls or figurines and other toys and given the opportunity to play with them. At some point, the examiner tries to join in the play. However,

this task is typically used with younger children and did not seem age appropriate for our target users. Furthermore, it did not include a specific prompt that could easily be adopted for a dyad task. In the cartoon task, children are asked to study a six-frame cartoon and then tell the story portrayed in the cartoon back to the examiner. One of the main goals of this task is to elicit gestures. However, the cartoons are short and would not provide much opportunity for turn taking and interaction. This left storytelling from a wordless picture book, where children narrate a story while going through the book, and the make a story task, where children tell an imaginative story using selected objects in the story.

We tried both these tasks with the children with ASD, matched together in dyads. The storytelling from a wordless picture book did not translate well to a dyad task because it was not clear how the children should take turns and did not easily hold the children's attention. The make a story task, however, successfully provided a structure for the interaction. This task, and how it fulfills the task requirements, is described in detail below. In addition to children with ASD performing the task in dyads, typically developing children (four dyads) performed the task in dyads as models of typical behavior and for designing stories for the virtual peer.

Final Task Description

The make a story task from the ADOS is used in Modules 3 and 4 (for verbally fluent children and adults) as an opportunity "to observe creativity in a play-like situation that is appropriate for adolescents and adults" (Lord et al., 2002, p. 86). The child selects five objects from a bag—some of the objects have a clear narrative purpose, such as a pair of miniature glasses, while others are more abstract, such as a piece of string. Children are asked to make a story using all five of their objects.

We modified this task to be dyadic. We collected a number of objects similar to those used in the ADOS and divided them into two bins—one for the objects with a clear narrative purpose and one for more abstract objects. Since we were collecting a larger number of objects than provided in the ADOS, we wanted to ensure that children had some of each type of object. While this was not critical for the current goal of developing reciprocity, it makes the task relevant to a broader range of skills, such as creativity, imaginative use of objects, and functional use of objects. Children were then asked to select an object from each box and then one more object from either box (with two children, they took turns selecting the fifth object). Thus, in dyads, the children had five objects to share, or with the virtual peer, the child had three objects and the virtual peer had two objects in the virtual world. The children, or child with the virtual peer, were then asked to make up a story together using all five of the objects. By working together to tell a story, children had to negotiate turn taking and use reciprocal discourse to engage

their partners. We compared dyads of typically developing children completing this task to dyads of children with ASD and found very different performances.

Typically Developing Children Performing the Task Together

When typically developing children performed the task, they used skills that fit the task requirements. Consider the following transcript of a typical interaction:

TD1: This is the drive-thru *[setting a plain wooden block in the center of the table]*. OK, my bus and then your lamb, and then my skateboard.
[coordinated play with one boy driving the bus up to the drive-thru, and the other boy driving his toy—a rocking horse figurine—up to the drive-thru as well]
TD2: I'm going first. Hey!
TD1: Hey!
TD2: Hey!
TD1: Beep beep!
TD2: I was here first!
TD1: Fine.
TD2: Excuse me. I'd like one Double Whopper, two orders of large fries, and a Diet Coke, please.

Child 1 initiates a story based on a common script of a drive-thru, but not a retelling of an existing story. He quickly establishes the context for the story and uses a plain wooden block as a drive-thru, demonstrating imaginative use of objects. He uses eye gaze to confirm that his friend agrees to the context. He also drives his bus up to the drive-thru, demonstrating functional use of objects. The two boys coordinate their play and seamlessly demonstrate reciprocity throughout the interaction.

Children With ASD Performing the Task Together

In stark contrast, when two children with ASD engage in the task, a number of behaviors characteristic of autism are revealed. Consider the following interaction:

ASD1: *[holding a bear figurine on the table]* Once upon a time there was a little girl named Goldilocks. Suddenly, her mother says to her, be careful, don't get lost in the woods. And finally she went outside to the backyard. And then she saw three little bears, and then she went into a pretty house . . . *[unintelligible] [puts head down on the table mumbling]*
[ASD2 is turned away from ASD1 and is engaging in stereotyped play with the toy bus by spinning the wheels]

In contrast to the first typically developing child, the first child with ASD does not attempt to establish a common context with his partner. His interaction is not reciprocal, and in fact by the end he is speaking too quietly to be intelligible. Furthermore, his story is a simple retelling of a common fairy tale, with no creative contributions. The second child with ASD shows no signs of interest in the task or his partner. Instead, he demonstrates some behaviors, including stereotyped play with one of the toys, self-stimulating behaviors, and lack of eye contact.

Thus, the task appears to provide opportunities to engage in the targeted reciprocity skills of the intervention, and in fact the typically developing children do so with no problem. However, when the children with ASD perform the task, their challenges with reciprocity (and other) skills are evident, thus providing intervention opportunities.

Implementation in the Virtual Peer

Based on one of the stories told by the typically developing children, we wrote several short turns for the virtual peer (one to three utterances long) that included story expansions and questions. We also included backchannel feedback utterances, utterances to fix mistakes, and utterances to start and end the interaction. This story was then used to introduce children to the authoring system. As children became familiar with the system, they modified this story and created new stories.

Phase 2: Development of Authoring Interface

The authoring tools aim to give children control of the virtual peer's behaviors while it interacts with another person, allow them to plan the pieces of a story they will need, and create new story segments for the virtual peer.

Interface Requirements

The tools had to fulfill several requirements:

1. Make certain reciprocity skills explicit:
   - Expanding on what someone said
   - Asking questions
   - Providing backchannel feedback
   - Fixing mistakes
2. Enable children to plan a conversation
3. Enable revisions
4. Be specific to the targeted skills (reciprocity) but flexible to extend to future skills

Final Interface Description

The final interface consists of two separate types of functionality for operating the virtual peer while it interacts with another person and authoring the interaction by creating stories.

Operation Functionality

The tools to operate the virtual peer are designed as a series of panels. At the top of each panel is a navigation bar of all the panels in the system. Below is a collection of buttons. Each button, when pressed, launches a script for the virtual peer to perform and then displays a specified panel in the system.

Each panel contains buttons for a skill related to reciprocity: expanding on what someone else says (called *Add to Story*), asking questions (called *Ask a Question*), providing backchannel feedback (called *Show Interest*), and fixing mistakes (called *Fix*). Two additional panels include buttons for starting and ending a story. These specific panels could be changed for future studies depending on the specific skills targeted.

Authoring Functionality

In authoring mode, buttons on panels can be selected and modified or removed. The system includes three author mode functions: (a) *Add*, (b) *Change*, and (c) *Remove*. Adding a new button allows users to select and edit a button from a larger library of buttons or create a new button. When users create a new button, they specify a label for their new button, record the audio, and select the next panel. To select an appropriate next panel, children must think about the structure of a reciprocal conversation. The final version of the system also allows children to select some basic gestures, such as waving or pointing. The Change function enables the user to modify any of the content of the button, including the audio (by making a new recording) and text, and what button panel will appear next. The final functionality is illustrated in Figure 4.2.

Phase 3: Generalizing With Children of Varying Abilities

The final phase of the research introduced new participants with more diverse abilities as users of the authoring system. The children with higher levels of receptive and expressive language—Cindy, Mikey, and Chuck—were able to use the tools similarly to Paul and Tony to create and revise story interactions. However, Chris and Peter had more difficulty. They had more trouble understanding the concept of selecting an appropriate response for the virtual peer based on what the interlocutor said. Future work could investigate if a more scripted system for

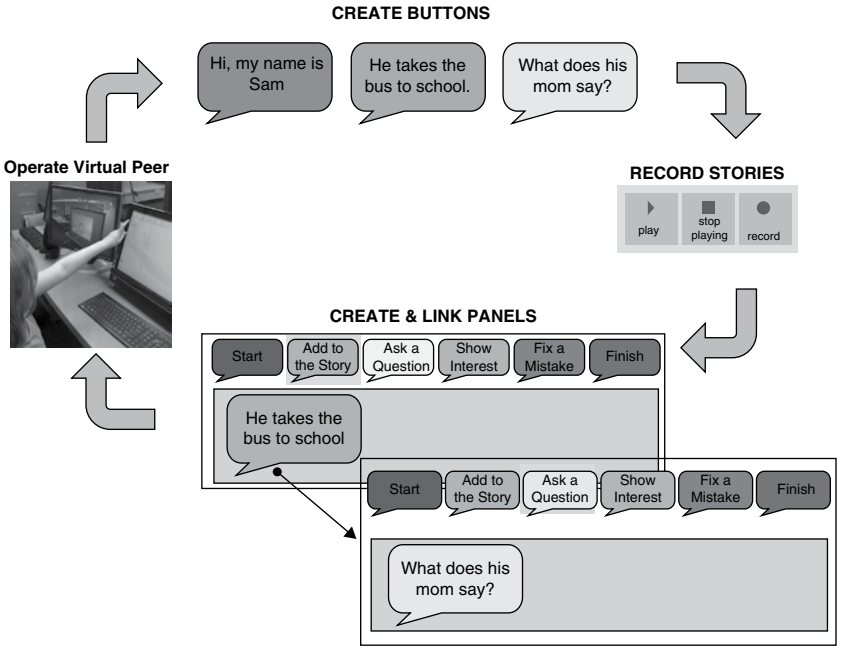

FIGURE 4.2 Authoring a virtual peer.

controlling the virtual peer could help children with language ability below a first- or second-grade level develop more basic skills of turn taking that occurs during social interaction. The system could include one turn per panel, labeled with simple icons (such as a question mark for questions), instead of the text of the utterance.

Outcomes

The goals of a DBR project are twofold: (a) develop an intervention tool that is theoretically motivated and (b) increase our understanding of learning by embodying theories in the design of a system and evaluating the theories by evaluating the system (Sandoval, 2004). Toward the first goal, we developed an AVP system motivated by constructionist theory of learning by building artifacts (Harel & Papert, 1991). With the system, children can build social interactions.

Toward the second goal, the three phases of design research suggest the following about ASD, storytelling, and play:

1. *AVPs can help us identify behaviors that may be affecting reciprocity in ASD or different ways in which children are not reciprocal.* Some of the children, when

recording new utterances for the virtual peer, would record long story segments that did not provide opportunities for input from the other person. For example, while some children's interactions lack reciprocity because they do not ask questions, others do not wait for responses from their interaction partner. The difficulty one child had waiting for responses was evident in one of the utterances he authored for the virtual peer, "Wanna hear a scary story? Well, if you said yes, that's good. If you said no, then too bad, 'cause I'm about to tell one. One day . . ." *[continues on with the story]*.

2. *AVPs can help children with ASD employ the targeted reciprocity skills, including adding to what someone has said, asking questions, listening, and providing backchannel feedback*. The authoring tools are designed to make each skill explicit both when using the system to operate the virtual peer and when authoring new utterances for the virtual peer. Children categorize utterances by skill during the authoring tasks and use these skill categories to find buttons while operating. The authoring task of specifying what panel should come next makes explicit how these skills come together in interactions with a partner.
3. *Using the AVP, children with ASD can employ metalinguistic skills to monitor and modify social behavior*. Perhaps most importantly, and relevant to the design conjecture, children showed evidence of monitoring and revising their interactions. In general, children tended to talk out loud while they were operating the virtual peer and either suggested things they couldn't say or pointed out that a relevant utterance was not available. They also indicated afterward that they did not make the virtual peer say something they should have. For example, from the very first session, Tony showed evidence of monitoring the interaction between the virtual peer and the research assistant by noticing things he wanted to say but which were not available. When the person interacting with the virtual peer asked about a grade on an assignment, the participant said, "I don't know. There really isn't a grade that I can tell." Later in the session, he reflects on this, "Well, when you were [asking] some things, I didn't really get a chance to answer them because they weren't on the computer." In a later session, he reflects on one of the interactions, comments that he should have used more question buttons, and asks to repeat the interaction. Children also modified their own recordings, expanding on their stories after an interaction. They also previewed new utterances while creating them (before an interaction) and changed them when they did not like them.

Lessons Learned and Conclusion

This chapter set out to answer the question: How we can leverage the ability of children with ASD to make contingent contributions in interactions with a virtual peer to design tasks and a technology system for learning about

reciprocity? Using an iterative, DBR method, we developed a system that encourages children to monitor and reflect on reciprocity by making explicit the components of reciprocity (e.g., expanding on what someone has said, asking questions) and how they are sequenced. We present evidence that suggests that children can use the AVP tools to plan and construct storytelling interactions, monitor the limitations of their stories while controlling the virtual peer in an interaction with another person, and revise their stories. Furthermore, we suggest that virtual peers can help identify children's behaviors that may be affecting reciprocity and help children employ targeted skills by making them explicit.

In the process of designing the AVP, we developed techniques and tasks that can be applied to the design of future interventions and studies for understanding storytelling and play in children with ASD. First, we developed three techniques to maximize the participation of children in the design of the system: (a) conduct individual design sessions with familiar children to allow for monitoring and responding to individual needs, (b) use a process of iterative sessions with individual children and iterative introduction of new participants to capture as many problems as possible before using a new participant, and (c) assess relevant abilities to inform generalization. In addition, we developed a task that is well suited for our goals but that could also be applied to other skills such as turn taking, initiating an interaction, imaginative use of objects, functional use of objects, and creativity. We adapted the make a story task for the ADOS so that children tell a story together using objects. Since this task is from the ADOS, it is relevant to current research on ASD.

Although children's use of the virtual peer authoring system suggests that the tasks and technology developed in this study support children's use of reciprocity skills and that children employ metalinguistic skills for planning, reflecting on, and revising their use of language while authoring, this study does not evaluate transfer of children's use of the targeted skills to face-to-face interactions with peers. Furthermore, although this research was carried out in the context of a clinical social group program, the system was not part of a comprehensive intervention. These are the goals of another study that suggests that the system can be incorporated as a component of a group social skills program and that interactions with the AVP support children's use of reciprocity during interactions with peers (Tartaro et al., 2015).

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Notes

1 This book chapter is a portion of a doctoral dissertation, *Authorable Virtual Peers: Technology as an Intervention for Difficulties with Peer Social Interaction in Children with Autism Spectrum and Related Disorders* (Tartaro, 2011).
2 All participants have been assigned a pseudonym.

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