StoryMat: A Computer-Mediated Space for Children's Fantasy Play and Collaborative Storytelling

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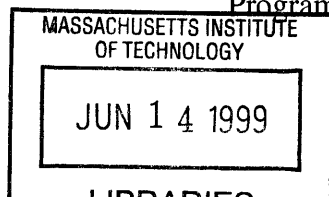
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Abstract

Fantasy play serves an important role in preschool children's development. Making up characters and telling stories around them are activities through which children make sense of and test out their hypotheses about the world. While computers are increasingly present in the world of young children, there is a lack of computational systems that would support children's voice in everyday storytelling, particularly in the context of fantasy play.
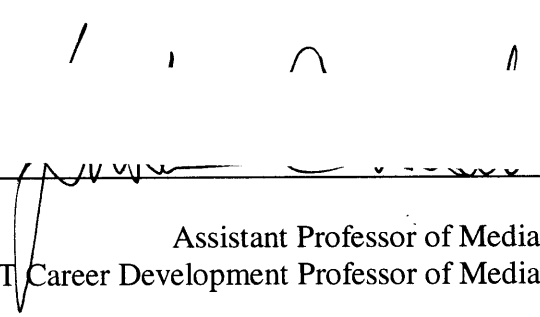
This thesis introduces StoryMat, an instantiation of a system that supports children's fantasy play. StoryMat offers a child-driven play space by recording and recalling children's own narrating voices, and the movements they make with their toys on the mat. Stories from the past are conjured up on the mat as a narrating moving shadow of the toy, when they are triggered by the present stories that are similar to them. The empirical research with preschool children showed that StoryMat fostered a particular kind of fantasy play that is storytelling. It was also shown that children, with or without a playmate, on StoryMat listened to and incorporated elements from StoryMat stories, in a similar way they do with stories from their real life peer. By listening to and incorporating elements from peer stories offered by StoryMat, the children's stories and the experience of telling them became richer. The thesis addresses the importance of supporting children's fantasy play and suggests a new way for technology to play an integral part in that activity.

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My family in Japan: My mother for always being my soul mate, my father for supporting me with everything, and my brother for sharing the mat and memories with me.

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My Sky, who was the first to believe in me that I would make it at the Media Lab. Who believed in and was so excited about the idea of StoryMat from the very beginning. Sky, who always supported me and helped me in any way he could. Thank you with all my heart. This thesis is dedicated to you...

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Chapter 1 – Scenario

Once upon a time...

There was a residential complex in a town called Emerald. One of the few public rooms in the complex was called "Kids Place," where kids in the area came to play at different times. Kids Place had a variety of toys for kids: blocks, dolls, drawing boards, etc.. Among all these toys, there was a play mat on which different girls and boys played.

On the mat, there are trees, houses, different shaped and colored fields, and paths. Kids like to play on the mat with their little stuffed animals, pretending that they are the little animals living and experiencing fantastic adventures. Like Kate and Tom, who are playing together today, are making up stories on the mat -

"Hop, hop, hop, hop... Me looking my map for the treasure." Four-year-old Kate tells a story as she moves her stuffed bunny along the paths on the mat. "It says to go right here... And go back! And then, cut the field... And go right over... there!" Six-year-old Tom, follows Kate. Hopping along the paths, but as a zebra, which is his stuffed animal. "Goody! I found some!" Tom says and makes his stuffed zebra run around the field. "Here! You can have some!" Tom shares his treasure with Kate. They continue to tell other stories on the mat until they have to go home.

A few days later, seven-year-old Liz comes to the Kids Place by herself. But when she arrives, there is no one at the Kids Place. It isn't surprising for her because she knows there aren't many kids around in the town of Emerald. She is the only child in her family, like most of the kids she knows. Not many kids have a sibling these days. Only very few have more than one sibling.

As she walks around the Kids Place, Liz finds the play mat in a corner. She grabs a stuffed bunny that was on the mat and moves the bunny on the mat. She says, "One day,

a little bunny was looking for his friend. He walked and walked. But he couldn't see his friend..."

Suddenly, Liz hears another kid's voice -

"Hop, hop, hop, hop... Me looking my map for the treasure..."

Liz also sees a shadow of the rabbit appearing on the surface of the mat and moving on the mat -
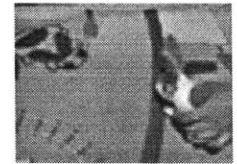
"It says to go right here... And go back! And then, cut the field... And go right over... there!"
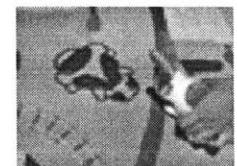
The moving shadow navigates the paths, synchronized to the narrating voice. It looks as if the rabbit shadow is telling a story as it travels. There's a smile on Liz' face.

Kate's story from few days ago is revived on the mat because Liz' story was told at the same place on the mat, with the same stuffed bunny as Kate. Kate's lively story is recalled on the mat with Liz' story being the trigger. Yet, Kate's story triggers Liz' next story because now Liz is about to tell a sequel to Kate's story –

"One day, a little bunny heard that there was a treasure buried somewhere on the island. So he found his friend and they went to see the island..."

When she finishes her story, another story is conjured up on the mat. Liz again is curious to find out where the story takes her and what her next story can bring about –

Liz is playing on the mat, alone, in the traditional sense. Yet, Liz is able to hear stories told by other children in the past. By telling her stories and hearing other children's stories in return, Liz' storytelling style and themes change. In a way, Liz is able to

collaborate with stories from the past. Children's past stories play the role of an imaginary play mate for Liz. Even though Liz is playing on the mat by herself, she is inspired by and influenced by her peer's imaginative creations and fantasy worlds, to tell and create her own.
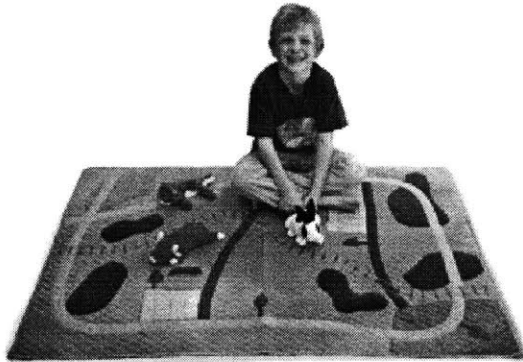
Chapter 2 – Introduction

"Stop daydreaming! Start facing your problems!"

People demand practicality and authenticity in things we do or things we produce. For adults, imagining what we could hope for or pretending to be something we wish to be, doesn't seem serious and is even considered silly. It is the general trend in society to be serious and productive at what we do. Just imagining or pretending is not our priority today. However, the question is whether children should be made to exhibit the same manner of being serious in order to be successful in this society. Make-believe activities have a great impact on us, especially when we are young. It is important for children to imagine what they could become or imagine what they could hope for. But it is a concerning fact that today, children's make-believe activities are diminishing as they are learning to take on the adult's trend of being serious.

The following newspaper article provides such a concerning fact:

> In years gone by, children in Cheryl Silveira's family daycare in Windham, N.H., would get very excited if she found a refrigerator box. They could play for hours pretending it was a boat or a house or maybe a space ship.
>
> This year, when she proudly plunked a refrigerator box into the play area, the children's response was far different. "They didn't do anything," says Silveira. "When I said, 'Wow! Isn't this a great box, we can pretend all kinds of things with this!' they said, 'But it's just a box.'"
>
> Silveira crawled inside and pretended it was a school bus. The six children, ages 1 ½ to 5, were happy to crawl in and out with her, but says a disappointed Silveira, "They never got carried away with it. It never was more than a box to them."
>
> When a box is only a box, preschoolers may be in trouble.
>
> The ability to create make-believe worlds lays the foundation for academic learning and healthy development, according to researchers. "Being able to pretend is not a luxury, it's a necessity," says Yale University psychologist Jerome Singer. Singer is sad but not surprised to hear what's happening in Silveira's Bugle Bear Day Care. Unfortunately, he hears it from teachers all over the country.
>
> Martha Smith, who runs a three-day-a week laboratory preschool at Ipswich High School as part of the child development curriculum, sees the lack of imagination most in children" artwork. "It used to be that kids would prefer a blank piece of paper for coloring and they'd create elaborate

stories to go with the drawing. Now," she says, "they either want a coloring book or they want us to tell them what to draw." Smith, who has worked with preschoolers for seven years, laments, "They look to the adults for how things should be rather than pretend how they'd like them to be."

There's no single, overarching reason why teachers are seeing less pretend play. Silveira attributes it to too much TV and computer time. Singer says it's that, plus too many programmed activities at too young an age, and overworked parents with too little time to play. Early childhood educator Mary Mindess of Lesley College has another theory.

"Society in general doesn't value play as a learning process," she says. "We want results, as in test results, so we push academics too early, letters and words at age 3. The message kids get is that pretending isn't valuable." ...

This article may bring up different childhood memories for us. As I read the article, I think about the toys I have played with as a child. I realize that when I was a child, toys were not as *loud* as toys of today. Dolls, blocks, and play sets were all passive physical objects, and were all quiet. I would have to lend them my own voice or make up stories around them so that they would come to life through imaginary personalities and activities. With my imagination, the toys became meaningful and interesting in my play.

Things are different today. Technologies are increasingly incorporated into toys that children play with. Today's toys seem to be very loud. Toys make sounds and noises, or toys provide different actions and reactions on their own. Children do not have to do anything but absorb the various features the toys themselves come with. It seems as if the toys do the thinking and talking for the children. It is true that children enjoy being entertained by such toys. Adults too enjoy watching little gadgets that do neat things on their own. But such passive consumption of entertainment has a much greater effect on children than adults. Children may learn to take a passive role, not seeking out their own solutions, ideas and styles in their play. They may learn to play only in the way they are told or suggested to play in.

Throughout this thesis, I argue for the need for toys that can listen to children rather than just spew out information to them. I argue for such toys by presenting an instantiation of

a system that can elicit stories from the children and encourage their storytelling in collaboration with their peers. With the tools to express their own ideas, to experiment and to share with others, children's ideas become powerful inspirations to their friends and even to themselves.

The newest technology is also incorporated into educational toys or tools with the promise to foster children's learning skills. However, not many designers may be aware of the possibilities and significance of incorporating technology in such a way that it simply supports children's own voice. Children's own voice is both the process and product of their imaginative exercises. There seems to be an important value in supporting children's imaginative play and providing a place where such imaginative creations can be shared with others. Make-believe play and storytelling among children is important, and technology could do a better job at supporting it.

2.1. Overview of the Research

StoryMat is a system designed to support children's collaborative storytelling in the context of their fantasy play. StoryMat is a soft play mat that provides an undetermined play space for children to tell their own stories. It is also an "active" play mat that supports children's storytelling play by recording and recalling their own stories. When children tell their stories with a toy on StoryMat, their narrating voices and the associated movements of the toys are recorded. The recorded story is then compared with other stories told by children who have previously visited the mat. One of the past stories, that shares a similar pattern (specifically, the length of the story, the pattern of the path the toy took, and the identity of the toy) with the present story is recalled on the mat, as a moving shadow of the toy accompanied by its narrator's voice. This, in turn, provides a space where a child may fantasize her own story triggering another's to come alive. The child may tell her subsequent story by coming up with a creative solution to the story she just heard. Or she may continue to tell what she was telling but incorporating some story elements from the story she just heard. A fundamental function of StoryMat is to become

a play space where children can collaboratively tell and listen to their own and others' stories. Through such activities, children may inspire and become inspired by others as well as by their own past stories.

2.2 – Contribution

I believe the framework I provide for the design and research of collaborative storytelling play technology contributes to research in at least three different ways. Firstly, it contributes to the research of "Things to Think with" at the Media Lab as my research explores the ways for children to interact with one another's stories as "objects" with which they think and tell further stories with. Secondly, it contributes to the research of "Gesture and Narrative Language" as my research may suggest a new way to support children's collaborative storytelling in the context of their fantasy play. Last but not least, it contributes to research in human factors and computer interface design as it explores ways of representing abstract stories, and mediating the environment in a way that is story evoking and emotionally engaging for children.

Also my thesis work contributes to the field of Children and Technology as it provides an evidence that technology could play a role in supporting children's fantasy play to foster their collaborative storytelling. It also contributes to the field by exploring and providing technology for supporting children without the luxury of having co-temporal co-spatial playmates.

2.3 Personal Motivation – a few words about the mat
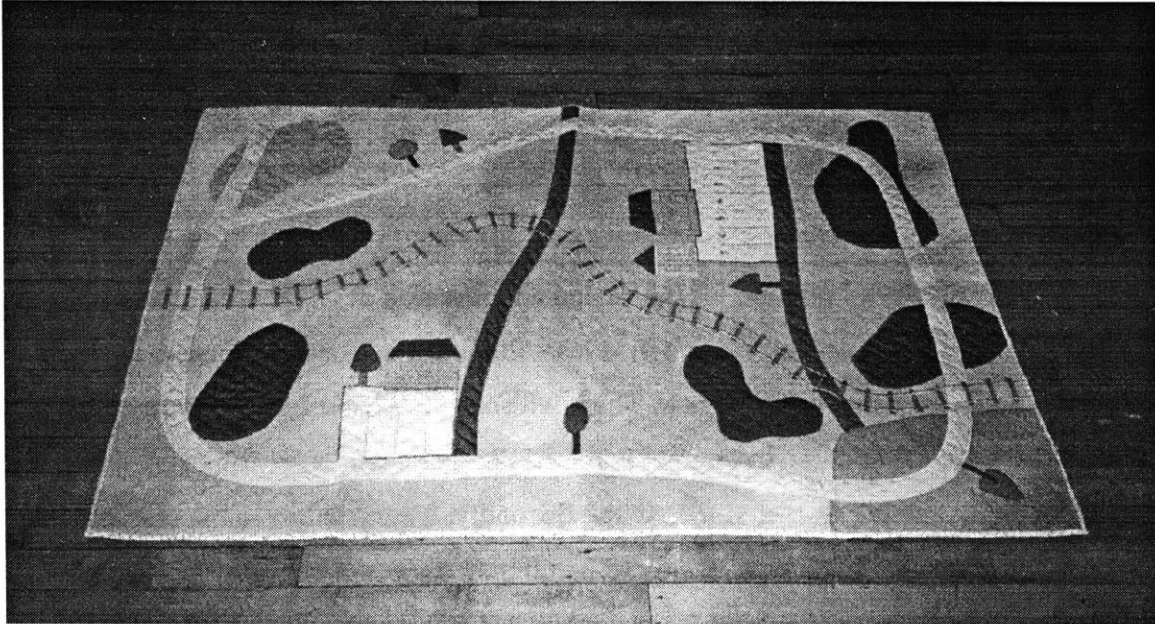
My thesis project, StoryMat, was inspired by one of my own childhood objects: The mat, made by my mother for me and my younger brother when we were little.

My mother initially designed it for my brother's toy cars and trains. That is why there are things like paths, parking lots, and train track. But for both me and my brother, it was more than simply a track or path for our cars to run. The mat was the world in which we could immerse ourselves to be whatever we wanted to. It was the world in which we could make up and play out whatever came to our minds. I remember playing on the mat and telling so many stories.

Now, it's almost 20 years later. But the mat is still in pretty good shape after being stomped on by me, my brother, and our friends. I would touch the mat and try to think about my childhood play. Some memories are brought back but I realize it's too bad that I can't hear those stories I told many years ago. All those stories I and others told, which were once alive on the mat are gone and lost. It was a very obvious task for me to think

about different ways to link the physical object, the mat, and abstract objects, the stories. To capture children's storytelling play so that their stories can be once again heard on the mat. This personal experience and memory brought me to StoryMat.

The mat allowed me to make up most imaginative stories. It was one of the toys I remember playing with my brother the most. I recall that it was also the only toy I was able to share with boys. Boys generally didn't like to play with my toys (girls toys such as dolls and play house sets). But they would play on the mat with me. These memories gave me a lot of insight when I was shaping my research goals and designing the actual features of StoryMat.

The mat provided a symbolic place of my childhood. The mat is the place where I remember visiting, but because the mat presented a map of a world, it was more like a symbolic place to me than just a quilt with different things on it. For example, I remember playing on one of the parking lots on the mat a lot. In my play, I would always make up reasons to make a stop there. Now I do not remember why. Perhaps, I imagined the parking lot to be any object I wanted. The mat served as a symbolic *place* for me rather than a physical object.

What if, as a child, I was able to listen to other children's stories which were told at the same place of the mat as my stories? What if I was able to listen to my own stories on the mat as I told stories on the mat? What if I could listen to my own childhood stories as I tell my stories as an adult now on the mat? These are the questions that kept me pursuing the research and questions that I will keep asking myself as I think about systems for people's storytelling in the future. Thinking about ways to listen to my own voice through my childhood object led me to think about supporting children and people's voice in their storytelling.

Chapter 3 – Context of the Work

Many of today's computer-mediated tools use constantly improving technology to produce more sounds, graphics, or actions that make the toys look better. Children are attracted to the new flashy toys for their ease of use and colorful nature. However, these toys are not necessarily empowering them by giving them a role to express and create or co-create using their own imagination. Indeed, they leave children as passive consumers of adults' pre-programmed conceptions (Turkle, 1995).

There is a need for today's computer-mediated systems to move toward "child-driven" systems, where children are in control of the content of the objects they interact with. Children feel a great sense of achievement and empowerment of self when they know that they can create and control the content of objects they interact with (Papert, 1980).

In this thesis, I argue for the need for child-driven systems, especially in the context of supporting children's fantasy play. Whether the object of their interaction is a physical one such as a block or a doll, or an abstract one such as a story or an idea, children should be able to take an active role in defining the content of such an object. That is children should not be limited to the way certain toys tell them to play, but should be able to use the toys in such a way that allows them to direct their play and foster their own imagination. Children are naturally capable of such imaginary activities. They make up different character roles and events in their play. With a place to exercise their make-believe activities, they are able to foster their imaginative skills.

My thesis work, StoryMat, provides a place for children's make-believe activities by supporting their storytelling. Children engage in make-believe activities with stories in their minds. Children communicate and share their imagination with others by telling stories about such activities. By supporting children's storytelling, StoryMat provides a place where children are encouraged to share their imaginative creations with their peers.

To build up an argument for why a system should support children's collaborative storytelling play in the context of their fantasy play, I have broken down the context of the work into four sections.

First, I will provide the reason for supporting play activity of a particular period of children's play. Second, I will provide the background of children's fantasy play and the importance of such play in their development. Next, I will provide the importance and advantage of such fantasy and storytelling play in the context of children's collaboration. Finally, I will provide interface for supporting such children's collaborative fantasy and storytelling play.

3.1   Young Children's Play: Developmental Perspective

The preschool period, ages between 4 and 8, is a particular period of childhood when a child is artful at his/her play. During this period, a child becomes competent at taking another's perspective and engaging in make-believe play, as well as becoming able to do so in a cooperative way. This section provides a background for choosing the particular age group for my thesis subjects, as I introduce the developmental trend of children's play styles.

Children's play pattern changes as they get older. Children start out by engaging in an individualistic play style and gradually learn to engage in more social play. The following is a categorization of styles of play children engage in, presented by Parten (1932) and similarly by Peller (1955).

At age 2, children's play is solitary. In solitary play, children play alone with toys regardless of their proximity to other children. A child may be playing with a toy car right next to a child who is playing with a toy truck. But neither of them attempts to get close to the other. They seclude themselves from the presence of others and their interest

is only in the interaction between the object and themselves. As in Piaget's (1932) view of child's egocentrism, children are preoccupied with their own points of view. Children in this stage are able to take the point of view of only one person, which is their own.

At age 3, children are predominantly focused on "parallel" play or what Peller (1955) calls "mirroring" play. A child who engages in parallel play still does not show any attempt to influence the others' play with his own. But the child plays with similar toys in the same play style as other children. We may see a child who is playing in a very similar way to a child who is playing right next to him. For example, one child plays with his train toy and says, "Chu-ga chu-ga.". And another one says the same thing, "Chu-ga chu-ga," with his toy. Yet there is no interaction between them. The child is playing in proximity to other children, but not in interaction with other children. Their play activity is parallel rather than intersecting.

By age 4, children engage in more social play. Their play becomes more "associative" and "cooperative." They are concerned with common activity and able to have conversation with a common goal. They are also able to engage in the higher level of activity as they are able to play with others in the "shared-imagination" world (Damon, 1983). They coordinate their actions and interpretation of the world in a cooperative manner.

Therefore, as they develop, children are more likely to interact cooperatively (Piaget, 1932, 1962), and able to engage in make-believe activities and share the world with others. Make-believe play is at its peak when a child is between the age 4 and 7 (Vygotsky, 1967). By age 8, a child begins to reason more like an adult. A child seeks out more logical and realistic scenarios than imaginary made-up scenarios (Miller, 1979). For example, children in the Miller's study, heard a story such as this one from an experimenter:

"Once there lived a kitten and a mouse. The kitten wanted the mouse for a dinner and the mouse did not want to be eaten. Can the kitten and the mouse both get what they want?"

7-year-old in the study answered, *"Yes. The mouse was married, and then she gets children. The kitten eats her and not her children, and she might be happy that she gives her life to save her children."* Whereas, 10-year-old answered, *"It's impossible. The cat will have to catch the mouse, but then the mouse won't have its way. But if the mouse ran away, the cat won't have its way."* (Miller, 1979, pp.43-47). This example illustrates that older children are focused on coming up with a logical and realistic solution rather than coming up with a playful make-believe outcome.

Preschool children between the age of 4 and 7 are able to engage in social play. They are also said to be the most artful in the way they play. While children aged between 4 and 7 are able to construct make-believe roles or situations, they are also able to engage in such activity with others in a cooperative manner (Damon, 1983). This period of childhood seems to be devoted to preparing or practicing imaginative skills, especially in a social context.

While the preschool period of a child's life is dominated by the preparation for their school tasks, such as learning math and writing the letters of the alphabet, there seems to be a need for systems designed to support the way preschool children play. I am choosing this particular population of children for my research, because there is a special need for and advantage to supporting their fantasy play, as I will show in the next section.

From hereafter in my thesis, I will use the "children" to refer to the children of age between 4 and 8. The next section will look at exactly how fantasy play and storytelling play a role in children's development.

3.2 Fantasy Play and Storytelling

Fantasy play, which is prominent especially in preschool children, has an important role in children's development. In this section, I will show how exactly fantasy play is advantageous to children's development, and provide the relationship between their fantasy play and storytelling.

In children's spontaneous play, their language and actions are both the process and the product of their fantasy play. For example, a child who is holding a piece of block tells her playmate, "Pretend this was a train, OK?" The playmate replies by saying, "Tou, tou, tou!" As the children move the block in the air, now an imaginative train traveling, they start to build up a story around it. "Look! There's a field with magic flowers! The next stop, the magic field!"

Children display in language ("Pretend this was ...," "Look! There's a ...") and in thought, a sense of possibility – the concept of "what might be" (Singer & Singer, 1990). Children transform a real object into an imaginative object, and such an activity defines and directs their play. By fantasizing and pretending, children are able to move in perception and thought away from the concrete given of "what is" to "what could have been," and "what one can try for."

There are at least four levels at which fantasy/pretend play contributes to children's development: 1) **emotionally**, 2) **morally**, 3) **cognitively**, and 4) **linguistically**.

3.2.1 Emotionally

Make-believe allows young children to change the world to fit the ego without the adaptation to present reality (Piaget, 1962). In their fantasy play, children are able to act out and explore different possibilities, even their emotional possibilities, without the risk of failure and frustration from unexpected events. No matter how embarrassing their act

may seem to others' in their make-believe play, it's just them playing. Fantasy play provides a place where children are able to gain control over their emotional ability in an unusual way.

For example, a child may tell a story about a boy who is lost in the woods. The child plays out the character in his story and cries out for his friend. In a very low tone, he says, "Hey... Where are you? How do I find my way home..." In doing so, the child may go through and experience the emotional state of the character. As the child places himself in the role of the character, he may go though the various possible next actions. "If I don't hear anyone, what would I do? Would I just cry until I can no longer do so, or would I try to find my way home?"

In fantasy play, children are in control of their character's emotional actions and reactions. As they play out their characters, they experience and explore their own emotional state. Pretense provides a unique opportunity for children to control their own emotional arousal and to maintain a level that is both comfortable and stimulating (Fein, 1987). By freeing sensations from their immediate environment, a child can deal with them in the abstract and thus, to some extent, can achieve greater self-control and greater control over the environment (Csikszentmihalyi, 1981). Therefore, children's fantasy play becomes a place for their compensatory action (Curti, 1930), as children may go through something scary or something challenging in their life, as an imaginary character.

Also related to children's emotional development, one of the major benefits of fantasy play is a feeling of well-being. It has been shown that imaginative children spend happier childhoods than unimaginative children. In their longitudinal study, Tower and Singer (1980) found that children who engage in imaginative play scored higher in positive emotions such as liveliness, excitement, elation, and joy than those who did not. Connolly, Doyle, and Reznick (1988) found more positive and less negative affect during social pretend play than during non-pretend social activities such as putting puzzles together or playing bowling game. Rich history of imaginative play may also lead to a

creative adult as it may prepare a person to solve problems opportunistically, in an organized, and flexible way (Rogoff, 1990).

3.2.2 Socially

Fantasy play also provides an opportunity for children to develop and test out hypotheses about possible interactions and relationship among humans. For example, a child who had a fight with her friend may tell such a story to her teddy bear, "Good girl. But fighting is not so nice... Maybe you should go tell your friend, sorry..." In this, play provides the child with practice in assembling bits of behavior into imaginary sequences. As an imaginary character, the child may go through possible solutions to overcome her current situation. Therefore, fantasy play has a cathartic quality that leads to learning of new ways for handling difficult social situations (Isaacs, 1940). In dealing with difficult situations, play allows players to be vulnerable to the world around them, to notice the "irrelevant" possibilities and details of things and events (Rogoff, 1990). Sylva, Bruner, and Genova (1976) also claimed that the essence of play is the dominance of means over ends: "Freed from the tyranny of a tightly held goal, the player can substitute, elaborate and invent."

Pretend play is thus one of children's manifestations of the ability to characterize and manipulate their own and others' cognitive relations to information and society. This ability will eventually lead to the child's ability to characterize social relations such as believing, expecting and hoping, and manipulating these relations in others, for example, getting someone to expect something will happen by promising (Leslie, 1987).

3.2.3 Cognitively

Thirdly, fantasy/pretend play has an important role in children's cognitive development. Of special importance for pretend play is the capacity to sustain the object in thought, that is, to develop an image, cognitive map, or plan of it in its physical absence (Schachtel, 1959).

Fantasy play enables children to make sense of their world and accommodate to it by the very act of bringing it down to the size they are able to handle. Play allows children to gain control by organizing a game's plan or themes and applying what they learn in a play sequence to the everyday cognitive and social demands of life (Singer. 1990).

Fenson (1984) characterized the growth of pretend action in cognitive aspect in three trends: **decentration, decontextualization**, and **integration**.

- **Decentration**: the child's increasing tendency to incorporate the point of view of players other than self into play activities (Piaget, 1946/1962). That is the child is able to take another's perspective. Children learn to do so starting age 3 and become more competent as they get older.

- **Decontextualization**: the child's ability to transform a realistic object to an imaginary object (Werner & Kaplan, 1963). Children are able to use less realistic objects to play as they get older (Jeffree & McConkey, 1976; Corrigan, 1982).

- **Integration**: the child's increasing ability to combine separate actions into coordinated behavior sequences. Shotwell, Wolf, and Gardner (1980) described the ability to represent actual or imagined experience through the combined use of objects, motion, and language is required in symbolic play.

With development, children engage higher cognitive processes, which include decentration, decontextualization, and integration. As fantasy play provides a place for children to exercise such processes, fantasy play is an important activity in children's development.

Vygotsky suggested that development occurs in play, which is the "leading activity" (the central goal) in development during the preschool years, from 3 to 7. In play, children enjoy ignoring the ordinary uses of objects and actions in order to subordinate them to

imaginary meanings and situations. In such play, with pleasure and imagination, children free themselves from the constraints of everyday time and space (Rogoff, 1990). They ignore the ordinary meaning of objects or actions, to develop greater control of actions and rules and understanding of their surroundings. As such, play "creates its own zone of proximal development of the child. In play a child is always above his average age, above his daily behavior; in play it is as though he were a head taller than himself" (Vygotsky, 1967, p.552). Therefore, fantasy play prepares children by supporting cognitive development.

3.2.4 Linguistically

Finally, through fantasy play children practice and learn their linguistic skills. As mentioned above, by age 3, children are able to represent objects, actions, and feelings in a symbolic way. Make-believe/fantasy play is also called symbolic play in Piagetian terms because in a make-believe play, a child is able to represent objects or actions with something that stands for them. And one of the tools that the child uses to represent things symbolically, is language. A child's ability to represent objects, actions, and feelings symbolically is therefore paralleled by a corresponding ability to represent those in language (Nicolich, 1977). That is, language is the skill children use and foster in their fantasy play.

With development, children's language style becomes more sophisticated. Children practice such language skills in their play. In particular, fantasy play seems to provide a good place for that practice.

Language in fantasy play:

Children practice language, to express and speak from different perspectives. When Children are in the 2 to 3 year-old range, they use action-defining words such as, "ruff-ruff" or "yum-yum" in their narration (Garvey, 1988). Children play with the sounds they are able to produce and practice a rudimentary rhyming play.

Fantasy play also gives children divergent possibilities for language usage. Children may do so by taking on adult's conversation forms. For example, a child may pretend to be a school teacher in her play. She says in a low but a strong tone, "Children! Take out your pencils and write out your names!" She practices an imperative form of speech as she takes on the role of an adult with an authority. Next, she may pretend to be a student who just got scolded by a teacher. In playing the role of the student, she has to change her tone completely to sound sorry and helpless. In such a way, children may learn appropriate emotional tone for various contexts (Singer, 1990).

Fantasy play allows a child to engage in the use of language in something more than just action to speech. Three-year-old may start calling pieces of blocks on a table, "A carrot, an apple, a peach..." She plays with the blocks and through out her play, she refers to them as a carrot, an apple, and a peach. Vosniadou (1987) claims that such a child's pretend re-naming activity is an early form of metaphor. Of course, the metaphor is not to be interpreted in the same sophistication level as the adults'. Yet, the child is able to exercise the use of language in an abstract way. And the fantasy play provides a place for such an exercise.

Story language:

In their play, 2 to 3-year olds speak predominately as themselves, referred to as "egocentric speech" by Piaget. For example, a child may say, "What's that?" or "Go away!" in his play, but he does not introduce the quoted speech. By age four, children become increasingly competent at speaking from a perspective that is different from their own. Auwarter (1986), in his experiment with children age between 3 and 9, found that the ability to take a character role identity in a story increased as children became older. Auwarter also found that children's ability to produce the neutral perspective (narrator's perspective) increased as the children got even older. While younger children are able narrate from the character's point of view as in "This tastes really good!," older children

were able to also narrate from the neutral observer, the narrator's point of view, as in, "So, he ate some delicious apples."

Auwarter's result leads to the next development, Storytelling. There is a difference between just pretending and speaking from a character role and actually telling a story. A child could be immersed with his own character, "Hey that's mine! Now get out!" But the listener of such talk may not have any idea what the child is talking about. In addition to be able to take on and speak from different perspective, as they get older, children learn to use more sophisticated narrative language.

According to Polanyi (1989), to be a "story" at all, a linguistic text must encode a specific past time narrative description of the goings-on in a unique past time story world over a period of time.

Scarlett and Wolf (1979) explained the difference between symbolic play and storytelling in the following way:

Characteristics of Symbolic Play:
It is quite fluid. Children move in and out of the stream of enacted events. Symbolic play lacks the strictures about how episodes connect and how problems are solved.

Characteristics of Stories:
Actions must follow from the previous narrative events rather than from the impulses of the storyteller. The narrative world must appear autonomous and self-sufficient. The narrator must structure how his audience is to construe what is happening within the story.

As children grow older, their fantasy play becomes more storytelling: children are able to integrate roles, events, and consequences (Scarlett and Wolf, 1979). Children may do so by learning story language such as incorporating beginnings with a formal opening

phrase such as "Once upon a time" and ending with a formal closing "The end" are conventions associated with "telling stories" (Sacks, 1972). Children exercise such story language as they explore different possibilities with language in their fantasy play.

Therefore, fantasy play seems to lead to an effective use of more complicated narrative sentences during the children's play.

StoryMat was designed to foster children's fantasy play and storytelling

There seems to be an advantage in supporting preschoolers' fantasy play and encouraging their storytelling. The goal of this thesis work is to provide a child-driven play space that supports children's fantasy play, and it does so by encouraging children's everyday storytelling.

The goal is to provide a space where children can define and control the content of the object they interact with. That is, children create their own imaginative objects by telling stories about them and around them, and share their creations with others. As Nicolopolou (1996) claimed, by fostering the development of children's symbolic imagination and providing a field for its exercise, fantasy play and narrative activity prepare the way for the development of abstract thinking and higher mental processes.

StoryMat supports and fosters fantasy play by first listening to children's stories. It records children's own narrating voice with associating movements they make with their toys in telling the story, so that StoryMat supports and fosters fantasy play by telling them back their own stories. Second, StoryMat can bring back the stories for their friends to hear.

In listening to children's stories, StoryMat provides a space where the stories can be heard once again for the author or others to interpret. Children tell many stories with their toys, but their stories are usually not stored for their further elaboration. While they

could be telling most interesting stories, they rarely have the chance to listen to their own stories. Generally, stories children tell are not saved for adults or for themselves to hear on a later occasion. Instead, they just slip unobtrusively into the flow of children's everyday play (Miller & Sperry, 1988). By listening to children's own voices, that is by capturing their own stories, StoryMat gives their everyday ephemeral story existence. Children's stories are remembered by the mat at the place where the story was told. So when a child goes back to and tell another story at the place where he told a story before, he is able to listen to other stories that were told at the same place.

In telling the children's stories back, StoryMat provides a space where children can listen to each other's imaginative creations. By sharing their imagination with others, children influence and become influenced by others. It is the exchange and interpretation of their own symbolic play/creation on StoryMat, which determines the direction of the play, not the preprogrammed appearance/voice/function of the mat or the toys on the mat. Therefore, StoryMat is a place space where children's own fantasy world influences the play, rather than the identity of objects they play with.

Moreover, by supporting fantasy play, StoryMat may foster children's storytelling skill. By giving children a place where they can listen to each other's stories, StoryMat gives a space where they are encouraged to tell stories rather than a place to pretend. The collaborative and social aspect of the space StoryMat fosters more storytelling than pretend actions.

3.3 Peer Collaboration / Collaborative Storytelling

In the previous sections, I presented preschool children's fantasy play and its important role in their development. We saw that because of the collaborative nature of fantasy play, children learn to engage in storytelling rather than simply playing a character role by themselves. Furthermore, there is an advantage in fostering and supporting such preschool children's fantasy play in their interaction with their *peers* in contrast with adults. In this section, I will provide a motivation for supporting children's fantasy play in the context of peer collaboration.

3.3.1 Children's World

As stated in the introduction, children's make-believe activities are diminishing. There is a reason for that. As imaginative and creative as children can be, their fantasy play which would give them an opportunity for practice is not always encouraged. All too often, parents are too busy to be patient about their child's fantasy games, and some parents may even fear that their preschool child's overt self-talk reflects "craziness" (Singer, 1994). As a consequence, a child may feel that imagining or pretending is not worthwhile and may withdraw from practice of imaginative game skills.

Therefore, children's play and collaboration among their peers give them an important place for their fantasy play and storytelling. Several researchers have shown the advantage of children's peer collaboration as opposed to child-adult collaboration. Overall result is that children may be freer when interacting with peers than adults. Kruger and Tomasello (1986) found that in working with logic arguments, children of 7 and 11 years, expressed logical arguments more with their peers than with their mothers. Later, Kruger found that 8-year-olds who had discussed moral dilemmas with their peers progressed more in their moral reasoning than did children who had discussed the dilemmas with their mothers (Kruger, 1988). In addition, the more interactive logical

discussions of partners' ideas that characterized peer conversations were positively correlated with progress in moral reasoning.

Dunn and Dale (1984) found significant differences in how 3-year-olds at home play with their older siblings compared to when playing with their mothers. Children playing with siblings engaged in pretend games involved transformations of role identity, location, or psychological state, whereas their play with mothers was more likely to involve labeling or acting on a realistic object. Moreover, the play with siblings commonly involved close meshing of the partners' actions in complementary pretend roles, whereas mothers generally observed and supported the play without performing pretend roles or actions.

Adults may be trained to be better at participating in children's imaginative play. In an experiment in a Soviet kindergarten that involved adult educators acting like peers with the children (avoiding use of authority and demonstrating uncertainty and errors), the children's classroom activities became more creative and independent (Subbotskii, 1987). While mothers tend to be a young child's main play partner and the initiator of most episodes of pretend play (Haight & Miller, 1991), there is a limit in what mothers can do, as Rogoff (1990) writes, "Mothers report that it is very tiring to have to pretend to be 3 years old to keep their children entertained - but 3-year-olds can keep up play with one another for hours!" Compared to busy adults, peers offer common availability and time.

Therefore, it is important to consider the role of children as playmates and collaborators, doing childish things that adults do not regard as having a purpose. In play and playful approaches to the activity of children, peers fill important roles seldom taken by adults. Peer collaboration fosters exploration and imagination without immediate goals such as adults may impose, which leads to insightful solutions to unforeseen problems.

3.3.2 Peer Storytelling

Not only does peer play gives an opportunity for children to become free from adults' expectations, it also serves a unique role in fostering their storytelling.

In collaborating with peers, storytelling becomes an important part of children's interaction. Making up the role they play ("I'm a doctor and you are my patient...") and setting up their scenarios ("There's the bed and here's my chair..."), the process of their play itself becomes storytelling. Language helps to create, clarify, maintain, and negotiate the children's pretend experience (Garvey & Berndt, 1985).

Children are better at such collaborative storytelling with their peers than their parents, as peer play has more negotiation and is more improvisationally creative (Barker & Wright, 1955). The coequal status of participants in children's play stands for them to learn some things even better with peers than with their parents (Corsaro, 1985). Fein & Fryer (1995) found no evidence that mothers contribute to the quality or sophistication of peer storytelling. Peer play and storytelling is more creative because it lacks the external control and rules, which leads to freedom and enjoyment of the activity. Its playful exploration is important for new solutions to given problems. And such an exploration leads to more interesting and sophisticated storytelling.

One reason why peer play and storytelling are more creative is the social functions of peer play. Children may use storytelling as vehicles for seeking and expressing their friendship, group affiliation, and prestige (Nicolopoulou, 1990). For example, a child may include all of his friends in the story by providing a large number of characters, in order to express his friendship. It gives children the sense of power and influence as directors, the play reflecting their own social relationships.

Overall, collaboration with peers seems to bring children the *collective* advantages to their storytelling (Corsaro, 1992). In children's collaborative storytelling, peer's stories serve as new suggestions for children to enact and tell their story creatively within their

dramatic frame (Baker-Sennett, Matusov, & Rogoff, 1992). Even if one partner's attention is lagged in telling a story, it could be revived by the new views and proposals of the other (Bos, 1937). It is the collective routines among peers that take children's stories even further.

In summary, these research findings suggest that peer collaboration plays an important role in fostering children's storytelling. Therefore, in bringing technology to support children's storytelling play, it seems important to support child-child collaborations in contrast to child-computer collaborations.

Today, technology is incorporated in many ways to offer children so-called interactive storytelling. However, in many of these programs, children passively listen to computer generated stories. It is called an interactive textbook approach (Druin, 1996), and is a way for children to learn educational materials much in the same way they do with a traditional textbook, only the medium is digital. Programs taking this interactive textbook approach give children adult-made instructions and the children take the passive role in learning.

Computer programs are programmed and designed by adults. It has been claimed that media programs, TV and video games, influence the style of children's storytelling (Kinder, 1992). Instead of taking a passive role, children can and should take an active role in influencing their own play or storytelling style. An active role will give children greater sense of control and provide a play space to practice their creativity.

As we saw, peer stories serve an important role in making the process of children's storytelling creative and sophisticated. Instead of offering children computer generated stories, the computer could offer stories that were told by peers who shared the same play space. Instead of listening to computer generated stories, children could listen to each other's stories.

One may argue that adult software authors could pretend to be peers or provide a computer character that generates peer-like stories. However, it is difficult to create such software that has the same sophistication as real peers.

Therefore, rather than making a computer intelligent and have it play the role of a child collaborator, the approach of this thesis work is to have the computer bridge storytelling carried out by children of the present and storytelling by children of the past. As a consequence, children on StoryMat are able to listen to peers' insightful stories beyond the limitation given by time and space. StoryMat offers a space where children can listen to and tell stories with peers, not to tell stories in collaboration with the computer itself.

The idea is to have the children's own stories be the objects of their collaboration. StoryMat attempts to make children's past stories play the role of a collaborator by matching them to the present stories.

When a child tells a story on StoryMat, it plays back one of the stories which were told by children who played on the mat before. StoryMat brings back stories from the past that are similar to the child's story in its length, the movement pattern of the toy, and the location where it was told. By offering a past story, which may be related to the story a child just told, StoryMat may be able to offer a place where the child could collaboratively tell his stories with peers past stories. Again, the idea is not to encourage a child-computer collaboration, but rather encourage child-child collaboration. Children are being influenced by peer's stories from the past, rather than computer's stories. On StoryMat, children's voices take active roles in their collaboration rather than the computer's voice.

3.4 Interface for Fantasy play and Collaborative Storytelling

In the first section, I provided the developmental perspective of children's fantasy play. I showed that supporting fantasy play is important in fostering their imaginary skills and storytelling. In the second section, I presented the important roles peers provide in children's activities. In particular, how peer collaboration fosters children's creative processes in their storytelling. This suggests an advantage of building systems that support children's fantasy play and storytelling in their collaboration with peers.

In this section, I will discuss how to actually implement such an environment to support children's fantasy play and storytelling. I also look into ways to support the environment that takes advantage of the creative processes children's peer collaboration offers. First I will explore different existing systems for children that employ storytelling. Next I will look into different physical interfaces that go beyond the traditional desktop computer interface. Such tangible interfaces may play an important role in supporting children's storytelling. And lastly, I will look at the systems that connect children with stories and the history of the objects they are interacting with.

3.4.1 Systems for Storytelling

Interactive storybook:

A series of software published by Brenda Laurel's company, *Purple Moon*, offer children characters with different personalities. The characters experience activities and problems that occur in the children's everyday environment like their school or their backyard. As one of the characters, a child embarks on a journey though stories of that character. This software was designed particularly for girls as it invites girls to think about what they are concerned with (e.g. how they make friends) using storytelling. By providing the content that interests them, the software also invites more girls to use computers.

Authoring environment:

Imagination Express, (EDMARK/IBM) is an authoring environment that allows a child to make up different visual stories using animated graphical characters on the computer screen. In Imagination Express, a child is the director of his/her stories. Much like a sticker book where a child places different sticker characters on the book to make different story scenarios, a child in Imagination Express places characters with predefined movements and sounds on to the screen stage. By providing pre-made moving characters and background events, Imagination Express makes it easy for a child to control and navigate his/her own stories.

Collaboration in narrative environments:

MOOSE Crossing (Bruckman, 1994) encouraged children to construct a virtual environment in which they could interact with one another. In MOOSE Crossing, children designed and built a virtual space using story writing. MOOSE Crossing brought a relaxed learning environment for children, as they took roles of a teacher, a learner, and a user at the same time.

Hayes-Roth's Improvisational Puppets System (1995) provided an environment where children could act out being someone different than themselves by using a personality rich character. By manipulating the characters on the computer screen like a puppet, children explored different actions and reactions. Hayes-Roth and her colleagues also found that using the system, children are able to construct stories collaboratively both with their peers and their parents (Hayes-Roth, et. al, 1996).

In both MOOSE Crossing and the Improvisational Puppets system, children are able to *collaborate* in a computer-mediated environment using storytelling. There seems to be an advantage in designing systems that would support story creation in an environment where children could work collaboratively.

3.4.2 Story Evoking Interface

Interface for Children:

Moving towards ubiquitous computing and tangible user interfaces (Ishii & Ullmer, 1997) is important, especially in an effort to support children's emotional engagement in their storytelling. Incorporating soft stuffed toys as an alternative to the traditional monitor and keyboard interface seems to create more familiar and less intimidating atmosphere for children (Druin, 1987; Glos, 1997; Umaschi, 1997; Johnson et al, 1998).

StoryMat and its small toys are made with cotton especially for creating such a soft interface. The quilt is soft to touch, unlike a board of plastic. This creates more familiar and less tense environment where children can think about stories.

Moreover, StoryMat uses the voices and the movements produced by children as input. Therefore, unlike SAGE Storytellers and Rosebud where soft toys were used in addition to the keyboard-monitor interface, the soft toy itself is the interface of StoryMat. Free from the confinement of typing and the general desktop arrangement, children on StoryMat move around and narrate freely with their toys. By using their body on the mat, children are more focused (Winnicott, 1971) and able to make strong personal connections (Papert, 1980) with the stories on the mat. As Csikszentmihalyi (1981), "because of their physical structure, objects lend themselves to the expression of raw physical power."

KidsRoom (Bobick, et al., 1996) provided a play room where children's body movements are tracked by computer vision. Children navigated a computer's story by making different body movements at different places in the room. Children in the KidsRoom moved freely through the space without being constrained by a desktop.

As in the KidsRoom, children on StoryMat move freely on the mat without any constraints. While stories in KidsRoom were pre-programmed to evolve in a fixed direction and children took a passive role in the actual unfolding of story events, stories on StoryMat are driven by children themselves.

Story-Evoking:

Children's play and language tend to follow the themes suggested by the toys (Quiltich & Risley, 1973). A miniature kitchen set, a doctor's kit, and a truck, all suggest particular themes or props that children tend to stick to in their play.

Children are creative on their own. Pulaski (1973) found that significantly more varied themes and richer fantasy were elicited by the minimally structured materials presented to children from preschool through second grade than were elicited by highly structured toys.

In addition to providing a larger-than-themselves interface, there are reasons for this particular quilt being a play mat that is story-evoking. Objects sewn on the mat are story evoking. There are paths going different directions, trees, houses, and fields of contrasting colors. These objects serve as kind of "story starters" for children to jump start their stories, yet the shapes are plain and simple enough to be transformed into any objects children imagine them to be. For example, a house can be imagined by one child to be a candy shop and another child to be her own house. A blue field can be a magic spring or a field filled with blue flowers. Objects on StoryMat serve as symbols, which can be both "models of" and "models for" reality, as explained by Geertz (1966). In the first sense, they reflect what is. The house may be a house for someone. In the second, they foreshadow what could be. The house may be a police station or a time-machine.

3.4.3 Interface for Children's Storytelling

Representation of Stories:

By standing between the world of formal systems and physical objects, the computer has the ability to make the abstract concrete (Turkle & Papert, 1992). Today, moving towards ubiquitous computing and tangible user interfaces (Ishii & Ullmer, 1997), the objects children learn with in the computer are literally becoming objects that children can physically manipulate. Play objects such as balls, blocks, and beads - descendents of Froebel's twenty kindergarten gifts (Brosterman, 1997) - are reinvented by embedding computational and communications capabilities in them. These digital manipulatives, which take the form of traditional toys, can teach children advanced abstract concepts such as feedback and emergence that were perceived as too advanced for children to learn (Resnick, et al., 1998).

While the digital manipulatives are focused on mathematical thinking, efforts to represent abstract stories as manipulatable objects have been made. In the Rosebud system (Glos, 1997), the number of stories a child creates with a stuffed animal was represented by the number of lights being lit on the animal. Stories in SAGE (Umaschi, 1997) were treated by a child as one of the objects with which she programmed her own storyteller. In both systems, children's own stories became manipulatives for them to think about, beyond the scope of traditional storytelling.

Therefore, it seems possible to represent stories as objects for children to manipulate. In StoryMat, children's stories are represented as objects used in their collaboration. Each story on StoryMat is made out of the child's narrating voice and a projected moving image of the stuffed toy the story was told with. The image is synchronized to the voice and replicates the exact path the child made with the toy. Such stories being played back on the mat can be stopped and taken over by a child who wishes to make a diversion by simply putting her stuffed animal over the moving shadow. Just as a child would knock a stuffed lion sitting on a grass field on the mat with her stuffed bull because she decides

now the bull is taking over the spot to nap instead of the lion, a child can easily take over a story played on the mat with her stuffed toy. Stories played back on the mat become more like physical toys/objects placed on the mat, which a child can manipulate to tell new stories. These manipulative stories may serve as an unique representation for children collaboratively telling stories with others' and their own past stories.

3.4.4 Collaboration between stories of the past and present

By capturing children's stories and retelling them, StoryMat provides a space where children encounter stories from the past. There are two ways in which the past stories may be interpreted: First, the children may be able to collaborate with their own stories. It gives children a place where they may be able to reflect on their own stories, alone as well as with others. Second, it provides a sense of narrative history.

Collaborating with One's Own Stories:

While collaborating with others and listening to others' stories brings a much richer experience to telling one's story, listening to one's own stories can be as inspirational as listening to others' stories. Revision has been the main process for people to modify and think about their own stories objectively. Revision is also a process used primarily for written stories. There are many systems that are designed to aid children's written stories by encouraging them to revise. Moving away from just offering the spelling or grammar checker, Catch system (Daiute, 1985) offered questions that encourage children to play a role of reader. In Eddie Edit (Montfort, 1998), such questions were offered by a conversational character.

While traditional revision is focused on improving or polishing up a piece as a whole, the "re-visiting" of one's story needs not to be separate from the actual process of creating and telling the story. One's past stories can be revisited to inspire and evoke yet another story of one's own. On StoryMat, children hear their own past stories told on the mat as well as others' when they tell their stories. Hearing their own stories, children may

modify them by adding diversions to their own creation, much like they would in dealing with their friends' stories. In a way, children are able to *collaborate* with their own past stories. StoryMat adds a new dimension to their collaborative storytelling by having their own voice as one of their co-storytellers. This may bring yet more creative extensions to the collaborative storytelling, as well as the revision.

Sense of History, Upon an Object:

As I wrote in the introduction, the quilt (the mat) means a lot to me personally. As it is my childhood object, no one would have the same kind of attachment to it as I do. Yet, even this particular mat started out by being just a mat to me. As I played on it by myself, with my brother, or with my friends, it became a meaningful object for me and an object I would come back to.

Csikszentmihalyi (1981) described that when a person invests his or her intentional psychological act into an object – a thing, another person, or an idea – that object becomes "charged" with the energy of the person. In that sense, my mat accumulated my play activities. And over time, it got charged with my energy.

Nevertheless, this representation of a person's energy, in my case the stories, is not always captured. The Rosebud system (Glos, 1997) augmented stuffed toys such as a teddy bear, and made a connection between the abstract history of the toys, represented as a collection of stories, and the physical objects themselves. The Rosebud toys were digitally charged with history - stories told by children who interacted with the objects.

While Rosebud is a toy a child would come back to, to tell his stories or to listen to his stories from the past, the Victorian Laptop (Cassell & Smith, 1999) is a physical object that travels with a person to collect their travelogues. The Victorian Laptop augments stories told by a traveler in the present time with stories told in the past, based on where the traveler is standing while telling these stories. In the Victorian Laptop, stories a

traveler tells are associated with the history of places the person travels to, as well as the physical object itself.

StoryMat takes on characteristics of both Rosebud and the Victorian Laptop. Children pretend to be a character experiencing different adventures on the mat. In their storytelling play, objects on StoryMat (such as a blue field or a purple house) become like real objects to the character they are playing. For example, when placing and moving a stuffed animal up to a purple house on the mat, a child may say, "This is where I live!"). As a character, the child pretends to *travel* to different *places* on the mat. Like the traveler using the Victorian Laptop encounters stories offered at the places she travels to, children on StoryMat travel in the imaginary world and encounter stories at different places they visit as a pretend character. Physical places on the mat that stand for children's symbolic *places* are charged with energy of children who have *visited* and told stories there. Like Rosebud, such places are charged with stories they can come back to and listen to or take further.

Stories told on the mat represent the energy spent on the mat. The mat becomes a meaningful place for the children, as Csikzentmihalyi says, "part of their life has been transferred to the object – part of their ability to experience the world, to process information, to pursue goals has been channeled into the task to the exclusion of other possibilities." (Csikszentmihalyi, 1981, p.8) Children on StoryMat meet stories from the past at symbolic places they play at. Supported by the collaboration between the past and present, children on StoryMat exchange their imaginations to *cultivate* the place of their fantasy further.

Chapter 4 – Technical Implementation

The previous chapter provided the background research of children's fantasy play and storytelling, and provided an evidence for how a computer system could support such activities. Now I turn to the design and implementation of such a system, StoryMat. The goal of the implementation is to investigate how such a system could be instantiated using the state-of-the-art technology.

In this chapter, I will first provide the observation I made from the field study, which was useful in realizing the system. Second, I will provide the components of the StoryMat implementation.

4.1   Field Observation

Before the actual implementation of the StoryMat system, I observed children playing with their playmates on a passive mat (the quilt) using stuffed animals. Two girls and two boys volunteered for this. Their ages were 5, 6, 7, and 8. This observation yielded insights that was useful when I prepared to design the system.

The following observations were made:

- The children seemed to understand what a play mat is without any explanation.

    Even when they hadn't seen anything like it before, they did not need any explanation of how it should be played with. They were able to pretend that they were in the world presented by the mat without any practice.

- The children were good at using the stuffed animals on the mat.

They moved the small stuffed animals around on the mat vicariously. When they were narrating, "… then go to the path…," they moved their stuffed animal along the path on the mat.

- The children were good at staying on the mat.

  Once they started to play, their focus play area stayed on the mat. This gave me an estimate of how large the sensing area needed to be (approximately the size of the mat).

Ideas for the interface design:

- Stuffed animals used on the mat needed to be wireless. Tethered toys may make users feel that the objects look somewhat unfinished or broken.

- Children should be able to record a story at any location on the mat. That was the reason why it was important to track the stuffed animals continuously across the whole mat surface. One of the first suggestions for implementing StoryMat was to use the tag reading technology - To define some *hot spots* on the mat and have the stuffed animal send different signals to the computer depending on which hot spots it is at (Poor, 1996). Rosebud (Glos, 1997) used such technology.

4.2   Implementation

Overview of the system

An ultrasonic transmitter embedded in the small stuffed animal allows wireless tracking of the animal's movement on the mat. Squeezing the stuffed animal, triggers the computer to start recording the child's narrating voice and the two-dimensional coordinates of the stuffed animal. When the child lets the stuffed animal go, the coordinates and the voice are combined into a movie file and saved in the computer to be played at the appropriate locations of the mat. When new input is subsequently encountered at the same place on the mat, the movie file is then automatically triggered and played back via a projector mounted above the mat and heard through a pair of speakers next to it.

The current version of StoryMat contains three hardware components (the stuffed animals, the mat, and the projector), and a software component written in Lingo for Macromedia Director 6.5. The next two sections will explain the each component in more details.

Overall Interface Design

The use of the children's play mat as a projection screen is modeled after the implementation of the metaDESK (Ullmer & Ishii, 1997). As in the metaDESK, using a back-projected screen would have been a good solution, especially for the reason children on StoryMat will be moving their body on the surface. However, projecting images from above was necessary in order to incorporate the soft quilt and have the space available for children to move their body.

4.2.1 Hardware

The stuffed animals:

A wireless 3D ultrasonic mouse[1] is embedded in a stuffed animal. The circuit board of the mouse was encapsulated in a box inside the animal to protect it from the children's possible rough handling. The left mouse button was extended in order to provide a natural grip by soldering a new button to an existing button with a longer wire.
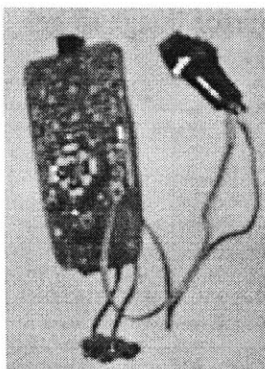
Picture 1:
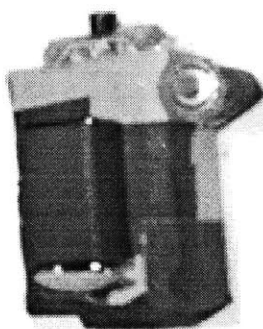The circuit board of
3D ZoneMaster with
an extended mouse
button.

Picture 2:
The circuit board
secured in a box.
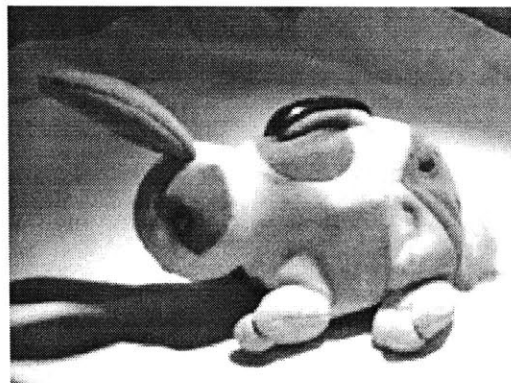
Picture 3:
The secured circuit board embedded inside of
a stuffed animal with the transmitting speaker
and the button sticking out.

There are two stuffed animals prepared to be used on StoryMat. One is the bunny pictured above, and the other is the bull, which is in the same configuration as the bunny except for the button. The bull has the right mouse button being extended from the same transmitter board.

Therefore, the StoryMat program knows which animal is active on the mat by listening to which button is sending the signal.

---

[1] 3D ZoneMaster by Techmedia/Pegatech Inc

The mat:

A microphone and a pair of speakers are installed at the surface level of the mat. They face the users.

The projector:

A VGA projector is mounted above the mat. The size of the projected screen image is matched to the size of the mat. The receiver unit of the ultrasonic mouse is installed above the mat facing the mat's surface. Because the receiver unit is hung over the mat in reversed-x-axis mode, the projector image is projected in horizontal mirror image to get back the original orientation.
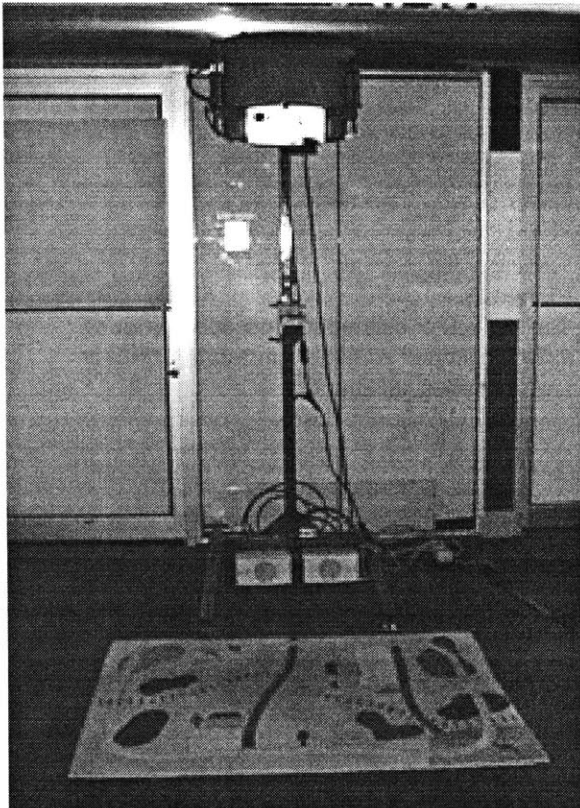
Picture 4:
A projector mounted above the StoryMat.

4.2.2 Software

The main program divides the active area of StoryMat, which is to be projected onto the mat, into 126 dimensions. Stories can be recorded at any of the 126 places.

Recording a session:
While a user squeezes the stuffed animal (i.e. while the mouse button inside the stuffed animal is being pressed), the computer records the user's voice and the mouse movement. When the button is released, the voice and the mouse movement data are saved as a sound file and a text file of coordinates. Our program written in Lingo takes this data, matches it with the graphic image of the stuffed animal, and produces an animation of the toy travelling across the mat, accompanied by the child's voice-over story.

Playing back a session:
When new input is subsequently encountered at the same coordinates on the mat as a previous recorded storytelling session, the input is recognized by the computer program as a trigger event to reproduce and project a stored storytelling animation. That animation is then played, by the projector, with corresponding audio heard through the speakers. The animation of the stuffed animal travels the course of the recorded path in synchrony with the voice.

Matching a story:
When there are multiple sessions stored at the same place on the mat, the one with most similar size and pattern (the length of the story session, pattern of the path the toy took, and the identity of the toy) to the new triggering session is chosen to be played back.

Example Sequence:
A child tells a story with the stuffed bunny on the mat. He starts his story at a place near the purple house and goes to the yellow house on the mat (path B in the Picture 5 below). The child's story is matched with one of the past stories recorded at the same place as his

and also with the one that has similar length and the pattern as his. In this case, there are two stories existing at the place where he told his story, story A and story C. The child's story, story B has similar length as story A, but story B's path pattern is closer to story C's than story A's. Since the similarity is greater in the path pattern than the story length, in this case, the child with story B hears story C.
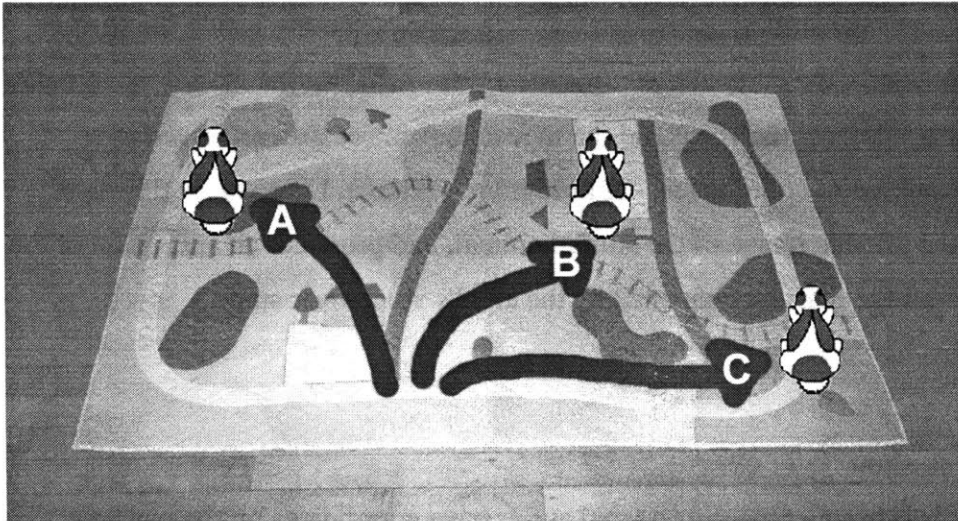
Picture 5

The idea behind matching the length of stories is that it may provide a better setting for turn-taking between the child and StoryMat. If a child is telling a short story, about 15 seconds, the child may not be interested in hearing a 2-minute story offered by StoryMat. By responding to the child's short story with another short story, and a long story with another long story, StoryMat may be able to take turns with children.

Branching:

During the course of playback, if the user squeezes the stuffed animal and begins to tell a new ending for the played-back story, a new animation is created of the first child's beginning and the second child's ending, and this new animation is stored in the library of possible stories to be played back on the mat. Thus, layers of children's stories accumulate in the library alongside the original one-child stories.

Chapter 5 - Empirical Research

The goal of the empirical research is to investigate how children listen to stories StoryMat offers and how that effects the children in telling their stories further. This chapter is broken down into two parts: The Pilot Study and the Empirical Study.

Pilot Study

In order to examine whether the implementation is ready for use by children in a real environment, the system was first tested in a pilot study environment. The goal of the pilot study is 1) to check hardware and software issues, 2) to evaluate and establish a protocol (how to prompt kids to storytelling), and 3) to take a first look at the kind of data to be expected from the experiment.

Subjects:

15 children volunteered to play on the mat.

Results:

- The buttons/circuit board inside the stuffed animal had to be very sturdy

  When the first pilot subject squeezed the bunny, the sensor circuit was not embedded securely enough so different parts of the circuit, including the other button were pressed causing the mouse to function in unexpected ways.

- The microphone setting and installation

Embedding a wireless microphone in the stuffed animal was not practical since the stuffed animal was used very actively by the children. Also, making children wear the microphone was not practical since their rapid movement caused the units to either fall off from their body or to record scratchy noises. Having one microphone in front of them worked best especially when there were two children.

- The speaker boxes needed to be hidden

   One pilot subject told the experimenter that she knew how the system worked. She pointed out, "I made the mat do something, but the boxes are really the ones making the stories." Later the speakers were covered with dark cloth so that children would not be distracted by the hardware of the system during their task of storytelling.

- The experimenter had to be careful in the practice session

   Children watched carefully what the experimenter was doing during the explanation of the mat. When the experimenter showed that it was OK to interrupt the story, or it was OK to make up any stories or make a sequel to an existing story, children attempted such activities on their own as well. The experimenter had to be consistent at demonstrating and also had to come up with fair enough explanation to the StoryMat group because they didn't know whether they could work with the stories or not.

5.1   StoryMat: Empirical Study

The goal of the empirical study is to investigate whether StoryMat provided a place where the children were able to 1) engage in more sophisticated storytelling activity; and 2) engage in collaborative storytelling independent of the presence of a co-temporal and co-spatial playmate.

Therefore, the hypotheses for the empirical study are:

Hypothesis 1: StoryMat fosters sophisticated storytelling in the context of fantasy play.

Hypothesis 2: StoryMat provides a place for collaborative storytelling independent of the presence of a co-temporal and co-spatial playmate.

In order to compare how the recording and recalling of stories changes the experience of children who are playing alone and playing together with a playmate, groups of children who play alone and children who play with a playmate on StoryMat were compared with that of a control condition. Groups in a control condition play on the passive mat, without the recording and recalling function of stories.

Design:

	Passive Mat Play mat **without** recording & recalling functions	**StoryMat**
One child	**Group 1** 6 children	**Group 2** 6 children
Multiple (two) children	**Group 3** 6 couples (12 children total)	**Group 4** 6 couples (12 children total)

Subjects:

36 children between the age of 5 to 8 volunteered for the study.

Procedure:

Children were randomly assigned into two groups: 1) StoryMat group, who played on StoryMat and 2) a control group, who played on the mat without any software. In each group, 6 subjects played alone and 12 subjects played with another playmate, resulting in 6 dyads and 6 singles in each group.

It is natural for children to pause their activity when they become aware of being watched. Children are sensitive to the presence of adults. For example, the level of interaction in 5-year-old and 8-year-old peer dyads was reduced when they were in the presence of adult observers (Brody, Stoneman, & Wheatley, 1984). In order to prompt children to tell stories on the mat with the stuffed animal, and still observe them in unobtrusive way, the following procedure was designed.

Introduction 1 Explain the task	**Experimenter**: "Let's pretend that we are living in this world (mat)! Would you tell me different stories that happen in this world?" "First, I will play with you. But I will leave the room later so that you can be alone to tell your stories on the mat."	
Introduction 2 Explain StoryMat (StoryMat conditions only)	**Experimenter**: "Do you see a button here? (show the button on the stuffed rabbit) You have to hold down the button while you tell your story so that the mat knows you are telling your story. And you let the button go when you are done so that the mat know	

	you are done with your story."	
Introductory Play (5 min.)	**Experimenter**: "I'll start!" (In StoryMat groups, the experimenter show that she holds down the button and lets it go when she's done.) "The bunny was walking down the street one day, and found a railroad track. The bunny wondered where the track would go, and followed the track." "Now, would you tell a story?" **Child**: (tells a story) **Experimenter**: "The bunny one day heard there is a wishing tree somewhere. She didn't know where the tree was, so she decided to make a wish at the first tree she found. 'I wish I had more friends.' Nothing happened, so she decided to go home and wait." **Child**: (tells a story)	**StoryMat** plays a story on the mat. **StoryMat** plays a story on the mat. **StoryMat** plays a story on the mat.
Experimenter leaves	**Experimenter**: "I have to go now. But you keep telling stories on the mat, OK? I will be back."	

The introductions and introductory play were given in the same way in all four groups,

except for the explanation of the button on the stuffed bunny, which was given only in

the StoryMat conditions.

5.2　Method of Analysis

In order to investigate **what kind** of stories StoryMat fostered and **how** such stories were fostered by StoryMat, both the stories the children produced (the product) and the activity of storytelling itself (the process) were studied.

5.2.1　Product: Stories that children told – for Hypothesis 1

The product of the children in this study was first compared across the groups in terms of how much the children in different groups were talking. Next, the product was analyzed to investigate whether it was the product of storytelling or the product of pretend actions. Finally, the product was analyzed to investigate whether it was the product of creative or imaginative activity.

The following measures were used to analyze the product of the children's discourse in the study.

- **Total number of words**
- **Total number of unique words**

  The number of words and the number of new words a child produces reflect the child's vocabulary size and the ability to use different words in his/her speech (McCabe & Peterson, 1942). These measurements were used to analyze how much talking the children engaged in.

- **Number of formal opening statements**

  Formal opening phrases such as "Once upon a time" are conventions people use in association with telling a story (Sacks, 1972). Whether the children in

different groups were telling stories or simply engaging in pretend play was investigated, by collecting and comparing the number of formal opening phrases in the children's discourse,.

- **Number of imaginary objects** created in children's stories that emerge from the shapes of quilted objects on the mat.

Sheldon and Rohleder (1996) collected the number of imaginative objects a child transforms from a realistic objects as a measure of the child's imagination. With development, children are able to use less realistic objects in their play as they are able to transform the objects into imaginative objects that fit into their play scenario (Jeffree & McConkey, 1976; Corrigan, 1982). By using the same method as Sheldon and Rohleder, imaginative objects the children produced were collected and compared across the groups to investigate how much the children engaged in creative and imaginative activities.

5.2.2 Process: Storytelling of children – for Hypothesis 1 and 2

Secondly, the children's discourse in this study was studied in terms of how the stories were produced. In order to investigate how complex their storytelling process was, the roles the children took in telling their stories were analyzed. The following measure was used to investigate this factor.

- **Speaker Identity**

    Auwarter (1986) used three types of "Speaker Identities" in evaluating fictional reality in children's play: 1) Everyday personal identity [a child is speaking as himself/herself], 2) Neutral observer identity [a child is speaking as a narrator], and 3) Character role identity [a child is speaking as a character who is different from him/herself]. He found the developmental trend was to

move from the Everyday personal identity to the Neutral observer identity and the Character identity. He also found that with development, children become more competent at using the two roles, Neutral and Character, in their stories to generate more complex narrative lines. Using the same method, the children's stories in this study were analyzed in order to investigate which groups were able to engage in more complex storytelling by using different roles in their stories.

Index of collaborative storytelling:

Additionally, in order to look at how the presence of a peer and the presence of stories offered by StoryMat influenced the children's storytelling, elements the children incorporated from their peer or the StoryMat were analyzed.

- **Incorporation of elements**

In telling stories collaboratively, children adapt their own definition of the pretend situation in order to incorporate others' elements and respond in ways that confirm their plan (Singer, 1990; Giffin, 1984). I looked for such activities in the discourse of the children on StoryMat. Two kinds of adaptation and incorporations were looked at: 1) language style (a certain way of saying a word was adopted), and 2) imaginative objects (a certain imaginative object was incorporated).

Chapter 6 – Results

In this chapter, I will provide the results of the study. I will first give an introduction to the types of discourse I have collected from each of the four groups. I will then provide both quantitative and qualitative analysis of the discourse.

Because a number of children had to leave the room during their 15 minute play, for different reasons (going to the bathroom, getting water, etc.), only 10 minutes of discourse sample were collected consistently from all the child subjects. All the 36 children's discourses, a total of 24 10-minute sessions (12 singles and 12 dyads sessions) were transcribed.

Among the 36 children who have participated in the study, there were 3 5-year-olds, 12 6-year-olds, 9 7-year-olds, and 12 8-year-olds. The age distribution was similar across the groups. The following table shows the age distribution.

Table ?: Age distribution of the children in each group.

Group 1 Singles on Passive Mat	Group 2 Singles on StoryMat	Group 3 Dyads on Passive Mat	Group 4 Dyads on StoryMat
Child 1 = 7	Child 1 = 8	Dyads 1 = 8 & 8	Dyads 1 = 7 & 8
Child 2 = 8	Child 2 = 7	Dyads 2 = 6 & 6	Dyads 2 = 6 & 6
Child 3 = 6	Child 3 = 7	Dyads 3 = 6 & 6	Dyads 3 = 8 & 8
Child 4 = 6	Child 4 = 6	Dyads 4 = 6 & 7	Dyads 4 = 7 & 8
Child 5 = 8	Child 5 = 5	Dyads 5 = 6 & 6	Dyads 5 = 8 & 8
Child 6 = 7	Child 6 = 6	Dyads 6 = 5 & 8	Dyads 6 = 7 & 7
Average age = 7.0	Average age = 6.5	Average age = 6.5	Average age = 7.3
Average age of all 36 children = 6.9 years			

All the groups had a similarly distributed age range. The only difference between the groups was their condition (i.e. playing alone on the passive mat, playing alone on

StoryMat, playing with a peer on the passive mat, or playing with a peer on StoryMat). Therefore, age was not an independent variable in this empirical study.

6.1   Children's Discourse on the Mat

In this section, I will present sample discourse segments from each group and give a preview to the general characteristics of each group.

Group 1 (One child on the passive mat):

Children in Group 1 were asked to tell stories using stuffed animals on a passive mat. In general, children in this group produced fewer utterances than other groups. They tended to have long pauses between their utterances. There were many occasions when they moved their stuffed animals on the mat, but did not say anything. In fact, two out of the six children in this group played on the mat and moved the stuffed animals around, but did not make any utterances at all during their session.

When they produced speech, their speech was mainly the product of pretend actions; they spoke mostly as a character that was different from them, and they rarely took a 3rd person narrator's role. Their utterances were fairly short, focusing on sounds (e.g. making slurping sounds), greetings, and question/answer.

They also tended to lose focus on their task and often did things like singing or beating rhythms while away from the mat. The following is an example:

> Alexandra (8)
>
> "Hello, zebra!" "Hello, lion."
> [laughs]
> "Let's go play, hop-scotch." "OK."
> [hhu! Hhu!, she makes the animals jump on the parking lot]
> "Hi" "Hello" "Do you wanna do that again? In the grass field?" "Yeah!"

[she holds the animals in the air]
<pause>
"OK" "OK" "OK" "Ohhhh hy!" [makes the sound]
<pause>
"Er!"
[moves the animal around the mat]
"That was fun!" "Yeah."
[pauses/does nothing for 50 sec]
[she moves the animals]
[does nothing for 30 sec]
[starts to beat rhythm with her hands on the lap, away from the mat for 30 sec]
[moves the animals for 12 sec]
[starts singing away from the mat for 30 sec]
[experimenter walks in and tell her to tell stories]

"Hello, zebra" "Hello!"
"I was at the wishing tree."
[makes the eating sound]
"Oh, I ate the wishing tree!"
[makes the eating sound]
[moves the animals to the lake]
[makes the eating sound]

This example shows that the child was speaking as a character and not as a narrator. It is also evident that the discourse lacks a general point, which is required in order for it to be a story according to Polanyi's (1989) definition. It is difficult for others to see why the characters she created were going through the things they were going through. This child can be said to have engaged in pretend play rather than storytelling.

Group 2 (One child on StoryMat):

Children in this group played alone on StoryMat. Even though they played in the environment alone, children in this group produced a large number of utterances in contrast to the children in Group 1. The children took roles, both as a character (e.g. 'Wow! Isn't that great!') and a narrator (e.g. "One day, a rabbit was..."). Compared to the children in Group 1, their product was more storytelling than pretend actions.

The following example shows that a child who heard two stories on StoryMat with an experimenter during the practice session continued to tell stories alone on StoryMat.

(Note: Words in italics indicate the story provided by StoryMat)

Josh (8)

"One day, a bunny liked to play basketball, he liked basketball so much that, he ran and ran, and he liked, and he liked.. so that <pause> and that he was on the team. And then in the team, there was a trial, to run. And then he helped the team, because, he was the best."

"One day, a rabbit was – he was , he ran a lot and then a lot and then a lot then a lot, then he went to a street. Then he ran and ran and ran. Then he liked it so much he jumped all the way to the top. And then and then he met his friend zebra, zebra said hi there. <pause> and then zebra said 'How are you doing, and then zebra said 'Did you know I made it into the team?' 'Wow, no way! I'm soo surprised. How I think that --- could be…' And then the rabbit went home, then told his rabbit mother, 'I made the team and then did---' 'Wow! Isn't that great? Well let's have a party.' And then the rabbit invited all of his friend all over the city."

<One day the rabbit was, the rabbit was, walking one day he was walking down the street, and and he crossed the rail road track and then he bought some jewelry, then he crossed then he made sure there's no one in the parking lot, and then kept walking. And went for a swim and then he went on to another parking lot, and he did not know his big <pause> pu pu and the word thing for, and he went in the field and walking around, and he went to see the tree. The beautiful green tree. Then he went to the baseball field and running around and crossed the track and then went to the brown <pause> road. And then he walked and walked and walked and walked and walked. And he walked and walked. >

"Then he climbed on the tracks then he climbed and climbed because he sniffed some po- and he kept on going and the train was coming. He turned around. He turned around. And went faster and faster."

The example shows that the child was predominantly taking the 3rd person narrator role. He used a character identity only to mix well with the story he was narrating. For example, when he used the character identity, it was always marked by the narrator's comment such as "then he said, 'Did you know …'"

As I will show later, children in this group took turns with StoryMat. They also listened to stories provided by StoryMat and became influenced by the stories. This example shows that Josh was telling a story about a rabbit making it into a team and having a party. But after having heard a story about the rabbit going to different places and doing a lot of walking, he continued his story in a way similar to the story he just heard. The event of Josh's character changed from having a party to going to different places.

Group 3 (Dyads on the passive mat):

Children in Group 3 played on the passive mat with a playmate. In general, the children produced many utterances as they were able to have conversations with a co-temporal co-spatial playmate. Like the children in Group 1 who played on the passive mat alone, the children in this group rarely took the role of a narrator. Their speech was based on their pretend actions. This contrasts with the children in Group 2 who played on StoryMat alone, and took roles of both a character and a narrator.

Carrie (8) and Katy (8)

C: "Let's try to on this blue tree"
K: "OK. What is this blue tree?"
C: "We wish <p> to.. <p> What should we wish?"
K: Huhh?
C: "We could <p> Maybe we could wish to have a family."
K: "OK. We wish we have a family."
C: "Let's see if we find anybody. See if you found anybody."
<p>
K: "No."
C: "I didn't. This isn't a wishing tree. Let's try the one that's next to it."
K: "We wish we had a family."
<p>
K: "There's still nobody."
C: "NO. Maybe that's the only wishing tree in the country. Is that.."
K: Let's try these!
C&K(together): "We wish we had a family."
<p>
K: Hey! There's a note! It says, there's a family.
C: Where? Humm.
K: Look in your house.
<p>

The example illustrates that each of the two children was speaking as an imaginary character and having a conversation in an imaginary world. Unlike the children in Group 1, the children in this group had a co-temporal and co-spatial playmate with shared imagination. However, like the children in Group 1, the children produced series of pretend actions rather than narratives.

Group 4 (Dyads on StoryMat):

Children in Group 4 played on StoryMat with a co-temporal co-spatial playmate. Like the children in Group 3 who also had a playmate, children in this group produced many utterances. Particularly interesting is that children in this group took roles of both a character and a narrator, as well as had conversations with their playmate. Compared to the children in Group 3, their product was also more storytelling than series of pretend actions.

(Note: Words in italics indicate the story provided by StoryMat)

Rebecca (7) & Kamilah (7)

K: "Once upon a time, there was a <p> bunny. He was going down the train track. And he suddenly saw <p> Um. A trail. Then he went <p> Then he saw the house. Then he wanted to go in there. But people didn't let him. So he went back. He went to the trail way. Then, then he saw another one. And he went to the house. And he couldn't go in. And then, he saw, beautiful <p> zebra! And he said, 'Hello! Do you know the way <p> to my house? You've been there before, have you?' 'Oh, yes, I have.'"

[the mat doesn't play back]

K: Oh, I just keep saying.

K: "So then, he came back. <p> Then the zebra told him, 'I know your way. Follow me.' So he did."

<Once upon a time, there was a zebra with a rabbit swimming in a warm bath . And he met a beautiful king <pause> zebra, he said, she was, that he was gonna fall in love with.>

K=>R: Go.
R=>K: OK.
<p>
R: "Once upon a time, there was a zebra. And he <p> I mean <p> a bunny. And he lived by a lake. Then one day, he went down the railroad tracks. And he found the trail. And he went down the trail. And then, he saw a house. He looked in, he looked at it. But no one was home. So he kept going. Then he found a zebra stuck in a hole. And then, the zebra said, 'Help me out.' So the bunny went <p> pulled the zebra out. And then, the bunny went back home."

The example shows that the two children are taking three different perspectives: the third person narrator role (i.e. "Once upon a time, there was..."), a character role (i.e. 'Oh, yes I have'), and their everyday personality (i.e. "OK," or "Go" addressed to the partner).

6.2 Children's Discourse Patterns on the Mat

In order to visualize a general pattern of the children's discourse on the passive mat and StoryMat, I generated a graph based on the quantity of the children's speech. The following graph shows **how much** children are talking on the mats, and **when** they are talking during their 10-minute session. For Group 2 (one child on StoryMat) and Group 3 (dyad on StoryMat), it also shows the patterns of how the children and StoryMat were taking the turns.

Graph 1: Children's Discourse Patterns on the Mat

Singles on Passive Mat
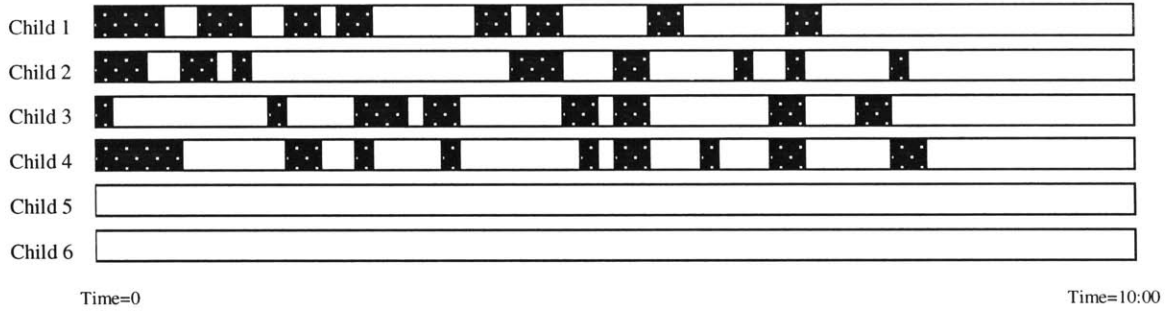
Singles on StoryMat

Dyads on Passive Mat

Dyads on StoryMat

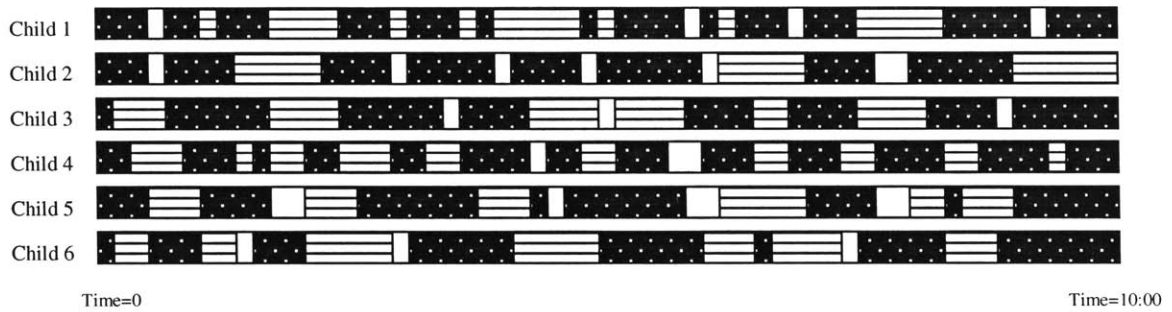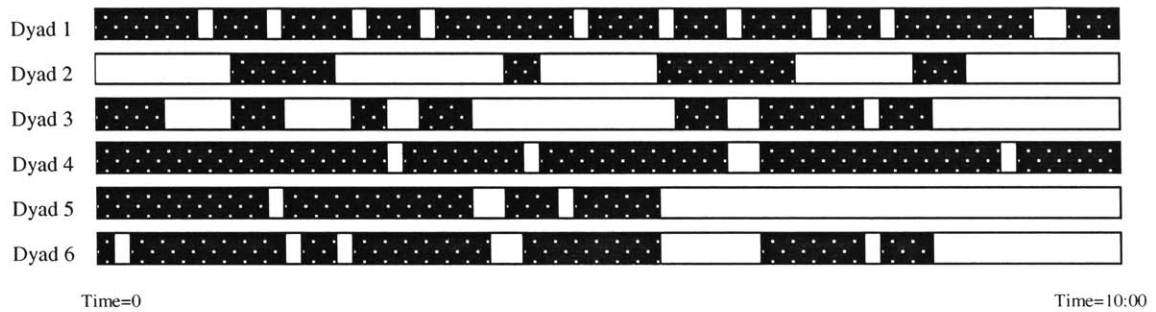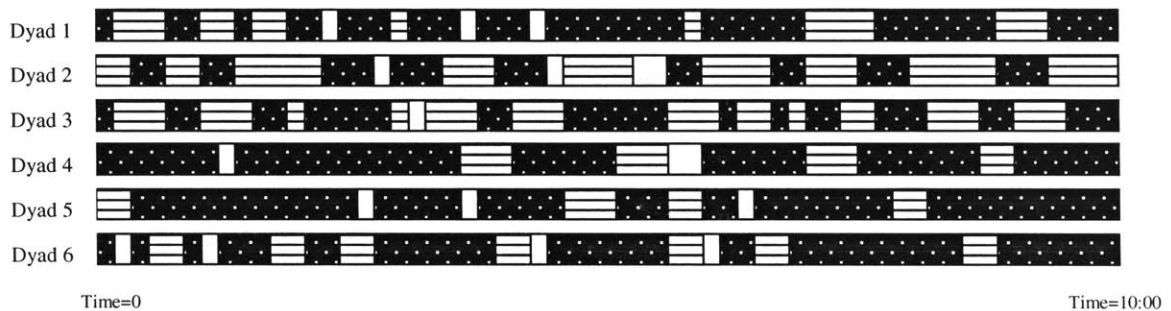This graph shows that the children on StoryMat, both the singles and dyads, had much fewer pauses than the children on the passive mat. The children on StoryMat also seem to have talked throughout the 10-minute session, while the talk by the children on the passive mat especially the singles on the passive mat seemed more sparse. Therefore, children on StoryMat seem to have engaged in more talking than the children on the passive mat.

From the graph, it seems obvious that the singles on StoryMat were talking more than the singles on the passive mat. It also seems that singles on StoryMat were talking as much as the two children on both the passive mat and StoryMat. The pattern of the singles on StoryMat is very similar to that of two children on StoryMat. From the graph, it seems that the singles on StoryMat were as verbal as they were with a playmate.

The graph provides a general pattern of the children's discourse on StoryMat and the passive mat. It also shows how children in the StoryMat groups took turns with the stories offered by the mat. By listening to stories of StoryMat, singles on StoryMat seem to have talked as much as the children with a co-temporal and co-spatial playmate.

6.3 Product: Stories that Children have told

This section provides the quantitative analysis of the children's stories, the product of the their activities on the mats. I will first provide the results from comparing the number of words and the number of unique words the children produced in each group. I will then look at how children use a particular story language, specifically by comparing the number of opening phrases used in each group. Finally, I will look at the degree of creativity in their storytelling by comparing the number of imaginative objects produced by the children in each group.

6.3.1 Number of Words

The number of words is used for quantitative analyses of children's discourse by a number of researchers (see McCabe & Peterson, 1942 for a review).

By using the text analysis software, *WordSmith*[2], I compared the total number of words used in the 10-minute transcriptions by the children in each group. This included all the repeated words produced by the children. For example, a child who said, "And then, and then, and then, the bunny went to the park," was said to have produced 12 words. The number of unique words (tokens) produced by the children will be discussed in the next section.

The following graph shows the number of words produced by the children in each group.

---

[2] *WordSmith* Version 2.0 by Mike Scott, 1997

Graph 2: The number of words produced by the children in the four groups.

	128.67	492.50	245.58	297.58
	Group 1	**Group 2**	**Group 3**	**Group 4**
	Singles on Passive Mat	Singles on StoryMat	Dyads on Passive Mat	Dyads on StoryMat
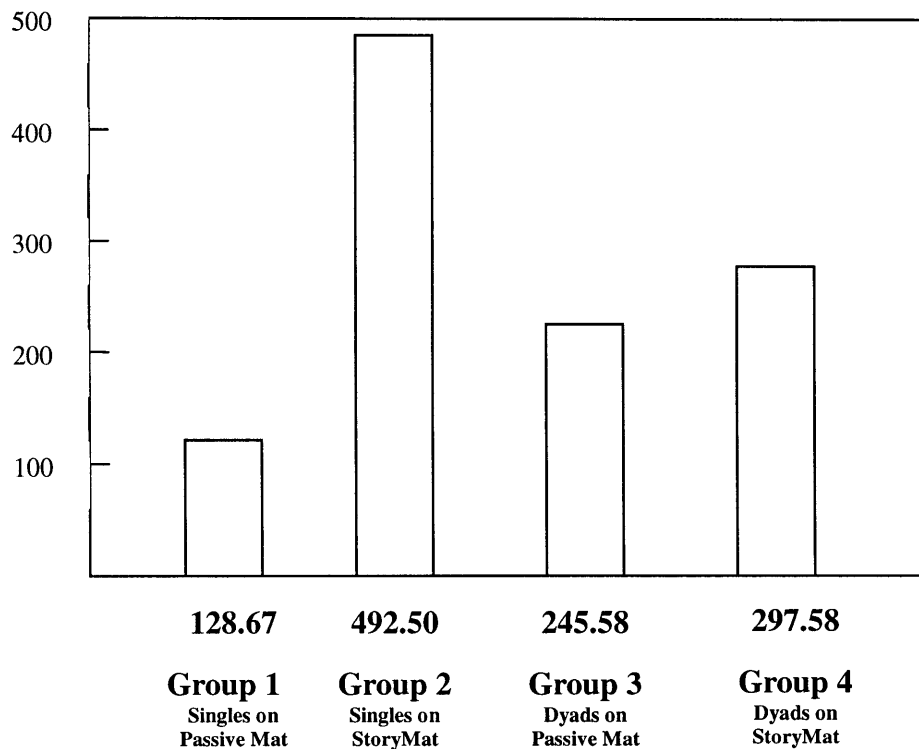
With an alpha level of .05, the difference between the singles on StoryMat and the singles on the passive mat was statistically significant, F (3, 32) = 2.90, p < .05. However, there were no significant differences between the singles on StoryMat and the other two groups.

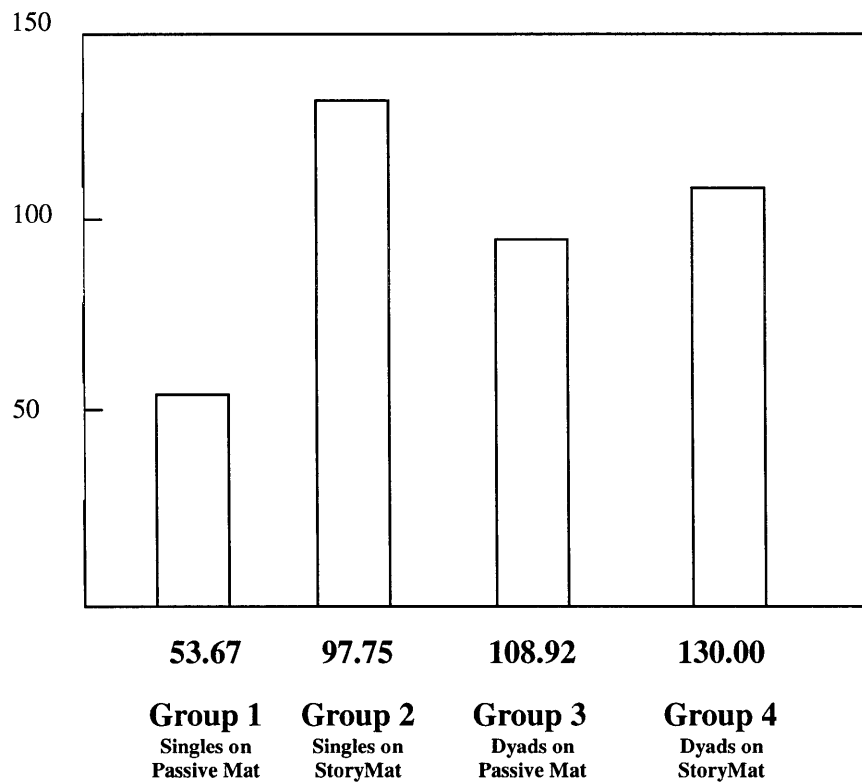The result shows that the children who played on StoryMat alone produced the highest number of words. The result suggests that a child alone on StoryMat is more likely to verbalize than a child on the passive mat. We could postulate from the result that StoryMat provides a space where a child is able to have an engaging verbal play even without a co-temporal co-spatial playmate.

6.3.2 Number of New Words

Next, the number of new words produced by the children was collected and compared. It indicates the number of different words produced by the children. For example, a child who said, "And then, and then, and then, the bunny went to the park," was said to have produced 7 new words.

The number of new words in a child's discourse indicates the child's vocabulary size and ability to use different words in his/her speech (McCabe & Peterson, 1942; Garvey, 1977). The number of new words in the context of storytelling is an indicator of sophistication, as the child is able to incorporate different events (verbs) and characters (nouns).

Graph 3: The number of new words produced by the children in the four groups.

	53.67	97.75	108.92	130.00
	Group 1	**Group 2**	**Group 3**	**Group 4**
	Singles on Passive Mat	Singles on StoryMat	Dyads on Passive Mat	Dyads on StoryMat

The result shows that the children on StoryMat who played alone had the highest number of new words in their discourse. The children who played on the passive mat alone had the lowest number. However, the difference between the groups was not statistically significant, F (3, 32) = 2.90, p < .05.

The statistically insignificant results seemed to be caused by a large within-group variation and a somewhat small sample. If there were more than 6 subjects in each group, the results may have looked different.

In the next section, I will look at the story language used by the children in each group.

6.3.3 Number of formal opening phrases

Beginning with a formal opening phrase such as "Once upon a time" and ending with a formal closing such as "The end" are conventions which people use in association with telling stories (Sacks, 1972). In order to find out whether a conventional form of storytelling was fostered by StoryMat, the number of formal opening phrases in the children's discourse was collected and compared.

However, the opening phrases had to be collected carefully. Some children used such phrases more than once in a story as they changed their mind or made a mistake. For example, a child said, "One day, the bunny was. One day, the zebra was walking down the street." In this case, two opening phrases were used. However, it is clear in this case, only the second phrase, "One day" should be considered as the opening phrase, not both. Also, the children in the StoryMat groups were interrupted by the stories offered by StoryMat during their storytelling. In such a case, the children often resumed their story by using an opening phrase.

Therefore, it was necessary to count one opening phrase per story. In order to do so, the children's discourse was first segmented into stories.

Peterson & McCabe (1983) classified children's narratives by series of utterances following chronologically and thematically-linked events provided by children. Using the same classification as Peterson and McCabe, the children's discourse was broken down into narratives that followed a particular theme or chronological events. The following is an example of a child who produced three stories on the passive mat by himself.

[Note: the story boundary is indicated with = = = = =]

Michael (6)

= = = = =
"Hey, brother!" "Do you wanna go to play house tonight?"
"Sure, no problem!"
[moves the animals]
"It's fun to play basketball. But do you know Air- ee?"
"Yeah!"
[moves the bunny]
"Ahhrggg!" "Pshh!" [makes noise]
"Good job! You are the best, buddy! Because <p> you get play to each other and stuff at those..."
"Because we are really good friends, we can go have some more fun. Let's go.. wanna have fun."
"Oh, what a fun..." "Oh, I have to go home."
<p>
"Bye, Sleeper."
"Bye!"
"But you are my best friend, right?"
"Right. No problem, I'll be your friend. They told me to play basketball, and that's us!" "Bang!"
"Shoot in, my friend!"
= = = = =
<p for 40 seconds>
[grabs the bunny, leaves zebra outside of the mat]
[as he sings and moves]
"I'm walking for rail roooad. Rail-rooad. I'm walking for rail-rooooado. There's .. rail fun. I'm having a little fun. I'm having a little fun. Having littee"
<p for 10 sec>
[grabs zebra]
"Zee.."
[grabs rabbit]
"I'm having a little bit of fun, but I can't go to my friend." "I think he's here <p> some place."
[studies rabbit for 15 sec]
[sings]
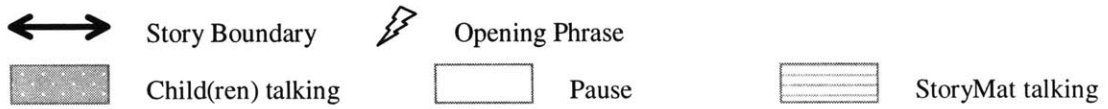"One, two, three. Let's go walking. One two three. Let's go walking"
<p for 30sec>

[reaches for rabbit]
"Hello? Where is my friend?"
= = = = =
<p for 6 sec>
"I'm gonna go eat some food, OK."
"Oh! There's a train! I have to run! Ah!! Ah!! Ah!! Ah.. jump!!"
[he places a rabbit at a place. And moves away from the mat for 20 sec]
[Sings as he grabs the rabbit]
"Let's rock it baby. Let's rock n'!"

In the first narrative, Michael told a story about two friends and the theme seems to be about playing sports. The second narrative is different from the first one because he shifted from using two characters to one character, and the theme seems to be about finding a friend. Likewise, the third narrative has a different theme from the second one. A character is no longer looking for a friend and goes through series of different events.

All the children's discourses were segmented into narratives. Then the number of opening phrases such as "Once upon a time," "One day," and "Once," was indexed and compared across the groups.

The following graphs show how many different stories the children have produced and how they have used opening phrases in telling their stories.

Graph 4: The distribution of story boundaries and opening phrases.

Story Boundary   Opening Phrase

Child(ren) talking   Pause   StoryMat talking

Singles on Passive Mat

Child 1
Child 2
Child 3
Child 4
Child 5
Child 6
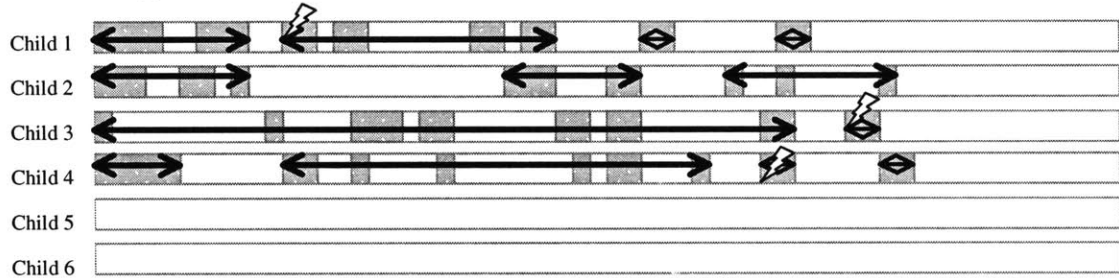
Time=   Time=10·00

Singles on StoryMat

Child1
Child 2
Child 3
Child 4
Child 5
Child 6
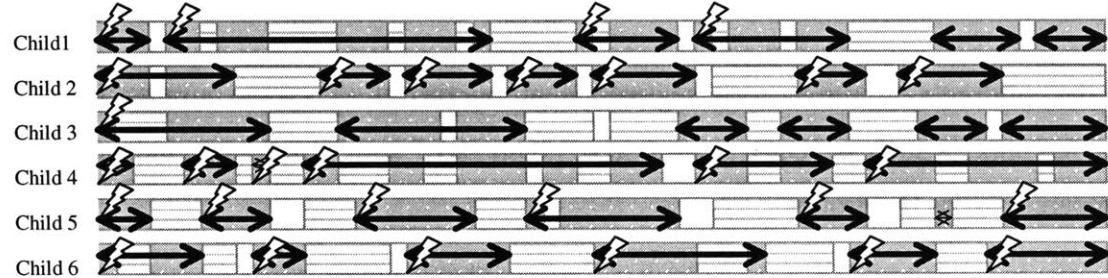
Time=   Time=10·00

Dyads on Passive Mat

Dyad 1
Dyad 2
Dyad 3
Dyad 4
Dyad 5
Dyad 6
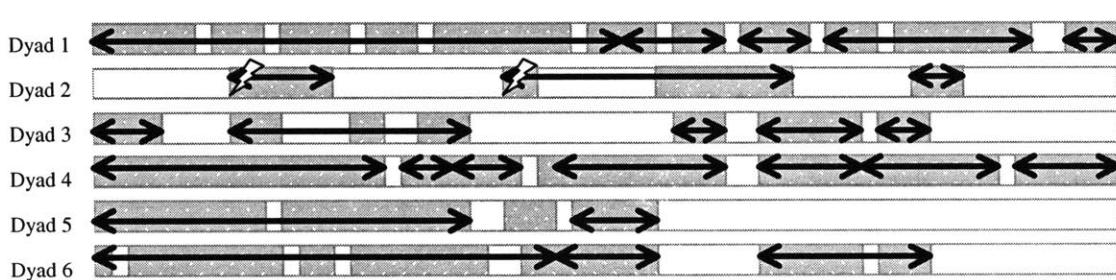
Time=   Time=10·00

Dyads on StoryMat

Dyad 1
Dyad 2
Dyad 3
Dyad 4
Dyad 5
Dyad 6

Time=   Time=10·00

76
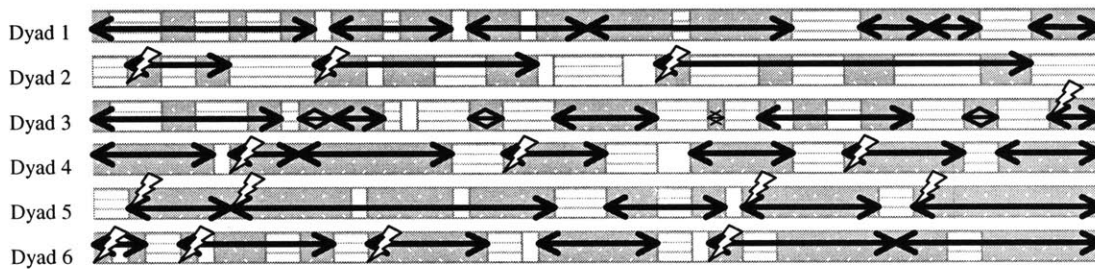
The diagram below shows the results.

Graph 5: The number of formal opening phrases produced by the children in four groups.

	0.50	5.00	0.33	2.50
	Group 1	**Group 2**	**Group 3**	**Group 4**
	Singles on Passive Mat	**Singles on StoryMat**	**Dyads on Passive Mat**	**Dyads on StoryMat**
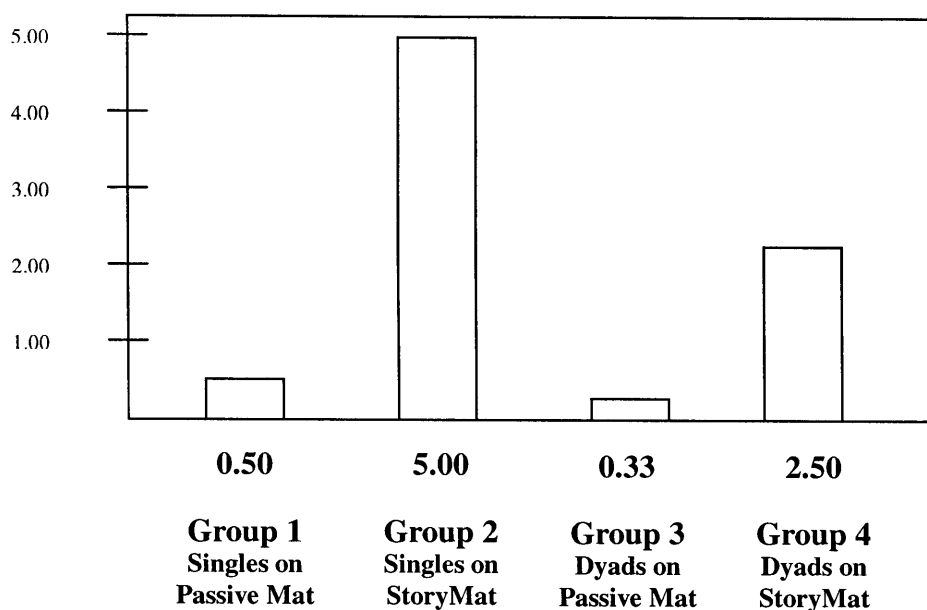
The children who played on StoryMat alone produced more opening phrases in their discourse than the children in Group 1, Group 3 and Group 4. With an alpha level of .05, the difference was statistically significant, $F (3, 20) = 3.49$, $p < .05$.

The result suggests that a child who plays alone on StoryMat is more likely to tell stories with a particular storytelling convention in his/her mind than a child who plays on the passive mat with or without a playmate, and a child who plays on StoryMat with a playmate. Although the difference was not statistically significant, the dyads on StoryMat also seemed to produce more formal opening phrases than the children who played on the passive mat.

By using an opening phrase such as "Once upon a time," a child set up a unique past time storyworld (Polanyi, 1989). The uses of opening phrases by the children in StoryMat

groups suggest that StoryMat fosters a particular kind of fantasy play that is storytelling, and perhaps, the passive mat fosters pretend play rather than storytelling.

The use of an opening phrase reflects a convention that people use in association with storytelling (Sacks, 1972). Therefore uses of opening phrases by the children in StoryMat groups also suggest that the children on StoryMat were able to engage in storytelling in the way acclaimed by society without being immersed in a traditional social environment. Perhaps, by listening to stories offered by StoryMat, the children on StoryMat were able to engage and practice storytelling with an audience in their mind, which is important in producing stories (Scarlett & Wolf, 1979).

6.3.4. Number of imaginative objects

Finally in this section, I will look at the creativity of the stories the children produced.

Sheldon and Rohleder (1996) used the number of imaginative objects children transform from realistic objects as a measurement for their imagination. For example, when a child used a drinking cup as a magic wand, the magic wand was counted as an imaginative object.

Using the same method, the number of imaginative objects that were transformed from the objects sewn on the mat was compared across the groups.

Simple identification of objects on the mat without any transformation, such as "the field," "the house," "blue tree," and "brown road," were not counted as imaginative objects. When a child used words such as, "my house," and "magic tree," they were counted as imaginative objects.

The following table shows a variety of imaginative objects that were transformed from the objects on the mat by the children in each group.
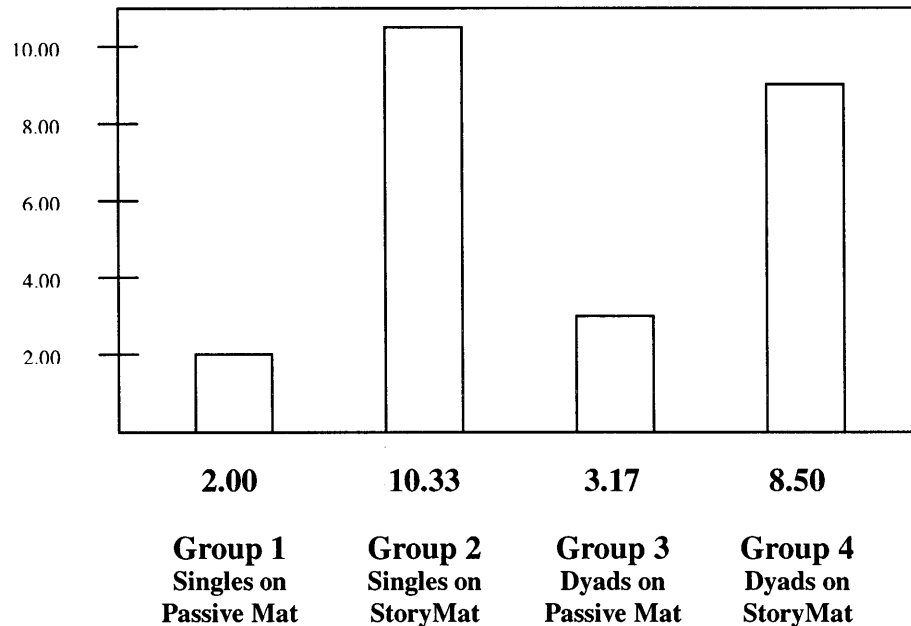
Table 1: [x #]: # indicates the number of times the word was used.

Objects on StoryMat	Group 1 One on Passive Mat	Group 2 One of StoryMat	Group 3 Dyad on Passive Mat	Group 4 Dyad on StoryMat
House	My house	My house/Home [x3]	My house/Home [x3]	My house [x2]
	X's house [x3] (zebra's house or my friend's house)	X's house [x6]	X's house	X's house [x5]
	Play house	Party	Garage	Garage
		Police station	school	Store
		School	Note	Hospital
		Arcade		Town
		Hospital		
		Castle		
		Room		
		Little fence		
		Club house		
		Cage		
		Goodies		
Green area	Grass	Park	Mud hole	Grass
		Farm		Play yard
				Hole
Blue area	Lake^3	Lake [x3]	Lake	Lake [x2]
	Pond	Pond [x2]	Pond [x2]	Pond [x3]
	Beach	Puddle		Blue fluffy field
		Metuce (thing in the water)		Sea
				Big pool
				Footprint
				Boat
Yellow area		Poo		Lava
				Rolling stone
Other area		City		
		Baseball field		
		Trial (for a sport)		
		woods		
Area with numbers	Hop-scotch field	Parking lot [x2]	Music ding	Measuring thing
			Parking lot	Music palette
				Piano
Tree		Carrot [x2]		Berries
		Fruit		
		His tree		
		Snack		
Path	Rabbit trail	Door		Big wall
Stuffed animal	Train	Train [x3]	Train [x4]	Train [x4]
		Mouse	Goose	Supper dog
		Prince	Snake	Bad guy
		King	Paper	Little boy
		Cat		Kitty
		Soldier		Cloud
		Rabbit mother		Best friend
		Car [x2]		Space ship
		Furry coat		Medicine
		Dog		Needle
		Troll		Doughnut
		Rabbit father		Tea
		Frog		Frog
		Rat		Dog
				Bunny-zilla

[3] Some may point out that calling a blue field, "a lake" is not transformation. However, the blue field can be identified by a child simply as "a blue field" instead of "a lake." They are also collected equally across the groups. Therefore, it does not become a confound.

The diagram below shows the mean number of imaginative objects used by children of different groups.

Graph 6: The number of imaginative objects used by children in the four groups.

2.00	10.33	3.17	8.50
Group 1	**Group 2**	**Group 3**	**Group 4**
Singles on Passive Mat	**Singles on StoryMat**	**Dyads on Passive Mat**	**Dyads on StoryMat**

The children who played on StoryMat alone had the highest number of imaginative objects. The children who played on StoryMat with a playmate also produced a higher number of imaginative objects than the children who played on the passive mat with or without a playmate. With an alpha level of .05, the differences between Group 2 and Group 1, Group 2 and Group 3, Group 4 and Group 1, and Group 4 and Group 3 were statistically significant, F (3, 20) = 3.49, $p < .05$.

Both the singles and the dyads on StoryMat produced significantly high number of imaginative objects than the singles and the dyads on the passive mat. The results suggest that the children on StoryMat were able to transform objects into imaginative objects more than the children on the passive mat. As they grow older, children become

more competent at transforming realistic objects into imaginative objects in their play (Jeffree & McConkey, 1976; Corrigan, 1982). It is this ability to decontextualize, which leads to the development of a child's cognitive skills (Fenson, 1984). By offering peer stories, StoryMat seems to provide a place for children where they are able to exercise their imaginative skills by telling their own creative and imaginative stories.

The next section will look at the identity roles the children took in their discourse. Then, it will look at the ways children incorporated and became influenced by the stories offered to them by StoryMat.

6.4 Process: Storytelling of Children

This section provides the quantitative analysis of the children's storytelling, the process of their activity on StoryMat and the passive mat. I will first show how the complexity of storytelling was fostered by StoryMat, by providing the results of different speaker roles used by the children in different groups. Second, I will show how a co-temporal and co-spatial peer and the stories offered by StoryMat influenced the children's storytelling, by providing the results of incorporations made by the children.

6.4.1 Speaker Identity

Auwarter (1986) used three types of "Speaker Identities" in evaluating fictional reality in children's play: 1) Everyday personal identity [a child is speaking as himself/herself], 2) Neutral observer identity [a child is speaking as a narrator], and 3) Character role identity [a child is speaking as a character who is different from him/herself].

Using the same method, the percentage of utterances using each identity role were compared across the groups. Based on the story boundary data from the previous section, the average percentages of different roles taken by a child in telling a story were compared across the groups. The following graph shows the result.

Graph 7: The percentage of the use of three different roles.

☐ Everyday personality role   ▦ Character personality role   ▨ Narrator personality role
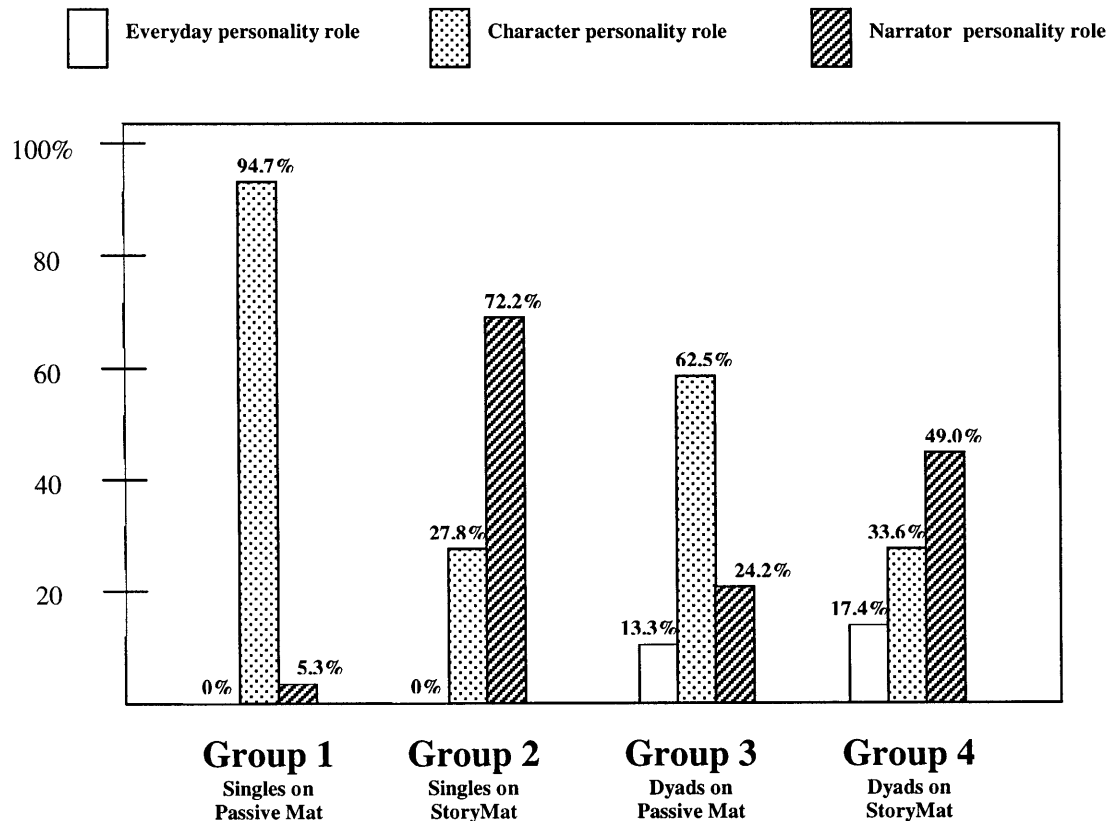
Narrator personality role: The singles on StoryMat used the narrator role more often than both the singles and the dyads on the passive mat. With an alpha level of .05, the differences were statistically significant, F (3, 20) = 3.49, $p < .05$. There was no difference between the singles and dyads on StoryMat.

Character personality role: The singles on the passive mat used the character role more often than both the singles and the dyads on StoryMat. With an alpha level of .05, the differences were statistically significant, F (3, 20) = 3.49, $p < .05$. There was no difference between the singles and the dyads on the passive mat.

Everyday personality role: The dyads on StoryMat used the everyday personality role more often than both the singles on the passive mat and the singles on StoryMat. With an alpha level of .05, the differences were statistically significant, F (3, 20) = 3.49, $p < .05$.

There was no difference between the dyads on the passive mat and the dyads on StoryMat.

The results show that the singles on the passive mat mainly took the character role. The very rare use of the narrator role reflects that the children did not introduce quotes of a character (i.e. "Then he said, 'Oh, no!'"), but rather only acted out as a character (i.e. "Oh, no!"). Therefore, they could be said to have engaged in pretend play, rather than storytelling.

The singles on StoryMat took the narrator's role most of the time, but also took the character role fairly often. The results indicate that the singles on StoryMat were narrating but in conjunction with the use of a character role. The fact that they used the narrator role more than the character role reflects that they were able to introduce quotes of a character. By introducing quotes of a character, the story becomes understandable by others and becomes more self-sufficient (Scarlett & Wolf, 1979). The singles on StoryMat both acted out as a character and told stories about the character. But they seemed to successfully mix the two roles to tell stories, rather than engaging in pretend play.

The dyads on the passive mat took three different roles, everyday, character, and narrator. As an everyday personality role, they had a conversation with their peer (e.g. "Let's do a school story!"), but the role was seldom taken. The dyads on the passive mat mainly used the character role and sometimes the narrator role. The fact that they used the character role more than the narrator role indicates that the dyads the dyads on the passive mat engaged mainly in pretend play rather than storytelling. This contrasts with both the singles and the dyads on StoryMat.

The dyads on StoryMat also took three different roles. They had a conversation with their peer as an everyday personality, used a character role, and used a narrator role. An interesting contrast between the dyads on the passive mat and the dyads on StoryMat is the use of the narrator role. The fact that they used the narrator role more than other roles

indicates that they were narrating and were able to mix other roles. The big difference between the two dyad groups is that StoryMat dyads narrated most of the time while those on the passive mat spoke as characters most of the time.

The results suggest that StoryMat provides a place where children are encouraged to narrate rather than to engage in pretend play. As explained by Scarlett and Wolf (1979), storytelling allows others to understand the intention of the author. The audience has to be able to construe what is happening within the story. In conjunction with the results presented in the previous section, the results of this section seem to suggest that StoryMat creates an environment where a child is encouraged to tell stories, not just pretend on his/her own.

The results also suggest that the children on StoryMat were able to narrate but also take different roles. With development, children become competent at using different roles (Auwarter, 1989). Taking different roles and being able to use such roles successfully is the key for making the stories autonomous.

These results suggest that by offering peer stories, StoryMat fosters storytelling and provides a space where a child is able to imagine an audience. Therefore, StoryMat provides a place for a child's practice and performance of storytelling.

6.4.2 Collaborative Storytelling

In fantasy play, children include others' make-believe games into their own by transforming objects, acts, or themes that follow a sequence or order (Singer, 1990).

Both the dyads and single children on StoryMat seemed to incorporate elements from stories offered by StoryMat. Two kinds of incorporation were made by the children: incorporation of the imaginative objects, and incorporation of the language style from the

StoryMat stories. Additionally, listening to StoryMat stories seemed to change the direction/genre of a story a child was telling, which is defined below.

- **Imaginative objects**: Incorporating an imaginative object suggested by others into one's own story. The following is an example:

Xenia (8) and Andrew (8)

X: "Yes, Let's go <p> to your house now, zebra!" "That's a great idea!" [X holds zebra on the other hand]
X: "So, <p> why don't we go to my house now."

< "Let's see what this yellow house is. It doesn't look like a garage." "Click Click Click [making the sound]" "No answer." "Let's try this one." "Click Click Click [making the sound]" "There might be a note inside like our houses." "Let's go look. No nothing." "Wait, here's something! It says, 'This is a mysterious music pad. Go on it and have some fun.'">

X: "Oh, boy! A mysterious music palette! That's so much fun! Come on! Look, it's a piano! All I have to do is say something, and it turns on!" <p>
X: "Come on! Let's go back to the ..."

In the example, Xenia hears a story about "A mysterious music pad." Then she plays on the place where the story was told, and tells her story, "Oh, boy! A mysterious music palette!...")

- **Language style**: Incorporating a particular style of saying a word or a phrase.

Miriam (7)

A little bunny rabbit was playing by the pond. Suddenly he heard a noise <pause> The noise was very strange. So he went, and all the way home. <pause> And then he went to, to this place. And knocked on the door. And asked if he could come in. But no one answered. And then, he kept on walking.

<Once upon a time, there was a zebra with a rabbit swimming in a warm bath . And he met a beautiful king <pause> zebra, he said, she was, that he was gonna fall in love with.>

A little bunny hopped along the path. And. and then, came to a beautiful castle. He went inside and knocked on the door . And looked inside. There was a --- at the door. "Excuse me. May I come inside? Please?"

Miriam hears a story of a king zebra with a child pronouncing the word, beautiful, "beauuuuu- ti ful!" In telling her story later, she copies the exact intonation and word.

- **Story direction/genre**: Hearing a story on the mat changes the direction or the genre of the story children tell.

Josh (8)

Then he climbed on the tracks then he climbed and climbed because he sniffed some poo and he kept on going and the train was coming. He turned around. He turned around. And went faster and faster. And faster and faster and faster and faster 'n faster <pause> then jumped off. Then got crossed before. Then splashed into a puddle. Take a bath. Then he liked it so much, he went back.

<Once upon a time, there was a zebra with a rabbit swimming in a warm bath . And he met a beautiful king <pause> zebra, he said, she was, that he was gonna fall in love with.>

Once upon a time, there was a rabbit and a zebra.

<One day, the rabbit was walking down the street, he went here there, <pause> here there, and he did not know where to go. So he walked and walked. And suddenly, he saw this big building. he did not know what it was, so he started looking around it.>
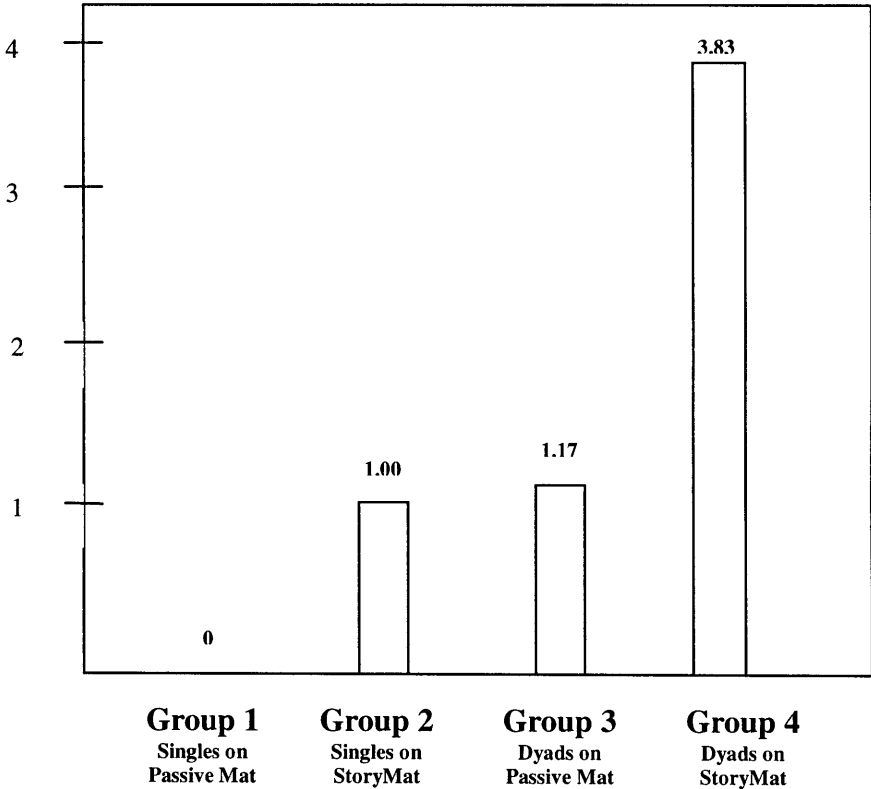
One day, a rabbit, and he was walking around. And then some- yelled at him. So the rabbit turned and he saw Zebra. And he fell in love with the zebra and then they we- around a little bit. And then they went to ..'s house. And they are still together all the time. <pause> And then, they, but the rabbit, he had to go home. So he ran home went ran home so fast so fast! Because sometimes, he is supposed to remember to eat. "Bye!" Bye!" See you tomorrow! Then went home. Everybody got home. Zebra went home and he took a bath.

Josh was telling a story about a character traveling to different places. After hearing a story, which had a completely different content (i.e. a character falling in love with another character), he started a new story. Unfortunately, his utterance was interrupted by an erroneous turn by StoryMat. However, after the story, Josh continued to tell his new story, which had a character falling in love with another character. His new story had an event similar to an event in the story he heard on the mat. Yet, his story was not a mere copy of the story he just heard. He incorporated a story event from the story to tell his own original story.
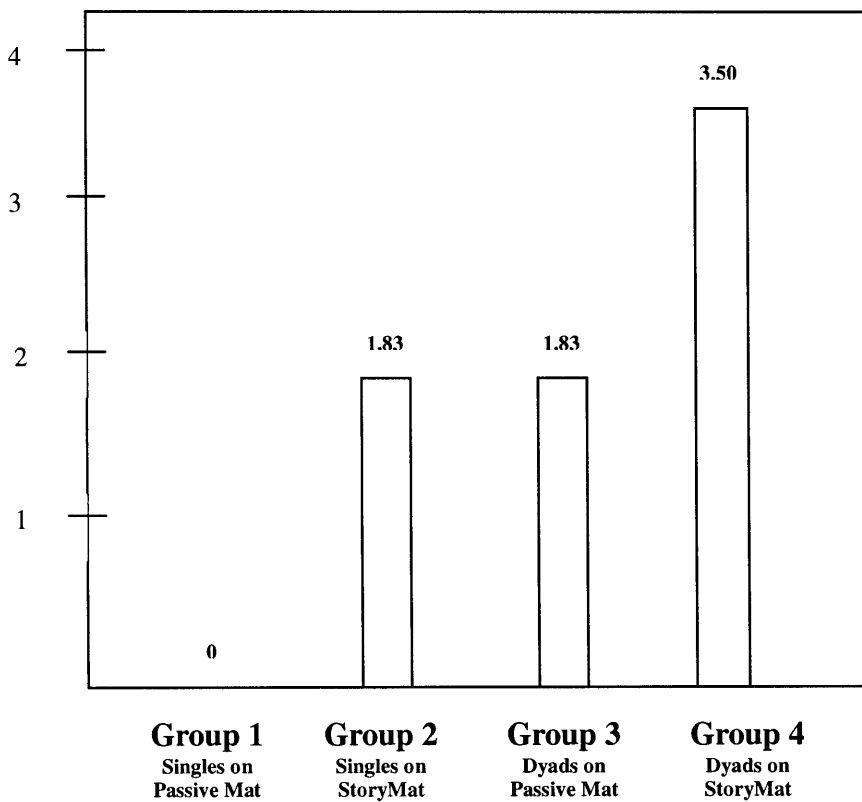
Quantitative Analysis: In corporation of language styles and imaginative objects.

The number of incorporated imaginative objects and incorporated language style elements was compared across the groups. The following graphs show the number of incorporated imaginative objects and the number of incorporated language style respectively.

Graph 8: Incorporation of imaginative objects.

Graph 9: Incorporations of language styles.

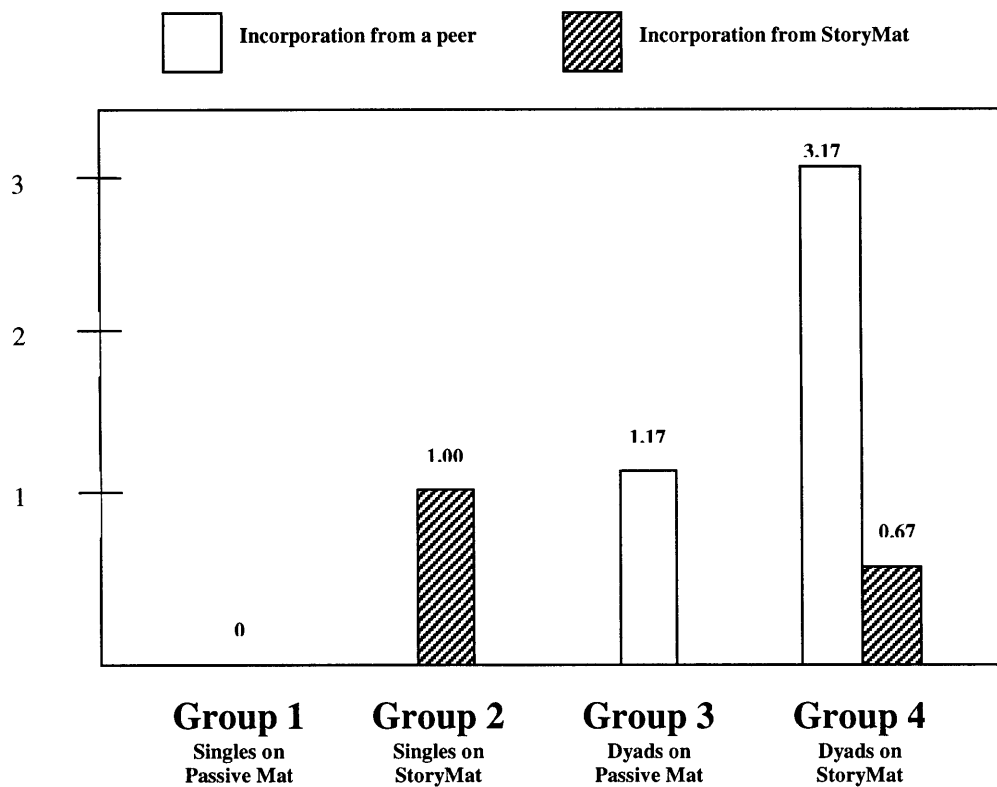|			
	1.83	1.83	3.50
0			
Group 1	**Group 2**	**Group 3**	**Group 4**
Singles on Passive Mat	Singles on StoryMat	Dyads on Passive Mat	Dyads on StoryMat

The dyads on StoryMat had the highest number of both incorporated language styles and imaginative objects. With an alpha level of .05, the difference was statistically significant, F (3, 20) = 3.49, $p < .05$. There were no significant differences between the singles on passive mat and StoryMat and the dyads on the passive mat.

The reason that the dyads produced the high number of incorporations becomes evident with further analyses of the results.
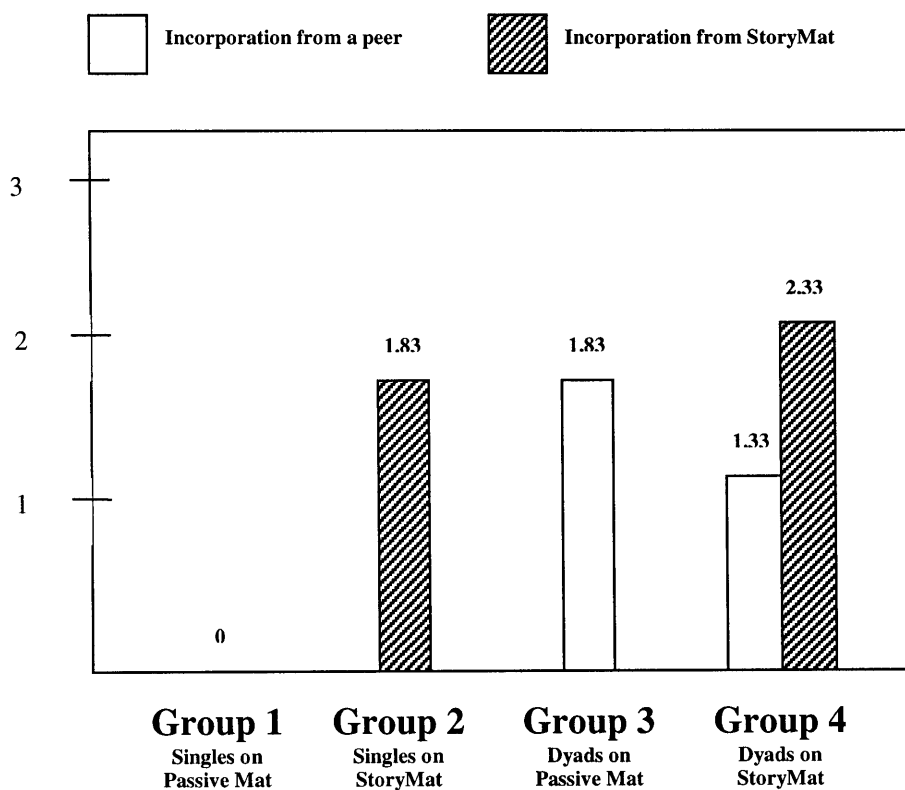
The dyads on StoryMat seemed to have two collaborators, a peer and StoryMat stories. The dyads on StoryMat incorporated elements both from their peer and StoryMat stories. The incorporations made by the dyads on StoryMat were broken down into those from their peer and those from StoryMat stories.

The following graphs show how the children in each group incorporated elements from stories they heard on the mat or their peer. Particularly interesting is how the dyads on StoryMat incorporated elements from both the peer and StoryMat stories.

Graph 10: Incorporation of Imaginative objects from a peer or StoryMat.

☐ Incorporation from a peer   ▨ Incorporation from StoryMat

		3.17	
3			
2		1.17	
	1.00		0.67
1			
0			

Group 1	**Group 2**	**Group 3**	**Group 4**
Singles on Passive Mat	Singles on StoryMat	Dyads on Passive Mat	Dyads on StoryMat

Graph 11: Incorporation of language styles from a peer or StoryMat.

☐ Incorporation from a peer   ▨ Incorporation from StoryMat

```
3 ─┼
                                                          2.33
2 ─┼              1.83          1.83                       ▨
                                                   1.33    ▨
1 ─┼                                                ☐      ▨
         0
```

Group 1	Group 2	Group 3	Group 4
Singles on	Singles on	Dyads on	Dyads on
Passive Mat	StoryMat	Passive Mat	StoryMat

The dyads on StoryMat incorporated more imaginative objects from their peer than StoryMat. With an alpha level of .05, the difference was statistically significant, F (3, 20) = 3.49, p < .05. Also the dyads on StoryMat incorporated more language style elements from StoryMat than from their peer. While this result was interesting, the difference was not statistically significant.

A co-present peer has a much stronger presence for a child than the stories offered by StoryMat. So it makes sense that a child would respond to and continue stories told by her co-present peer more than the stories that pop out on the mat.

However, interestingly, the dyads on StoryMat seemed to incorporate more language styles from StoryMat than from their peer. One example is how they incorporated opening phrases from StoryMat stories, "Once upon a time..." This provides supporting evidence for my earlier findings about the dyads on StoryMat using many opening phrases, but not the dyads on the passive mat.

The singles on StoryMat also incorporated elements from StoryMat stories as much as a child did from a peer on the passive mat. The result was not statistically significant. However, it shows that StoryMat provides a space where a child is able to listen to peer stories and become influenced by them as they incorporate elements into their own stories, even when he/she is playing alone.

As Singer (1990) explains, in telling stories collaboratively, children incorporate other's story elements into their own stories, within their dynamic story frame. Both the dyads and the single children on StoryMat incorporated elements from stories provided by StoryMat, in much the same way they do with their real life peer.

6.4.2 More on collaborative storytelling on StoryMat

The dyads on StoryMat took turns with both a playmate and the mat. Each child held the stuffed animal to tell his/her story. When he/she was done, the animal was passed on to the other child.

Sometimes the children took a collaborative approach in manipulating the stuffed animal: As one child was holding and moving the animal on the mat, the other child narrated instead of the child who was holding the animal. The following pictures illustrate the point:

As Andrew [left] holds down the bunny, Xenia [right] tells a story.

6.5 Discussion

The children's discourse was studied both as the product and the process of their storytelling. The analyses of the children's stories and their process of producing such stories provided evidence that StoryMat fosters children's storytelling and provides a place to practice imaginative skills.

First, it was shown that the singles on StoryMat engaged in verbalization significantly higher than the children in any other groups. The children who played alone on StoryMat engaged in more verbalization than the children who played with a co-temporal and co-spatial playmate. By providing a place where a child is encouraged to tell his/her own stories, StoryMat seems to foster a child's verbal production, which correlates positively with engagement and enjoyment in their play (Singer, 1990).

Secondly, it was shown that the singles on StoryMat used significantly more opening phrases than any other group. As use of opening phrases set up a particular past event in a storyworld (Polanyi, 1989), the children on StoryMat could be said to have engaged in storytelling. This suggests that StoryMat fosters a particular kind of fantasy play that is storytelling.

The dyads on StoryMat also produced more number of words and opening phrases than the children on the passive mat, and while they were not statistically significant, they approached significance. These results also suggest that the presence of a peer fosters pretend play, rather than storytelling.

Both the singles and the dyads on StoryMat produced significantly more imaginative objects in their stories than the singles and the dyads on the passive mat. Children's ability to transform objects into imaginative objects increase with age and such an activity of decontextualization is important for children's cognitive development,

(Fenson, 1984). By offering peer stories and encouraging the children to tell their own stories, StoryMat seems to foster and provide a place for their imaginative exercise.

The analyses of the children's storytelling process revealed that StoryMat encouraged more sophisticated storytelling. It was shown that the singles on StoryMat told stories by taking a narrator's role but also used a character role to act out some of their imaginary characters. Such a character role used by the singles on StoryMat was mostly accompanied by an introduction (e.g. "Then he said, 'Hello!'"). This contrasted with the singles on the passive mat who predominately took a character role. By using the character role in conjunction with a narrator role, the singles on StoryMat created the world of stories that is more self-sufficient (Scarlett & Wolf, 1979). The singles on StoryMat were also able to switch between different roles to introduce more complex narrative utterances (Auwarter, 1986).

The similar pattern was also observed between the dyads on StoryMat and the dyads on the passive mat. The dyads on StoryMat mainly used a narrator's role but in conjunction with a character role. Whereas the dyads on the passive mat predominately used a character role. However, there was no statistically significant difference between the use of narrative role by the dyads on StoryMat and the dyads on the passive mat. These results suggest that StoryMat fosters storytelling, while the presence of a peer and the passive mat foster pretend play.

Finally, it was shown that the dyads on StoryMat had more incorporations than any other group. Further analysis of the results showed that the dyads on StoryMat incorporated elements both from their co-temporal, co-spatial peer and StoryMat. This result is interesting as it provides an evidence for a child being able to collaborate with StoryMat stories at the same time as with a physical playmate.

The dyads on StoryMat incorporated significantly more imaginative objects from their peer than from StoryMat. However, interestingly, the dyads incorporated more language style from StoryMat than their peer. This result was not statistically significant, yet it

suggested the dyads on StoryMat listened to and thought about stories offered by StoryMat. The result provided evidence for why the dyads on StoryMat were using more opening phrases and their product was more storytelling than pretend actions. Though not statistically significant, the singles on StoryMat also incorporated elements from StoryMat stories as much as a child did from a peer on the passive mat.

Both the dyads and the singles on StoryMat incorporated elements from stories provided by StoryMat. By incorporating others' story elements into their own stories within their dynamic story frame (Singer, 1990), the children on StoryMat told stories in much the way they may with their real life peer.

This chapter has shown that StoryMat fosters storytelling in the context of fantasy play, particularly when a child is playing alone on the mat. By offering peer stories, StoryMat also provides a place for collaborative storytelling even when there is no physical co-storyteller.

Chapter 7 – Evaluation of the System

The empirical study looked at how children listened to the stories they heard on StoryMat and how that changed the way they told their following stories. This chapter will look at how the system actually worked in the environment with children and provides the general observation of the experience the children had on StoryMat.

7.1   StoryMat with children

- The left/right mouse buttons gave a solution for having multiple characters at hand. Unfortunately, the stuffed animals could not be used on the mat simultaneously. When the two animals were on the mat at the same time, the wireless tracking became weak. Therefore, only one animal was used for the empirical study.

- The children's storytelling on StoryMat was interrupted a number of times by the stories offered by the system. It was caused by the inconsistency of the button press. Even though the children remembered to hold down the button on the animal, the button was not sensitive enough to detect the children's grip consistently.

- The children wanted to listen to their own stories stored on StoryMat, but they were not able to. The first reason is length of their interaction with StoryMat. StoryMat did record the children's stories at various locations on the mat. However, the 15 minute session did not give the children enough time to search for their own stories. The second reason is a design flaw. The active area of StoryMat had 126 dimensions. Stories were recorded at any of the 126 places. However, there should have been less dimensions. What many children thought of as one place actually consisted of multiple places. For example, even when a child thought that he was telling a story at the same place as he did before, if it was not exactly at the same place as before,

StoryMat interpreted it as a different place. As many children asked why they were not able to listen to their own stories, further refinement of hardware and software design that allow children to listen to their own stories smoothly is needed.

- The children interrupted stories offered by StoryMat. The interruption during a story play-back was interpreted by StoryMat as a modification of the story. Therefore, StoryMat made modifications and collected modified stories. However, the children did not necessarily mean to modify an existing story when they made an interruption. They seemed to interrupt a StoryMat story because they were not interested in hearing the story, and instead wanted to tell their own story. During the practice session, the children were not introduced to the idea of making a modification to a StoryMat story. This may be the reason why they did not modify StoryMat stories intentionally.

- The children watched the animation of the stuffed animal projected onto the mat in various ways. Many children placed their hands over the projected image either to try to grab it or to follow the movement. The stuffed animal was the interface to tell stories on StoryMat. However, incorporating the use of children's actual hands on the mat may be useful in the future system.

- Children remembered to hold the button on the animal as they narrated. There was no specific instruction as to how the animal should stay flat on the mat. Therefore, the children moved the animal in various ways. As long as the children held the button while they were moving the stuffed animal, StoryMat was able to record their stories. The following pictures show how some children manipulated the stuffed animal.
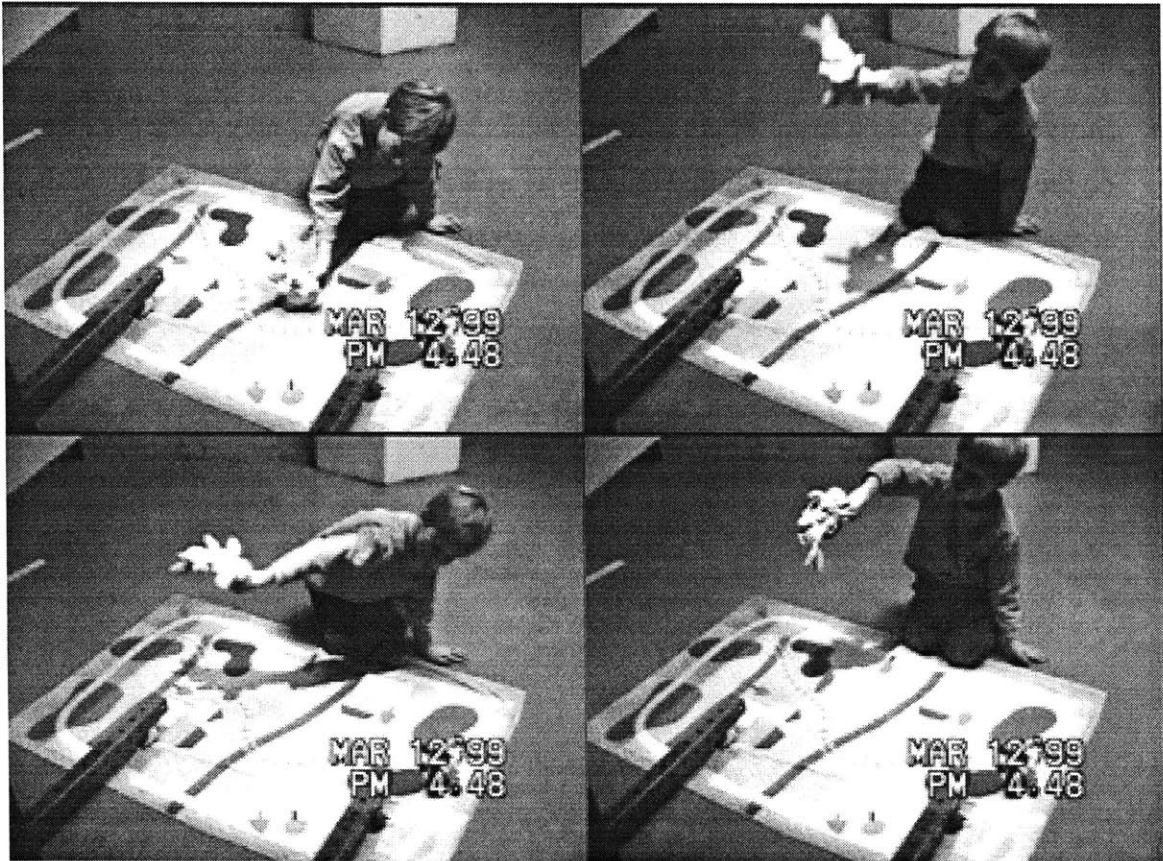
Even when the stuffed animal was upside down (i.e. the signal between the transmitter and the receiver was lost), StoryMat recorded the child's story.

7.2   Children's experience on StoryMat

- StoryMat provided a space where children were able to narrate freely using their body on the mat. By moving the stuffed animals as well as their own body on the mat, they seemed to engage in the task of storytelling actively.

- Children's experience on StoryMat in general seemed to be positive. This was contrastive with that of children who played on the passive mat. Children on the passive mat in general got bored with their task quickly.
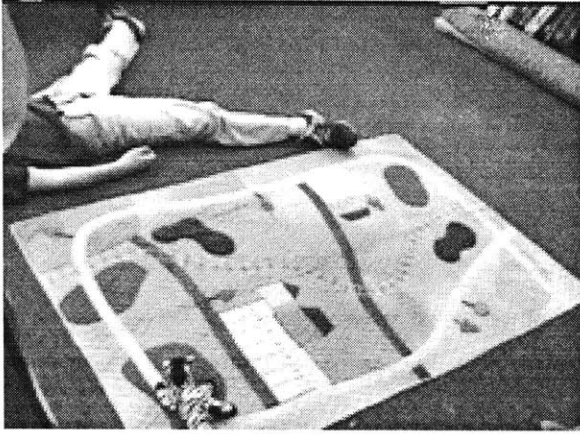
A child alone on the passive mat got bored quickly.

Chapter 8 – Conclusions

The thesis provided a background of children's fantasy play and storytelling from the developmental perspective. Preschool children's fantasy play is important in their emotional, social, cognitive, and linguistic development. It was argued that by encouraging children's fantasy play and supporting their storytelling, technology could play an important role in their development. Such children's play activities in the context of peer collaboration is also important as peers serve a unique role in fostering creative solutions to their problems, which is rarely provided by adults. The thesis argues for and provides an instantiation of a system, StoryMat that encourages children's fantasy play and supports collaborative storytelling.

The empirical research has shown that by listening to and reacting to the stories offered by StoryMat, the children on StoryMat were more likely to tell creative/interesting stories than the children who played on a passive mat. The children on StoryMat were more likely to engage in storytelling than the children on the passive mat whose actions were predominantly pretence. Children on StoryMat were more likely to tell stories in a socially acclaimed style. Such an evidence suggests that StoryMat provides a space where children are able to imagine an audience in their storytelling, which is important in fostering their storytelling. By offering peer stories, StoryMat seems to provide a place where children are able to practice and foster their storytelling skills.

The thesis has also provided evidences for collaborative storytelling between the children and peer stories offered by StoryMat. The children on StoryMat listened to peer stories offered by the mat in much like the way they do with the real peers. Listening to peer stories offered by StoryMat changed the way they told their further stories. The children incorporated elements such as imaginative objects, language style, and the genre from the stories they heard on the mat. By offering peer stories, StoryMat seems to offer a place for a child to have collaborative storytelling regardless of the absence of a co-temporal and co-spatial playmate.

It was also shown that StoryMat provided a play space where children were able to tell stories as they move their body freely. Such a space created a relaxing environment for children to compose their stories while they play naturally with their stuffed animals.

The evaluation of StoryMat system showed that the further refinement of the hardware and software design is needed in order to provide a space where children are able to reflect on their own stories within their storytelling play.

I believe that the framework I provided for the design and research of collaborative storytelling play technology contribute to the Media Lab community and to the field of Children and Technology as it provides an evidence that technology could play a role in encouraging children's fantasy play to foster their collaborative storytelling.

Chapter 9 - Future Direction

9.1   Future Research

Collaboration among children is based on their social interaction. While interactions with others play an important role in their identity construction, children spend significant amounts of time with same-sex companions (Whiting & Edwards, 1988). Their social interaction depends on shared knowledge and interests in order to be successful and satisfying (Leaper, 1994). Often, young children *choose* same-sex partners to play with since those who share their interests and knowledge are easier and more fun to be with.

And this peer collaboration is an important activity through which children construct their gender identity. By the age of five, gender is well established in children's play (Paley, 1984). Girls and boys tell different stories (e.g. domestic and non-domestic tuned stories), weaving shared symbolic imagination with same-sex friends (Sheldon & Rohleder, 1996). Kindergarten teachers' attempts to create gender neutral zones in nursery schools by avoiding the traditional "doll corner and block area," are defeated when children persist in maintaining domains of conventionalized interactional and discourse practice (Cook-Gumperz & Corsaro, 1977). Presence of same-sex friends creates the pressure for children to establish their in-group status, and the presence of opposite-sex friends threats them to uphold even stronger group identity (Cook-Gumperz & Scales, 1996).

One of the goals of StoryMat may be to suggest a move towards more subtle gender identity construction among children, by giving them a place where they listen to the content of other children's voices rather than the surface value of the voices. Stories on StoryMat are neutral in that they do not reveal the gender identity of the storyteller. The

stories are recalled on the mat for children to hear, the moving shadow and narrating voice played back by the system does not particularly reveal the gender identity of the teller. StoryMat provides a space where both girls and boys can listen to stories that are woven together by both girls and boys, without the mask of gender being in the way. The activity of storytelling itself participates in the construction of a child's gender, without a preconceived notion of who she or he is (Cassell, 1998). By supporting collaboration between stories from the past and the present, StoryMat may draw more interaction and collaboration of children across gender.

In order to investigate this, I propose an experiment to study the way children listen to and tell stories differently according to the gender of collaborators and the genre of stories they hear on StoryMat. In order to compare the differences in storytelling resulting from the genre and the gender of the collaborator, StoryMat may be pre-programmed to play 1) only "domestic" stories told by girls, 2) only "domestic" stories told by boys, 3) only "non-domestic" stories told by boys, and 4) only "non-domestic" stories told by girls. On each configured StoryMat, a group of children may play alone and a group of children may play along with a same-sex playmate. This may allow comparison between absence and co-presence of same-sex collaborator in their storytelling.

9.2 Future System

- EM sensor: In conjunction with Rich Fletcher (Physics and Media) I plan to work on a new version of StoryMat using electromagnetic sensing technology. The mat will be wired to form a grid, which senses a stuffed animal with a magnetic tag inside, traveling above the grid. This will provide more accurate tracking of the movements of the stuffed animal on the mat.

- Distributed StoryMat: This thesis focused on asynchronous collaboration between children. As a future direction for StoryMat, it could be interesting to have distributed StoryMat that allow synchronous collaboration between children at two different locations. For example, two identical play mats at two different locations could be networked to allow a child at one place to collaboratively tell stories with a child at another place.

- Speech processing: The current implementation of StoryMat does not process any speech information of the children's discourse. By using a speech recognition software, the processing of children's discourse on StoryMat may be possible. For example, a child may tell a story about making friends. By processing the child's speech, StoryMat may be able to offer her other children's stories about making friends. The processing of children's discourse on the mat may be useful in providing a more *responsive* play space.

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