Analysis of Characteristic Turn-taking Behaviors for the Development and Design of Virtual Peers as Interventions for Children with Autism

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Abstract

Children with autism are known to have a variety of deficits in social and communication skills. These skills are important not only for academic success, but also in the construction of meaningful relationships. Interventions targeting the social interaction and communication can be effective in improving these skills, especially when children are treated at an early age. In this paper, we analyze the effects of an intervention for children with autism, called a virtual peer, on the turn-taking behaviors that these children exhibit. Additionally, we suggest changes that could be made in order to improve the virtual peer as a turn-taking intervention for children with autism.

This study evaluated the use of fourteen characteristic turn-taking behaviors observed in two different groups of children: an experimental group composed of six dyads of one child with autism and one typically developing child and control group composed of six dyads of typically developing children. Each participant was asked to complete three tasks: storytelling with a peer (the other child in the dyad), storytelling with the virtual peer, Sam, and a Theory of Mind assessment. All interactions were videotaped and turn-taking behaviors were classified using a turn-taking coding scheme that allowed statistical analysis.

The analysis described in this paper yielded statistically significant results showing that children with autism instigate speaker change, take assignments more often, create gaps more frequently, and respond more often when they are interacting with Sam rather than with a typical peer, but that they also initiate and take transfer points less frequently when storytelling with Sam. Thus, this study concludes that the positive aspects of Sam as a turn-taking intervention for children with autism are that he elicits utterances from them more frequently than typical children do, as seen in the increase in speaker change, assignments taken, and responses, and that he causes children with autism to create gaps which allow Sam to take a turn. However, we also note that Sam’s design could be improved to make children with autism more likely to initiate and take transfer points. Specifically, it is suggested that Sam begin storytelling activities by asking for a real life story from the child and then gradually tell stories that require more imagination. This could be an effective change because children with autism struggle with imaginative play and may be more likely to initiate and take turns when a story is about something factual and familiar. Also, we suggest that when the stories are imaginative, Sam should create more assignments than transfer points because, as we have shown, children with autism are extremely likely to take turns when assignments are created.
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1.0 Introduction

Research has shown that a child’s social and communication skills have a definitive impact on his or her emotional health, ability to form relationships, and academic success [1]. Communication, whether verbal or nonverbal, is at the foundation of first bonds formed in a child’s life. In order to develop a relationship with parents and siblings, a child must first be able to interact and communicate with them. Without adequate communication and social skills, children with developmental disorders like autism struggle to exchange their thoughts and feelings with others, making relationship building an especially difficult task. Although children with autism may not perceive themselves as lonely, their underdeveloped social and communication skills often isolate them by prohibiting the formation of normal relationships with others [2].

Forming healthy relationships is a crucial step in a child's development. Along with increasing emotional stability, the establishment of emotional bonds with parents and friends impacts the effectiveness of a child’s learning environment. In fact, studies of children as young as three-years-old show a significant positive correlation between academic competence, the development of strong emotional bonds with parents, and peer acceptance [3]. Conclusions drawn by other studies also support the connection found between social skills and academic success, finding that when a child is able to form relationships with teachers and classmates he is more likely to participate in class and less likely to have a high number of absences [4].

Connections between social skills and academic success can also be seen in research that shows peer interaction as an extremely effective component of learning environments. A proficient student helping others learn is not only assisting him peers, but is also solidifying concepts in his mind. Likewise, a pair of equally proficient children benefit greatly from collaboration and knowledge exchange. As a result, learning technologies taking advantage of the educational benefits of peer interaction have been
successfully developed and are frequently used in a collaborative learning environment [5].

Unfortunately, even though they are often in the same classroom, children with developmental disorders like autism are unable enjoy the same benefits of a collaborative learning environment as typically developing children. Autism and similar developmental disorders cause children to have deficits in communication and social skills, both of which are imperative for a child to effectively take part in activities that involve peer collaboration. Since children with autism are unable to take advantage of the numerous teaching methods and learning tools involving social interaction and communication, it is vital that interventions are created to assist in the development of their social and communication skills. The study described in these pages analyzes and provides feedback as to the strengths and weaknesses of the design of one such intervention.

The research reported in this paper utilizes a virtual peer as a technology-mediated intervention for children with autism. Depicted as a life-sized projection of an animated child, the virtual peer simulates peer interaction by initiating conversation and appropriately responding to a child’s input. Through this controlled interaction, a virtual peer can help children with autism learn social and communicative behaviors.

A virtual peer is a promising intervention for children with autism as they often show great interest in technology. Additionally, because a computer never tires or becomes impatient, a virtual peer is a valuable collaborator for a child with autism as he learns to appropriately interact. Moreover, since children with autism often struggle with contingency, or creating statements that make sense in the context of the conversation, having a tireless and accepting playmate available is a great benefit.

In the following pages, we will investigate one particular aspect of interaction with a virtual peer: turn-taking. Turn-taking skills are necessary for organized and effective communication with others because they provide us with a means of signaling for a response or for another person to smoothly take over the conversation. Humans use a variety of cues, from eye-gazes to direct addresses, to coordinate
turns when interacting with each other. Unfortunately, as we will explain, the cognitive deficits experienced by children with autism make it difficult for them to naturally master turn-taking behaviors. Thus, it is important that any intervention for children with autism targeting social and communicative behaviors provide practice and guidance for the development turn-taking skills.

In order to evaluate and improve the effectiveness of our virtual peer, Sam, as a turn-taking intervention for children with autism, we will observe and analyze the way children tell stories with each other and the way they tell stories with Sam. First we will analyze how a typical child’s turn-taking behaviors change when they interact with Sam as opposed to a human child. The differences between the way typical children interact with each other and the way they interact with Sam will help us determine how accurately Sam simulates the turn-taking behaviors of a typical child.

Additionally, we will compare the turn-taking behaviors of children with autism as they interact with Sam to those of typical children interacting with Sam. In this comparison, the typical children serve as a control group that will allow us to distinguish between changes in behavior that may be attributed to a type of child and those that are mainly caused by Sam. For example, if both children with autism and typical children ask fewer questions during interaction with Sam, we can infer that this is a trait resulting from interaction with Sam rather than a characteristic linked to either group of children.

Next, we will examine the ways that the turn-taking behaviors of children with autism change when they are interacting with Sam rather than a typical human child. To fully analyze these differences, we will first compare the interactions between children with autism and Sam to the interactions between children with autism and typically developing children. This comparison will allow us to determine whether or not children with autism exhibit more typical turn-taking behaviors when they are interacting with a human peer or with Sam.

Lastly, we will compare the interactions between children with autism and Sam to those between two typically developing children. The differences between these two groups will allow us to determine
whether children with autism use turn-taking skills in a manner that is more similar to that of typical children when they are interacting with a human peer or with Sam. This phase of the analysis is important because it can show us whether or not children with autism are able to employ turn-taking skills with Sam that they are not able use interaction with a typical child. If children are able to utilize new turn-taking skills with Sam, then it is possible that these skills can be practiced and generalized so that they would eventually be exercised during interaction with a human child.

2.0 Existing Literature

2.1 The Importance of Turn-taking Behaviors

A child’s ability to take turns during interaction and conversation is extremely important to the development of his social skills throughout childhood and young adulthood. As a typical infant develops, he learns to use verbal and non-verbal cues, particularly eye gaze, to coordinate interaction with his parents [22]. At first, coordination of turns between mother and infant is controlled almost exclusively by the mother. However, studies have shown that by the time a typical child is two-years-old he gives twice as many turn allocation cues to his mother than he did as a one-year-old [22]. These cues are largely based on eye-contact as the child will look up to signify that he is yielding the turn. This study also found that overlap in turns decreased markedly in children over two years of age, suggesting some comprehension of turn-taking behaviors on the part of the child at this stage of his life [22].

Numerous studies have found evidence that typically developing children learn to cooperate and take turns with others by the time they are two or three-years-old [22][23]. Children usually learn turn-taking and cooperation skills by imitating others and engaging in reciprocal play. As children continue to develop, they improve their means of conveying messages to others through complex combinations of eye-gaze, gestures, and vocalization [24]. Typically developing children are able to communicate in a way that can be easily understood because they use conventional means of communication, whether verbal or non-verbal, to express themselves to others.
Since typically developing children begin to learn to take turns at a very young age, the norms of interaction are instilled in them and they are able to react appropriately in cooperative situations without thought. Through the use of conventional turn-taking behaviors, typical children are not only better understood, but they gain social understanding. This understanding is necessary for children to participate in cooperative learning activities, which have been shown to be extremely effective in many educational environments [25].

2.2 Turn-taking Behaviors Exhibited by Children with Autism

Autism is a developmental disorder characterized by an absence or delay in the development of cognition and language skills related to communication and social interaction. Children with autism rarely display joint attention, imitation, and toy play behaviors, all of which are associated with early language development. During early childhood, typically developing children acquire motor and language skills through imitation of their parents and siblings. Similarly, typically developing children learn behaviors associated with social interaction and communication through imaginative toy play. These behaviors help typically developing children acquire the ability to express their feelings and detect the intentions of others [5]. Since children with autism do not exhibit such behaviors, they have deficits in the areas of reciprocal social interaction, social communication, and imagination [6]. Specifically, children with autism lack the ability to show joint attention, create context in conversation, or comprehend the mental states of others [7][8].

According to Schertz, displays of joint attention allow children to “… visually coordinate attention with a partner to an external focus, showing social engagement and an awareness of the partner’s mutual interest …” [9]. Joint attention skills are found in typically developing children by the time they are toddlers, allowing them to successfully engage in collaborative play using toys and other props. Children with autism develop joint attention skills at a much slower rate than typically developing children, causing them to struggle to show social interest in or awareness of a playmate. Thus, a deficit in joint attention makes it difficult for children with autism to follow along as another child plays or to contribute in collaborative activities [9].
The developmental delays and deficits in children with autism noticeably affect their ability to interact with others. During interaction, children with autism cannot recognize that others are unaware of their thoughts and cannot distinguish between shared knowledge and information that must be communicated. Because they do not understand the listener’s state of mind, children with autism often fail to provide necessary contextual information when engaged in conversation. Without context, utterances seem disjoint and confusing, severely limiting a child’s ability to coherently and effectively communicate with an outsider [10].

Children with autism face even more challenges with communication as their lack of outside perception causes them to have difficulty recognizing the intended meaning behind a statement or action [10]. In a study of intentionality detection by Baron-Cohen [10], children with autism and typically developing children were instructed to imitate a simple action performed by an adult. During the task, the adult would sometimes make an unintentional movement, making it evident that the action was an accident by saying “oops” or a similar expression. When typically developing children imitated the adult, they consistently omitted the accidental movement, whereas children with autism included it in the imitation. The study concluded that the children with autism were unable to perceive the intentionality of the behavior and therefore included the unintentional action in their imitation, whereas typically developing children identified the intended action and repeated it instead of what they actually saw [10].

Since children with autism have limited perception of mental states and intended meaning, they are often unable to create coherent narratives or understand stories told by others. Children with autism tend to interpret all statements literally, bypassing any deeper intended meaning. Baron-Cohen’s study also showed that children with autism do not readily recognize irony, sarcasm, metaphor, and other non-literal language, further diminishing their ability to comprehend the meaning of a statement as intended by the speaker [10].

The narrative form poses additional troubles for children with autism because they do not actively engage in imaginative play during developmental years [5]. In a study of 54 children with autism and 17 typically developing children Helen Tager-Flusberg [26][27] found that when children with autism were
asked to create a narrative based on a wordless picture book, they did not provide causal explanations for events nor did they describe the inner feelings of characters in the narrative. Two other studies performed by Capps, Losh and Thurber [28] and Tager-Flusberg and Sullivan [27] confirmed the results of Tager-Flusberg’s initial research with regard to explanation of causal relations. These studies involved 13 children with autism, 13 children with other developmental delays, and 13 typically developing children and found that children with autism rarely considered relationships between the cause of a feeling or event when explaining a story [28]. Moreover, the children with autism involved in the study rarely explained how an event might affect the characters of their story in non-physical terms. For example, a child might say that a person made his mouth angry or happy instead of saying that the person himself was angry or happy [7].

Deficits in joint attention, imitation, context creation, and perception of outside mental states all affect the turn-taking behaviors of children with autism. While typically developing children use joint attention and imitation to focus on a subject of mutual interest and engage in collaborative play, children with autism do not have these skills and are unable to follow along with another child to know when it is appropriate to take a turn [9]. Even when a child does take a turn in conversation, he often will not provide adequate context and thus the statement made will have be lacking contingency [10]. Additionally, since children with autism do not understand the other mental states, they do not understand the intention of their playmates, further hindering their ability to identify a turn opportunity. The result of these deficiencies is that children with autism are slow to respond to attempted turn allocation or questions during collaborative play and tend fail to maintain the subject of mutual interest when they do take turns.

2.3 Typical Interventions for Children with Autism

The deficits in social interaction and communication found in children with autism have led researchers to develop a variety of interventions to target these problem areas and promote the development of new behaviors. Although implementations of interventions vary greatly, Heather
Whitford Erba emphasizes the overall importance of intensive intervention during a child’s developmental years throughout her overview of intervention programs for children with autism [14]. The necessity for consistent and intensive exposure to interventions is also highlighted by Jennifer Hillman [12] in her analysis of the role of the psychologist in the life of a child with autism and his family. Throughout her paper, Hillman emphasizes the importance of selecting personnel that will be able to work with a child with autism over long periods of time so that the child will have a consistent and continual intervention experience [12].

Applied behavioral analysis (ABA) is a practice that is frequently at the foundation of interventions for children with autism. The goal of ABA is to help children with autism learn new skills and behaviors while maintaining and using those that a child already possesses. The ABA practice can be applied to a wide variety of behaviors, from talking to playing and interacting. Since children with autism struggle to learn from their environment, ABA creates a very structured setting for children with clear positive reinforcement and guidance for good behaviors [12]. The effectiveness of ABA shows the importance of positive feedback and guidance in interventions designed for children with autism. One drawback of ABA is that it conventionally requires direct contact with another human for guidance and positive reinforcement. Although great efforts are made by teachers and parents of children with autism, the amount of time and interaction necessary to maximize improvement is not always available. It is in the gap between the time needed by the child and the time actually available that the virtual peer can play an important role. Unlike a parent or teacher, the virtual peer is always available and can provide the positive feedback and guidance to the child by ABA practices.

One intervention for children with autism that practices ABA is a method called discrete trial training (DTT). The key to this intervention is the consistent expression positive reinforcement of good behaviors and lack of recognition or punishment of inappropriate behaviors. DTT intervention is employs applied behavioral analysis (ABA) and is tailored to each child’s strengths and weaknesses. Trainers identify stimuli for a child’s unwanted behaviors, and periodically introduce them during training
sessions. The consequences, either reward or punishment, of the child’s reaction are determined and the stimulus is repeated later. Over time, researchers believe that the good behaviors will be dominant and the unwanted behaviors will become extinct. An important aspect of this intervention is the necessity for consistency in the responses of the trainer, parents, and others in frequent contact with the child so that good behaviors continue to be reinforced at all times [14]. Although it may be difficult for peers or parents to react to a child’s behavior in a controlled and completely consistent manner, the automated quality of virtual peers ensures that responses are invariable in both tone and contents.

Research has shown that interventions using techniques that are less strictly defined than those of ABA can also be effective over time. One study performed by David Koppenhaver [13] involved three-year-old children with autism in classroom settings and included children with severe communication impairments. Through his research, Koppenhaver concluded that interventions as basic as increasing the number of literacy tools and activities available during a child’s daily routine can lead to improvements in literacy and cognition [13]. Additionally, this study found that literacy activities done independently or with parents during early developmental years help children acquire phonemic recognition and metacognition skills, which are imperative for children to have normal social interactions [13]. As it combines literacy tools like storytelling activities with the positive reinforcement and guidance of ABA, a virtual peer becomes a promising intervention for children with autism.

Another commonly used and studied intervention for children with autism is known as Floor Time. This intervention involves consistent interactive play first with parents and then with peers. Floor Time targets social interaction skills that typically developing children have acquired by the age of four or five, but are limited or absent in children with autism. Efficacy studies of this intervention have shown that it improves social relationships and communicative behaviors. Thus, it can be concluded that interaction with other human beings, whether parents or peers, helps children with autism learn to build social relationships and communicate with others [14]. A virtual peer is clearly not the same as a human peer, but it does accurately simulate the behaviors of a human child. Therefore, a virtual peer has the
potential to positively affect the social and communicative behaviors through the same means as interaction with a human child.

2.4 Intelligent Tutoring Systems

Intelligent tutoring systems are technology-based tutors that have been put into place largely as customizable tools for education. While they were originally developed for use by typically developing children, the potential value of intelligent tutoring systems as intervention tools for children with developmental disabilities is now being explored. Sam, the virtual peer used in this study, developed from research involving intelligent tutoring systems and literacy tools for children.

The power behind intelligent tutoring systems lies in their ability to adapt to different learning styles and students in order to be effective for a diverse range of individuals. Additionally, intelligent tutoring systems allow for one-on-one interaction with students, which has been shown to be far more effective than a typical 25 to 30 student classroom [19]. Presently, intelligent tutoring systems are able to generate appropriate responses based on their current circumstances and can assess the level of knowledge the user possesses in order to react appropriately. Furthermore, an intelligent information system can adjust its difficulty level and instructional methods in response to each individual. Each system is able to “self-train” in order to improve instruction over time. Current systems allow for students to initiate questions, making interaction with a computer more like conversation in reality [19].

Although distinct from intelligent tutoring systems, research by Marina Umaschi Bers and Justine Cassell [8] involving story listening systems is particularly relevant to the current study. Story listening systems did not strive to tutor a child, but to allow them to explore his or her identity. Bers and Cassel developed and tested SAGE, the Storytelling Agent Generation Environment, which used conversational agents embodied in stuffed animals with which the children could interact. As the agents were authorable, children could create their own storytellers. Children could tell the agent stories, listen to stories told by the agent, and, as the agents were authorable, create their own storytellers. Bers and
Cassell found that children were comfortable with the agents and were willing to share parts of their own lives through their stories since the agent was embodied in a child-friendly toy [8].

Research done by Bers and Cassell showed that SAGE not only provided a soft and friendly storyteller for children to play with, but also helped improve their communication and social skills. By incorporating personal life experiences in the stories they told, children were able to realize their own identities, which is an important aspect of emotional and social interaction. Additionally, children were able to control and change the behaviors, stories, and interactions that occurred with SAGE by using its authoring capacity. SAGE allowed children to directly observe the ways that changes in behavior and interaction affect the conversation in the same way that a child with autism can observe and learn from the changes in their interactions with a virtual peer [8].

Building upon the work done in SAGE, another story listening system known as TellTale was developed by Ananny and Cassell in 2001 [5]. This device took the form of a caterpillar with separable body pieces, each of which could record approximately 20 seconds of a child’s narrative. After recording the narrative, a child could take apart the pieces of the body of the caterpillar and rearrange them in any order to hear the way the story changed. This system was largely used to help children learn about the structure of a narrative by observing the relationship between each portion of the story. Aside from this, TellTale was used as a tool to improve writing literacy in children [5].

Along with the work done on TellTale, another story listening system was developed called StoryMat. This tool appeared to be a quilt with characters on it accompanied by small stuffed animals. When squeezed, the stuffed animal would cause videotaping of child to begin so that he could tell and record a story. Upon letting go of the stuffed animal, the toy’s coordinates were recorded so that the narrative movie could be replayed for the next child when the same location was encountered. In this manner, one child could build on the story of another and collaborate with peers using StoryMat as an
intermediary playmate. The overall goal of *StoryMat* was to help children improve their collaborative reciprocal storytelling abilities, which have been shown to be linked to literacy [5].

Experimentation with *StoryMat* was carried out with 36 children as participants. Half of the participants played with the *StoryMat* while the others played with stuffed animals that looked the same but had no functionality. Each group was divided so that 12 children played in pairs whereas the other six played alone. Experimenters were primarily interested in the sophistication of the narratives, sophistication of fantasy play, and the level of collaboration with *StoryMat* seen in each group. Results showed that children playing with the active *StoryMat* incorporated more transformations of the characters on the quilt to characters in their narratives, demonstrating a more sophisticated level of fantasy play. Single children playing with the active *StoryMat* incorporated the same number of words and ideas from the mat as the pairs children playing with the passive mat incorporated from their human playmate. This observation supports the use of the device as an “imaginary playmate”. Finally, there was a correlation between children playing with *StoryMat* and taking the role of the narrator rather than a character in the story. This behavior shows that *StoryMat* generally inspired more sophisticated narratives amongst the participants [5].

After the development of *StoryMat*, Cassell moved on to create a new literacy tool for children called a virtual peer [5]. Virtual peers are computer-animated life-sized children that are projected onto a screen. The particular virtual peer developed by Cassell, and used in this study, is known as *Sam the CastleMate*. Sam’s appearance and voice is androgynous, allowing children of both genders to easily identify with their playmate. Sam was originally used as a storytelling partner for young typically developing children, but studies showing that Sam was effective in significantly improving the literacy skills of the children that interacted with him inspired the adaptation of Sam into an intervention for children with autism [5].

2.5 Technology-based Interventions for Children with Autism
Since children with autism show great interest in technology, research involving the use of technological innovations in interventions for children with autism has been done using a variety of tools. A study in 2007 implemented a ten week intervention program based on computer software called Mind Reading [15]. Mind Reading software was to be used as an aid in teaching children with autism to understand the emotions and state of mind of others. The hope of the developers of this software was that children with autism would be able to generalize the knowledge they gained from interaction with the Mind Reading software to real life social situations. Research on the efficacy of this software involved three children with autism and was assessed any improvement in social and communication skills after continual use of the software. Improvement of these skills would imply that children with autism were able to generalize skills to some degree. Unfortunately, because of the small number of participants, evidence of improvement was statistically insignificant. Further research is being done to modify the software so that it will have the capacity to effectively adjust to each child’s learning style [15]. Results of this research are relevant to our study because the virtual peer must be designed in a way that makes generalization of skills feasible for children with autism. This means that the virtual peer must be similar enough to a human child for a child with autism to be able to make a connection between behaviors learned with the virtual peer and behaviors expressed to an actual child.

Computer-mediated interventions have also been developed to help children with autism that have limited verbal skills. One such intervention, a speech-print software system developed by Blischak and Schlosser [16], allows a child to both see each letter and hear the sound that it makes. This software has been shown to significantly improve literacy in non-verbal children with autism. Another phase of the study showed an increase in communicative behavior when a child only heard the word being spoken [16]. In our research, children with autism hear the virtual peer speak and are able to practice speaking while interacting with him. Since Blischak and Schlosser’s study showed that hearing words spoken helped children, it follows that interaction with Sam should also help improve a child’s communicative behaviors.
Another technology-based intervention was used to help children learn to identify false belief and understand another person’s state of mind [17]. The children in this study were presented with scenarios involving false belief and were asked questions pertaining to the thoughts of the characters in the scenario. Children were subsequently shown videos of adults correctly completing the same false belief tasks and then were asked the questions again. After seeing several videos of adults’ answers, multiple children began to answer new false belief questions correctly before seeing the videos of the adults. This suggests that role modeling and practicing correct behavior may allow a child to better generalize knowledge and apply it to similar situations, even in the context of false belief and comprehension of others’ minds [17]. This research has extremely important implications to the research at hand, as we are using a virtual peer as a role model and collaborator so that children with autism can watch the and practice the behaviors exhibited by the virtual peer.

Particularly pertinent research using computer software to help children with autism gain turn-taking skills has been done by Jill Fain Lehman [18]. The software used, *Simone Says*, follows the general turn-taking structure of the Simon Says game familiar to children, but also helps children learn new vocabulary words. Thus, children using *Simone Says* software are not only practicing turn-taking skills, but are also improving their literacy skills at the same time. While the efficacy of this tool has not been thoroughly tested, its use of a typical turn-taking game to engage children with autism parallels our use of storytelling activities [18]. Just as *Simone Says* uses words during the game to help improve a child’s literacy, the virtual peer’s contributions to stories introduce new words and ideas to children as they collaborate and play.

3.0 Purpose

The purpose of this study is to identify and compare the turn-taking behaviors of typically developing children and children with autism as they interact with another child or the virtual peer named Sam. Specifically, we will compare dyads of one child with autism and one typically developing child,
dyads of two typically developing children, dyads of one child with autism and Sam, and dyads of one typically developing child and Sam as they engage in storytelling activities. We will compare the behaviors of between each group to determine how each group’s turn-taking behaviors change when the children are interacting with Sam instead of a human child and how effective Sam is as a turn-taking intervention for children with autism. Finally, we will use the results of this study to make design suggestions that could help improve Sam as a turn-taking intervention for children with autism.

4.0 Questions & Hypotheses

As we will discuss in the pages to come, numerous studies have found significant differences between the social and communicative behaviors of children with autism and typically developing children [2][7][9]. Given these differences, our research will be motivated by the following questions pertaining to the impact of interaction with Sam on the turn-taking behaviors displayed by children with autism and typically developing children.

1. How do the turn-taking behaviors of typically developing children change when they are interacting with Sam rather than a typical human peer?

2. How do the turn-taking behaviors of children with autism change when they are interacting with Sam rather than a typical human peer?

3. How do the turn-taking behaviors of children with autism differ from those of typically developing children when both groups are interacting with typical children?

4. How do the turn-taking behaviors of children with autism interacting with Sam differ from those of two typically developing children?

5. How do the turn-taking behaviors of children with autism interacting with Sam differ from those of typically developing children interacting with Sam?

6. How can this information be used to help improve the design of Sam as an intervention that targets turn-taking behaviors?

Given these questions, we begin our investigation of the turn-taking behaviors of children with autism and the impact of Sam working under the following hypotheses:
1. Typically developing children will have more frequent speaker change and more frequent gaps between turns during interaction with Sam than during interaction with another typically developing child.

2. Children with autism have more varied turn lengths, more frequent responses, more frequent gaps between turns, more transfer points taken and more frequent speaker change during interaction with Sam than during interaction with a typically developing child.

3. Children with autism interacting with typically developing children will initiate, induce speaker change, and take transfer points less often and create gaps more often than two typically developing children.

4. Children with autism interacting with Sam will take assignments and transfer points with the same frequency as two typically developing children and have the same variance in turn length as two typically developing children.

5. Children with autism interacting with Sam will create gaps, respond, take assignments and take transfer points with the same frequency as typically developing children interacting with Sam.

These five hypotheses allow us to assess how interaction with Sam changes the turn-taking behaviors of a typical child and how interaction with Sam changes the turn-taking behaviors of a child with autism. The first two hypotheses address precisely how Sam changes the characteristics of turn-taking behaviors exhibited within the groups of children with autism and typically developing children. The third hypothesis provides us with a base comparison that shows us the differences in the turn-taking behaviors of children with autism and typically developing children when both groups are storytelling with human peers. The fourth and fifth hypotheses compare the differences found in the first two hypotheses, giving us the ability to determine whether or not Sam elicits turn-taking behaviors in children with autism that are more similar to those of typically developing children than those of a child with autism interacting with a typical child.
5.0 Methods

5.1 Participants

Twelve dyads of children between the ages of 7 and 12-years-old participated in this study. These dyads formed two groups, the first of which included six dyads that were composed of one typically developing child and one child with autism. The second six dyads were made up of two typically developing peers. No two children in a dyad in either group had an age difference greater than one year. The typically developing dyads were chosen to match the chronological ages (within one year) of the dyads that included children with autism. In both groups, each child picked a peer he knew and had interacted with so that he would be comfortable with collaboration during the experiment. The children were all recruited from the region but were not selected from a particular school or type of school. Participants were of varying ethnic backgrounds but all spoke English fluently. Although participants knew that we wanted to learn more about the ways children tell stories together, they were not aware of the details of the study before participating. Both the consent of the parent and the child’s assent were obtained before participation in the study.

5.2 Procedure

Each participant completed three tasks over the course of the experiment, which lasted approximately one hour per child. All phases of the study were videotaped in the same room with the same surroundings and props. First, the participants’ understandings of critical aspects of the mind were measured using a short Theory of Mind test. This task employs questions that can only be answered correctly if a child is able to understand the mental states of others and comprehend false belief. A child understands the concept of false belief if he realizes that the knowledge he possesses is not necessarily shared and is able grasp what is known by others. Recognition of the contents of others’ knowledge bases is foundational in the understanding of others’ mental states. For example, if a child knows that there is a
cookie in the box but he also knows that his friend has never looked in the box, he should be able to deduce that his friend does not know what is in the box.

During the Theory of Mind task, an experimenter gave children scenarios involving other people or things, represented by dolls or pictures, and asked them what the people would do, how they would feel, or what they would know in the presented situation. The experimenter followed a script during this portion, and the same five scenarios were presented to each child, regardless of whether the child is typically developing or a child with autism. Questions were asked continually throughout the Theory of Mind task to ensure that the child understood the circumstances and was using proper reasoning.

Excerpt:

Experimenter: Here’s a woman. And this woman wants her morning snack, and here are two foods, a carrot or a cookie. Which is your favorite?

PAT115 (child): Um I’m going with the cookie.

Experimenter: Cookie? So that’s a good choice but the woman doesn’t like cookies, she likes carrots.

PAT115: Yeah.

Experimenter: She likes carrots best of all.

PAT115: Oh yeah.

Experimenter: So the woman can only choose one food for her morning snack. Which will she choose?

PAT115: Uh, carrots?

Experimenter: Carrots, okay.

Experimenter: This girl wants her cat and the cat is hiding. It could be in the bushes or it could be in the garage, okay? Where do you think the cat is?

PAT115: The cat is in the bushes.

Experimenter: In the bushes? Well that’s a good idea, but the girl thinks the cat is in the garage, so where will the girl look for her cat?

PAT115: In the garage.
Experimenter: In the garage, okay.

For typically developing children, the questions asked during the Theory of Mind evaluation were extremely simple; they were usually able to answer them with 100 percent accuracy because they could understand that a person’s belief about reality may not actually coincide with what the child knows is the truth. In the example given earlier, a typical child would understand that his friend might believe that there is a puppy in the box even though the child knows with certainty that there is actually a cookie in the box. On the contrary, a child with autism struggles to answer Theory of Mind questions because he has not conceptualized the way knowledge is communicated or how another person’s mind might differ from his own. The Theory of Mind test is a necessary component of this research because it provides us with basic and consistent comparison between the cognitive reasoning skills of the children with autism and of the typical children that participated in our experiments. Additionally, a study by Capps, Kehres, & Sigman [29] found a significant correlation between the ability to correctly answer Theory of Mind questions and the ability to respond to another person with relevant information during conversation. Since our study analyzes storytelling conversations, the results of the Theory of Mind task may be highly related to how much the child is able to contribute to the storytelling activity.

After the Theory of Mind test, the two remaining tasks were performed in a randomly assigned order. One of these tasks involved each individual child telling stories with the virtual peer named Sam (Figure 1). During this phase of the experiment, the first experimenter took the child is into the experiment room and showed him a castle with dolls and other props. The child was told that he would be telling stories with Sam during this portion of the study and the second experimenter in the control room turned on the projection of Sam and cued the virtual peer to say “Hi, I’m Sam!” Sam appeared on a
large screen in front of the child and was accompanied by an image of a toy castle that looked exactly like the castle the child was given to play with - this allowed Sam and the child to really play “together”. The first experimenter then explained to the child that Sam would start the first story but that the two of them would be collaborating to tell several stories together. Each child was given the opportunity to tell four stories with Sam, but he could leave at any point or decline when Sam asked if he “wants to tell another one”.

While a child was interacting with Sam, he (or she, depending on the perception of the child) was being controlled by the second experimenter through a computer in the control room. The experimenter was able to see the child through a two-way mirror and used a control panel (Figure 2) with buttons that allowed her to choose the story she started and then choose appropriate verbal and non-verbal responses based on the child’s inputs. The control panel also contained multiple continuations (middle parts) that Sam could make for each story, as well as an appropriately generic ending for each story that could be added if the child did not terminate the story himself. Throughout the duration of the experiment, the experimenter controlling Sam used not only verbal back channel responses like “uh huh” and “wow!” to encourage continued interaction, but also used non-verbal responses like a head nod to show attention and offer feedback. These mannerisms allow Sam to be more lifelike and help keep the child engaged in the activity.

Excerpt:
Sam: Once there was a boy called Jamie, and a girl called Nicky. They were good friends. On Jamie's birthday, his mom and dad took him and Nicky to a toy factory. The toy factory had all sorts of toys: dolls, robots, teddy bears, space ships, and soldiers. There were lots of small elves making these toys. As they were making the toys, they would sing songs, “la la la”, and move like robots. Jamie and Nicky were looking at the elves, and they lost their parents along the way. They walked into this big room where there were hundreds and hundreds of different kinds of toys all put neatly on a shelf. The room had a high ceiling and the toys were piled all the way to the top. Suddenly the door closed, and Jamie and Nicky were left alone in this cool room full of toys. And then…….

PAT118: Then they and then they called and called.

PAT118: And they couldn’t find many things but it was dark.

PAT118: They- they called and called parents.

PAT118: They stumbled through the dark and fell right on top of each other.

Sam: Uh-huh.

PAT118: And then finally the parents found them.

PAT118: They brought- they had a few toys with them so they said, “Here you go.”

PAT118: “This is for you.”

PAT118: “This is for you.”

After each child finished telling stories with Sam, the experimenter re-entered the room and asked the child about his experience playing with the virtual peer. She asked the child what he liked or disliked about playing with Sam, what he thought Sam was, what Sam reminded him of, how Sam could be a better playmate, and more. The responses questions were recorded to help improve Sam’s design and make him a more adaptable playmate for children of different ages and genders.

In addition to storytelling with Sam, each dyad of children told stories with each other. During this phase, the children were in the experiment room with the same castle and toys, but Sam was not projected on the screen behind the castle. The children were told by the experimenter that they would be given fifteen minutes and that they were free to play and tell stories about whatever they wanted. The experimenter also told the children that they could use the toys and the castle if they wanted to, but they did not have to use them. If the children did not have any questions, the experimenter left the room and
checked back in fifteen minutes to ask if the children wanted five more minutes to play. If they wished to continue for five minutes, they were allowed to do so, if not, the activity ended and any remaining phase of the experiment was completed by the children.

When the experiment was over, the children were given the opportunity to learn about how Sam was controlled and how the data we collected was being used to help children with autism. They were shown the control panel that we used to control Sam and were given the opportunity to click buttons and see Sam react. In some cases, one child played with the control panel while the other child did mock storytelling with Sam. Any questions the children might have had about the study were answered as well as possible and then the study terminated.

5.3 Methods of Analysis

All three tasks performed by each child participating in the study were videotaped by four cameras, each capturing a different angle of play. Once the videotapes were digitized, they were completely transcribed by one researcher and checked for discrepancies by a second researcher. Transcripts listed not only spoken words, but also laughter, pauses and gaps that occur during interaction. The transcripts divided the interaction by utterances, and labeled the number of utterances made by each speaker. Once a final transcript was agreed upon, the utterance numbers and corresponding speakers were entered into a spreadsheet. A turn-taking coding scheme was applied in order to analyze the transcript spreadsheet and the videos.

5.4 Turn-taking Coding Scheme

In order to best analyze the data we collected and compare the data from typically developing children with the data from children with autism, we needed to be able to quantify the turn-taking skills we were observing. This was be achieved by creating a data coding scheme that identified characteristics of turns and turn-taking behaviors. The turn-taking coding scheme we developed was based on Sacks’ research exploring typical human turn-taking interactions, and a study by Catherine Adams examining the
most accurate ways to label different parts of a turn [20][21] and has several components used to analyze and compare the behaviors of children interacting with Sam and with each other. Since we are using this coding scheme to analyze turn-taking behaviors, we define a turn as our unit of analysis and mark each turn beginning and turn ending on the transcript spreadsheet.

The length of each turn, in utterances, is recorded in the spreadsheet in associated with the speaker taking the turn. Recording the length of the turns is important because it is believed that children with autism generally have rigid and short turn lengths during storytelling activities. We believe that children with autism struggle to create longer turns during storytelling activities because imaginative play behaviors do not come naturally to them as they do with typically developing children [5][6]. Because of their deficits in the area of imaginative play, plot expansion, which frequently results in extended turns, is rarely accomplished by children with autism. By measuring the variance of the length of a child’s turns, we can assess the rigidity in turn length exhibited by children with autism during storytelling activities.

Turns are defined as beginning either with an initiation, a response, or a neutral speaker change. An initiation is created when a speaker introduces a new topic or actively seeks input from the other child. Initiations may be questions or statements that clearly induce some sort of affirmation or even a non-verbal response. Responses are made by an individual other than the initiator and clearly relate to the topic introduced during the initiation. A direct question may induce the response, but a response is possible after any initiation even if it is not a specific question. Neutral turn beginnings occur when a speaker changes and the second speaker maintains the conversation without initiating or responding. Neutral turns can also occur when one speaker offers a turn but it is not taken, so he simply continues on with the same topic. One way that a speaker can take multiple turns in a row is if, for example, the speaker first responds to his partner and then initiates a new topic. In this case, the first turn begins with the response and the second turn begins when the speaker changes the topic with an initiation.

Excerpt:

PAT218: “I’ll carry the rocking horse.” \textit{beginning of turn 1}
PAT218: “And you get your baby brother off.”
PAT218: “Okay?” end of turn 1  
PAT118: “We can’t sell him.” beginning and end of turn 2 (response)  
PAT118: “Hey, what’s going on around here guys?” beginning and end of turn 3 (initiation)

Once the utterances have been divided into turns, each turn is labeled as an initiation, a response, or a neutral beginning.

Speaker changes are marked for frequency analysis because, as in the example above, multiple turns can be taken without a change of speaker. Multiple consecutive turns are often taken by the same speaker when a child asks a question requiring affirmation (like “okay?”) and does not get a response, leading him to continue on himself. Since we believe that children with autism frequently fail to respond to initiations by their peers, marking speaker change allows us to evaluate the hypothesis that speaker change is less frequent when children with autism interact with typically developing children than when two typically developing children are interacting.

Non-verbal responses made by each child are noted in a separate column from verbal initiations or responses, and the nature of the non-verbal behavior is recorded separately to resolve potential discrepancies between coders. It is hypothesized that non-verbal responses would be less frequently used with Sam, and that children with autism generally use fewer non-verbal responses since they have deficits in joint attention. These joint attention deficits make it difficult for children with autism to display outward signs of attention, like looking at the object his peer is talking about or nodding in agreement as someone makes an assertion. Thus, children with autism may appear to be uninterested or thinking of something else instead of exhibiting natural non-verbal reactions [9].

Gaps that have occurred between turns are labeled with the number of seconds they lasted. We did not note gaps that occurred within a turn because, while pertinent to the deficit in communication skills exhibited by children with autism, these gaps do not supply information about turn-taking. Since the coding of gaps provides number of seconds they last, we can easily compare the interactions of children with autism and typically developing children based not only the frequency, but also length of gaps between turns.
An assignment, a focused type of turn allocation, occurs when a child directs a question or statement toward the other child that specifically calls for an immediate response from a particular child. In conversation with more than two people, assignment would occur when the speaker directs his question at one particular person, but since we only have two children interacting at one time, any directed question is an assignment, or part of one.

An assignment is taken when the second speaker replies (verbally or non-verbally) when he is addressed by a direct question from the first speaker. If a speaker says “okay?” and pauses for an answer and there is neither a verbal nor a non-verbal response, then the assignment is not taken. Assignments given are recorded in association with the speaker who gives the assignment, and those taken are identified with the speaker who takes the assignment.

The creation of a transfer point, or point at which the turn could be passed to the other speaker, is labeled in association with the speaker who is allocates the new turn. It must be emphasized that a transfer point is a moment in the conversation where the speaker could change smoothly and is not an assignment. For a smooth transition to occur, the speaker must pause at the end of an utterance and allow for a reply. If a speaker were to pause in the middle of a sentence because he stumbled or needed to recall something, there would not be a transfer point. Transfer points must be times where the utterance is completed and the speaker has created an opportunity for a transition.

The creation of a transfer point by one speaker does not necessarily imply that the other speaker actually will take a turn. In fact, many times when there is a pause and the other person could speak, he chooses not to and the first speaker continues. It is important to note that if one speaker creates a transfer point and then continues because it is not taken by the other speaker, then the transfer point is not marked as being taken by the same speaker who offered it – a speaker can only take a transfer point created by someone else. Transfer points taken by each child are also marked in association with the speaker who took over the turn.
Overlapping turns are identified and labeled with the seconds of overlapping speech, and each occurrence of overlap is associated with the last speaker to begin talking. If both speakers begin speaking at the same time, the overlap is associated with both of them. Overlap is a common error that occurs in human turn-taking, but it is easily repaired as one speaker yields the turn. Thus, repair mechanisms for communication error, specifically overlap, are noted by marking which speaker stopped speaking and conceded the turn after overlap began.

Interruptions, defined as occurring when a speaker takes a turn that was not offered either by a transfer point or assignment, were counted in association with the interrupting speaker. Interruptions occur at each instance of overlap, but they also occurred in instances when a speaker cut in during a short pause that was clearly not intended to yield the turn. Examining the frequency of interruptions is particularly interesting as typical children may accidentally interrupt children with autism more often than they would another typical child because some believe that children with autism may be slower to speak and finish their thoughts.

5.5 Methods of Measuring Hypotheses

Since the turn-taking coding scheme we developed required identification of fourteen aspects of turn-taking in each child (listed below), it is important to clarify how the analyzed data were used to evaluate each hypothesis. The aspects of turn-taking behaviors coded for each child were: number of turns, turn length (in utterances), speaker change, gaps (in seconds), initiation, response, overlap (in seconds), repair of overlap, transfer points created, transfer points taken, assignments created, assignments taken, interruption, and nonverbal responses. Data describing these behaviors was combined into four major groups and compared in order to evaluate the hypotheses asserted in this paper. The four groups are as follows: A) children with autism interacting with typically developing children, B) children with autism interacting with Sam, C) typically developing children interacting with typically developing children, and D) typically developing children interacting with Sam. In all instances, it is important to note that frequencies of speaker change and gaps are measured with respect to the total number of turns taken during the interaction.
1. *Typically developing children will have more frequent speaker change and more frequent gaps between turns during interaction with Sam than during interaction with another typically developing child:* comparison of identified turn-taking characteristics during interaction with Sam (group D) and interaction with a typical child (group C).

2. *Children with autism have more varied turn lengths, more frequent responses, more frequent gaps between turns, more transfer points taken and more frequent speaker change during interaction with Sam than during interaction with a typically developing child:* comparison of identified turn-taking characteristics during interaction between a child with autism with Sam (group B) and interaction between a child with autism and a typical child (group A).

3. *Children with autism interacting with typically developing children will initiate, induce speaker change, and take transfer points less often and create gaps more often than two typically developing children:* comparison of identified turn-taking characteristics during interaction between a child with autism and typically developing children (group A) and the frequencies of these behaviors during interaction between two typically developing children (group C).

4. *Children with autism interacting with Sam will take assignments and transfer points with the same frequency as two typically developing children and have the same variance in turn length as two typically developing children:* comparison of identified turn-taking characteristics during interaction between a child with autism and Sam (group B) and the frequencies of these behaviors during interaction between two typically developing children (group C).

5. *Children with autism interacting with Sam will create gaps, respond, take assignments and take transfer points with the same frequency as typically developing children interacting with Sam:* comparison of identified turn-taking characteristics during interaction between a child with autism and Sam (group B) and the frequencies of these behaviors during interaction between a typically developing child and Sam (group D).
General comparisons between turn-taking characteristics identified in the coding scheme but not listed in the hypotheses will be made between groups and tested for statistical significance. This analysis will provide additional information to help answer the question regarding how Sam can be improved as an intervention for children with autism that targets turn-taking behaviors.

6.0 Descriptive Results

While statistical analysis of our quantitative results will be used to evaluate our hypotheses, we also find it beneficial to provide descriptive results in the form of excerpts from the transcripts of the storytelling tasks performed by participants in our study. Since the sample size in our experiment is relatively small, descriptive evidence that supports our hypotheses allows us to argue that, while our sample size may not be large enough yield statistically significant results in all cases, the characteristic turn-taking behaviors about which we hypothesized do occur and merit further investigation.

6.1 Comparison of Typical Children and Sam to Two Typically Developing Children

The first comparison we will make will be within the group of typically developing children. In the following section, we provide excerpts from transcripts, graphs, and descriptions of behaviors in order to contrast the turn-taking behaviors exhibited by typically developing children telling stories with Sam to those of two typically developing children telling stories together.

*Increased frequency of speaker change and short gaps*

The most obvious example of increased frequency of speaker change can be seen in the interaction between two ten-year-old male typically developing children, PAT342 and PAT442 (excerpt below). While PAT342 and PAT442 tell stories together, PAT442 talks for extremely long periods of time without any contribution from PAT342. Although PAT442 does occasionally pause during his stories, he does not directly engage PAT342 or ask him for input. During the joint storytelling activity PAT442 speaks 77 utterances in a row at one point and over 40 utterances in a row in another instance.
However, during the storytelling activity involving PAT442 and Sam, PAT442 never makes more than 13 utterances in a row. In both cases, PAT442 speaks more than 100 utterances, implying that the decrease in uninterrupted speech was not a result of a lowered level of contribution to the conversation by PAT442. Overall, during interaction with PAT342, PAT442 took 36 turns and there were 23 instances of speaker change whereas, during interaction with Sam, PAT442 took 34 turns and there were 44 instances of speaker change.

Excerpt (PAT342 and PAT442):

PAT442: And (laughter) one day she heard a thunk
PAT442: She was like “what was that” and she got her towel on and she got her clothes on a walked down
PAT442: And she saw something startling
PAT442: This little flipping door here was (moves the sliding door in the dollhouse) here when she went in the shower
PAT442: And this one was here (slides other door as he is saying this) here when she
PAT442: Her foot was stuck in one of the holes
PAT442: “Ohhh!”
PAT442: And then she said, she’s like “Hey someone help!”
PAT442: So, she tries to get up, but…

PAT442: What about this?

PAT442: …and she gets pinned to the wall
PAT442: So…so the husband comes home and comes up the stairs
PAT442: “Agghhh!” and he faints (laughter)
PAT442: And he dies because of that
PAT442: So, the little girl comes home from her friend from her school
PAT442: And she-and she’s listening to her iPod
PAT442: So, she…she doesn’t realize that something is wrong and she reaches the step
PAT442: And she’s going there and she climbs into the tub
PAT442: And she turns around and she’s listening to her iPod
PAT442: And she had a little plug here
PAT442: And she turns on the water and when it gets full she turns it off
PAT442: All of a sudden, something bad happens

Excerpt (Sam and PAT442):
Sam: Uh-huh

PAT442: So they…they said “Let’s split up and search where.”
PAT442: So Jamie went one way and Mik-Nicky went the other way

Sam: Uh-huh

PAT442: Nicky kept on going
PAT442: It seemed like he was searching for hours and hours and hours and hours
PAT442: And then … he finally came across the dead-end
PAT442: It was … a blank wall, nothing on it, no door, no window, nothing
PAT442: And…

Sam: Jamie walked around the room too and found a robot. The robot could wind up and Jamie
wound it up and the robot started moving. It turned to Jamie and said, “I’m your robot. Tell me what
to do and I can do it for you.” Jamie thought really hard and said to the robot...

PAT442: Jamie followed the robot… or asked the robot to know where the way out is…
PAT442: And the robot said …uh… “There is no way out. Kids who come in…kids go in and kids
never come out.”

Throughout the interaction between PAT442 and Sam, Sam makes a concerted effort to stay active in the
conversation by making remarks like “uh huh” and “cool!” The structure instilled in the conversation by
these backchannel comments seems to remind PAT442 to take turns and he easily allows Sam to take
over the story. Both the initiative Sam takes to remain engaged in the activity and the structure he adds to
the conversation seem to increase the number of speaker changes that occur during storytelling and ensure
that the conversation is better balanced between speakers.

Increased frequency gaps

Both PAT440 (see graph at right) and PAT342 are excellent examples of an increase in frequency
of gaps during interaction with Sam as opposed to interaction with another typical child. While PAT 440 creates 9 gaps, 8 of which are short, during his 70 turn interaction with PAT340, he creates 21 gaps, 20 of which are short, during his 42 turn interaction with Sam. Clearly, PAT440 is more likely to pause to allow Sam to take over or comment rather than PAT340, but he still manages to avoid the creation of long or awkward gaps.

In the case of PAT342, he creates only 4 short gaps during interaction with PAT442 and 18 short gaps during interaction with Sam. This may be because PAT342 felt that he had to fight for a turn to talk during interaction with PAT442 and, as a result, felt less willing to yield the turn once he began speaking. In contrast to his interaction with PAT442, it seems that PAT342 quickly realized that Sam would continually ask him to contribute and help with the storytelling. As a result, PAT342 generously offered turns to Sam and took advantage of the collaborative nature of the activity.

6.2 Comparison of Children with Autism and Sam to Children with Autism and Typical Children

The second comparison we will make will be within the group of children with autism. Once again, we will provide excerpts from transcripts and descriptions of behaviors in order to contrast the turn-taking behaviors exhibited by children with autism telling stories with Sam to those of children with autism telling stories with a typical peer.

*Increased variance in turn length*

All but two of the children with autism who participated in our study showed an increase in the variance of their turn lengths when they interacted with Sam instead of a typically developing child. The most drastic improvements can be seen in PAT107 and PAT116. Although PAT107 contributed actively to the stories while he interacted with a typical child, PAT207, his turns were almost all one or two utterances long, which did not allow him to greatly expand the story. When PAT107 interacted with Sam he continued to contribute to the stories, but was able to take turns of more varied lengths, at times contributing significantly to the plot development. As a result, the variance of the length of turns taken by
PAT107 jumped from 1.5 during interaction with PAT207 to 9.87 during interaction with Sam (see excerpts below). While interacting with her typical partner, PAT116 had a total of four turns, each of which was one utterance long. Of course, the variance of the length of her turns during interaction with human peer was zero. However, during interaction with Sam PAT116 spoke frequently and the variance of the length of her turns jumped to 1.13.

**Excerpt (PAT107 and PAT207)**

PAT207: “Okay.”
PAT107: “Weeeeeeeee!”
PAT107: (2.0) “Weeeeeeeee!”
PAT207: “[Rosa] wake up!”
PAT207: “Ow”
PAT207: “I fell out of bed.”
PAT107: ((() Pretend he’s gone.
PAT207: “Hey!”
PAT207: “Where’d he go?”
PAT207: “Where’d they go?”
PAT107: (4.0) “I thought you were upstairs in the attic.”
PAT207: “Did you hear that?”
PAT207: “They’re in the attic.”
PAT207: “I’ll stay here.”
PAT207: One of them in the attic for …
PAT107: Pretend that he’s been shot in the [unintelligible].
PAT207: “I found you!”
PAT107: No.
PAT107: Pretending he shot me.

**Excerpt (PAT107 and Sam)**

*Sam: Okay, now it’s your turn.*

PAT107: Okay.
PAT107: Two boys came into the- two boys came home from school.
PAT107: And- one of them said, “Let’s play hide-and-go-seek.”
PAT107: And so like his big brother goes into the- she- he hides into the- he hides in the dark outside.
PAT107: And he counts.
PAT107: “One, two, three”
PAT107: And then he hides into- and he hides in the bathtub and closes the curtains.
PAT107: Then he says, “Ready or not, here I come!”

**PAT107 continues, 6 utterances later...**

PAT107: “I wonder where he could be.”

PAT107: He looks in the toilet.

PAT107: He looks in his cupboard.

PAT107: Then he goes over to the toilet and says, “Hello!”

PAT107: Then he-

Sam: Cool!

PAT107: And then So like he quietly tiptoes, and then sticks his head in the toilet.

PAT107: “Wahhhhh!”

PAT107: “Wahhhhh!”

Sam: That's cool!

PAT107: And then he runs for his life.

PAT107: Then he decides to hide somewhere else.

PAT107: Then he hides into the- he hides behind the bed.

PAT107: Crawls down and looks under.

PAT107: And he said, “Whoom.”

PAT107: Then his sister came in from home school.

**PAT107 continues**

As can be seen in the excerpts above, PAT107 is much more active in the development of the story when interacting with Sam rather than PAT207. Although, in the excerpt, it may seem that PAT107 is dominating the conversation with Sam, the complete transcript reveals that they both contributed significantly to the stories and took about the same number of total turns – Sam took 30 turns while PAT107 took 35 turns.

*Increased gap frequency*

Every single child with autism created more...
gaps during interaction with Sam than during interaction with a typical child and maintained a very low number of long gaps. The absence of long gaps is important because it shows that the children have been able to prepare their thoughts and are able to rejoin the conversation immediately if Sam does not take a turn during the short pause. Long gaps between turns were often problems for children with autism interacting with typically developing children potentially because the pace of the conversation does not correspond with their rate of cognition and they have not decided what to add next.

*Increased frequency of response to partner initiation*

All but one child with autism that participated in our study responded to initiations made by Sam more often than initiations made by the typically developing human child with whom they told stories. One potential cause of this difference is that Sam distinctly waits for a response when he finishes an initiation, making it easy for a child with autism to determine that a turn has ended and it would be appropriate to respond. When typically developing children finish an initiation, they generally pause but do not necessarily make it evident that they are waiting for a response. It may be that, because the signals they receive from their partner in conversation are not completely clear, children with autism become confused and fail to respond and take turns when it would be appropriate to do so during interaction with typically developing peers.

*Increased frequency of speaker change*

As was the case with interaction between two typically developing children, there are instances where one child dominates the conversation when a child with autism is interacting with a typically developing child. However, either child could dominate the conversation, as can be seen by comparing the interactions of PAT115 and PAT215 with those of PAT116 and PAT216. While PAT215 politely waits for PAT115 to finish turns of up to 20 utterances and takes uninterrupted turns whose combined length is nearly 30 utterances, PAT216 does not actively attempt to illicit any response from PAT116 from her second utterance until her 102^rd utterance. This example shows the marked differences between
individual children – while one child allows the other to continue on when most would take a turn themselves, the other does not actively try to bring her partner into the conversation until she has spoken over 100 utterances in a row (see excerpt below). The total number of speaker change occurrences during the interaction of PAT116 and PAT216 was 4 and a total of 42 turns were taken whereas the total number of speaker change occurrences during the interaction between PAT116 and Sam was 109 and a total of 130 turns were taken. Clearly, the proportion of speaker change occurrences to turns taken is much greater during interaction between PAT116 and Sam than during interaction between PAT116 and PAT216.

**Excerpt (PAT116 and PAT216)**

PAT216: Once upon a time, there’s a little girl and boy who were playing house.
PAT216: They just woke up from bed.
PAT216: And they went to brush their teeth.
PAT216: And the sister asked, “Who will go first?”
PAT216: “The sister or the brother?”
PAT216: And the sist- and the brother said that the sister could go first.
PAT216: So the sister brushed her teeth.
PAT216: And now, it was the brother’s turn.
PAT216: And then they went- the boy went to take a shower.

**80 utterances later without speaker change**

PAT216: The mom said that she would be up there in just a couple minutes.
PAT216: She’s just gonna clean up the kitchen.
PAT216: And the girl went up the stairs to the bathroom.
PAT216: Then she took- she took a shower.
PAT216: And ten minutes passed and she got out.
PAT216: And then, she brushed her teeth and washed her face and went to the bathroom.
PAT216: And then her mom came up, right?
PAT216: Her brother was in her bed.
PAT216: So she went downstairs to…tell her mom.
PAT216: “Mom!”
PAT216: “Brandon’s in my bed.”
PAT216: So what happened then… was…
PAT216: Guess what happened?

**PAT116: She put on her pajamas.**

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**PAT216: No.**

**PAT116: Oops.**

PAT216: And the- the mom told Ashley that she could sleep in the bunk-bed with her mom.  
PAT216: And so she did.  
PAT216: She climbed up and laid down.  
PAT216: And when the mom put on she- the mom went upstairs and took a shower- and took a shower.  
PAT216: And then- then they were…  
PAT216: She took a shower and she brushed her teeth and washed her face and went to the bathroom.  
PAT216: And she went back downstairs.

**PAT216 continues**

Despite there certainly were points where PAT116 could have entered the conversation, she does not and PAT216 does not explicitly address her or engage with her until the storytelling period is more than half over. However, as can be seen in the excerpt of PAT116 interacting with Sam, the speaker changed quite often and PAT116 participated actively in the storytelling activity.

**Excerpt (PAT116 and Sam)**

_Sam:_ Once there was a boy called Jamie, and a girl called Nicky. They were good friends. On Jamie's birthday, his mom and dad took him and Nicky to a toy factory. The toy factory had all sorts of toys: dolls, robots, teddy bears, space ships, and soldiers. There were lots of small elves making these toys. As they were making the toys, they would sing songs, “la la la”, and move like robots. Jamie and Nicky were looking at the elves and they lost their parents along the way. They walked into this big room where there were hundreds and hundreds of different kinds of toys all put neatly on a shelf. The room had a high ceiling and the toys were piled all the way to the top. Suddenly the door closed and Jamie and Nicky were left alone in this cool room full of toys. And then…….

**PAT116: Uh, jack in the boxes.**

_Sam:_ Uh-huh.

**PAT116: (()) Handles (()) with on it.**

_Sam:_ Then…

**PAT116: A spaceship.**
Sam: Then what happens?

PAT116: Um uh a canoe.

Sam: Uh-huh.

PAT116: And a book.
PAT116: And a book.

The contributions made by PAT116 are not necessarily content rich, but she does consistently comment throughout the interaction and shows great enthusiasm and interest for the activity. The manner in which Sam is able to engage PAT116 by creating opportunities for speaker change occurrence makes a drastic difference in the balance and educational value of the conversation.

*Increased frequency of transfer points and turns taken*

As can be seen in the excerpts above from PAT116, even though PAT216 occasionally pauses creating points where PAT116 could smoothly begin speaking, PAT216 fails to take a turn. Just like PAT216, Sam pauses and creates transfer points where PAT216 could take over the story, and in this situation PAT116 frequently takes turns. In order to understand this difference, we must examine the ways that PAT216 creates transfer points and compare them with the ways Sam creates them. While PAT216 pauses at the end of an utterance once her thought is complete, Sam usually creates transfer points mid-thought, which gives PAT116 a clear starting point and a prompt for what she should be talking about. Additionally, Sam speaks as though he is stuck trying to think of how the story should continue, which gives his partner motivation to contribute to the conversation. Whether or not it is this particular aspect of Sam’s behavior that elicits speech from his partners, he was clearly effective with PAT116 as she took 91 percent of the transfer points he offered her and 92 percent of all the turns (including assignments) offered her whereas she took 5 percent of the transfer points created by PAT216 and only 10 percent of all the turns PAT216 offered her. PAT108 also improved drastically with respect to transfer points and turns taken when he interacted with Sam as he went from taking 53 percent of
transfer points and 57 percent of all the turns PAT208 offered him to taking 85 percent of transfer points and 86 percent of all the turns Sam offered him.

6.3 Comparison of Children with Autism and Sam and Two Typically Developing Children

While comparing participants within groups of children with autism and typically developing children yields important information, it is also necessary to make comparisons between typically developing children and children with autism. We will compare the behaviors of two typically developing children from our control group to those of a child with autism and Sam in order to determine whether the turn-taking behaviors of children with autism and Sam are truly more similar to those of two typically developing children than the turn-taking patterns of a child with autism and a typical child.

Frequency of transfer points and turns taken when offered

The included excerpts from the transcript of the tasks performed by PAT116 clearly show that PAT116 takes transfer points and turns more frequently when she is interacting with Sam than when she is interacting with her typical peer, PAT216. In our study, we have matched PAT116 with a participant from the control group, which included only typically developing children. A comparison of PAT116’s turn-taking behaviors to those of the control, PAT445, a typically developing female within one year of PAT116’s age, shows stark differences while both children are interacting with typically developing peers. First, PAT445 takes approximately 82 percent of the transfer points that are created by PAT345, while PAT116 takes 5 percent of the transfer points created by PAT216. Additionally, PAT445 takes 84 percent of the turns offered to her by PAT345, while PAT116 takes only 10 percent of the turns offered to her by PAT216. However, as was previously mentioned, when PAT116 interacts with Sam, she takes about 91 percent of transfer points offered and 92 percent of the turns created by Sam. Clearly, the turn-taking behavior patterns, with respect to transfer points and turns taken, displayed by PAT116 during interaction with Sam are much more similar to those of two typically-developing children, PAT445 and PAT345, than those that she exhibited during interaction with her typical peer.
Variance in turn length

The increase in the variance in turn length of PAT116’s interaction with Sam also shows a change in the nature of her turns that makes her behavior more similar to that of a typical child. While PAT116 takes only turns that are one utterance long during interaction with PAT216, resulting in zero variance in turn length, the variance of the length of her turns as she tells stories with Sam is 1.13. Since the variance in the length of PAT445’s turns during interaction with Sam is 0.83, we can see that the changes in PAT116’s is once again behaving, with respect to turn-taking, in a manner more similar to that of PAT445, a typically developing child, when she interacts with Sam rather than a typical child.

6.4 Comparison of Children with Autism and Sam and Typically Developing Children and Sam

Although our goal is to design Sam to simulate the behaviors of a typical child as accurately as possible, we do recognize that a typically developing child may not take turns with Sam in exactly the same way that he interacts with a typical human peer. For this reason, we feel that a comparison of children with autism interacting with Sam and typically developing children interacting with Sam is necessary as there may be changes in the characteristic turn-taking behaviors of both groups as they interact with Sam.

Frequency of response to initiations by Sam

Multiple children with autism showed an increase in the frequency of responses they made when they interacted with Sam instead of a typically developing peer. At the same time, typically developing children did not consistently respond more or less often to Sam than a typical peer. As a result, some children with autism actually responded more often to Sam than the typically developing children did to either Sam or their typically developing peer. For example, PAT115 responded approximately 32 percent of the time while interacting with a human peer and 77 percent of the time while interacting with Sam. In contrast, PAT444, the typical control matched with PAT115, responded 37 percent of the time to his typical peer and only 27 percent of the time to Sam. This difference may be due to the fact that
children with autism are generally interested in and excited by new technologies while typically children may be suspicious or uncertain about how or why they should talk to something that is not human. For example, during experimentation, a PAT444 asked how she was “supposed to talk to a screen”, and seemed to remain doubtful throughout the entire task of telling stories with Sam.

*Frequency of transfer points taken*

PAT115 and PAT444 also provide an example for the similarity of the frequency of transfer points and turns taken by each child when interacting Sam instead of a typical child. PAT115 is active during both interactions, but the frequency of transfer points taken increases approximately 43 percent when she interacts with Sam. In comparison, the control child, PAT442, has only a 10 percent increase in the frequency of transfer points taken during interaction with Sam and with his typical peer. Both PAT115 and PAT442 took roughly 50 percent of the turns they were offered during interaction with a typical peer and even though the frequency of transfer points taken increased for both children, there was actually a greater difference between the frequency of transfer points taken by PAT115 and PAT444 when they interacted with Sam instead of a typical peer. Overall, children interacting with Sam almost always took between 60 and 100 percent of the transfer points offered to them, regardless of whether they children with autism or typically developing.

7.0 Statistical analysis and discussion of results

Multiple statistical models were used to analyze the data gathered during this study. Only one of the 24 children who participated in our experiment was not included in our statistical analysis. The omitted child, PAT441, was part of the control group of typically developing children and was not included because he did not complete at least ¾ of the storytelling activity with Sam due to illness. PAT441 did complete the peer storytelling task and, because of this and the fact that he completed the full Sam task, PAT341 was included in the analysis. The analysis in the following pages can be separated into two major parts, the logistic regression analysis and the OLS regression analysis with the Wilcoxon
signed-rank test. In this study, we consider statistical significance to exist at or above the 95 percent certainty level.

7.1 Logistic Regression Analysis

In the logistic regression analysis, the unit of analysis was a turn and all outcome variables were restricted to those that could be represented in binary. In each regression, we controlled for the participant because of the heterogeneous nature of groups consisting of children with autism. The logistic model allowed us to analyze the following characteristics of turn-taking behaviors:

1) Speaker change likelihood
2) Gap occurrence likelihood
3) Initiation likelihood
4) Response likelihood
5) Likelihood of a transfer point being taken
6) Likelihood of an assignment being taken
7) Interruption likelihood
8) Non-verbal response likelihood

The logistic regression model showed that the variable ASD, which was valued one when the child with autism was speaking, was a valid predictor of several behaviors during interaction with typically developing children and during interaction with Sam. Each child with autism was identified in the regression by a specific identification number, which served as a control. The number of observations of each regression varied based on the number of turns relevant to the behavior being analyzed (see Figure 3 below). First, our regressions showed that the probabilities of speaker change and assignments being taken by a child with autism are higher when children with autism are interacting with Sam than with a typical child. Second, we found that the probability of a child with autism initiating or taking transfer points is lower when they are interacting with Sam instead of a typical child. Additionally, we found that, regardless of their storytelling partner, children with autism are more likely to take an
assignment than to take a transfer point (see Figure 3 for detailed z-statistics, coefficients, and odds ratios).

Our logistic regression model also showed marked differences between the predicted behaviors of typically developing children when they are interacting with Sam and when they are interacting with a typical peer. We included only typically developing children from the control group that were matched by age to a child with autism in this regression. The variable TD was valued one when a matched typically developing child was speaking. Each child was identified by a specific number, which served as a control in the regressions. Once again, the number of observations of each regression varied based on the number of turns relevant to the behavior being analyzed. Our regressions showed that TD was a valid predictor of behaviors when typically developing children were interacting with Sam and when they were interacting with each other. First, we found that speaker change initiated by the matched control children is more likely when typically developing children are interacting with Sam instead of another typical child. We also found that initiation is less likely when the control children were interacting with Sam instead of a typical peer. While the variable TD was not a valid predictor of assignments taken when the interaction was with another typical child, it was a valid predictor of assignments taken while interacting with Sam. During interaction with Sam, the logistic regression a high probability of assignments being taken (see Figure 3 for complete statistics).
Interaction pair | Turn-taking characteristic | N (turns) | Predictor | Coefficient | Odds ratio | z-statistic | P>|z| |
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<td>ASD &amp; TD</td>
<td>Speaker change</td>
<td>980</td>
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<td>ASD</td>
<td>1.765</td>
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<td>ASD</td>
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<td>ASD</td>
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<td>2.51</td>
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Figure 3: Logistic Regression Results

7.2 OLS Regression Model Analysis and Wilcoxon Signed-Rank Test

The OLS portion of our analysis addressed the frequency statistics, represented as percentages, for each child that participated in our study. For example, while the logistic regression took as input the raw data of 0 or 1 representing speaker change during each turn taken by PAT107 or his partner, the OLS regression took as input the percentage of speaker change occurrences out of the total number of turns taken by PAT107 and his partner. The OLS regression model was applied to the following characteristics of turn-taking behaviors:

1) Speaker change frequency: number of speaker change occurrences/total number of turns taken by the dyad.
2) Average turn length
3) Variance of turn length
4) Gap frequency: number of gaps created by one child/number of turns taken by that child.

5) Initiation frequency: number of initiations taken by one child/number of turns taken by that child.

6) Response frequency: number of responses made by one child/number of initiations made by the other child.

7) Frequency of transfer points taken: number of transfer points taken by one child/number of transfer points created by the other child.

8) Frequency of assignments taken: number of assignments taken by one child/number of assignments made by the other child.

9) Frequency of interruption: number of interruptions made by one child/number of turns taken by that child.

10) Frequency of non-verbal response: number of non-verbal responses made by a child/number of responses made by that child.

In order to assess whether or not there were statistically significant differences between the turn-taking behaviors exhibited by each group of children, we used the Wilcoxon signed-rank test as a non-parametric alternative to the paired t-test. We chose to use the Wilcoxon test because of the extremely small sample size (n=11 for within comparison of typically developing children, n=6 for all other analyses) of our data. We performed the Wilcoxon test on all of the behaviors listed in section above making comparisons between the following groups:

1) Base comparison: two typically developing children compared to one child with autism and a typically developing child.

2) Typically developing children with Sam compared to two typically developing children.

3) Children with autism and Sam compared to children with autism and typically developing children.

4) Children with autism and Sam compared to two typically developing children.

5) Children with autism and Sam compared to a typically developing child and Sam.
Each child with autism was paired with a typically developing child from the control group that was within one year of his or her age at the time of the experiment. These pairings persisted throughout all analyses that involved paired comparisons of children with autism and typically developing children.

Comparisons using the Wilcoxon signed-rank test resulted in seven statistically significant differences between groups. First, in our base comparison between typically developing children and children with autism interacting with typical peers, we found a statistically significant difference between groups in the frequency of initiations they made (see Figure 4 for complete z-statistics). Next, in the comparison within typically developing children (comparison number two above) and in the comparison within children with autism (comparison number three above), we found the frequency of gap occurrence to be significantly different when children are interacting with Sam instead of a typical peer. In comparison group number four (above), we found significant differences in the frequency of initiations and frequency of responses in children with autism interacting with Sam as compared to typically developing children interacting with Sam. Finally, we found that the turn length variance, frequency of assignments taken, and frequency of responses were significantly different when comparing children with autism interacting with Sam to typically developing children interacting with Sam (comparison group number five).

| Comparison group | Turn-taking characteristic | N  | z-statistic | P>|z| |
|------------------|-----------------------------|----|-------------|-----|
| 1                | Initiation frequency        | 6  | -1.992      | 0.0464 |
| 2 (TD only)      | Gap frequency               | 11 | 2.845       | 0.0044 |
| 3 (ASD only)     | Gap frequency               | 6  | 2.201       | 0.0277 |
| 4 (ASD only)     | Initiation frequency        | 6  | -2.201      | 0.0277 |
| 4                | Response frequency          | 6  | 2.201       | 0.0277 |
| 5                | Turn length variance        | 6  | -1.922      | 0.0464 |
| 5                | Response frequency          | 6  | 1.922       | 0.0464 |
| 5                | Frequency of assign. taken  | 6  | 2.108       | 0.0350 |

Figure 4: Wilcoxon Signed-Rank test
Along with the Wilcoxon signed-rank test, we performed a variety of OLS regressions on the turn-taking behaviors listed above. For comparison groups numbers one, three, and five (comparisons between children with autism and typically developing children) we regressed the behavioral characteristics with a dummy variable, ASD, which was valued at one for children with autism. For comparison groups two and three (within comparisons), we regressed the behavioral characteristics with a dummy variable, Sam, which was valued at one if the interaction involved Sam. In these regressions, we also controlled for the age and gender of the participants.

The OLS regressions yielded several significant relationships within the comparisons group. First, regressions on the data from the first comparison group yielded a significant negative coefficient on the ASD dummy variable in relation to frequency of initiations made (see Figure 5 for t-statistics). Regressions using the data from our second comparison group, involving only typically developing children, resulted in the finding of a significant positive correlation between the dummy variable Sam and gap frequency. In our third comparison group, involving only children with autism, we found significant positive correlations between both Sam and gap frequency and Sam and response frequency. When we

| Comparison group | Turn-taking characteristic | Dummy variable | Coefficient | t-statistic | P>|t| |
|------------------|---------------------------|---------------|-------------|-------------|--------|
| 1                | Initiation frequency      | ASD           | -0.2007     | -2.25       | 0.048  |
| 2 (TD only)      | Gap frequency             | Sam           | 0.2568      | 3.87        | 0.001  |
| 3 (ASD only)     | Gap frequency             | Sam           | 0.2306      | 2.30        | 0.035  |
| 3 (ASD only)     | Response frequency        | Sam           | 0.2100      | 2.27        | 0.0464 |
| 4                | Initiation frequency      | ASD           | -0.2367     | -3.34       | 0.007  |
| 4                | Response frequency        | ASD           | 0.2341      | 4.95        | 0.001  |
| 5                | Turn length variance      | ASD           | -3.83       | -2.93       | 0.017  |
| 5                | Response frequency        | ASD           | 0.2276      | 2.68        | 0.023  |
| 5                | Frequency of assign. taken| ASD           | 0.2642      | 2.36        | 0.04   |

Figure 5: OLS Regression Statistics
performed regressions for the fourth group, in which children with autism interacting with Sam are compared to two typically developing children, we found a significant negative correlation between the ASD dummy variable and initiation frequency and a significant positive correlation between ASD and response frequency. In regressions using the data from our fifth group, comparing children with autism and typically developing children when interacting with Sam, we found a negative correlation between turn length variance and the ASD dummy, and positive correlations between frequency of assignments taken and ASD and between frequency of response and ASD.

8.0 Discussion and Conclusions

Throughout this study, we sought to use statistical analysis and descriptive results to determine the characteristics of turn-taking behaviors exhibited by children with autism and typically developing children as they interacted with Sam and with typical children. After finding the traits of turn-taking behaviors exhibited by each group of children (two typically developing children, typically developing children with Sam, children with autism with typically developing children and children with autism with Sam), we made comparisons between groups to better understand the differences in their turn-taking behaviors.

From the results of the statistical analyses, we can see that there are some pointed differences between the way that typically developing children interact with Sam and the way that they interact with each other. First, we saw from the logistic regression that typically developing children are more likely to induce speaker change during interaction with Sam as compared to interaction with a typical peer. As we observed in our descriptive results, this may be because Sam makes often makes it clear that he expects his partner to continue the story by hesitating and prompting “then what happens?” so that his partner knows to take over. Both the logistic regression and the OLS regression also yielded the result that typically developing children are less likely to initiate during interaction with Sam than during interaction with a typical child. Again, we saw in our descriptive results that children can be hesitant to make
statements that would require the need for a response from Sam because they do not understand how a virtual peer works or the purpose of the exercise is not clear.

When comparing behaviors within the group of typically developing children, our OLS regression showed that typical children create gaps more frequently during interaction with Sam than during interaction with a typical peer. This is most likely due to the fact that children are sometimes unsure as to whether Sam is going to wait for them to start talking or continue the story himself, so they wait to see if he is finished. While many of Sam’s remarks make it clear that the child should take over, some of the backchannel remarks like “uh huh” may confuse the child and make him believe that Sam is going to begin speaking again. This causes problems because the experimenter controlling Sam may decide that the child is not going to take a turn and have Sam begin speaking again just as the child begins to talk. Of course, because Sam has interrupted the child, he becomes even more wary of speaking the next time, creating cycle of pauses and interruptions.

Our statistical analysis also provided us insight into the ways the behaviors of children with autism change when they are interacting with Sam instead of a typical child. Our logistic regression showed that, like typically developing children, children with autism are more likely to induce speaker change when they are interacting with Sam instead of a typical child. We believe that the reasons for this are likely the same as those given for typical children. Our regressions also showed that children with autism are not likely to initiate regardless of the identity of their storytelling partner, but they are even less likely to initiate during interaction with Sam than during interaction with a typical peer. The reasons for this may be similar to those explaining this result in typically developing children, but this also may be because the children with autism struggle with imaginative play, so they do not initiate because they do not know with certainty what is supposed to happen next in the story. Using the logistic regression model, we also determined that children with autism are less likely to take transfer points when interacting with Sam instead of a typical peer. At the same time, it is important to note that the likelihood of taking an assignment increased when children with autism were interacting with Sam. One reason for a decrease in transfer points taken may be that the child is uncertain as to whether or not he or she should
take the turn, because when a direct question is asked (an assignment) the child is very likely to take a turn. It also may be that children with autism hesitate to take transfer points because they have not formulated an idea of what would happen in the story next. When a child is offered an assignment, there is some direction suggested in the question they are being asked, but when there is simply a transfer point, the child may not understand what he should contribute to the story. This is a plausible explanation since it has been well established that children with autism are known to struggle with imaginative play. Because Sam creates many transfer points like “then...”, which do not provide much guidance to the child as to what he is expected to say, he may become overwhelmed and fail to take a turn at all.

Comparisons within the group of children with autism using OLS regressions showed us that children with autism create gaps and respond to initiations more frequently during interaction with Sam than during interaction with typically developing children. Since children with autism did not create gaps as frequently during interaction with typically developing children, we cannot necessarily attribute this characteristic to the deficits associated with autism; we must attribute the increase in gaps to the same reasons as we did for typically developing children – the children are waiting for Sam to finish. We believe that children with autism respond more frequently to Sam than a typically developing child perhaps because, as the interactions go on, they realize that Sam will simply ask another question if they initially do not respond.

While the differences within each group of children provide us with important information about their turn-taking behaviors, we also must examine the ways the turn-taking behaviors of a child with autism differ from those of typically developing children. Data from this study suggested that there were two major differences between the turn-taking behaviors of children with autism and typically developing children when they were interacting with typical peers: children with autism initiate less often and are less likely to induce speaker change. We believe that this summary of differences is not complete and that, as other studies have found, there are actually a much greater variety of differences between the behaviors of children with autism and typically developing children. The reason that we were only able to draw these two conclusions is that, in our logistic regression, we were unable to find a valid predictor for the other
characteristics in the group composed of dyads of two typically developing children. Therefore, even though we had significant results about the likelihood of response, assignments, and transfer points for a child with autism storytelling with a typical child, we were unable to fully utilize these results because we did not have significant statistics on the likelihood of two typically developing children displaying these behaviors. Since we lacked significant results in one of the two groups being compared to each other (with the exception of initiation and speaker change), we were not able to determine many of the differences that may exist between the turn-taking behaviors of children with autism and typically developing children.

Our OLS regressions comparing children with autism interacting with a typical child to two typically developing children led to the same lack of statistically significant results found in the logistic regressions. While we did find that children with autism initiate significantly less often than typical children, this result simply bolstered that of the logistic regression and did not provide us with a great deal of new information. Of course, our sample size in these OLS regressions is extremely small (N = 11), so it not at all surprising that we did not a great number of statistically significant results. We believe that the problems we have found in both the logistic and OLS regressions involving this comparison group could be improved upon by increasing the number of dyads of typically developing children we observe. We believe this because, as can be seen in our descriptive results, typically developing children can present drastic differences in storytelling and turn-taking behaviors as some of them are painfully shy whereas others are verbose and dominating.

Our comparison of the turn-taking behaviors of children with autism interacting with Sam to those of two typically developing children has yielded similarities to that of children with autism and typically developing children interacting with typical peers. Our regressions showed that children with autism are less likely to induce speaker change and create initiations than typically developing children regardless of the identity of their storytelling partner. Additionally, our OLS regression showed that children with autism are more likely to respond to Sam than a typical child is to a typical peer. We believe that children with autism are be more apt to respond to Sam because they do not seem as puzzled
and hesitant to have a back and forth conversation with Sam. As we previously mentioned, typically developing children have presented concerns about the point of “talking to a screen”. This attitude could easily make a child less likely to respond to Sam because they would see this as responding to a screen rather than to another person.

Our final comparison, which was between typically developing children interacting with Sam to those of children with autism interacting with Sam, has once again shown similarities to the comparison between two typically developing children and children with autism interacting with a typically developing peer. Our regression analysis has shown that children with autism are less likely to instigate speaker change and create initiations during interactions with Sam than typically developing children interacting with Sam. At the same time, children with autism are more likely to take assignments, regardless of their storytelling partner, than typically developing children. Moreover, while interacting with Sam, children with autism respond more often than typically developing children do while interacting with either partner. These correlations can be seen in the logistic regression model and in the OLS model, respectively. Another difference we found within this group using the OLS regression was that children with autism generally have lower variances in turn length than typically developing children when both groups are interacting with Sam. Since we do not have any statistically significant relating the variances in turn length of children with autism and typically developing children in of the other comparison groups or relating the average turn lengths of any groups, it is difficult to interpret any meaning behind this observation or its potential causes.

Combining the results of our statistical analysis and comparisons between groups, we can see that our data supports our first hypothesis completely in that typically developing children do create gaps more frequently and speaker change is more likely to occur during interaction with Sam than during interaction with another typical child.

In support of our second hypothesis, we found that there was an increase in the frequency of gaps and responses and a higher likelihood of speaker change when children with autism are interacting with Sam instead of a typically developing child. However, this hypothesis was not fully supported by our
data since children with autism actually take transfer points less frequently during interaction with Sam than during interaction with typical children. Furthermore, we do not have significant results pertaining to the turn length variance to support this aspect of our second hypothesis.

Our third hypothesis, addressing the differences between the turn-taking behaviors of two typically developing children and those of a child with autism interacting with a typical child, was also only partially supported by our data. We did find that children with autism are less likely to induce speaker change and initiate less frequently than typically developing children, but we did not have significant results with respect to the frequency of transfer points taken or gaps created. As we discussed earlier, we do believe that these differences may exist but we did not have a valid predictor of these behaviors in our logistic regression. We believe that having a larger sample size would improve our analysis of the validity of this hypothesis.

Our last two hypothesis involved comparisons of the turn-taking behaviors children with autism interacting with Sam to those of typically developing children. The first of these hypotheses suggested that children with autism would have the same turn length variance and take assignments and transfer points at the same frequency as two typically developing children. This hypothesis was not supported in that we did not have significant statistics relating the likelihood of assignments and transfer points taken nor did we have significant results pertaining to turn length variance. The second of these hypotheses asserted that there would be similarities between the groups of children with autism and typically developing children interacting with Sam with respect to the frequency of assignments and transfer points taken, gaps created, and responses. This hypothesis was not supported by our data since we found that children with autism interacting with Sam actually respond and take assignments more often that typically developing children interacting with Sam.

Finally, we will address the question of how we can use our comparisons to improve Sam’s design as an intervention that targets turn-taking behaviors in children with autism. The main benefit of interaction with Sam that was seen across all groups was an increase in speaker change occurrence. This means that children with autism do contribute to the conversation more frequently when they interact with
Sam instead of a typical peer. Other benefits included an increase in However, the nature of the contributions made by children with autism does not seem to change when they interact with Sam as they continue to fail to initiate as frequently as typically developing children. Children with autism also take transfer points less often during interaction with Sam as compared to interaction with typically developing children, which we have attributed to the fact that they have deficits in the use of imagination and are unsure of whether or not it is appropriate to take a turn.

In order to improve the deficits in initiations and transfer points taken seen during interactions with Sam, we must alter the design in a way that gives a child with autism ample time and many opportunities to initiate. One way to potentially increase the likelihood that a child with autism will initiate and take transfer points would be by first asking them to tell a story about real life. This could be beneficial because children with autism have trouble using their imaginations, so beginning with a true story would make it easier for them to initiate because they could use facts and incorporate reality. During this non-fiction story, Sam could create transfer points as often as he currently does because the child will be more likely to have ideas formulated about what happened next. After this story, it would be beneficial to have Sam tell the story that is easy for the child to relate to, like the first story used in the present study, which involves two children playing hide-and-seek. As the interaction progresses, the experimenter controlling Sam could choose stories requiring more imagination but offer more assignments than transfer points at first. As the child becomes more apt to contribute to the story, the experimenter could slowly increase the proportion of transfer points offered over time. Additionally, alternating these fantastical stories with some that are closer to reality would help ensure that the child does not become overwhelmed.

In conclusion, Sam is a beneficial turn-taking intervention for children with autism in that children with autism speak more frequently and take assignments more frequently when they are interacting with him instead of a typically developing child. However, turn-taking behaviors like initiating and taking transfer points occur less often when interacting with Sam. With the adjustments to Sam’s design, such as beginning with a non-fiction story and offering fewer transfer points and more
assignments during stories requiring use of imagination, the efficacy of Sam as a turn-taking intervention for children with autism could be improved.
References


