Making Space for Voice: Technologies to Support Children's Fantasy and Storytelling

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Abstract: Fantasy play and storytelling serve an important role in young children's development. While computers are increasingly present in the world of young children, there is a lack of computational tools to support children's voices in everyday storytelling, particularly in the context of fantasy play. We believe that there is a need for computational systems that engage in story-listening rather than story-telling. This paper introduces StoryMat, a system that supports and listens to children's voices in their own storytelling play. StoryMat offers a child-driven story-listening space by recording and recalling children's narrating voices, and the movements they make with their stuffed animals on a colorful story-evoking quilt. Empirical research with children showed that StoryMat fostered developmentally advanced forms of storytelling of the kind that has been shown to provide a bridnge to written literacy, and provided a space where children engaged in fantasy storytelling collaboratively with or without a playmate. The paper addresses the importance of supporting young children's fantasy play and suggests a new way for technology to play an integral part in that activity.

Keywords: Storytelling, young children, interactive narrative, interface, tangible interface

Epigraph

"The thing about playing is always the precariousness of the interplay of personal psychic reality and control of actual objects" [52]

1 Introduction

"I'm Cinderella." "You be Snow White."
"Pretend our mother is poor and we got lost and then we see a brick house that's empty."
"But really a godmother lives there – "
"And she's taking a walk and then she sees the two little girls and she's not angry."

"Pretend you're Wolfman and you come down the chimney and boil the wolf. And the next day the wolf jumps down the chimney and I'm Superman and I explode him. First I jump over him."
"No, the wolf throws a brick at Superman and it bounces right off and he flies up..." [40: p. 47]

Children incorporate elements from all of the media they come in contact with: books, television, CD-Roms, and increasingly the Internet. But the use that children make of these elements is often not that intended by the original authors. Cinderella meets Snow

White. The big bad wolf becomes "Wolfman." Little Red Riding Hood and Superman merge. This is how children's imaginations function, and it is a good thing too.

Many of today's computer-mediated toys and tools for children use the newest technologies to produce more sounds, graphics, or actions that make toys look better, but that come no closer to supporting children's creativity. Children enjoy being entertained by such toys. However, these toys are not necessarily empowering them to express and create or co-create – to use their imaginations. Indeed, they may leave children as passive consumers of adult conceptions of childhood, and result in play that is driven by the toy rather than the other way around. Such passive consumption of entertainment may have a much greater effect on children than on adults, as children may not learn to seek out their own solutions, ideas and styles in their play. Children may learn to play only in the way they are told. In fact, the general trend among today's parents is to discourage children's unconstrained play – a practice that is decried by developmental psychologists and educators who recognize the need for child-driven play. There is a need, then, for technologies that encourage children's creativity in open-ended ways.

The spontaneous stories that children tell are remarkably creative, dynamic, and collaboratively open-ended. Storytelling that happens naturally in children's play is a particularly important way for children to exercise their imaginations, acquire and practice language styles, and explore evolving social roles [34]. Sophisticated storytelling software exists on the market, but for the most part it does not support children's own storytelling. The kinds of software available may tell stories to children, encourage them to learn how to read by providing excerpts from children's literature, or may allow them to illustrate stories or fill in the blank in partially written stories. There is, then, a function for computational tools for children's storytelling play that can support and encourage their own talk and encourage them to explore language and imagination.

One essential aspect of children's spontaneous storytelling play is that it is child-driven. And this is important since children feel a sense of achievement and empowerment when they know that they can create and control the content of their play objects [41]. So, if technology is to encourage children's creativity and, in particular, play a role in children's storytelling play, it must not dampen that child-driven aspect of their play.

As computer-mediated toys are increasingly present in the world of young children, supporting their natural open-ended play becomes an important issue. In this paper, we examine the design and use of toys that support children's storytelling and fantasy play by listening to them rather than talking at them. We claim that such toys can play a particularly powerful role in enabling children to express and create, and to decide on the direction of their own play. We demonstrate our approach using a system that we have created called StoryMat to show how story listening systems may be designed, and the kinds of benefits they may provide for children.

2 Background

In this article, we talk first about the kinds of children's storytelling activities that we intend to support and enhance. We concentrate in particular on the skills necessary for them to develop a narrative perspective of the kind that allows understanding of the point of view of one's listener, practice mature language use of the kind that acts as a bridge to

literacy, and collaborate with other children in the process of creating rich and distinct narrative worlds. We draw our inspiration from the scholarship in developmental psychology and pedagogy, and from our own observations of children's spontaneous play. We then turn to a review of related work in the field of children and technology. Finally, we discuss the general nature of our own research program on technologies to listen to children, describing some of our earlier projects in this domain. This leads up to a discussion of the system *StoryMat* which serves as an example of the challenges and rewards of creating story listening systems for children.

2.1 Storytelling

What do we mean by storytelling and children's fantasy stories? Adults and children tell stories about events that they see present in the world around them, about events that they have experienced in the past, and about events that take place in their imaginations. Storytelling of all sorts is the primary form through which we understand and impose order on our experience. At the individual level, a narrative of our own lives enables us to construe our role in the world. At the family level, storytelling is used - often unwittingly - by parents to enculturate children, to teach what stories are appropriate and important, and aid their development in becoming competent tellers of the family's life stories. At the cultural level, narrative gives cohesion to shared beliefs and transmitted values. These effects may be gained from reading – or watching – stories that resonate for us (hence the tears cried by generations of children watching Bambi), but the gains are even stronger when we tell the stories ourselves.

Storytelling also allows children and adults to explore what it means to fill different roles in the social world. As Turner [49] suggests, "narrative is ...experiential knowledge." This function is apparent in the tales that parents tell about their children: "[My husband] said [to my daughter] 'tell your mother she's a creep' and that's when she said, 'nuh uh, Daddy.' She said, 'You're the creep'"), and the tales that children come to tell about themselves ("[I] didn't want other kids to play on [the slide]. I want I myself, I myself to play on it") (both examples from [36]). Children particularly use storytelling to experiment with their developing notions of roles. This function is apparent in a young version of storytelling which is pretend play. In fact, pretend play is a kind of co-produced storytelling where children share out the character roles, and take turns being the narrator: "you be the teacher and and I'll be the student, and I'll say I didn't do my homework and then you'll yell at me, and then . . .". Thus, in storytelling we experiment with, construct and express our identities.

Stories impose a structure on the events that we narrate such that listeners (including the storyteller) can understand them, and thereby gain some particular perspective on the events [43]. Stories have these properties because of the essential duality of their existence. On the one hand, stories are composed of events narrated in a particular order and told from a particular point of view. On the other hand, stories are *about* events that took place in a particular order and were experienced by particular people (potentally including the narrator of the story). The order of events in the telling need not mirror the order of events in what is described, nor does the perspective on events necessarily mirror the original perspective of the teller. When the order or perspective are not identical, however, narrative effects are triggered. This is how we build suspense ("what I have not mentioned until now is that . . . "), give our evaluation of what is happening ("all of this happened this way because . . . "), and make the story relevant to the interaction at hand

("this reminds me of what happened to us last summer"). Through these narrative effects, which for most everyday storytelling are included more or less unconsciously, tellers explore and convey knowledge and experience. We may choose to engage in such storytelling to inform others about our experiences or beliefs, or to get enough distance from those experiences to be able to reflect on them (what [8] refer to as a "cooling off function" of narrative). These narrative effects are acquired by children in a long developmental process that begins around age two [22] and that does not end until early pre-adolescence [29].

Finally, in storytelling children practice their command of language. Very young children may simply push stuffed animals across the floor, and express the animals' actions by saying "ruff ruff" or "vrrrrooom." As children grow older, they begin to speak in the voice of the characters they are imagining. By age four they may, once again, push a stuffed animal across a floor. At this age, however, they will supplement the action with dialogue: "What a lovely day. I think I'll go to the store. Then I'll come home and bake a cake for my friends." [2]. At this age, too, children begin to acquire metalinguistic awareness and become able to play with different linguistic styles. For example, a child may say in a stern tone of voice "Children! Take out your pencils and write your name very neatly!" [1]. The next stage of development, starting around age 7, finds children able to not only speak in the voice of their characters, but also in a *stage voice* – the voice of a narrator or playwright [2]. Children may say "and then the little dog pranced around saying "oh goody, I'm so happy"". Children at this stage also scaffold each other's linguistic performances by saying "OK, now you say "but my finger hurts" and then I'll tell you that I'll sew it up." This ability to shift from character to narrator perspective is an essential step in the process of beginning to take the story listener's perspective into account. It is only if one is able to narrate what is going on, as well as providing the dialogue of the characters, that a listener will be able to follow. This ability to shift perspective is largely acquired in the storytelling context, but is essential for a wide variety of cognitive tasks. It has been argued that children may actually use more mature language in their storytelling than in their everyday conversation [42]. Perspective taking and the ability to relate a story in several ways are essential skills, of course, since narrative features such as contextualization cues for an absent reader, are prime challenges in the acquisition and development of written language [33].

2.2 Fantasy Play

One common form of storytelling among young children is fantasy play. We can define this kind of spontaneous play by the fact that the children's language and actions are both the process and the product of their fantasy play. For example, a child who is holding a block tells her playmate, "Pretend this is a train, OK?" Children demonstrate in this language a sense of possibility – the concept of "what might be" [48]. Through their language and their actions they create the world in which they are playing.

Fantasy play, which can include role-playing, dress-up, and storytelling with objects such as stuffed animals, allows children to explore different possibilities in their life without the risk of failure and frustration from unexpected events. Pretense gives children a unique opportunity to explore their own emotional arousal [17], and also an opportunity to experiment with possible interactions and relationships among humans [32]. As such, fantasy play fulfills an important purpose in children's emotional and social development.

Fantasy play also fosters children's cognitive and language skills. In fantasy play, children practice their ability to represent objects, actions, and feelings with something that stands for them. Such ability is paralleled by a corresponding ability to represent in language [38]. 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 [39].

2.2.1 Peer Collaboration in Fantasy Play

Although children can engage in fantasy play alone, the structure of their play is more complex when they collaborate with peers. That is, children may invent more characters, narrate more complicated plot structures, add more narrative "special-effects," and fill their audiences in more completely as to the underpinnings of their stories when playing with peers. In fact, it has been shown that children's fantasy play is more complex with peers than with parents, as peer play demonstrates more negotiation and is more improvisationally creative [51]. Fein & Fryer [18] found no evidence that caregivers contribute to the quality or sophistication of fantasy play. By contrast, in children's play, peer's stories and imaginary creations serve as a new suggestions for children to enact and tell their story creatively within a dramatic frame [3]. It appears to be the "collective" routines among peers that take children's fantasy play even further [14]. These results are not surprising when taken in the context of other work on peer collaboration among children. For it has been found that even children's moral and logical reasoning skills are better in conversations with peers than with parents [31, 30].

There is abundant evidence, then, from the psychological and pedagogical literature that suggests that storytelling is an extremely important developmental arena for children. And within storytelling, fantasy play is a particularly rich space for the development of language and creativity, with collaborative play among peers providing the most leverage.

Given this evidence, one would imagine an equally rich practice of technology to support, encourage and enhance fantasy play of this sort, in the service of children's creativity, language learning and literacy goals.

2.3 Children's Technologies

Until very recently, interactive storytelling available commercially for children was limited to applications that read storybook stories to children, software that provided sample first sentences for child writers, or authoring environments that allowed children to choose from sets of predefined characters and predefined text to make up plays. Interestingly some of the most groundbreaking commercial work on computers and storytelling has taken place in the context of the recent drive to create software specifically for girls [11]. Software from Purple Moon, for example allows children to identify with the heroine of a story by offering a branching narrative whose branches are all about personality and character development (rather than the more traditional plot development interactive fiction demonstrated by classic videogames).

Even within the research community there is still not a wide range of work on storytelling systems for children, although some researchers have begun to address these issues.

MOOSE Crossing [7] allowed children to construct a virtual environment in which they could interact with one another. In MOOSE Crossing, children designed and built the objects and virtual characters in the virtual space themselves. Each object and character could engage in play behaviors when interacting with human participants, and the children were encouraged to write narrative descriptions of their creations, and for their creations to utter.

Hayes-Roth's Improvisational Puppets System [23] provided an environment where children could play-act by using personality-rich characters. By manipulating the characters on the computer screen like puppets, children explored different character actions and reactions. Hayes-Roth and her colleagues found that although children are able to construct stories collaboratively both with peers and parents, they engaged in more open-ended play with their peers than with adult partners [24].

One aspect of making technologies more accessible to a broad range of users is to make them more tangible [26]. This trend is particularly important where children are concerned, as children have an early emotional engagement to physical objects [52], which can be leveraged in building technology to support their cognitive and social development. Another important aspect of the *personalization* of technology for children is to embed it more seamlessly and more ubiquitously in the user's natural environment [25]. Employing soft stuffed toys, which are both tangible and part of the child's early environment, as an alternative to the traditional monitor and keyboard interface seems to create a more familiar, less intimidating, and more emotionally engaging atmosphere for children [15, 21, 50, 28].

Most commercial applications in the domain of tangible personal technologies for children are variants on dolls, with increasingly sophisticated repertoires of behaviors. Microsoft Actimates' Barney and Mattel's Talk with Me Barbie® have embedded quite sophisticated technology into familiar stuffed animals and dolls. These toys, however, deliver adult-scripted content with thin layers of personalization, and do not engage children in their own fantasy play. In both cases the toy is the speaker and the child is firmly in the position of listener.

In the research community, recently Druin and her colleagues [16] made a soft interface that can serve as a physical building block for children to build their own programmable stuffed animals with. PETS robotic soft animals can tell stories written by children with appropriate expressive behavior specified by the children in their story writing. In PETS (Personal Electronic Tellers of Stories), storytelling elements are the motor that drives the children's design and construction of their own storytelling pet/character.

In an effort to build a natural interface for children's storytelling play, and to embed technology in children's natural environment, a room-sized play space with all of its contents was explored in the KidsRoom [5]. The KidsRoom provided a play room where children's body movements were tracked by computer vision. Children navigated a story by following the instructions of a virtual character and 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. This unfettered movement is important as it may allow children to act out the contents of their imaginations, and to feel as if their own fantasy is driving the technology and not the other way around. However, in fact, KidsRoom allowed only a finite set of highly constrained behaviors.

2.4 Technologies for Listening to Children's Voices

In our own work we pay particular attention to the direction of influence: is the technology determining the content of the child's play, or vice-versa? Our philosophy is that good technology for children supports child-initiated and child-driven play. This kind of play does not depend on games and activities introduced by educational or commercial ventures and so the best and newest technology may well resemble the oldest forms of culture. So it is with storytelling technologies, which support that oldest of all human cultural behavior, telling stories. In the next section we lay out our design philosophy of technologies to listen to children's voices, and then turn to the StoryMat.

StoryMat is a part of a large-scale research program addressing the design of technologies to foster storytelling play in children, with the goal of supporting peer collaboration, language learning, and exploration of self and culture. This research program can be seen as an attempt to understand the role that computers can play as story *listeners* rather than storytellers.

As mentioned above, although there is quite a long tradition of computers and storytelling in the form of *interactive narrative*, much of this work is only interactive if one considers the designer to be the primary user. Interactive narrative is often more an expression of the designer's personal narrative, and not an exploration of a story that the user might wish to tell.

Our goal is likewise to support interaction and narrative activity and in this sense to construct interactive narrative systems. But our ultimate goal is to support children's voices -- and sometimes also the voices of adults [12, 10]. The term 'voice' in narrative theory has referred to whether an author speaks through a narrator or a character, or speaks as herself - it is the taking of different perspectives on a story. But, popular books on adolescence, and much feminist theory, use the terms "voice," "words," "language" metaphorically,

> to denote the public expression of a particular perspective on self and social life, the effort to represent one's own experience, rather than accepting the representations of more powerful others. [20: 176]

The two meanings of the term come together when we consider storytelling to be an activity in which one constructs a social self - and a place where one maintains one's perspective on one's own life - where one resists the attempts by more powerful others (in this case, adults) to silence one's perspective. If stories are one commonly available means by which people create, interpret, and publicly project culturally-constituted images of self in face-to-face interaction, then they are also occasions on which to defy others' versions of who one is.

Thus, storytelling is an important activity for the development of knowledge about the self, particularly in relationship to others. Storytelling is the time when we learn to tell what we know about social interaction and ourselves to the others who matter in our world. If narrative is experiential knowledge, as Turner says [49], then in stories we can learn to know our own experience as primary, we can try out versions of ourselves, we

can tell our stories, we can describe our version of the world, and learn to trust the value of our perceptions.

In previous work we have begun to explore several aspects of the role of technology in listening to children's stories. In Renga [9] we concentrated on the collaborative and community-building functions of storytelling. Like the round-robin storytelling game played by children in elementary schools, Renga (from the Japanese word meaning, "linked poem" or "linked image") encourages children to add a sentence to an ongoing story, and to become a part of the storytelling community. Renga incorporates many of the linguistic, imaginative, and community-oriented aspects of the old-fashioned round-robin story, but also adds the capacity for children who are not in the same room - in particular for children in different countries - to share in the circle. As children type in sentences, they are immediately added to the end of the story. If more than one child submits a sentence at once, a situation which potentially threatens the cohesion of the story, one of the sentences is added where it is intended, and the other(s)are held in a queue and added to the story at a later point according to a set of discourse rules that ensure that the sentence fits in syntactically and semantically.

In our initial introduction of Renga, we invited the participation of every school in the world that had web presence (214 schools, in October 1995). Children from fourteen schools in eleven countries accepted our invitation and used Renga to collaborate on a story during one 24-hour period in October 1995. While in general children found the system intuitive and enjoyable, our early experiences with Renga led us to realize how hungry for first-person voice children really are. In our first trials with the system we found that, while children were happy to add sentences to the existent story, they also tended to punctuate the story with statements about themselves. Thus, in the middle of an episode of the story about a little girl running away from a monster in the woods, one girl added "Hi, I'm Tracy and I like icecream. I live in Australia. Does anybody else like icecream". Tracy's contribution went outside the established story to create a collaborative narrative environment in which self-expression was primary. The realization that collaboration on the story did not suffice, but that children also needed to collaborate on community - on expressing who they were to one another - led us to change the format of the story and add a separate window where information about the author of each sentence is displayed. Clicking on a sentence now reveals information about the child who wrote that sentence, including whatever description of him/herself the child chooses to add. We also added a list of the last five children who submitted sentences, in order to give children a sense of who is in the 'room' at any one time.

In the Rosebud system [21], we first introduced stuffed animals as partners and collaborators in the storytelling process. In this system, the computer recognizes children's stuffed animals (via an infrared transmitter in the toy, and receiver in the computer) and asks the child to type in a story about the stuffed animal or, in a subsequent interaction, calls the stuffed animal by name and recalls what stories it has heard about that animal. The child is asked to tell a story about the stuffed animal for which the computer provides prompts along the way. With each play session, the child accumulates more stories about his or her stuffed animals in a personalized storybook. Once a story has been written, the child can choose to enter a revision mode where the computer plays the role of an encouraging listener, as well as a teacher, persuading the child to write, write more, edit, expand. In either case, the child is in charge of the interaction, deciding which stuffed animal(s) to play with and what stories to tell. The stuffed animal is the

fantasy imaginative object that becomes the hero of the story. The collaboration between child, computer and stuffed animal ends with the child recording the story in his or her own voice - the story is saved into the stuffed animal and the child can then ask the stuffed animal to repeat the story back.

Rosebud supports storytelling not only by one child and one stuffed animal, but also by multiple children each with his/her own stuffed animal, working together. In this literal sense of spoken voice and metaphorically, Rosebud supports children's voices through an open-ended storytelling framework for the child. Rosebud focuses on collaboration by allowing multiple-toy use and multiple-author storybooks, so that several children can write a story together about all of their stuffed animals. Likewise, since the toy serves as a storage device, children can trade their stories by lending their stuffed animals to a friend.

In early user testing of the Rosebud system we were interested in differences in the extent to which children would describe details of their own existence when telling stories using personal objects with child-ascribed characteristics (their own teddy bear) versus popularized objects with media-defined characteristics and behaviors (Barney or Winnie the Pooh). We found that any stuffed animal was equally likely to elicit a highly personal story, such as the following story told by one 9 year old girl playing with a Pooh Bear and an Eeyore animal.

> Once upon a time a very long time ago there were two friends named pooh bear and eeyore. They liked each other very much and let nothing get in there way. One day eeyore felt sad because his mother passed away. So he went to his good friend pooh bear to ask for advice. Eeyore asked pooh bear and pooh bear said to take it easy and relax. Eeyore said ok I will.

Here the emotional bond that often exists between a child and a stuffed animal appears to be more important than any pre-existing identity of the stuffed animal. We hypothesize that the bond between stuffed animal and child is particularly supported by the peer nature of the voice of the computer system which encourages and scaffolds the child's participation, but never suggests content or specific revisions.

Rosebud, then, did support creative child-driven storytelling play. The system encouraged children to explore their fantasy worlds (to think about their stuffed animals as the heroes of stories), and to explore the use of language to express those fantasy worlds.

Like Rosebud, SAGE [4] invites children into a three-way collaborative storytelling interaction between the child, computer, and a stuffed animal. However, in the SAGE system, rather than being the hero of the child's story, the stuffed animal becomes the child's listener, holding the secrets and stories that the child chooses to tell. Additionally, children can engage with SAGE in two modes: 1) by choosing from a library of sage storytellers and then telling a personal story to that persona, and 2) by creating their own characters and types of storytelling interactions to add to the library of personae. In the first, story-listening interaction, children are invited to talk about their lives with a wise old sage, who listens and then offers a relevant traditional tale in response. In the second, storyteller-designing interaction, children are invited to add to the library of wise old sages by designing their own storyteller for themselves and other children to interact with.

In order to support children as designers as well as users of the storytellers, a visual programming language was implemented. With it children can design and program: 1) the scripts that are used by the storyteller, 2) the conversational structure or flow of the interaction, 3) the body behaviors of the toy -which behaves as the storyteller's assistant; and 4) the database of stories that are offered in response by the storyteller. The stuffed animal is capable of some of the types of nonverbal behaviors that humans use to indicate engagement, and that are commonly found in conversational narratives between people. In interaction mode, children can watch the stuffed animal move as they converse with it. In design mode, children can decide on the toy's communicative behaviors as well as the different personalities and conversational styles that it might demonstrate.

The power of designing SAGE storytellers is that children are being invited to design their own ideal listeners. In doing so, they express those parts of themselves that know how to listen to the stories that they themselves tell. When interacting with one of the sages that we had designed, children revealed aspects of their inner lives and the problems they face everyday. In building a SAGE, children designed listeners to whom they wished they could turn with their problems, and by doing so also revealed facets of their own inner lives. That is, since the children were creating their own characters and databases of stories, they were exploring different notions of self, and creating or imitating the narrative voices they wanted or needed to hear. When we invited children to use SAGE, children created storytellers as projections of fears, feelings, interests, and role models. These projections allowed the presentation of the self to themselves as well as to others. One child, for example, built a storyteller called 'Big Orange Fox' who tells stories about hard things that have happened to him in response to problems that the story writer describes. Big Orange Fox interviews the person interacting with him to find out if that person has "school problems, learning problems, teasing problems, subject problems, friendship problems, religion problems, and relative problems."

The SAGE system allows children to explore three different aspects of using their voices, and being listened to. First of all, children learn what it means to listen as they design a listener who must be able to react to different kinds of input, and engage in a conversation that must not look as if it has been scripted. Secondly, a particular child can design a SAGE storyteller who know how to respond in exactly the ways that that child needs. Finally, children design listeners for other children, as reflections of their own best listening skills. All three issues are ways of reflecting on the self and exploring identity and voice. The SAGE system, then, supports child-driven storytelling play, while encouraging some fairly sophisticated linguistic skills.

A more recent version of the SAGE system has been given a web interface (http://wise.www.media.mit.edu) so that children may design story listeners for children around the world to interact with. In the WISE system, the programming language has been simplified so that younger children can still program the storytelling interaction of their ideal listener. We have also added features to encourage children to reflect further on the role of language in storytelling – children pick the themes that identify the stories in their story listener's database, and also learn how to think through the different meanings of a single word as they instruct the system on how to match database stories to user stories.

Although the Rosebud and SAGE systems move into the domain of tangible personal interfaces for storytelling toys, they – like all of our previous technological toys – still maintain a connection with the desktop computer. Children, then, must know how to type and how to read in order to collaborate with the computer. Our current work attempts to overcome this constraint by working with children's spoken stories, where stuffed animals play the parts in the story. This allows the system to be accessible to younger children, and encourages children to play more freely.

3 StoryMat

StoryMat is designed to support children's collaborative storytelling through their fantasy play. StoryMat is a soft quilt-like play mat with appliqued objects such as houses and roads. It provides an under-determined play space for children to tell their own stories on, and yet it is an active participant in their play since it records and recalls their stories. As far as the child user is concerned, StoryMat functions entirely independently of a computer or keyboard, thus allowing pre-literate children to engage with the system. 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 visited the mat previously. 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 with its narrator's voice. This in turn provides an opportunity for a child to continue the themes of the story she heard by telling her own new story. The child may tell her subsequent story by coming up with a creative solution to the story she just heard. Or she may continue telling her own story and incorporate some story elements from the story she just heard. In this sense, StoryMat is a kind of imaginary playmate, but who also mediates natural collaboration between a child and her peer group.

Figure 1: A child playing with a stuffed animal on the StoryMat. The metal feet support the projector above the quilt.

Generally, the stories children tell are not saved for some special occasion or just for adults to hear. Instead, they slip unobtrusively into the flow of children's everyday play [37]. However, if there were a space where such stories were stored for the tellers or their

peers to hear and for them to explore further, in much the style of peer collaboration they are excellent at, the experience of storytelling might become richer.

StoryMat was designed to capture children's everyday stories as a way of supporting collaboration and exchanges of stories among children. By recording and recalling children's own stories, StoryMat offers more opportunities for children to listen to and interpret each others' stories even in the absence of physical playmates. As a result, a child who plays on the mat by herself could tell her stories collaboratively with stories that were told by other children on the mat, just as she might in playing with her real friend. And a child who plays on the mat with his friend will have access to more than just his partner's stories as he constructs his own narrative. In both cases, collaboration among peers is exploited to foster creative storytelling on StoryMat.

In addition to providing a larger-than-themselves interface, this particular kind of quilt serves as a unique interface for collaborative storytelling. Objects sewn on the mat are story evoking: paths going in different directions, trees, houses, and fields of contrasting colors. These objects serve as "story starters" for children, yet they are under-determined 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 home. A blue field can be a magic spring or a field filled with blue flowers. Children on StoryMat see and hear other children's imaginative creations and become inspired to tell their own stories creatively. Supported by a collaboration between the past and present, children exchange the product of their imaginations to further cultivate their fantasy worlds.

3.1 Technical Implementation

The StoryMat itself is a soft cloth quilt with appliqued figures on it. Software divides the mat into 126 areas, without any need for attached wires or grids. An ultrasonic transmitter embedded in a 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 go of the stuffed animal, the coordinates and the voice are combined into a movie file and saved in the computer to be played at the appropriate location on 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 animation of the stuffed animal is projected onto the mat and travels the course of the recorded path, complemented by the child's recorded voice (see Figure 2). When there are multiple sessions stored at the same place on the mat as the new session, the one with most similar length and pattern (the length of the story session, pattern of the path the toy took, and the identity of the toy) as the new session is chosen to

Figure 2: Telling a story with the stuffed bunny triggers a previously told story to be played back on the mat as an animation.

be played back. The goal is to mediate a collaboration between a child and the peer by connecting the present stories with the past stories, but also to have the computer play the role of a playmate by responding to the child's story with a peer story that is similar.

The stories on StoryMat are also designed to be manipulatable objects of collaboration in themselves. While another child's story is being played back, the user may grab the stuffed animal and begin to tell a new ending for the played-back story. In this case, a new animation is created with 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 original one-child stories.

4 How Children Play on StoryMat: a User Study

Our belief is that the StoryMat system acts as a kind of imaginary playmate or peer, standing in for absent children when a child is playing alone on the mat, and mediating communication between two children playing on the mat when children play together. We believe that StoryMat encourages the kind of creative child-driven open-ended exploration of language and narrative that is so important for young children, and that children are able to incite in one another. In order to investigate these claims, we examined how playing on StoryMat impacts the experience of children who are playing alone and playing together with a playmate, and we compared children who are playing on the active StoryMat and children who are playing on a passive quilt. That is, children who played alone and children who played with a playmate on StoryMat were compared with children playing alone and children playing with a playmate on a passive mat. The identical quilt without the recording and recalling function of stories is what we call the passive mat. In our analyses we looked at indices of creativity, the use of mature narrative devices, and the nature of collaboration on the mat.

4.1 Methodology

We recruited 36 children between the age of 5 and 8 for the study from local schools in Cambridge Massachusetts. This age range was chosen as children of this age engage in frequent episodes of fantasy play at home and in school, and they are actively working on the narratively-complex task of transitioning from oral storytelling to written literacy. Children were randomly assigned into one of two groups: 1) a StoryMat group, who played on StoryMat and 2) a control group, who played on the passive mat. In each group, 6 subjects played alone and 12 subjects played with another playmate, resulting in 6 dyads and 6 singles in each group.

The children played on StoryMat or the passive mat for 15 minutes or so. All children in all conditions were given identical instructions: "let's pretend that we are living in this world. Will you tell me stories that happen in this world? First I'll play with you some. But I'm going to leave the room in a little while so that you can be alone to tell your stories on the mat." Children on the StoryMat condition were given one additional instruction: "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 knows you are done with your story." The experimenter always told the first story, and in the StoryMat

condition the experimenter then sat and listened to the story that the mat gave back in reply. In all conditions the child was then invited to tell a story, and then the experimenter left the room. Thus, in all conditions children heard an equal number of practice stories before the actual session began. No additional instructions were given as to the functioning of the system, nor what was expected of the child. The experimenter was absent for the entire play session, as many studies have shown that children interact less with one another when they are in the presence of adult observers. The first 10 minutes of discourse were collected from all the children. Discourse from all 36 children, a total of 24 10-minute sessions (12 singles and 12 dyads sessions) was transcribed.

4.2 Description of Analyses

We first present sample segments of the children's stories to give a preview of the general characteristics of the kind of fantasy play we found in each group. After this impressionistic overview, we turn to a more detailed analysis. We first look at the temporal characteristics of the storytelling activity on StoryMat and on the passive mat – a descriptive analysis of who speaks when. Then we turn to a specific analysis of fantasy play and collaboration. We use a common measure of the sophistication of children's fantasy play: by counting the number of real objects in the environment that children transform into fantasy objects [47]. We quantify the quality of the collaboration between child and mat by counting the number of times children incorporate into their ongoing story an element proposed by StoryMat (op.cit.). We quantify the nature of the experience – pretend play or narrative-based storytelling – by looking at the number of narrative roles taken by each child [2]. And we look at the function of StoryMat in multiple child play situations by describing what kinds of scaffolder and critic roles children take with respect to one another when playing on the passive mat versus the StoryMat [44]. Finally, we conclude our description of the user study by giving one more impressionistic overview of the children's engagement in the different conditions. In none of these analyses did age turn out to be a significant factor (that is, no age differences were found . . . to the extent that this could be measured in such a small sample), and so age will not be mentioned in the analyses presented below.

4.3 Sample Story Segments from each Group

In the next four sections we give four examples of narratives produced by children when playing on the passive mat or the StoryMat, either playing alone or with another child.

4.3.1 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 and shorter utterances compared to other groups. They also tended to have long pauses between their utterances. They often moved their stuffed animals on the mat without saying anything out loud. 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 verbal contributions during their session.

When children in this group did talk, their speech was mainly the product of pretend actions: They spoke mostly in the voice of a character, and they rarely took a third 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 lie down, sing or beat rhythms away from the mat. The following is an example from a child who did actually speak during the play period:

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]

It is notable that, when Alexandra does tell stories out loud on the play mat, it is solely from the character point of view, with no third person narration. It is also notable that the discourse lacks a general direction or plot, elements that are required in order for it to be a story [43]. It is difficult for a listener to see why the characters she created were doing the things they were doing. This child can be said to have engaged in pretend play rather than storytelling.

4.3.2 Group 2 (One child on StoryMat):

Children in this group played alone on StoryMat. They produced many utterances, in contrast to the children in Group 1. The children took the role of a character (e.g. 'Wow! Isn't that great!') and of a narrator (e.g. "One day, a rabbit was..."). Compared to the children in Group 1, the product of these children's play was more like storytelling than pretend actions.

The following example shows that a child who heard 2 stories on StoryMat with an experimenter during the introduction phase continued to tell stories alone in collaboration with the StoryMat.

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

Josh (8)

"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."

This child predominately took the third person narrator role. He also employed the character voice to act out narrated sections. That is, when he used the character perspective, it was always marked by a narrator's introduction such as "then he said, 'Did you know ...'"

As we will discuss further below, children in this group took turns with StoryMat. They also listened to stories provided by StoryMat and were influenced by those stories. In the example just cited Josh was telling a story about a rabbit making the 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 along the lines of the story he had just heard.

4.3.3 Group 3 (Dyads on the passive mat):

Children in Group 3 played on the passive mat with a playmate. In general, and not surprisingly, the children talked a lot, since they were able to have conversations with a real live playmate. Like the children in Group 1 who played on the passive mat alone, however, the children in this group rarely took the role of a narrator in their play. Their speech was based on their pretend actions, and was fairly unsophisticated in terms of the construction of a narrative world. These children form an interesting comparison with the children in Group 2 who played on StoryMat alone and took the 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 <pause> to.. What should we wish?”
K: Huhh?
C: “We could <pause> 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.”
<pause>
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.”
<pause>
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.”
<pause>

As the reader can see, each of the children was speaking from an imaginary character perspective, 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 whom to create a shared imagined space. However, like the children in Group 1, the children in this group produced a series of pretend actions rather than a narrative where perspective is imposed for a listener through the use of narrator voice.

4.3.4 Group 4 (Dyads on StoryMat):

Children in Group 4 played on StoryMat with a real live co-temporal co-spatial playmate. Like the children in Group 3 who also had a playmate, children in this group produced many utterances. But, unlike the dyads in Group 3 who played on the passive mat, it is interesting to note that children in this group took the roles of both a character and a narrator, as well as carrying on conversations with their playmates. Compared to the children in Group 3, the product of these children’s play was more like storytelling than like a 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 <pause> bunny. He was going down the train track. And he suddenly saw <pause> Um. A trail. Then he went <pause> 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.’”
<pause>

K: Oh, I just keep saying?
K: "So then, he came back. <pause> 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 to R: Go!
R to K: OK.
<pause>
R: "Once upon a time, there was a zebra. And he, I mean <pause> 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 <pause> pulled the zebra out. And then, the bunny went back home."

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, which in this context is a stage voice or *metanarrative* role (i.e. "OK," or "Go" addressed to the partner).

4.3.5 General Characteristics: Summary

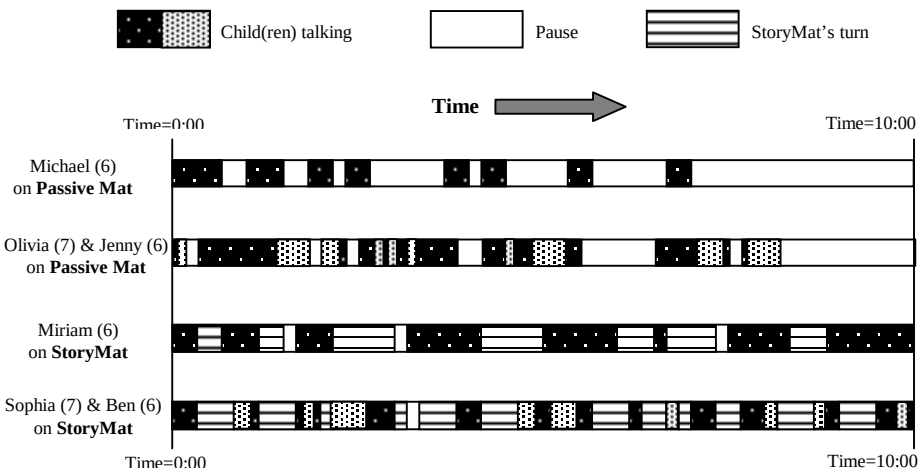
The preceding examples demonstrated a number of different characteristics of the children's storytelling. A single child on the passive mat did not verbalize much and often got bored. In contrast, single children on StoryMat listened to the stories offered by StoryMat and told stories as long as those they might have told if they had playmates who listened and responded. Two children on the passive mat had conversations with one another. Likewise, two children on StoryMat had conversations with one another, but they also listened to the stories offered by StoryMat and told narratively complex stories in response.

At this point, one may ask, how did the stories offered by StoryMat play a role in the children's storytelling? What did the StoryMat stories offer the children? Were the children on StoryMat able to collaborate with StoryMat in such a way that the system offered peer-like scaffolding? To investigate these points further, we now turn to look at the children's discourse patterns.

4.4 Children's Story Patterns on the Mat

In order to visualize a general pattern of the children's discourse on the passive mat and StoryMat, we generated a graph based on the quantity of the children's speech and where it fell with respect to StoryMat stories. The following graph shows an sample 10-minute session of children from each of the four groups (the children picked are each representative of their group). The graph shows **how much** children were talking on the mats, and **when** they were talking during their 10-minute session. In particular, for Group 2 (one child on StoryMat) and Group 4 (dyad on StoryMat), it shows the patterns of how

the children and StoryMat were taking turns. In later analyses we will dissect further these patterns, but for the moment it is instructive to see the overall pattern of interaction.



Graph 1: Children's discourse patterns on the mat.

First of all, one can see that in both dyad conditions, both children talked. Next, this graph shows that the children on StoryMat, both alone and in dyads, paused less than the children on the passive mat. In fact the children on StoryMat seem to talk throughout the 10-minute session (when the mat is not talking), while the talk by the children on the passive mat is more sparse (especially the single child on the passive mat). In fact, the pattern of the single child on StoryMat is very similar to that of two children on StoryMat. We see that the single child on StoryMat was as verbal as if he/she were with a playmate. This can be taken as an index of how engaged the children on StoryMat are.

One might think that the children on StoryMat are talking merely because the mat is talking, and that their talk is no more story-focused than the children on the passive mat. On the contrary, if one looks at the number of "story-initializing phrases" ("once upon a time," "one day") produced by the children it turns out that both single children (mean of 5.0 opening phrases in 10 minutes) and dyads of children (mean of 2.5 opening phrases in 10 minutes) playing on StoryMat are more likely to begin their segments of talk with story openings than single children (mean of 0.5 opening phrases) or dyads (mean of 0.33) playing on the passive mat ($F(3,20) = 3.49$, $p < .05$ only for the difference between single children on StoryMat and the other groups).

To further investigate exactly how StoryMat provided a space for collaborative fantasy storytelling, independent of the presence of a co-temporal and co-spatial playmate, we analyzed the transcripts along several dimensions. We next present these analyses of the children's discourse.

4.5 Analyses of the Children's Discourse

We investigated whether more or less developmentally advanced types of fantasy storytelling play were fostered by children using StoryMat in the different conditions. In

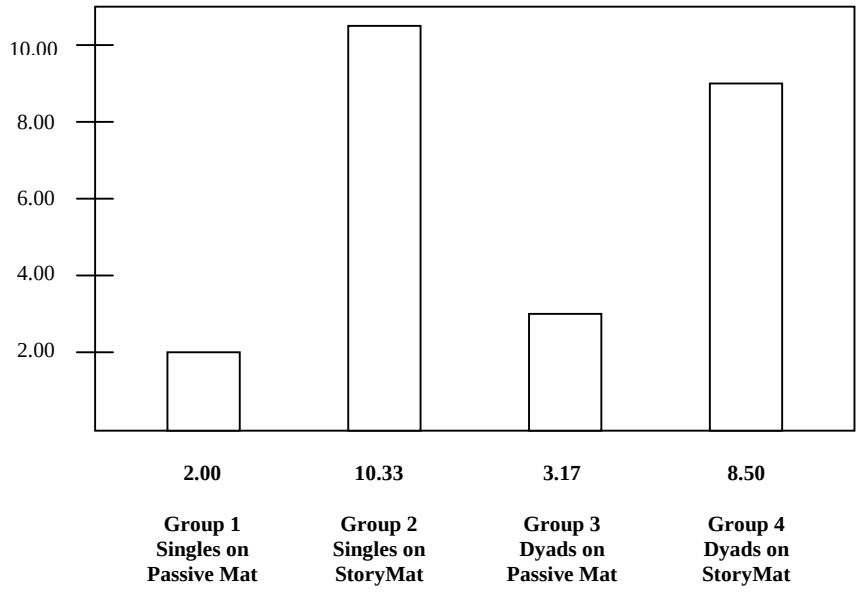
the next section we concentrate on whether there was any difference in the kinds of stories the children on StoryMat and the children on the passive mat produced.

4.5.1 Number of Fantasy / Imaginative Objects

Fantasy play requires developmentally advanced skills: the capacity to sustain an object in thought and to develop an image, cognitive map, or plan of it in its physical absence, and it fosters those same skills in children [46]. With development, children are able to use less realistic objects as the motor for their play as they become able to transform them into imaginative objects that fit their play scenario [27, 13]. For example, children begin to pick up blocks and hold them to the ear to listen to imaginary phone conversations. Such flights of the imagination reflect children's ability to engage in higher mental processes [39], and are an important index of development. For this reason, we were interested in investigating whether StoryMat encouraged the transformation of objects in the course of their fantasy play.

Sheldon and Rohleder [47] used the number of imaginative objects children transformed from realistic objects as a measurement of this skill. 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, we investigated the children's ability to transform realistic objects on the quilt into imaginative objects. The number of imaginative objects that were transformed from the objects sewn on the mat was compared across the groups. Simple description 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. "My house" counts as a transformation since the house on the quilt is patently not the child's own house.

The following graph shows the mean number of imaginative objects transformed by the children in each group. Only a new transformation by a different child was counted .



Graph 2: The mean number of imaginative objects used by children in the four groups.

In the table below, we show the variety of imaginative objects that were transformed from two elements in the play situation (the house and the stuffed animal).

Objects on StoryMat	**Group 1 One Child on Passive Mat**	**Group 2 One Child on 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		
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

Table 1: [x #]: # indicates the number of times the word was used by different children.

The children who played on StoryMat alone transformed 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. A full-factorial ANOVA revealed a main effect for the mat type, $\underline{F}(3,20) = 9.7$, $p<.01$. There was no main effect for the conditions the children played in (the single condition or the dyad condition), nor were there any interactions.

We might wonder how the children's storytelling changed over time in the different conditions. But, interestingly, there appears to be no increase in the number of imaginative objects produced by children in the stories they told at the end of their storytelling session with respect to the number of imaginative objects produced in their initial stories. And this is the case across conditions. Of course, with such a small number of subjects, and a short play period, these results can only be taken as suggestive.

In sum, both the single children and the dyads playing on StoryMat produced significantly high numbers of imaginative objects than the single children and dyads on the passive mat. These results suggest that the children on StoryMat were engaging in a more mature form of fantasy play (remember that it is older children who are more likely to transform objects) – that is more decontextualized from their actual physical play space. It is exactly this ability to decontextualize which leads to the development of a child's cognitive skills [19]. By offering peer stories, StoryMat seems to provide a place for children to exercise their imaginative skills in this decontextualized and story-like fashion.

4.5.2 Incorporations

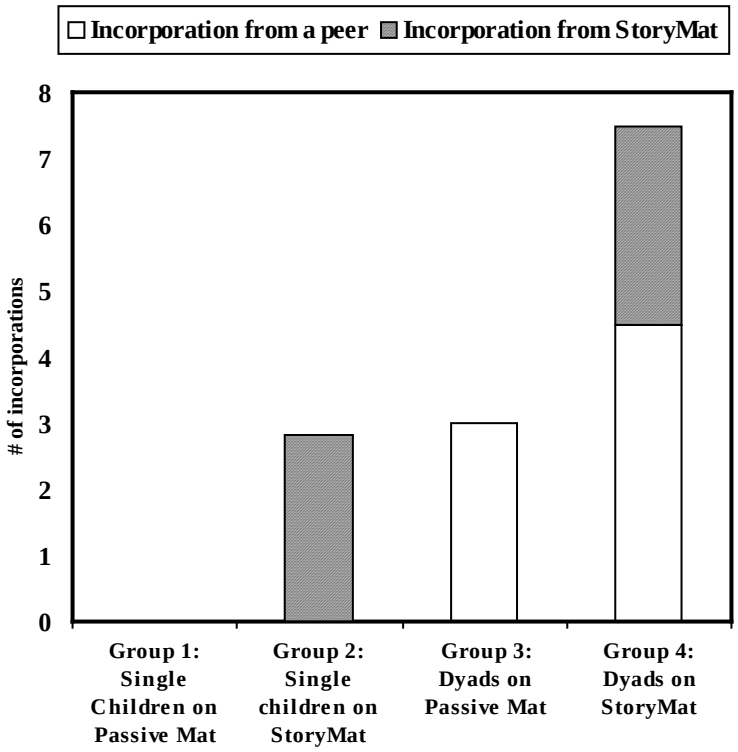
To this point we have assumed that there is something *collaborative* going on between a child and StoryMat, and that this collaboration is similar to a collaboration between two children. In order to investigate this point, we next looked at whether StoryMat provides a place for collaborative storytelling, and how collaboration was expressed among dyads and with solitary children. We analyzed the transcripts by examining the number of story elements from other children's stories and from StoryMat stories incorporated by the children in the different groups.

In fantasy play, children collaborate with one another by incorporating, as-is or after some transformation, the fantasy objects, themes, and words of their friends [48]. In order to investigate collaborative storytelling on StoryMat, we looked at incorporations of language style and incorporations of story elements made by other children. That is, we counted the number of incorporations of a particularly salient style of saying a word or a phrase, and incorporations of particular fantasy objects proposed by other children. The following is a discourse segment of a child who played in a dyad on StoryMat, which illustrates such an incorporation (incorporation is **bold-faced**).

> Xenia (8)
>
> [note: the words in italics indicate a peer story provided by StoryMat]
>
> *Let's see what this yellow house is. It doesn't look like a garage. click click click [child makes sounds]. No answer. Let's try this one. Click click click. 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.*
>
> 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!

In this example, the child hears a StoryMat story with the unusual story element of a 'mysterious music pad' with an associated moving image of a bunny at a place on the mat. Immediately afterwards, she moved her stuffed animal to the same place as the moving image she saw, incorporated the story element she heard into her own story, and continued the story in that vein. Other children incorporated language style, by adopting the high pitched voice or growling sounds they heard in the StoryMat story.

The number of incorporated story elements and language styles were compared across the groups. We were interested here in a 4-way comparison among the groups, as shown in the following graph.



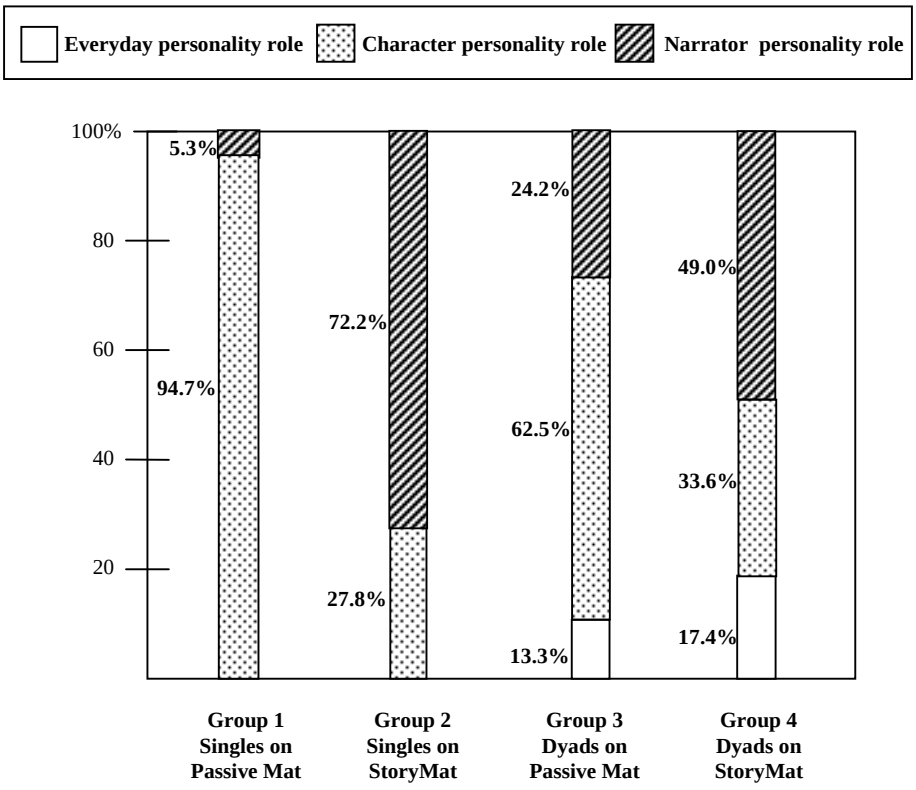
Graph 3: Children's incorporations of elements from other children and from StoryMat.

In this graph we have not distinguished between linguistic style incorporations and story element incorporations as both provide evidence for collaboration in the *content* of the stories told by children. We have, however represented the incorporations from peer stories and from StoryMat stories in such a way that it becomes clear that the dyads on StoryMat incorporated more elements than any other group. This result is interesting as it provides evidence for children being able to collaborate with StoryMat stories at the same time as with a physical playmate. Also striking is the fact that children playing alone on StoryMat incorporated as many elements into their stories as did children playing with peers on the passive mat. These results provide evidence for the fact that, in its role in encouraging collaboration on the content of fantasy, the StoryMat can stand in for a real co-present peer. The importance of these results is that, as outlined in earlier sections, peer contributions have a real effect in pushing children to be more creative, to produce more coherent stories, and to think through how to present stories for real listeners.

4.5.3 Speaker Identity

We have shown that children playing on StoryMat are more likely to tell creative stories, where narrative theme creativity is measured by the number of fantasy objects transformed from real objects on the quilt. And we have shown that children playing on StoryMat are more likely to exhibit collaborative behaviors such as incorporating story elements and linguistic styles. But we need now to examine the effect of these behaviors. Are stories told on StoryMat more mature stories? Are they more narratively advanced? In order to investigate this question, we looked at one very robust measure of 'narrativity' – the ability to shift back and forth between the roles of character, narrator, and "meta-narrator" (or, stage director). This aspect of narrativity is particularly interesting for two reasons. First, it is just being acquired in the pre-school to early-schooling age range that we examined in our study. Second, perspective taking is thought to be an essential bridge from oral to written literacy. When children first begin to write stories it is hard for them to realize that their listeners will not share a joint context and cannot see the their hand movements or hear the their voice changes. Narrative perspective is how mature storytellers set this context for their listeners.

To look at this property of narrative, we calculated the mean percentages of different narrative roles taken by children in each of the groups. The following graph shows the results:



Graph 4: Use of narrative roles by single children and dyads on the passive mat and StoryMat.

The results show that the single children on the passive mat mainly took the character role. The very rare use of the narrator role among children in this group is a reflection of the fact that children in this group simply acted as characters ("oh no!") rather than introducing speech by a character (i.e. "Then he said, 'Oh, no!'"). This exclusive use of character voice characterizes children's pretend play rather than fantasy storytelling, and is a comparatively younger form of play [2]. Children are *enacting* the different roles in their fantasy situation, but not *narrating* them.

The single children playing on StoryMat took the narrator's role most of the time, but also took the character role fairly often. These results indicate that single children on StoryMat were engaging in storytelling rather than pure fantasy play. When a character's words are introduced with verbs of saying (said, yelled, told), the story becomes understandable by others and becomes more self-sufficient [45]. The single children on StoryMat both acted as a character and told stories about the character. But they seemed to successfully mix the two roles to tell stories, rather than engaging solely in pretend play.

The dyads on the passive mat took three different roles, metanarrative, character, and narrator. In the metanarrative role, they held a conversation with their peers as a way of scaffolding an unfolding story (e.g. "Let's do a school story – you be the principal!"). They used this role extremely rarely, however (in fewer than 15% of their utterances). In fact, the dyads on the passive mat mainly used the character role (65% of their utterances), and occasionally the narrator role (24% of utterances). The fact that they used the character role more than the narrator role indicates that the dyads on the passive mat were more engaged in pretend play than storytelling. This contrasts with both the single children and the dyads on StoryMat.

The dyads on StoryMat also took three different roles. They held stage-directing conversations with their peers, spoke in character, and introduced character speech in the 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 setting up an overall structure for the story being narrated. That is, narrative utterances accomplished the function of filling in the listener as to what was going on ("and then he walked into the sunset"). The biggest difference between the two dyad groups is that dyads playing on StoryMat narrated most of the time while those on the passive mat spoke as characters most of the time. The balanced mixture of roles displayed by the dyads on the StoryMat is the most characteristic of mature storytelling.

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 [45], storytelling with a narrating voice allows others to understand the intention of the author. It allows the audience to construe what is happening in the story. The results suggest that StoryMat creates an environment where a child is encouraged to engage in this kind of mature audience-focused storytelling.

4.5.4 StoryMat Mediating Collaboration Between Children

We have found that StoryMat provides a place for collaborative storytelling independent of the presence of a co-temporal and co-spatial playmate. Our intention as designers,

however, is **not** to obviate the need for real child playmates! What role does StoryMat play in mediating collaboration between co-temporal and co-spatial playmates? In order to examine this question we looked specifically at the kinds of collaboration engaged in by the dyads in the two conditions.

In child-child storytelling, child collaborators serve a similar role in critiquing and facilitating storytelling as adult collaborators [44]. Children supplement various kinds of information in the partner's text by pointing, verbalizing the partner's gestures, adding elements to the story, additionally characterizing the addition of elements in the reference situation given in the text, and so on [6]. In our study, we observed that such scaffolding was present in the dyads playing on StoryMat, but not in the passive mat condition.

The following is an example discourse segment from a dyad on StoryMat, demonstrating such supplemental information and scaffolding (scaffolding is shown by highlighting):

> Matthew (8) & Becky (8)
>
> M: "So the little boy went to..., the little rabbit went ... to zebra. And the zebra said, 'How do you do?'"
> B: [laughs]
> M: "And then, the rabbit said, 'Hello?' 'Hello?' And then, the zebra said 'Come on over here! I wanna give you some candy!' And so then he came over <pause> and then he came over and he went 'Zap!' And he bit his leg off!"
> B: [laughs]
> M=>B: Your turn.
> B=>M: OK.
> <pause>
> M whispers to B: "And then he grew a leg."
> B: "OK. So <pause> he grew another leg! And then he went walking to his other friend zebra. <pause> And, he's..., he's..."
> M: [M whispers "he's ..." and shows B to use the stuffed zebra]
> B: "And his friend said, 'Hi! Let's go swimming in the lake!' So then went, 'Ooogidi...!' 'Schsss!'" [makes the animals swim]

In the example, Matthew was telling a story using both the third person narrator voice and an imaginary character voice. He gave up the floor by telling Becky that it was her turn to tell a story. While she was thinking about what she would say next, Matthew whispered his suggestion to her. Becky followed his advice, but as she was continuing her story, she again paused. Matthew was again attentive in listening to her storytelling and suggested how Becky should continue.

This type of scaffolding and supplementing was often observed in the interactions among the dyads in the StoryMat condition. Dyads on StoryMat acted as if they were explicitly collaborating on a story (e.g. "Then he said ...?" "There was a ...? [with a clear gesture showing that it is the partner's turn]"). On the other hand, the dyads on StoryMat seemed more conscious about their collaboration with a partner because they were intentionally making a "room" for the partner to fill in (e.g. "There was a ...?"). As children grow older, they are more capable of mutually inciting and supporting one another in the reciprocal roles of narrator and listener [35]. As we saw above, StoryMat encourages the use of more developmentally advanced forms of storytelling. By inviting children to tell

more complex narrative, StoryMat may also invite more sophisticated collaboration among peers.

4.6 Children's Experience on StoryMat:

In this last section we address briefly children's physical experience on the StoryMat. We believe that StoryMat offered a natural, child-directed, story-evoking and collaborative play environment. It accomplished this in part by providing a space where children were able to narrate freely using their body on the mat space. By moving the stuffed animals as well as their own body on the mat, the children actively engaged in the task of storytelling. Without specific instructions, the children moved around on the mat with the stuffed animals, both enacting and telling stories about the animals in the play world. As shown below, the children seemed to be relaxed and having fun. We believe we have shown that computationally-enhanced play spaces like the StoryMat are important advances in creating a natural engaging story-evoking interface for young children.

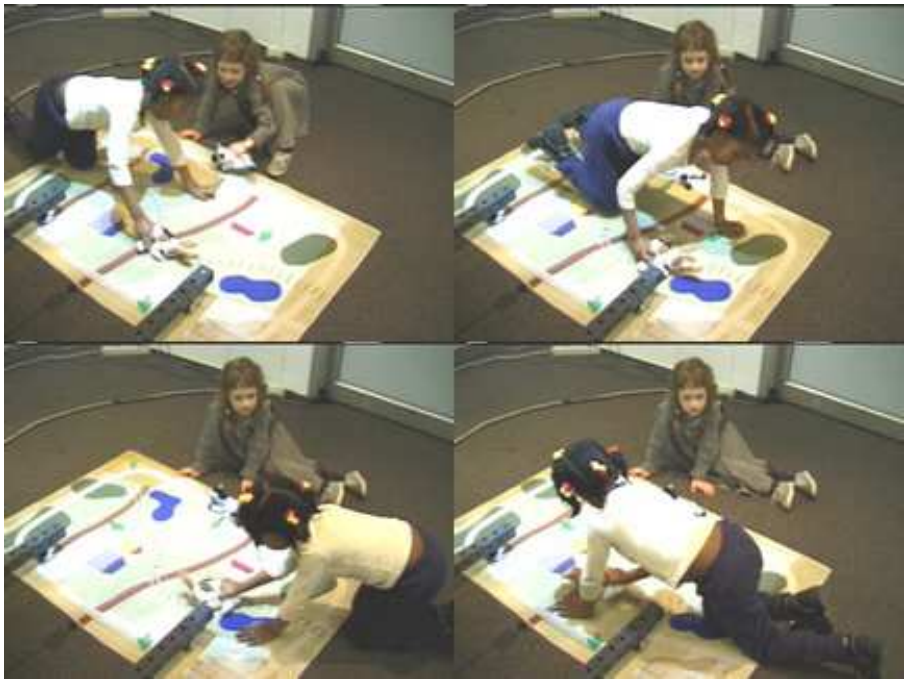


Figure 3: Two children playing on the StoryMat.

5 Summary of Results

An analysis of the children's stories show that both the single children and the dyads playing on StoryMat transformed significantly more imaginative objects in their stories than the single children and dyads on the passive mat. Children's ability to transform objects in their environment into imaginative objects increases with age and is an index of children's ability to create a narrative world separate from the real world. Independently this skill is an important step in children's cognitive development, [19]. By offering peer

stories and encouraging the children to tell their own stories, StoryMat seems to foster and provide a place for this sort of exercise of the imagination.

In general terms it is clear that children playing on the StoryMat *take turns* with the mat in much the same way as pairs of children playing alone. In their turn-taking we see that they are also paying heed to the content of the stories told by StoryMat. Children playing on StoryMat incorporate into their own stories both story elements and linguistic devices from the stories told by the mat. When two children play on StoryMat, they are capable of playing as if they are three real-live peers, incorporating elements from one another and from the mat.

Perhaps most interestingly, analyses of the children's storytelling show that children on StoryMat create linguistic productions that are more like developmentally advanced narratives, and less like pretend play. That is, the children on StoryMat sometimes take the role of an overarching narrator who contextualizes the story for a listener [45]. When two children play on StoryMat, the children not only take the role of a narrator, but also stage-manage one another's productions, collaborating on the *process* of storytelling as well as its content [2].

Finally, observations of children on the StoryMat show that children are comfortable on the mat, that they need no instructions to play there, and that their whole bodies become caught up in the process of using their voices.

6 Conclusions

We started off by quoting from some children's stories that demonstrate that children make their own uses of the media they encounter. In the same way, children can always find a way to make technology suit their own ends. However, particular technologies are easier or harder to thwart, and the introduction of particular technologies into schools and homes can have an effect in convincing parents and teachers that certain play styles are more or less appropriate. As technology is increasingly embedded in children's lives, we have to make sure that the technology is not designed to determine how children play, and what they play. Instead there is an valuable role for technology that supports child-driven play and creativity. One arena in which this role is important is as support for children's spontaneous storytelling play. This kind of play allows children to flex their imaginations, practice their language use, and develop important narrative skills. In this paper we have argued that there is a largely unmet need for computational tools to support and enable children's storytelling play. We demonstrated our approach to such tools by discussing the design and use of a *story-listening* system called StoryMat.

StoryMat provides a place where children are able to practice and foster their storytelling skills. By offering stories recorded by other children who played on the mat at another time, StoryMat also seems to offer a place for a child to experience collaborative storytelling regardless of the presence of a co-temporal and co-spatial playmate. The children on StoryMat listened to and interacted with peer stories offered by StoryMat in much the way they do with stories offered by real life peers.

Importantly, this collaboration and storytelling occurs in a play space where children are able to move their body freely, without the necessity of being tied down to a keyboard or

desktop. Such a computer-mediated but keyboard-free space creates a relaxing, and easy-to-learn environment for children to compose their stories while playing naturally with their stuffed animals.

We believe that StoryMat creates a good intermediate space between children and their imaginations – a way to negotiate the "precariousness of the interplay of personal psychic reality and the control of actual objects [52]. While the small scale of the mat encourages children to be imaginative, it also provides a big enough space for children to work with others within a shared play world. In this sense, although StoryMat allows solitary children (for example, those shut in by illness) to experience the benefits of collaborative storytelling, it is not a technology that isolates children from their social setting. Instead, StoryMat enhances children's experience by supporting connections, inter-child scaffolding, and the exchange of narrative fantasy in the form of a natural and open-ended collaboration.

StoryMat and other similar systems may allow pre-literate children to practice and develop important storytelling skills. Some of those storytelling skills are essential bridges to written literacy, and so in our future research we would like to explicitly investigate the intermediate links that can allow children to become as fluent writers as they are speakers. We expect that story listening systems can play a new kind of role in encouraging children to bring perspective and structure to their stories, as well as the contents of their fertile imaginations. It is exactly in such environments that children learn to find their voice.

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